REPORT

of the

Indian Sugar Committee

1920

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ERRATA.

Page ii, para. 51, *for* "varities" *read* "varieties."
Page vi, para. 186, *for* "Gujrat" *read* "Gujarat."
Page ix, line 14, *for* "sur" *read* "gur."
Page xii, last line, *for* "Sayar" *read* "Sayer."
Page xii should read xiii.
Page xii, line 4, *for* "Wheih" *read* "which."
Page xii, lines 15, 16 and 17, *for* "May" *read* "Map."
Page 9, last line of para. 8, *for* "cultivato" *read* "cultivator."
Page 9, para. 9, margin, *for* "aken" *read* "taken."
Page 11, para. 11, penultimate line, *for* "effiviency" *read* "efficiency."
Page 21, table, yield of cane—4th column, *for* "1.075" *read* "1,075."
Page 22, line 2, *for* "Geerlig" *read* "Geerligs."
Page 22, line 4, *for* "Geerlig's" *read* "Geerligs'."
Page 23, line 3, *for* "cane" *read* "crane."
Page 36, para. 50, last line but two, *after* "for the present" *insert* "we."
Page 51, line 19 from bottom, *for* "are actually" *read* "area actually."
Page 56, para. 81, *for* "develpment" *read* "development."
Page 65, line 12, *for* "seedings" *read* "seedlings."
Page 65, para. 93, 2nd line, *for* "generallly" *read* "generally."
Page 66, third line from bottom, *for* "believe" *read* "believes."
Page 72, para. 104, sixth line, *for* "suggested" *read* "suggested."
Page 79, line 10, *for* "forest" *read* "frost."
Page 80, last line of para. 115, *for* "conditio" *read* "conditions."
Page 81, penultimate line of para. 117, *for* "ran" *read* "rain."
Page 85, third line from bottom, *for* "difference" *read* "differences."
Page 90, fourth line, *for* "prospects" *read* "prospect."
Page 94, line 8, *for* "Mojara" *read* "Mojorah."
Page 104, last line of para. 146, *for* "from" *read* "form."
Page 106, line 12, *for* "is treaches" *read* "in trenches."
Page 107, para. 152, twelfth line, *for* "committtee" *read* "committee."
Page 113, para. 157, line 1, *for* "thu" *read* "thus."
Page 115, line 13 from bottom, *for* "mst" *read* "most."
Page 121, para. 167, ninth line, *after* "circumstances and" *insert* "as."
Page 123, para. 167, last line, *for* "demonstrtion" *read* "demonstration."
Page 125, line 19 from bottom, *for* "Mojara" *read* "Mojorah."
Page 127, line 16 from bottom, *for* "carts loads" *read* "cart loads."
Page 152, line 16, *for* "this completed" *read* "this is completed."
Page 159, para. 217, twenty-eighth line, *for* "caster" *read* "castor."
Page 170, line 21 from bottom, *for* "probabkle" *read* "probable."
Page 170, line 19 from bottom, *for* "thrughout" *read* "throughout."
Page 170, line 18 from bottom, *for* "naure" *read* "nature."
Page 170, line 15 from bottom, *for* "ane" *read* "cane," *for* "ufficient" *read* "sufficient."
Page 170, line 8 from bottom, *for* "ammounium" *read* "ammonium."
Page 170, line 7 from bottom, *for* "hat" *read* "that," *for* "ugar" *read* "sugar."
Page 170, para. 232, twenty-second line, *for* "cultivaion" *read* "cultivation."
Page 170, line 3 from bottom, *for* "equivalnt" *read* "equivalent."
Page 172, last line, *for* "indust" *read* "industry."
Page 177, first line of para. 243, *for* "ex" *read* "experi-."
Page 180, last line, *for* "word" *read* "work."
Page 185, sixth line, *for* "are" *read* "is."
Page 185, twelfth line, *for* "use" *read* "us."
Page 190, second line of recommendation 17, *for* "1" *read* "1-10th."
Page 190, last line, *for* "develope" *read* "developes."
Page 196, line 27, *for* "he same" *read* "the same."
Page 198, fourth line, *before* "different" *insert* "a."
Page 198, fourteenth line, *for* "third the" *read* "third of the."
Page 212, sixth line from bottom, *for* "efficiency" *read* "efficient."
Page 216, para. 291, fifth line, *for* "mils" *read* "mills."
Page 216, para. 293, margin, *for* "(*a*)" *read* "(*b*)."
Page 220, para. 299, last line, *for* "gasses" *read* "gases."
Page 223, line 11 from bottom, *for* "this been" *read* "this has been."
Page 227, para. 306, last line, *for* "mortgage" *read* "mortgagee."
Page 227, line 14 from bottom, *for* "need" *read* "needs."
Page 233, para. 314, last line, *for* "pargraph" *read* "paragraph."
Page 241, twentieth line from bottom, *for* "value" *read* "values."
Page 243, third line from bottom, *for* "junctio" *read* "junction."
Page 248, eighteenth line, *for* "fatory" *read* "factory."
Page 257, heading of para. 344, *for* "systme" *read* "system."
Page 261, items (4) and (5), the first lines to be italicised.
Page 263, item (26), *for* "sepecially" *read* "especially."
Page 264, para. 351, tenth line, *for* "necessary" *read* "necessary."
Page 274, para. 360, last line but four, *for* "can" *read* "cane."
Page 275, fifth line, *for* "Tal" *read* "Total."
Page 286, line 11, omit one "is."

291, thirteenth line from bottom, *for* "as great measure" *read* "as great a measure."
294, first line of recommendation No. 17, *for* "politcy" *read* "policy."
297, line 10, *for* "then" *read* "thern."
299, fifth line from bottom, *for* "form" *read* "from."
299, last line, *for* "envolving" *read* "evolving."
300, third line of para. 389, *for* "seedling" *read* "seedlings."
301, third line from bottom, *for* "premisses" *read* "premises."
303, sixth line, *for* "scales" *read* "scale."
303, para. 394, 7th line, *for* "Panhasi" *read* "Pansahi."
303, para. 394, last line but three, *for* "filll" *read* "fill."
305, item (11), *for* "investigation" *read* "investigations."
307, tenth line from bottom, *for* "if not possible" *read* "if not impossible."
319, twenty-sixth line, *for* "Irrigator's" *read* "Irrigators'."
322, para. 13, sixteenth line, *before* "money" *insert* "a."
323, seventeenth line, *for* "picked up" *read* "pick up."
324, last line, *for* "conumption" *read* "consumption" and *for* "highset" *read* "highest."
325, eighth line from bottom, *for* "Rs. 9 acre" *read* "Rs. 9 per acre."
326, third line from bottom, *for* "extention" *read* "extension."
328, penultimate line of para. 23, *for* "showness" *read* "slowness."
329, first line of para. 26, *for* "ton" *read* "tons."
330, fourth line, *for* "circumstance" *read* "circumstances."
333, second line, *for* "semes" *read* "seems."
333, eighth line, *for* "then" *read* "them."
334, para. 33, seventeenth line, *for* "Iand" *read* "Land."
334, twenty-first line from bottom, *for* "probablities" *read* "probabilities."
335, last word of para. 35, *for* "neverlessness" *read* "nervelessness."
335, last word of para. 36 which is omitted *should be* "factory."
336, fifteenth line, *for* "restriction my" *read* "restriction on my."
336, line 32, *for* "be" *read* "he."
337, para. 40, thirty-sixth line, *for* "following" *read* "follows."
337, line 35, *for* "this mean" *read* "this means."
337, Algebraic table, 100 as numerator omitted in (*b*) of Committee's scale.
337, para. 40, thirty-ninth line, *for* "(X-10)" *read* "$\frac{2}{3}$ (X-10)."
338, para. 40, top line, *before* "serics" *insert* "a."
342, eleventh line from bottom, *for* "accordingly" *read* "according."
343, line 21, *for* "investiments" *read* "investment."
344, para. 49, fifth line, *for* "postopene" *read* "postpone."
352, para. 67, twelfth line, *for* "producers," *read* "producers'."
355, thirteenth line from bottom, *for* "82" *read* "82$\frac{2}{7}$"
356, eighth line from bottom, *for* "as far they go" *read* "as far as they go."
357, seventh line from bottom, *for* "learn" *read* "learned."
367, Appendix III, part C, line one, *for* "Above 4" *read* "Above 14."
370, serial No. 7, *for* "Baijnath Juggilal's" *read* "Baijnath Balmukund's."
376, item 4, *for* "oil fue" *read* "oil fuel."
380, recommendation No. 58, *for* "came area" *read* "cane area."
381, recommendation No. 87, *for* "present grown" *read* "at present grown."
390, recommendation No. 288, *for* "douletful" *read* "doubtful."

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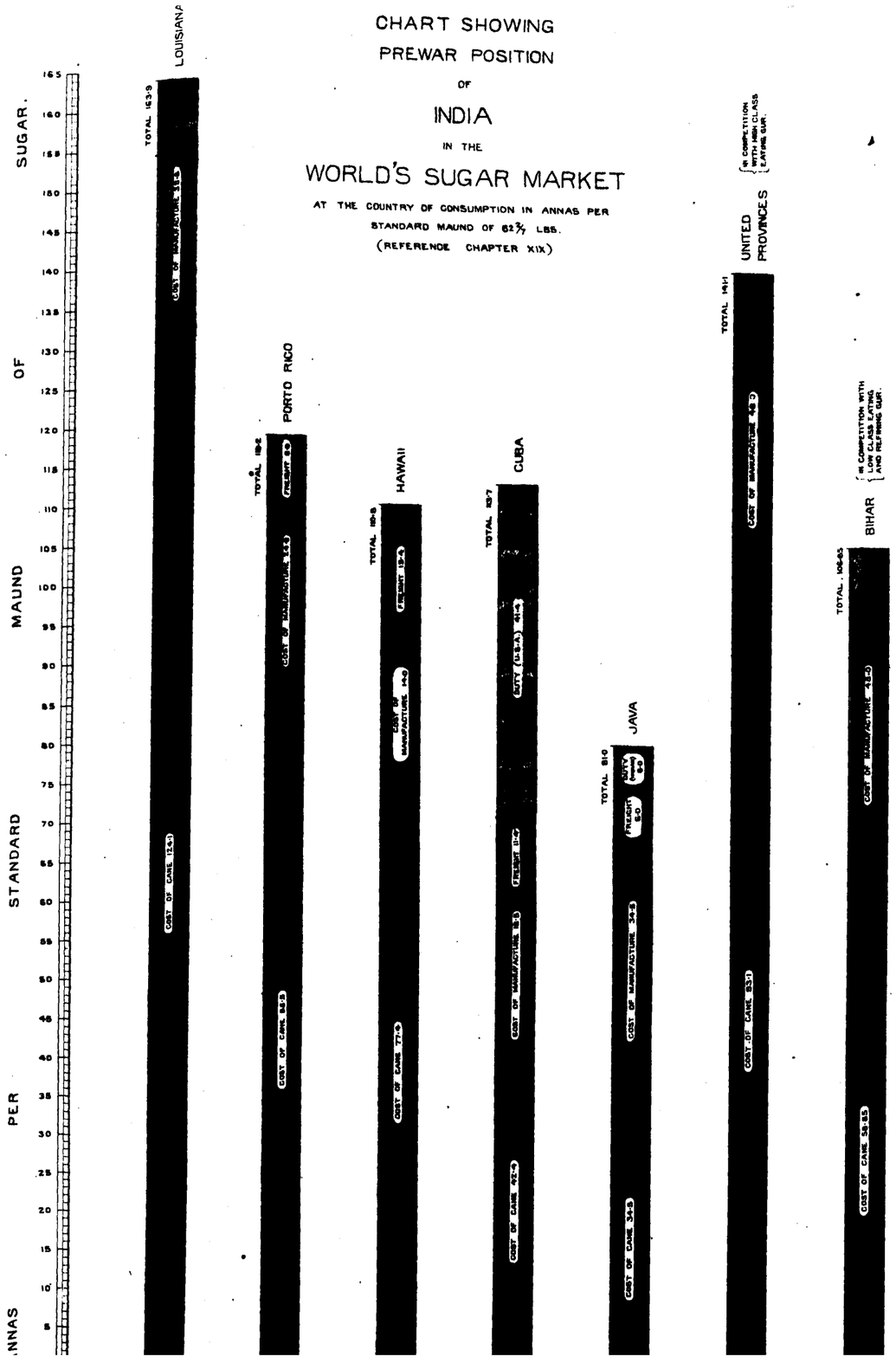
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REPORT

OF THE

INDIAN SUGAR COMMITTEE

CHAPTER I.

INTRODUCTORY.

Appointment of Committee and terms of reference.

1. The Committee was appointed by the Governor General in Council under the Resolution of the Revenue and Agriculture Department No. 949-151, dated October 2nd, 1919, which is reproduced below.

"Among the many questions which have been brought into prominence by the war that of the possibility of organising and developing the Sugar Industry in India stands high in importance. It is not a new question. It has been considered by the Board of Agriculture in India from time to time, and formed one of the main subjects of discussion at its last meeting at Poona in December, 1917, when the necessity for a Bureau of Information on the Industry was emphasized. A beginning in this direction has already been made ; and Mr. Wynne Sayer of the Indian Agricultural Service was in February last placed on special duty to undertake the collection and co-ordination of all available information regarding the industry. But this is only a beginning and the Government of India realise that much remains to be done if any material expansion of the industry is to be looked for.

"Regarding the desirability of such expansion there can be no doubt. The food value of sugar is high : the annual consumption has been increasing steadily for many years, and in India no less than elsewhere. Sugarcane is indigenous in India which until very recent years stood first of all countries in the world in its area under cane and its estimated yield of cane-sugar, and even now ranks second only to Cuba. Yet it is notorious that the yield both of cane and raw sugar per acre and the percentage of available sugar extracted from the cane are undesirably low. While, therefore, India, should be in a position, as she was in the past, to produce a surplus of sugar for export, she has in fact had to supplement her own supplies by imports the tendency of which steadily to increase has only been checked by war conditions. The same conditions have also served to emphasize the disadvantages involved in relying upon external sources of supply. The world prices of sugar have risen enormously, with the result that, while imports between 1913-14 and 1917-18 fell in quantity from 900,000 to 500,000 tons approximately, they rose slightly in value from 14.96 to 15.32 crores. The beet sugar industry has been disorganised over extensive

areas in Europe and, if India cannot now look to herself to supply her own wants, she is faced with the alternative of either reducing her consumption of sugar, or paying increased amounts to obtain it.

"But if the desirability of extending the sugar industry in this country is obvious, the difficulties involved are hardly less so. Apart from the difficulties attending the cultivation and manufacture of cane-sugar in all countries, the Indian industry is confronted with problems which are either peculiar to India or exist there in a special degree. The systems of land tenure exhibit great variety and are complicated by the customary laws of inheritance and joint ownership. Again, the bulk of the sugar produced in India is consumed in its crude state as gur or jaggery ; and this fact has an essential bearing on the prospects of a successful venture for the production of factory sugar in any particular locality. There are indications that the incentive of present prices of sugar is attracting considerable attention to India as a further source of supply ; and that the necessary capital and business enterprise would be forthcoming if the whole question both in its agricultural and manufacturing aspects were thoroughly investigated, and the conditions essential to the establishment of an organised industry authoritatively defined. The Government of India, are, therefore, of opinion that the time is opportune for the appointment of a representative Committee to investigate the problem in all its bearings and to advise whether a definite and co-ordinated line of policy can be laid down for the promotion of further development. They have accordingly, with the approval of His Majesty's Secretary of State, decided to appoint a Committee for this purpose during the coming cold weather, under the presidency of Mr. J. MacKenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India, and with the following terms of reference :—

1. to examine the various sugarcane growing tracts of India with a view to determining the nature of the expansion possible in such tracts either by the development of a factory industry or by improvements in the existing indigenous methods ;

2. to examine the possibility of consolidating the areas under cane and the extent to which this is limited by the existing systems of land tenure ;

3. to report on the work already done by the Sugar Expert with regard to the breeding and selection of improved varieties of cane and to make suggestions as to the extent and direction in which this work can be further expanded ;

4. to examine the present methods of co-ordinating work on sugarcane adopted by the Agricultural Departments working in the various provinces and the efficiency of agricultural practice in vogue in India or recommended by the Agricultural Department ;

5. to examine the existing sugar factory industry in India and to advise in what localities and under what conditions a factory industry can be successfully established ;

6. to examine the economic and labour conditions now prevalent in the various districts where expansion of the sugar industry is likely and the question of improving railway facilities and other means of transport which may be required with a view to furthering the spread of the industry ;

7. to investigate the work that is being done in the introduction of improved small power plants and small power factories ;

8. to review the position of India with regard to the world's sugar supply and to formulate recommendations for the improvement of that position ;

9. to investigate the conditions under which refined and raw sugar and molasses are imported into India ;

10. to examine the effects of controlling such imports by a duty, and, where necessary, grading this duty so as to give preference to sugar grown in British dependencies ; and

11. to examine the present conditions governing the manufacture of rum under license from Government and the question of distributing such Government contracts.

"The Committee is expected to assemble on October 26th. It will tour to such extent as may be necessary for the local examination of existing conditions, and it will examine witnesses with a view to the thorough consideration of all shades of informed opinion. The Government of India trust that Local Governments and Administrations and their officers will afford the Committee all facilities for the furtherance of its investigations, and will comply with any requests for information or advice which it may address to them.

"The Government of India are not yet in a position to announce the names of all those who will serve as members of the Committee ; but its composition and personnel, in so far as these have already been decided, will be as follow :—

1. Mr. J. MacKenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India, *President*

2. A member of the Indian Civil Service as *Vice-President* (to be nominated later).

3. The Hon'ble Mr. Lalubhai Samaldas, C.I.E., Bombay.

4. Sir Frank Carter, Kt., C.I.E., C.B.E., of Messrs. Turner, Morrison and Company, Calcutta.

5. Sirdar Jogendra Singh, Punjab.

6. Mr. J. W. Macdonald of Messrs. Henry Tate and Sons, Limited, Sugar Refiners.

7, 8. Two other experts to be obtained from England (will be announced later).

9. Mr. Wynne Sayer of the Indian Agricultural Service

In addition to the above the Committee will co-opt. Mr. A. B. Shakespear, C.I.E., of Messrs. Begg Sutherland and Company, Cawnpore, as a member for the period of its tour in the United Provinces, and it is proposed similarly to co-opt. a representative of the industry in Southern India. Mr. A. E. Gilliat, I.C.S., will act as Secretary to the Committee."

Personnel and itinerary.

2. The Committee as finally constituted consisted of the following :—

1. Mr. J. MacKenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India, *President.*

2. Mr. F. Noyce, C.B.E., I.C.S., *Vice-President.*

3. Mr. J. W. Macdonald of Messrs. Henry Tate and Sons, Limited, Sugar Refiners, London and Liverpool

4. Mr. W. W. Craib, late Sugar Planter, Demerara and Cuba.

5. Sir Frank Carter, Kt., C.I.E., C.B.E., of Messrs. Turner, Morrison and Company, Calcutta.

6. Sirdar Jogendra Singh, Taluqdar of Oudh

7. Mr. B. J. Padshah of Messrs. Tata Sons and Company, Limited, Bombay.

8. Mr. M. Wynne Sayer of the Indian Agricultural Service.

9. Mr. A. B. Shakespear, C.I.E., of Messrs. Begg Sutherland and Company, Cawnpore, co-opted member for the whole of Upper India and Burma,

with Mr. A. E. Gilliat, I.C.S., *Secretary.*

Mr. Padshah took the place of the Hon'ble Mr. Lalubhai Samaldas who was unable to join the Committee. Mr. Shakespear unfortunately only found it possible to accompany the Committee during a brief portion of its tour in the United Provinces, and it proved impossible to co-opt a representative of the industry in Southern India. By a happy coincidence, however, both Mr. Shakespear and Mr. J. W. Neilson, Manager of the Nellikuppam factory of the East India Distilleries and Sugar Factories Company, Limited, Madras, were simultaneously in Simla when we were engaged on the drafting of our Report. At a series of discussions they gave us the great benefit of their experience of the sugar industry in Northern and Southern India respectively and, while we ourselves remain wholly responsible for our own recommendations, we are fully conscious of the help we derived from those discussions.

We assembled at Delhi on October 26th, 1919 and thereafter toured in the United Provinces, Bihar and Orissa, the North-West Frontier Province, and the Punjab, and adjourned at Delhi on December 22nd for the Christmas holidays. Whilst in Bihar we were present at the 11th meeting of the Board of Agriculture at Pusa. After reassembling at Calcutta on January 4th, 1920, we toured in Assam, Bengal, Burma, Madras, Hyderabad, Mysore and Bombay. A section of the Committee then paid a second visit to Bihar, after which we reassembled at Simla on April 15th. Mr.MacKenna ceased to be President of the Committee on April 26th, on his appointment as Development Commissioner, Burma, and was succeeded by Mr. Noyce. Mr. MacKenna rejoined as a Member of the Committee from August 21st to September 23rd and we are glad to state that we have thus had the benefit of his advice and assistance in drafting the Report, which he has signed. Mr. G. Clarke, Agricultural Chemist, and Principal of the Agricultural College, United Provinces, was appointed to the Committee on May 12th to fill the vacancy created by Mr. MacKenna's resignation. From April 15th to May 10th we were occupied in preliminary discussions. On May 11th we left Simla for Calcutta *en route* to Java. We arrived in Java on May 30th and left again for India on June 26th arriving at Madras on July 5th. We then visited Jamshedpur with reference to the question of agricultural machinery and toured in the Central Provinces, and after a return visit to Nawabganj and Pilibhit, arrived in Simla on July 19th. A copy of our itinerary is appended (Appendix I). In the course of our tour we travelled 26,924 miles by rail, 7,969 miles by steamer and 3,154 miles by road.

3. Altogether we held 82 sittings for the formal hearing of evidence, in the course of which we examined 222 witnesses, almost all of whom had previously put in written evidence. Of the 222 witnesses 92 were officials, mainly from the Agricultural and Public Works Departments, and 130 non-officials. 111 witnesses were Europeans, 98 Indians, 12 Burmans and one Chinese. We also received memoranda from 31 witnesses interested in our enquiry who were not orally examined. In addition to visiting practically every Government farm on which cane is grown in the various Provinces and Native States we inspected all the sugar factories and distilleries in India with a few unimportant exceptions, and held many informal meetings with cultivators, gur and raw sugar manufacturers, representatives of co-operative societies and irrigation associations and other persons connected with sugar. We wish to take this opportunity of acknowledging the great assistance rendered to us throughout our enquiries and the excellence of the arrangements made for us in all the Provinces and Native States we visited, especially by Directors of Agriculture on whom the chief burden of the detailed preparations fell. We are also especially indebted to the Darbars of Hyderabad and Mysore for the hospitality we received from them during our tour in those States. Above all we would here record the very great obligations we are under to the Government of the Netherlands Indies, the General Syndicate of Sugar Manufacturers in the Netherlands Indies and the Research Station and Association of the Java Sugar Industry. Collectively and through their executives these bodies gave us every possible facility for obtaining a thorough insight into all branches of the organisation which has earned for the Java sugar industry its great and well-merited reputation, while their individual officers and members throughout received us with a courtesy and cordiality which we can never forget.

Evidence received and acknowledgments.

4. In our terms of reference we were directed to review the position of India with reference to the world's sugar supply and to formulate recommendations for the improvement of that position. Our recommendations to that end will be found later in this Report ; but we would here offer some comments on the position of India in relation to the world's sugar supply, as it was this which led to the appointment of the Committee. We give in Appendix II a series of tables showing the yield per acre of cane and beet sugar in the various sugar producing countries of the world, so far as statistics are obtainable, together with figures of the world's production and consumption of sugar. A most striking fact brought out by these statistics is the extraordinarily low production of sugar in India per acre compared with that of the other main cane growing countries. The average outturn of sugar in India during the five years ending 1918-19 has been 1.07 tons per acre as against 1.96 tons in Cuba, 4.12 tons in Java and 4.61 tons in Hawaii, the only three countries besides India which contribute more than half a million tons of cane sugar to the world's supply. Comparison with Cuba is particularly instructive, as conditions of cultivation there approximate nearly to those of India. 80 per cent. of the Cuba cane crop is grown by " colonos ", or independent farmers, with hired and ill supervised labour of which the supply is inadequate. Cultivation is consequently neglected and agricultural methods are very imperfect. The position of India is really much worse than these figures indicate, when it is remembered that by far the largest part of the sugar produced in India is in the form of gur, which is in reality merely concentrated cane-juice and contains all the molasses that exist in the juice, whereas the statistics for other countries refer only to sugar, from which the bulk of the molasses has been separated in the process of manufacture. The extent of this difference can be gauged from the fact that,

India in relation to the world's sugar supply.

(a) *The world's production.*

whilst cane sugar from other countries yields on the average 90 per cent. of refined sugar, gur does not yield more than 50 per cent. of refined sugar, the rest being molasses and waste. In actual sugar India's production per acre is thus less than one-third that of Cuba, one-sixth that of Java and one-seventh that of Hawaii. The great scope for improvement is, therefore, evident ; and in view of the enormous acreage under cane in India, which represents nearly half the cane area of the world, even a small increase in the acre outturn of gur will have far reaching effects in improving her position as a sugar producing country.

How necessary it is that India should contribute a greater proportion of the world's sugar supplies than she has done in the past will be seen from the Tables of production printed in Appendix II. Stated briefly, the position is that the total sugar crop of the world, excluding India herself, for 1917-18 was 13¾ million tons against 15¾ millions in 1913-14, the last pre-war year. The crop of 1918-19 fell again slightly to under 13½ million tons ; while that of 1919-20, allowing for the fact that the returns are not yet quite complete, is little more than 12 million tons. Even if the peculiarly low quality of raw sugar produced in India be included, the drop in production of 3¾ million tons since 1913-14 is only reduced to 3 million tons. This fall is wholly due to the disorganisation of the beet sugar industry in Europe during the war, the effects of which have only been intensified since the cessation of hostilities. Consequently the beet sugar production of the world has fallen since 1913-14 by not far short of 5 million tons, or some 60 per cent. with the result that, whereas beet sugar in 1913-14 represented 44.6 per cent. of the world's sugar crop, in 1919-20 it represented no more than 21.1 per cent. Another interesting fact brought out by the statistics is the comparatively small extent to which the cane growing countries were able to take advantage of this opportunity by increasing their own output of sugar. That increase amounts only to some 1½ million tons in the six years subsequent to 1913-14, against an increase of nearly 3 million tons during the previous six years over the total crop of 1907-08. The figures are a vivid illustration of the fact that most of the important cane growing countries of the world other than India are fast approaching, if they have not already reached, their limit of economic production.

5. The steady fall in the world's total output since the war began resulted in unprecedented prices for sugar and in the strict rationing of the available supplies in several of the most important consuming countries. It is principally for this reason that we have not attempted to balance our Tables of production with Tables of consumption for the same period drawn up on similar lines. Complete and reliable statistics are, in fact, not obtainable ; but even if they were, they would reflect no more than the results of abnormal prices and abnormal regulation of supplies, and would furnish no criterion of the probable development of demand as prices recede and external control over the ordinary operations of trade is relaxed. While, therefore, it is indisputable that the vast destruction of wealth caused by the war will for some time to come impede the revival of normal tendencies which were interrupted by its outbreak, we are confident that gradually or rapidly those tendencies

(b) The world's consumption.

NOTE.—These figures of production are not quite complete, as they take no account of sugar from other sources than beet and cane. The only other commercially important sugars are the maple and palm sugars, and of these we have been unable to obtain any reliable statistics. Their total contribution, however, is probably less than a million tons yearly, and so far as we are aware, there has been no marked fluctuation in their output from season to season. Their omission, therefore, in no way vitiates our argument.

will revive, and that it will be more instructive to consider the progress of the *per capita* consumption of sugar in the United States of America and all European countries during the ten years previous to the war the statistics of which we reproduce in Appendix II from the Tables appended to the Report on the Cane Sugar Industry in Hawaii, Porto Rico, Louisiana and Cuba published by the United States of America Bureau of foreign and domestic commerce in 1917 (Miscellaneous Series, No. 53). This Table shows that during the decennial period the consumption per head increased in the United States of America by 17.48 lbs., or 24.4 per cent., in the United Kingdom by 12.02 lbs., or 14.8 per cent. and in all European countries by 8.90 lbs., or 31.9 per cent. The rate of consumption varies enormously from under 10 lbs. in the Balkan States other than Turkey to almost 100 lbs. in Denmark. To this Table we have added for purposes of comparison the consumption per head in India for the same series of years as nearly as we have been able to calculate it. In doing so we have estimated the indigenous production of cane gur in the manner explained in Note 2 to the Table of cane sugar production in Appendix II and have added thereto not only the balance of imports of sugars of all sorts (excluding of course molasses) in the same year after deducting exports and re-exports but also a fixed quantity of 300,000 tons yearly on account of palm gur, an estimate which is taken from the Memoir of Mr. Annett, Agricultural Chemist, Bengal, to which we shall refer in greater detail in Chapter XVI. We prefer his figure to the 480,000 tons estimated by Mr. Noel Paton, late Director General of Commercial Intelligence, who based his calculations on an unduly high estimate for the output of what are now Bengal, Bihar and Orissa and Assam. The figures, which can claim only a rough approximation to accuracy, indicate a somewhat unsteady advance in consumption of 2.9 lbs. per head, or 15 per cent., during the ten years. The main fact, however, is clear. There was a general tendency before the war in all countries for the demand to increase more rapidly than the population. The urgency of making good the present shortage of production will be accentuated as this demand revives ; and the decision of the Japanese Government to establish a beet sugar industry in Northern China and Korea foreshadows the development of a new demand in the Far East. Although, therefore, there are signs that the production of beet sugar in Europe will from now onwards exhibit a distinct recovery, there is no doubt that for a long time to come this increase will be more than set off by the more rapidly expanding demand.

6. The brief review given in the preceding paragraphs will show how essential it is that India should contribute more largely to the world's supply of sugar. We look forward to the time when India will again become an exporting country, but meanwhile this contribution can be made indirectly by such an increase in internal supplies as will reduce to vanishing point this country's dependence on foreign sources to supplement her own crop. As our Tables show, that crop, measured in terms of gur, has fluctuated between two and three million tons during the last seven years and we calculate that it has averaged 2,358,000 tons since 1910. During the four pre-war years 1910-14, the imports of sugar into India averaged 723,915 tons valued at Rs. 12.71 crores. During the four war years 1914-1918 they averaged 531,713 tons valued at Rs. 13.48 crores. Of this by far the greater part was contributed by Java. The imports from that country direct and by way of the Straits Settlements for the four pre-war years averaged 563,196 tons valued at Rs. 9.64 crores. For the war period they averaged 482,654 tons valued at Rs. 12.14 crores. The other main source of supply is Mauritius which in the

Indian production and Indian imports.

four pre-war years exported to India an average of 137,641 tons valued at Rs. 2.66 crores, and in the years 1914-18, 53,279 tons valued at Rs. 1.44 crores. In the four pre-war years India received from Austria-Hungary an average of 43,514 tons valued at Rs. 85½ lakhs. The figures bring out clearly the fall in imports and the cause to which this is attributable, namely, high prices. If the average be taken over the whole period, the annual import is 628,000 tons of sugar, which at present prices (October, 1920) would be worth almost 53 crores of rupees landed in Calcutta. It is our opinion that it should be perfectly practicable to produce the whole of this in India itself, and that the great benefit to India and indirectly to the rest of the Empire which would accrue from the realisation of this ideal fully justifies the effort that will be necessary for its attainment.

Broad aspect of the problem.

(a) Local conditions in Upper India.

7. The extent of the effort necessary and the lines along which we consider that it should be made will be set out in our succeeding Chapters, and the problem varies so much in the different parts of India that it is difficult to frame a comprehensive statement of it. Very briefly and very broadly, however, we may state the main aspect of the problem as it has presented itself to us as follows. Of the 2,718,000 acres which India has, on the average, devoted to cane during the past nine years no less than 2,034,000 acres or 75 per cent. have been provided by the three main Provinces of Upper India, the United Provinces (50 per cent.), the Punjab (15 per cent.) and Bihar and Orissa (10 per cent.). This is considerably more than the cane area of Cuba and about five times that of Java, while the United Provinces also surpass Java in the proportion of their total cultivated area on which cane is grown. The first of the two sugarcane maps of India which we publish with our Report best illustrates this concentration of India's present cane cultivation in the great Gangetic plain and the contiguous districts of the Punjab. Here also are to be found the main centres of the factory and refining industries ; and here, therefore, we are convinced, must be sought a most important contribution towards the solution of our problem. A brief survey of the conditions obtaining in this tract may help to adjust the balance fairly between its advantages and disadvantages. That its subtropical climatic conditions with their marked seasonal variations and their wide extremes of temperature impose definite limitations on the yield of cane obtainable and on its quality is indisputable ; nor are we under any delusions that the high average yields of Hawaii and Java can be attained in Upper India. Yet even here circumstances are by no means wholly adverse, as the considerable area under thick canes in the United Provinces producing an average of 20 tons to the acre testifies. The climate of those Provinces and of Bihar and Orissa and to a less extent of the Punjab possesses a feature which is not usual in subtropical regions. This is the prevalence during the monsoon months from June to September of high temperatures combined with high humidity, a condition very favourable to the growth of cane, though unfortunately limited in its duration and effect by the high temperatures without humidity of the preceding hot weather and the low temperatures of the succeeding cold season. So too the great obstacle to improvement presented by the extreme fragmentation of agricultural holdings, with which we shall deal at length in Chapter XIX, is counterbalanced not only by the cheapness of labour of which the large population in the tract is equally the cause but also by the excellence of much of the soil and the vast irrigation resources. A no less important asset is the existence of a large demand for sugar at the doors of the factory, which reduces the cost of marketing the finished product to a minimum.

(b) Effect upon cost of cane.

8. The effect of these various influences is brought out in the chart which we reproduce as the frontispiece to our Report showing the comparative cost in 1913 to six of the main cane sugar countries of producing a standard maund of sugar and placing it upon each country's most important market. The figures for the high class gur tract of the United Provinces are, of course, assumed figures and we shall deal with the special difficulties of establishing a factory industry in that locality in Chapter XIX ; but the Bihar figures are a record of facts and they indicate that, despite the low quality of the cane crushed with its adverse effect on costs of manufacture, the cane necessary to turn out a maund of sugar was being purchased at a considerably lower cost than it was in Louisiana, Porto Rico or Hawaii. It is true that pre-war costs are no longer a safe criterion and that the prices now being paid for cane by the Indian factories are much higher than they were in 1913. But they have not risen proportionately so much as the price of sugar, and we greatly doubt whether the rise has been so marked as in other countries where the factories depend on purchased cane. Even in Java the cost to a factory of cultivating its own cane and delivering it at the mill has in the seven years risen from 3.5 to 5 annas per maund, and the inclusive cost of producing a maund of sugar from Rs. 4.3 to Rs. 8.1. A more accurate guide would be the actual cost of growing cane to the Indian cultivator at the present day and a comparison of the profits accruing from cane and other competitive crops. Our attempts to secure reliable data from the various Provinces on these lines have not been successful owing to the impossibility of securing uniformity in the methods of estimation employed. After a careful examination of the returns furnished to us, however, we conclude as a tentative estimate that the average cost to the cultivator in 1920 of growing the thin indigenous canes of Upper India is between 5 and 6 annas a maund, and that of growing the thick Paunda canes of the Bombay Deccan 8½ annas a maund. This represents the actual cost of production and harvesting only, and does not include the cost of transport, which may be placed approximately at one anna per maund, nor any provision for cultivator's profit. On the other hand, the calculation for Upper India is based on the low average yields obtained at the present day, which do not exceed ten tons of cane to the acre ; and the enhancement of those yields will reduce the incidence of cultivator's costs per maund. And this, it need hardly be said, is the first object we have in view ; for our primary consideration throughout has been the interests of the Indian cultivato

Terms used and statistical periods taken.

9. We should perhaps offer a word of explanation regarding the meaning we attach to certain terms in our Report and our reasons for adopting them. In the first place, we should make it clear that when we speak generally of India we include also the geographically distinct Province of Burma and also Native States. We shall use the term "net area cropped" in the sense in which it is used in the "Agricultural Statistics of India" to include all areas on which crops were sown, whether they came to maturity or not, but to exclude all allowance for double cropping ; that is to say, each cultivated field is included in each year once only, no matter how many crops may have been sown on it. On the other hand, the irrigable and irrigated areas on Government canals throughout India always comprise the sum of the areas irrigated in the two main seasons—the *kharif* or monsoon season and the *rabi* or cold weather season—irrespective of the fact that the same field may receive water during both seasons. We shall also generally use the word "factory" to signify a plant

crushing its own cane and making sugar direct therefrom by the vacuum pan process as distinct from a refinery working on gur or some other intermediate product as its raw material. Our adoption of the word "gur" itself throughout the Report is in the interests of uniformity, and we trust that this reason will be accepted as adequate by those Provinces to which the word is strange and in which the same product is known as gul or jaggery. We plead the same justification, moreover, for adhering consistently to the standard or Railway maund of 82⅔ lbs. even when dealing with tracts in which the maund has an entirely different weight value. The standard maund is the weight generally adopted by the factory and refining industries of Upper India, and its use by the Railway administrations renders it familiar in commercial and industrial circles all over India. We might, it is true, eliminate every possibility of confusion by employing English weights as our medium of expression, but we doubt whether their significance would be readily understood, and whether most of our readers would not then be under the painful necessity of working out our figures in terms of Indian weights in order to appreciate the argument correctly. As far as possible we shall attempt to meet the difficulty by including the English equivalents of weights expressed by us in standard maunds.

We should further remove any appearance of inconsistency in the presentation of our statistical information. It will be found that, while frequently we shall quote figures for the year 1919-20, our averages will generally be for five or ten year periods ending with the year 1918-19. This is not because the returns of 1919-20 are liable to minor corrections, for, if these were more than insignificant, we should be less justified in citing them separately than in incorporating them into a periodical average. It is because statistics for the year 1919-20 are, as we write our Report, by no means always available, the Irrigation Reports of the various Provinces in particular not yet having been published. We have, therefore, thought it best to base our average figures on a period for which returns of all kinds are reasonably complete and thus to enable valid comparisons to be drawn between one average figure and another.

Scheme of the Report.

10. We propose to preface our Report with a Chapter on the cultivation and manufacture of cane sugar in Java, since we regard a thorough insight into Java conditions as essential to a correct appreciation of the position in India. Our main Report is then divided into three parts, the first of which deals with the agricultural and irrigational aspects of the problem, the second with its manufacturing aspects and the third with matters affecting the industry as a whole and its future organisation. As the problems in regard to the cultivation of cane and the possibilities of its extension differ so widely in different parts of India, we have thought it advisable to deal with these for each Province and Native State separately, and do so in Chapters III-XIV. In Chapter XV we discuss various agricultural questions of general application to all Provinces. In Chapter XVI we deal with the possibilities of other sources of sugar, such as the Date and Palmyra palms. These Chapters constitute Part I of the Report. In Chapters XVII-XX we deal with the important and complex problems regarding the manufacture of gur and sugar in this country. These Chapters constitute Part II of the Report. In Chapters XXI-XXV we discuss such other questions as the tariff on sugar, statistics and the organisation necessary for the development of the industry. These Chapters constitute Part III of the Report.

CHAPTER II.

JAVA.

Acknowledgments.

11. As we shall have frequent occasion throughout our Report to refer to the valuable information we obtained during our tour in Java and its applicability to Indian conditions, we propose in this Chapter to give a brief description of the organisation and methods which have brought the sugar industry in that island to its present dimensions and importance. We wish here to acknowledge our special obligations to Mr. S. J. Hirsch, President of the Board of the General Syndicate of Sugar Manufacturers in the Netherlands Indies, who scrutinised the draft of this Chapter and made a number of valuable suggestions which have been incorporated in it. It is to him also and to Mr. E. T. Campbell, Senior Partner in the firm of Messrs. McNeill and Co., Semarang, that we owe permission to reproduce the admirable photographs which will be found at the end of this Report (Plates 9-16) illustrating the effiviency of Java methods both in field and factory.

Organisation.

12. The political and economic interests of the manufacturers of sugar in Java are looked after by the "Algemeen Syndicaat van Suiker fabrikanten in Nederlandsch-Indie" (General Syndicate of Sugar Manufacturers in the Netherlands Indies) which has its headquarters at Soerabaia, and the agricultural and manufacturing interests by the "Vereeniging het Proefstation voor de Java-Suikerindustrie" (Research Station Association of the Java Sugar Industry). These two bodies work in close conjunction, (as is shown by the fact that the Chairman of the Boards, or executive committees, of both is the same) and possess separate but parallel organisations. Whilst the great majority of the manufacturers of sugar in the island are members of both bodies, there are a few who are members of one and not of the other and some who belong to neither. Neither the Syndicate nor the Association receives any financial assistance from Government; and we believe we are correct in stating that all research work in connection with the sugar industry in Java is now carried on only by the latter body, the Government Agricultural Department devoting its attention entirely to other products.

(a) The General Syndicate of Sugar Manufacturers.

13. The work of the second association was of special interest and importance to us; and all that we need say in regard to that of the General Syndicate of Sugar Manufacturers is that the Syndicate acts as the channel of communication between its members and the Government in regard to the relationship of the factories to the holders of the land, the imposition of an export duty and similar matters. Its organisation, however, is of sufficient interest and importance to the Indian industry to warrant a brief description. It is maintained by a levy on each constituent factory or plantation of 1.25 guilders per

bouw of cane cultivation within a limit of area of 1,750 bouws. It is proposed to enhance this contribution in 1921 to 1.45 guilders* per bouw. The powers and functions of the Syndicate are shared between three bodies—the Board, the Assembly of Members and the Council of the Syndicate. Of these the real executive authority is vested in the Board, which is subject only to the general financial control of the Assembly of Members, a body the constitution of which is sufficiently explained by its title. It is presided over by the President of the Board and meets twice a year to fix the annual contributions of members, to sanction the annual budget and to pass the Board's accounts ; but it may be convened more frequently on the initiative of the Board itself. The functions of the Council of the Syndicate are purely advisory ; but great weight is, we were informed, attached to its advice by the Board, and naturally so in view of its eminently practical and representative character. We should explain that the jurisdiction of the Syndicate (as also that of the Research Station Association) throughout Java is divided territorially into sixteen departments, the limits of which approximately coincide with those of the Residencies, administrative units of Government corresponding with what are known in India as Commissioners' divisions. Each of these sixteen local departments has its own Board and its own bye-laws, though these must be approved by the Central Board. The business of the departmental Board is to look after the strictly local interests of all factories within its jurisdiction which are members of the Syndicate, and, if necessary, to represent those interests to the local officers of Government. All other matters are beyond its scope and must be referred to the Board of the General Syndicate. The chairman of a departmental Board is always the manager of one of the factories within its jurisdiction ; and it is the sixteen chairmen of these Boards who collectively form the Council of the Syndicate on the one hand and the Council of the Research Station Association on the other. Half the elected members of the Board are chosen by the Council, the other half being chosen by the Assembly of Members which also appoints the President of the Board. In addition to the elected members, however, the representative of any concern or group of factories which supplies more than $\frac{1}{10}$ of the total annual contribution to the Syndicate is entitled to a seat on the Board, if he chooses to claim it. The number of members of the Board is not, therefore, fixed ; but in 1920 it was sixteen. Normally the Board meets once a month, and three members, including the President, form a quorum. Between meetings the business of the Board is transacted by the President assisted by a permanent, paid staff. Questions of policy and proposals for action are circulated by the President to the members for opinion and advice ; on receipt of which he decides, with due regard to the importance of the matter under consideration, whether to bring it before a meeting of the Board or to settle it on his own responsibility. Both President and elected members hold office from year to year only ; and they are not necessarily experts in any particular branch of the sugar industry. Mr. Hirsch, for instance, who held the office of President in 1920, is a distinguished member of the legal profession.

14. The Research Station Association of the Java Sugar Industry consists of three departments, an agricultural department located at Pasoeroean and chemical and engineering departments located at Semarang in Eastern and

(*b*) *The Research Station Association.*

*The standard value of the guilder is 1*s.* 8*d.* or $\frac{5}{12}$ths of the present standard value of the rupee. In view of the depreciation of the rupee, however, we have taken the guilder throughout our Report as the exact equivalent in value of the rupee.

One bouw = 1$\frac{3}{4}$ acres.

Central Java respectively. These scientific departments into which the research work of the Association is divided must, of course, not be confused with the territorial departments, into which the jurisdiction of the Association (in common with that of the General Syndicate) is divided. (See paragraph 13 above). Since 1912 all sub-stations of the Association have been abolished with the exception of that at Cheribon in West Java, as it was considered advisable to centralise the scientific work. The funds for the work of the Association are, like those for the Syndicate, provided by contributions from factories and plantations which are levied at the rate of 4½ guilders per bouw for the work of the research station and an additional half guilder, if there is a group adviser in the group to which the factory belongs, and the factory wishes to have the benefit of his advice. The functions of the group advisers are explained below. Each factory or plantation thus makes a total contribution of 5 guilders per bouw, but here also the maximum area in each case on which this contribution is levied is 1,750 bouws. We understand that the question of enhancing this contribution is now under consideration. The total amount expended by the Association in 1919-20 was 1,200,000 guilders.

15. In addition to the research buildings the department at Pasoeroean comprises some 25 bouws of land for experimental purposes, which it takes up on lease every year from the native owners under the usual terms. The executive charge of the department is vested in a Director who has an Assistant Director and a Secretary to relieve him of routine work and thus to enable him to find the time necessary to correlate the work of the scientific sections, to lay down in consultation with the chiefs of the different sections the lines of work which should be taken up and to study and draw conclusions from the experiments carried out on the factory and plantation lands under the supervision of the group advisers. The scientific work is carried out in the following sections, the head of each of which is recruited from Holland—physiology, agrogeology (including chemical analysis of soils), cane breeding, bacteriology, statistics and field experiments. The staff of the department formerly included an entomologist and a mycologist, but these are no longer considered necessary as it is held that proper methods of cultivation and the introduction of good varieties are the most important factors in the control and elimination of diseases. The Director and Assistant Director tour when necessary ; whilst the head of the section which deals with field experiments is principally a touring officer. The heads of the other sections only visit factories and plantations when necessary for their investigations.

(*i*) *Pasoeroean—*
(*a*) *The Headquarters organisation.*

Broadly speaking, the aim of the work which is carried on at Pasoeroean is to ensure that the right variety of cane is grown on the right soil, to evolve varieties which will combine hardiness with a heavy yield and to secure control and elimination of disease by proper methods of cultivation. In regard to the second of these, it should be mentioned that at present some of the varieties of cane grown in Java are apt to be weak. In countries where cultivation is less careful than in Java they would be liable to disease. The intensive system of cultivation which is followed is so expensive that heavy yields are essential ; and a certain degree of weakness is therefore tolerated, but efforts are made to overcome it by careful adaptation of cane to soil and attention to methods of cultivation.

16. The necessary link between the department and the factories and plantations is furnished by officers of the Association known as group advisers who hold local charges directly under the control of the Chief of the Field Experiments

(*b*) *The field staff.*

Section at Pasoeroean. There are now eleven of these officers in all, each of whom has from 10 to 20 factories or plantations in his group. They are recruited in Holland and are passed students of the Agricultural High School at Wageningen or graduates in pure science such as botany. Graduates in some science connected with the sugar industry are preferred as group advisers when it is possible to obtain them. In addition to being the medium of communication to the managers of factories and plantations of all the information published by the department the group advisers advise managers in regard to such matters as the naming of varieties and plants and the diagnosing of common diseases. They are responsible for the collection of the local information required at Pasoeroean regarding soils, climatic conditions, methods of cultivation and varieties of cane grown by different factories in different soils. They make soil surveys and soil maps of all the estates in their group, thus enabling the headquarters staff to make investigations and draw conclusions on the different subjects under study and consequently to distribute new varieties of cane to the best advantage. Important as these duties are, the chief work of the group advisers is the conduct of experiments on factory and plantation lands. At least one series of experiments is carried out on the lands of almost every factory. The cost of these experiments is borne entirely by the factory which receives no assistance from Pasoeroean beyond the services of the group adviser. The factories are, however, seldom, if ever, involved in any expense, as the crop of cane obtained from the experimental plots is almost always a good one, and the knowledge obtained from these experiments compensates for any extra labour required to conduct them. The plan of the experiments is carefully worked out by the departmental staff and no deviation from it is allowed, when accepted, though the managers of the factories are quite free to decide whether they will carry out the experiments recommended or not. The results are sent to Pasoeroean where they are tabulated and discussed, the conclusions of the whole series being published in the records of the Research Station Association. The most important experiments are the trials of new varieties, but other subjects at present under investigation are comparison of the value of seed from different sources, such as hill nurseries and plantations in the plains, the possibility of reducing the number of sets required per acre, the depth at which sets should be planted on different soils, the best width between rows, the possibility of replacing sulphate of ammonia by other manures, the amount of nitrogenous manure per bouw required for every field, the necessity for phosphatic manures, the best time for applying manures and the use of the waste products of factories as manure.

17. There are at Semarang, as already stated, two departments, chemical and engineering, which are independent of each other and have each its own director assisted by a secretary. They have as joint administrative head a vice president of the Research Station Association. The work of the chemical department is carried on in two sections, one of which is devoted purely to scientific and analytical research and the other to technological research and questions regarding the chemical control of factories. The engineering department is also composed of two sections, each under a Head Divisional Chief. The work of the first of these is carried out in the following four sub-sections—consulting, technical research, mill control and office,—the Chief of the last of these being the secretary of the department. The second section is entirely devoted to electrical work and is directly under its Head Divisional Chief. The Heads of the departments and sections and their assistants are recruited from the Technical High School at Delft in Holland. There is no intermediate

(ii) Semarang.

link between the departments at Semarang and the factories, as is the case with Pasoeroean. The Factories correspond directly with the station and the advice and assistance of the staff of the consulting sub-section and electrical section of the engineering department are always freely at their disposal in the factories themselves. The time of the staff of the consulting sub-section is, in fact, mainly taken up in visits to the factories with reference to such matters as mechanical troubles, alterations and extensions of installations and alterations in particular machinery. Amongst the subjects at present under investigation by the engineering department may be mentioned the briquetting of megasse, the behaviour of megasse under pressure, the best methods of taking samples of juice for mill work, and the best methods of driving crushing mills by electricity. The two departments publish not only fortnightly figures of the working of the factories, both on the chemical and engineering sides, but also a complete synopsis of these results at the end of each season for the benefit of the members of the Research Station Association. The extraordinary completeness of this synopsis is a point to which we would draw special attention in view of the reluctance we have observed on the part of some factories in India to allow the results of their working to be known outside the factory. The members of the Research Station Association in Java realise that nothing but mutual benefit can result from the publication of the fullest information of the working of all factories. We would mention that any factory can send its daily crushing figures to the mill control sub-section of the engineering department, which works them out at once and returns them with any advice which may appear called for. Evidence of the up-to-date character of the Java organisation is furnished by the fact that all the calculations in the engineering department are carried out with the aid of electrically driven calculating machines.

18. The success of the sugar industry in Java is undoubtedly largely due to the possession by the factories of entire agricultural control over the leased lands which supply them with cane. The arrangements between the factories and the landholders are, in fact, a survival of the culture system introduced about 1833 by the Governor-General, Van der Bosch, though the compulsion underlying that system has long been eliminated. No person who is not a native of Java can acquire land outright from a native; and the factory lands are therefore held under leases, the terms of which are regulated by an Ordinance of the Netherlands India Government, Staatsblad No. 88 of 1918, which has now superseded the previous regulations embodied in Staatsblad No. 240 of 1900. Its main provisions may be briefly summarised. Leases for longer than 21½ years are forbidden. When the lease is for a period of more than 3½ years the factory has to pay the minimum rent fixed by the Ordinance. Each factory operates under a license from the Government of Netherlands India which restricts its concession to a specified number of villages within which it is permitted to take up for cane a specified total area, provided that in no village or hamlet may the fraction of the total cultivated area leased in any one year exceed one-third. Subject to these limits, the factory makes its own arrangements with the villagers. In doing so it utilises in tracts in which the communal land tenure obtains the good offices of the village headman, an official of great influence in his village who often receives a small commission in proportion to the area obtained. The terms of the lease are scrutinised by a Controlleur, an officer whose status corresponds roughly to that of an Assistant Collector in India, before whom both parties to the lease are bound to appear in person. Registration of the lease is refused unless he is

Relationship of factories to landholders.

(a) Legal provisions affecting leases.

satisfied that it has been entered into voluntarily, but an appeal lies to the Assistant Resident, who corresponds to a Collector in India, from his decision.

(b) Rents, premia and advances.

19. Until 1918 the factory could lease land at any rates agreed upon between it and the commune or individual landholder. Under the Ordinance of 1918 minimum rates have been fixed by the Government in respect of those lands only which have been classified at Settlement as rice lands, the rates being based on the assumed net profit obtainable from the one rice crop and two unirrigated crops which might have been grown during the 18 months for which the land is occupied for cane. To this is added an amount which varies from 2 to 7½ guilders per bouw for restoring the land to its original condition. The value of rice taken for the purpose of these calculations is the average market price of the previous ten years. At the time the Ordinance was passed these rates were above those prevailing, but, owing to the great rise in the price of sugar and of rice during the last two years and its reaction on rents, they are now in many cases considerably below those which are actually paid. The minimum rates fixed by Government are subject to revision every five years. If the lease is for less than two years, an advance can be given by the factory, but not more than 15 months before possession is taken of the land. For leases of 2 to 3½ years' duration an advance may be given to an amount not higher than the rent for one planting period ; but it may not be given more than 15 months before the 1st January of the year in which possession will be taken of the land. No advance may be made, but payment of a premium is permitted, if the lease is for more than 3½ years. The minimum rent of land per bouw is now about 60 guilders per annum or 90 guilders for the cane season. The land revenue, which averages about seven guilders per bouw for rice land but is subject to revision every ten years, is paid by the villager who leases the lands.

(c) The communal tenure and its effect.

20. It should be mentioned that throughout Java, but more especially in the Eastern Regencies, the land in many villages is communal property. In most cases this means nothing more than that the land is held in individual ownership but cannot be transferred permanently or temporarily to anyone but a member of the village community, without the consent of at least two-thirds of all the members. In some villages, however, re-distribution is made annually or at longer intervals by the whole village, theoretically with reference to the capacity of each family in the village to cultivate the area allotted to it. Disputes are settled by the Controlleur. It would appear from the statistics published by the Netherlands India Government that communal property is disappearing and that this tendency is particularly marked in villages of which the land has hitherto been shared out afresh every year. In such villages the tendency now is for the land to be re-partitioned biennially or not at all—in other words, even in communal villages the greater part of the land continues in the possession of the same persons, although the ultimate communal ownership remains. The communal tenure in villages where redistribution is still practised has the advantage from the point of view of the factory that it enables the village community to provide elsewhere for a recalcitrant villager who is unwilling to lease his land to a factory and would thus prevent it from cultivating a compact block of land. The average holding in Java is less than one bouw, so that the agreement with each landholder is for less than one-third of a bouw per year. This means that, but for the communal system, a factory leasing an area of 1,200 bouws, which is the average, would have to enter into more than 3,600 separate agreements. In actual fact, where the communal

system prevails, as it does in the tracts in which most of the factories are operating, the leased area of each village is taken up in a compact block comprising the shares of it may be as many as 60 individual landholders. The agreements of each village are embodied in one list, so that the factory in reality enters into some 60 agreements only.

(d) Period of occupation by the factory.

21. An important feature of the Java system is that, although the land is leased for lengthy periods, it is actually only occupied by the factory during the period required for cane growing, *i.e.*, from 14 to 18 months. As soon as the cane is cut the commune or the individual landholder resumes possession. Under the Ordinance of 1918 the factory is required to hand the land back in the same condition in which it was taken over, *i.e.*, the land should be cleared and levelled and the boundary marks of the plots restored ; but, as in practice this is done by the villagers themselves, the Ordinance prescribes that in the minimum rate shall be included a fixed amount for this purpose. This varies according to local circumstances, as already stated, from 2 to 7½ guilders per bouw. Competition between existing factories for land is impossible under the Government regulations, as no new factory can be erected without a license from Government. This has long been refused in West Java, and for some time past no new factories have been permitted in Central or Eastern Java in order to prevent any further reduction of the area under food crops.

Methods of cultivation.

(a) Supply of sets.

22. One of the most striking features of the work of the Java plantations is the careful attention given to the supply of sets for planting new cane. The planters have still a lively recollection of the havoc wrought by the sereh disease and now do all in their power to ensure that only sound and vigorous sets are used for planting. Their material is derived from three sources. Hill sets (berg bibits) are immature canes of six to ten months growth which have been grown in nurseries on the hills at altitudes varying from 1,000 to 3,000 ft. These are taken either direct to the factory fields or to plantations in the plains for the growth of plains sets (vlakte bibits). The plains sets are, like the hill sets, derived from immature canes six months old, but are grown in plantations at lower altitudes and nearer the factory lands when not actually grown on the latter. All the hill nurseries and some of those in the plains are devoted entirely to the production of sets for sale. The third source of supply is the tops of ripe canes which have been cut for milling in the factory. Many factories have nurseries of their own from which they supplement the supply obtained from those devoted solely to raising seed. Plains sets are treated in two ways. Either the whole cane is cut after six months growth and used for planting, each young cane producing at least two but more generally three sets, or the top only is cut off to provide one set The rest of the cane is then left standing for a period of 10 to 45 days when the whole is cut for sowing, each set being cut so as to consist of one or two young shoots, the leaves of which are cut and trimmed to prevent the set drying by transpiration before the roots develop. Such sets are known as rajoengans. When they consist of one shoot only they are from 35 to 45 days old and are planted upright. Two shooted rajoengans, which are as a rule younger, are planted in a sloping position with the cane completely covered but with the ends of both shoots well above the ground. Rajoengans are generally used for the middle and later sowings and give as good a crop as when other sets are used. This method is followed only by factories which have nurseries of their own, owing to the difficulty in transporting sets of this kind.

It will be understood that it is an expensive matter to plant large areas of cane on factory lands with sets brought long distances from the hill nurseries. Whilst, therefore, some of the new cane on factory land is always planted with sets from hill nurseries, the tendency of late in some districts has been to rely less on the latter and to plant larger areas of cane from sets obtained from the nearer nurseries which have themselves used hill sets. This tendency is specially marked in the Djokjakarta tract which is favourably situated climatically and where only 4 per cent. of the area under cane is now sown with seed from hill nurseries against 66 per cent. from plains nurseries and 30 per cent. from tops of cane milled in the factory. In the remainder of Java the corresponding proportions in 1918 were 35, 31 and 34. The quantity of sets required to plant one bouw of new cane is about 3½ to 4½ tons, and in 1919 the cost of sets from the hill nurseries amounted to 90 guilders per bouw (that is, 51 rupees per acre) against 40 guilders (or 23 rupees per acre) for sets from those in the plains. It is thus a very heavy item in expenditure and one that appears likely to increase. The cane from which sets are obtained is planted in November and December. It is cut at the sowing season in June and July when it is six months old. As one bouw of seed cane may give in six months sets for eight bouws of new cane which can be sown at once and in another six months give sets for 64 bouws, it will be seen that after two years sets of any new variety it is desired to extend are available for 4,096 bouws. The speed with which new and better varieties of cane have replaced old ones during recent years in Java is thus accounted for, though it is not quite so rapid as the above figures would indicate, as, when a promising cane has been evolved, it has first to be propagated and tested at the Research Station for sucrose content and purity of juice and its ripening period ascertained, which takes three years. At the end of that period small parcels are sent out to factories with the request that the cane should be multiplied. In the case of very promising varieties these parcels are sometimes sent out after two years. In the event of the tests at the Research Station turning out well a supply of sets is in hand for further work. We were informed that five years are the minimum required to establish a good new cane over five to six thousand bouws.

23. Before passing on to the subject of varieties a word should be said regarding the preparation for planting of the tops of the ripe canes used for milling in the factories. These are collected in the fields when the canes are cut and are taken to sheds which are often of a permanent character. If a permanent shed is not available, a temporary thatched shed is erected near the field for which the cane is to be used. In this the leaves are carefully removed and the buds inspected, tops with injured or faulty buds being rejected. The sound tops each of which forms one set are then cut at both ends so as to leave three or at the most four healthy buds. The sets thus prepared are taken in baskets to the fields and planted. In one instance we noticed that the ends of the sets were dipped in tar before planting as a protection against pests. It is, however, more usual to dip the baskets of sets in Bordeaux mixture.

(b) Preparation of sets for planting.

24. The varieties of cane grown in Java have undergone much change during recent years. The earlier Chunni crosses made by Dr. Kobus and his co-workers, which were so successful owing to their almost complete resistance to serch, have almost disappeared. Whilst resistance to serch is as important a quality as ever, the intensive methods of cultivation have made it imperative that

(c) Varieties.

heavy yielding varieties should be grown. As we have already stated, in addition to the work which is done at Pasoeroean, many factory managers and owners of nurseries have taken up with enthusiasm the work of producing and selecting new seedling canes and have achieved remarkable success. In fact, most of the varieties we saw on factory land during our visit were selections from crosses made by factory managers and planters. New canes are subjected to very thorough tests by the staff of the department at Pasoeroean, and, if any cane shows undoubted superiority, it is recommended whatever its origin may be. The rapidity with which the variety EK. 28, which was produced by a factory manager, Mr. Emil Karthaus, has spread in the Djokjakarta tract, where in 1920, 50 per cent. of the total area of cane was under this variety as against 2 per cent. in 1915, shows that no time is lost by planters in taking up a new cane which is found suitable for a particular tract. We give below a table showing the percentages of the cane area in Java planted with the different varieties of cane in 1912, 1919 and 1920 :—

Cane.	Percentage of whole area, 1912.	Percentage of whole area, 1919.	Percentage of whole area, 1920.
247 B.	54	29	26
100 P. O. J.	32	16	10
E. K. 28	...	23	32
D. 1. 52	...	15	14
E. K. 2	...	6	6
90 F.	...	4	3
Tjep 24	...	1	1
S. W. 3	...	1	2
Other varieties	14	7	6

With one exception, 100 P. O. J. which is a variety evolved on the Research Station at Pasoeroean, all the varieties in the above list were originally produced on factories or plantations. The diminution in the area under the well-known varieties 247 B, commonly known in India as J. 247, and 100 P. O. J. is very noticeable.

25. The excellence of the methods of cultivation in use on cane lands in Java has long been recognised. The trench system known as the Reynoso system is in general use on all factory lands. Cultivation is still carried out almost entirely by hand labour and little progress has been made up to the present in the adoption of mechanical methods. Almost the only crop rotated with cane is rice, and the land is taken over from the cultivators immediately after the rice crop has been harvested in April and May. The first step taken is to construct drains. These are of two kinds, deep drains 2 feet wide and 1½ to 2 feet deep and shallow drains 1 foot wide and 1 foot to 1½ feet deep. The shallow drains run into the deeper ones. Where the land has exceptionally good natural drainage, the deeper drains are dispensed with. On such lands the shallow drains are made 30 feet apart, but when used in conjunction with deeper drains on land with poor natural drainage they are sometimes closer and may even be only 12 to 15 feet apart. The larger drains are 120 feet apart. This procedure results in a highly efficient system of drainage, and without it it would not be possible

(d) Field methods.

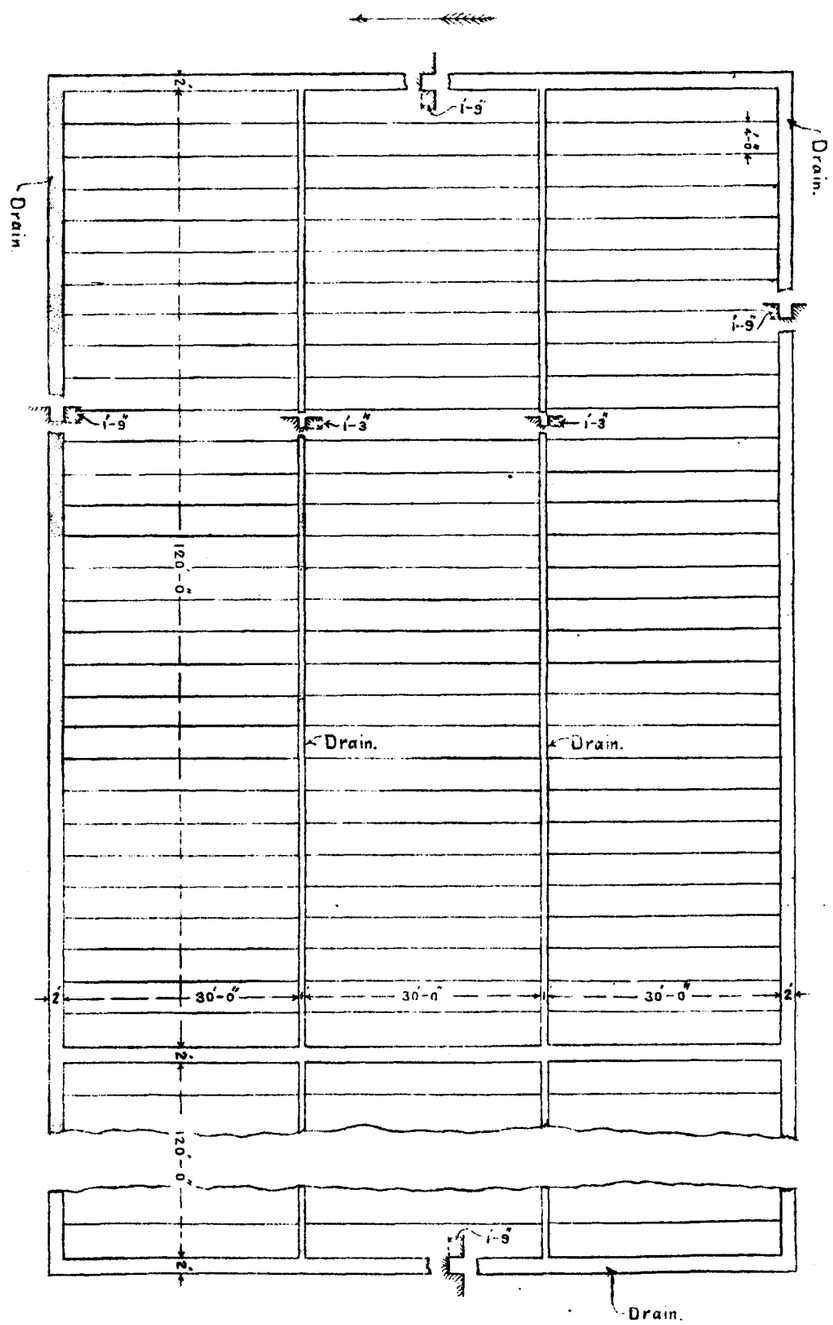
to grow cane on much of the land in Java. A plan of a typical field as drained in Java is reproduced on the opposite page. A prominent feature of the cane cultivation is the rapidity with which land is prepared for cane planting. The structure of the soils is such that they do not pack and dry into a hard mass when worked wet as happens with the soil of the Gangetic plain ; and no harm, therefore, results from working wet land. Immediately after the construction of the drains is completed, the making of the trenches is begun. These are made between the smaller drains and are thus 12 to 30 feet long. The standard dimensions are 4 feet from centre to centre, 1 foot in depth and a little less than 2 feet wide. After the trenches are made, the soil at the bottom is dug to a depth of six inches. The trenches are made gradually as the rice crop is removed and no preliminary ploughings are given. On an estate planting 1,600 bouws of cane, 50 per cent. of the area would be prepared between April 1st and May 1st. The planting season lasts from May till October, but the best results are obtained by planting in June and July. The sets are sown some six to eight weeks after the trenches are made and, as a rule, parallel to the sides of the trenches and only a few inches apart. In some cases the sets are planted at a greater distance from each other than this and at right angles to the trenches, being placed in small holes separated from each other by little dykes. The object of this method is to save water, and it is, therefore, adopted where irrigation facilities are limited or it is desired to avoid putting too much water on heavy soils. The sets with young shoots are, as already stated, planted in a sloping position. Other sets are planted at a very shallow depth in the trenches and are often not completely covered with soil. As soon as the canes are planted, they are irrigated, the drainage channels being used as irrigation channels. The rainfall in the cane growing tracts varies considerably but almost everywhere the facilities for irrigation are limited. The water requirements of the cane crop have been very carefully worked out and cane is consequently grown with the minimum of water necessary. The early irrigations after planting are very light and water is merely splashed on the trenches which are not flooded as in India. These light waterings are repeated at intervals of a few days until the cane is established. Weeding and shallow cultivation are done as required and, as the young canes grow, the trenches are gradually filled in. The canes are always thoroughly earthed up. This is done in three operations from October to December for canes which are planted in June.

(*e*) *Manures.*

26. Sulphate of ammonia is the usual form of manure. In some soils which are deficient in phosphorus superphosphate is necessary, but its use is not extensive. Potash salts are not used. We were informed that the economic optimum for most Java soils as worked out at Pasoeroean was 400 pounds of sulphate of ammonia per acre, approximately 80 pounds of nitrogen. Many factories have worked out the economic optimum for themselves, and the amount of sulphate of ammonia applied to some lands is as high as 550 pounds. The manure is applied in a somewhat unusual manner, being placed in small holes in the bottom of the trenches on both sides of the young plant, and covered with soil. Two doses are generally given, three and seven weeks after planting ; but, if a larger quantity than 400 pounds per acre is applied, there are three doses, three, seven and eleven weeks after planting. In one instance we found that on dry soils of coarse structure which contained 40 per cent. of coarse sand molasses was being used with good results at the rate of about 1,500 to 2,250 pounds per acre. This was said to effect a great improvement in the capacity of the soil to retain water.

PLAN OF A TYPICAL JAVA CANE-FIELD

Scale 20′=1″.



Photo, Zinco. January, 1921.—No. 2159-6.3000.

27. As the cost of production of cane in Java is a point of great importance in discussing the possibility of adopting the Java methods in India, we give below a table containing two typical sets of figures which were supplied to us in Java and also, for purposes of comparison, the costs of improved cultivation on the Government farms at Shahjahanpur in the United Provinces and Manjri in the Bombay Presidency.

Cost of production of cane.

	Java.				India.	
	(A)		(B)			
	Guilders per bouw.	Rs. per acre.	Guilders per bouw.	Rs. per acre.	Shahjahanpur. Rs. per acre.	Manjri. Rs. per acre.
Rent	90·0	51·4	90·0	51·4	30·0	80.0
Cultivation including irrigation	160·0	91·4	170·0	97·1	75·0	92·25
Manure	180·0	102·8	120·0	68·6	100·0	128·25
Sets	80·0	45·7	100·0	57·1	30·0	32·0
Cutting and transport to factory.	60·0	34·3	45·6	26·0	30·0	33·0
European supervision ...	15·0	8·5	15·0	8·5	15·0	15·0
Native supervision ...	4·0	2·3	4·0	2·3		
Total ...	589·0	336·4	544·6	311·0	300·0	380·5
...	†Picols per bouw.	Maunds per acre.	†Picols per bouw.	Maunds per acre.	Maunds per acre.	Maunds per acre.
Yield of cane ...	1,200	1,133	1,139	1,075	838	1,069
Cost of cane in annas per maund.	...	4·75	...	4·63	5·73	5·70

† 1 Picol = 136 lbs.

The first set of figures of the cost of cultivation in Java given in the table above were supplied to us by a group adviser, as were also the first set of figures for yield of cane. The second set of figures for cost of cultivation were supplied by a factory manager, but the yield of cane in this case has been obtained from the statement published by the statistical section at Pasoeroean, which shows the average acreage and outturn results of 177 factories, representing 90 per cent. of the area under cane for the harvest of 1918.* The costs and yields of cane at Shahjahanpur and Manjri were obtained from the records of the Sugarcane Research Stations at those places. It should be pointed out that the high cost of supervision they show is the direct consequence of their experimental objects, and under this head there is no really valid comparison.

The following statement shows the average yield of cane and sugar per acre in 1918 for the 177 factories mentioned above as calculated at Pasoeroean.

No. of factories submitting returns.	Standard maunds of cane per acre.	Standard maunds of sugar per acre.	Percentage of standard muscovado sugar in cane.	Percentage of fibre in cane.
177	1,075	126·5	11·7	12·4

* J. Van Harreveld, Statistiek van de verbreiding en productie der rietsorten in Oogst, 1918. Land bouw kundige serie, 1920, No. 2.

The figure of outturn of sugar per acre given in this statement differs from that given by Dr. Prinsen Geerlig in the issue of the International Sugar Journal for June 1920, which is the equivalent of 118 maunds of sugar per acre. The reason for this difference is that Dr. Prinsen Geerlig's figure is for 100 per cent. sugar obtained by the factories, whereas the outturn in the statement is that of available standard muscovado, *i.e.*, the amount of sugar calculated as standard muscovado which it is possible to obtain. All the results of the Java field experiments and some of the factory results are stated in this way.

Supervision.

28. At the present time the supervision of the agricultural branch of factory work is entirely European. An important part of the European staff is recruited in Holland and many of them are graduates of the Agricultural High School at Wageningen or of the Technical High School at Delft. We were informed that, wherever possible, young chemists are recruited from Holland and employed in the factories for three or four years. They are then offered the opportunity of going out on the plantations as assistant plantation managers, and their chance of promotion to the post of factory manager depends on their ability to master the agricultural side of the work. It is difficult to gauge the scale of salaries of chemists, engineers and agricultural overseers, as, in addition to free quarters, free medical attendance, and in some cases conveyance allowances, their salaries are supplemented by a generous bonus system. The scale of pay ranges from Rs. 200 to Rs. 600 for chemists, from Rs. 200 to Rs. 700 for engineers and from Rs. 250 to Rs. 600 for field overseers. All these participate in a bonus amounting in all to from six to eight per cent. of the net profits of the factory. The share of the senior field overseer would amount to $\frac{3}{4}$ or 1 per cent. of the net profits, and some indication of the possibilities may be realised from the fact that in 1919-20 this meant an addition of Rs. 20,000 to Rs. 40,000 to the emoluments of an overseer working in a good factory. It should of course be remembered that the circumstances of that year were exceptional. It has already been mentioned that the Research Station Association is in no way a Government institution. Frequent interchange of officers between its departments and the factories is thus possible and a successful group adviser has every prospect of obtaining a highly paid post in a sugar company. A note-worthy feature of the organisation of the sugar industry in Java is the great importance which is attached to the possession by all the higher officers of a factory, whether chemists or engineers, of knowledge of all branches of factory and plantation work.

Factory work.

(a) Delivery and milling of the cane.

29. The efficiency which, as will be evident from the preceding paragraphs of this Chapter, has been brought to bear on the agricultural side of the sugar industry in Java is equally apparent in the factories. We were greatly impressed by their up to date character. The machinery is of the most modern kind and the roominess and cleanliness of the factories conduce to high efficiency. There are in all 186 factories in Java. Of these the number which submit returns to the Research Station Association varies from 138 to 145, but only 77 to 100 include information regarding their engineering work. It is on these returns that the information which follows is based. The crushing season is considered to last from May to October, but it begins and ends at different times in different parts of the island. Some factories start work at the beginning of April and others do not close until the end of November ; but the average length of the season for all factories is 126 days, that is, just over 4 months.

The cane comes into the factory on trucks containing from six to eight tons. These are run alongside the carrier and the contents are hoisted bodily from the trucks by means of an electric cane and deposited on a sloping platform from which they are fed to the carrier by a rake which is worked mechanically. Few of the mills in the Java factories consist of less than 9 rollers with crushers, or 11 rollers in all, and many have 14 rollers. The figures for the 77 factories which submitted returns in 1919 were as follows :—

Factories with a crusher and four mills or 14 rollers in all ..	8
Factories with 4 mills only or 12 rollers in all	11
Factories with a crusher and three mills or 11 rollers in all ..	24
Factories with 3 mills only or 9 rollers in all	33
Factories with a crusher and 2 mills or 8 rollers in all ..	1

In most factories in India the milling plant consists of a crusher and two-three roller mills or 8 rollers in all. The advantages the Java factories have in being able to employ adequate maceration and consequently to extract more juice from the cane will be obvious.

(b) Processes followed in the sugar house.

30. The processes adopted in the sugar house are all found in India. They are ordinary defecation with lime, sulphitation in which both lime and sulphurous acid are employed and carbonatation in which lime and carbonic acid are used, the latter being obtained by the burning of lime stone. The ordinary defecation process is that most commonly employed in Java. 49 per cent. of the factories submitting returns in 1919 used it, whilst 38 per cent. used the sulphitation process and 13 per cent. the carbonatation process. The demand for plantation white sugar has in recent years led to the substitution of the sulphitation process for the defecation process in many factories. The carbonatation process is more expensive to instal and to work and gives little better results than the sulphitation process, as will be seen from the table in Appendix III showing the results obtained from the three processes in 1918, a particularly good year. Although the cane dealt with by the carbonatation process contained 14.03 parts of sucrose per 100 parts of cane against 13.71 parts in that dealt with by the sulphitation process, the white sugar produced by the former was 10.17 parts per 100 of cane and the raw sugar 1.5 parts against 10.13 and 0.97 parts respectively produced by the latter. The quantity of molasses turned out by the carbonatation process was, however, less than that turned out by the sulphitation process, the figures being 2.46 against 3.04 parts per 100 of cane. About 47 per cent. of the whole outturn of all the factories which submitted returns in 1918 was white sugar and 53 per cent. raw sugar.

Careful boiling in the vacuum pans and slow cooling in the crystallizers result in the factories in Java securing a high yield of sugar from the juice and therefore a much reduced proportion of molasses. The production of molasses in Java during the last five years has averaged 3.01 parts of molasses per 100 parts of cane. That of the 18 factories in India which actually worked on cane in 1919-20 varied greatly, but averaged as much as 4.15 parts per 100 parts of cane. It need hardly be pointed out that the higher the yield of molasses, the lower the yield of sugar ; and that the price fetched by the molasses is low compared with that of sugar.

(c) Some comparative results.

31. In 1918 the largest factory in Java, which was one of those we visited during our tour, produced 44,386 tons of sugar. The following table, which shows

the results of the working of this factory for the five years ending 1919, is of interest :—

Year.	Cane crushed in tons.	Sugar produced in tons.	Parts of sucrose per 100 parts of cane.	Parts of sugar obtained per 100 parts of cane.	Parts of sugar lost or left in molasses per 100 parts of cane.
1915	362,077	24,332	9·0	6·72	2·28
1916	423,309	33,865	9·88	8·00	1·88
1917	338,933	29,589	10·74	8·73	2·01
1918	407,955	44,386	12·76	10 88	1·88
1919	390,934	37,412	11·35	9·57	1·78
Average ...	384,642	37,917	10·75	8·78	1·97

It will be observed that the cane worked up in 1918 was so much better than that of 1915 and the efficiency of the factory had so improved that, although only 12.7 per cent. more cane was crushed, 82.4 per cent. more sugar was produced.

We now give a table showing the analytical results obtained by Java factories for the five years ending 1919, the most interesting feature of which is, as in the preceding table, the difference in the quality of the cane worked up in 1915 and 1918 :—

Year.	Number of factories making returns.	Parts of fibre per 100 parts of cane.	Parts of sucrose, per 100 parts of cane.	Purity of mixed juice.	Parts of glucose per 100 parts of mixed juice.
1915	138	13·26	11·63	82·0	1·32
1916	145	13·14	12·32	84·4	1·1
1917	143	13·02	12·82	85·8	1·03
1918	143	12·99	13·63	86·5	1·0
1919	142	13·01	12·38	83·7	1·11

Year.	Purity of clarified juice.	Parts of sugar obtained per 100 parts of cane.	Parts of molasses obtained per 100 parts of cane.	Number of factories working on cane with 13 parts or more of sucrose to 100 parts of cane.	Number of factories working on cane with 10 parts or less of sucrose per 100 parts of cane.
1915	83·5	9·36	3·28	8 (5·80 per cent.)	10
1916	86·1	10·1	2·86	35 (24·14 per cent.)	4
1917	87·3	10·63	2·73	58 (40·56 per cent.)	1
1918	87·9	11·32	2·78	102 (71·33 per cent.)	0
1919	85·3	10·1	3·11	40 (28·17 per cent.)	1

The great disparity in the sucrose contents of the canes worked up by different factories in Java should be mentioned. One factory, for example, crushed cane the sucrose contents of which for three years running were 6.75, 7.39 and 8.59 parts per 100 parts of cane respectively. From this it obtained 4.68, 5.58 and 6.59 parts of sugar only per 100 parts of cane. The sucrose content of the cane crushed by another factory in 1916 was only 9.1 parts per 100 parts of cane whereas in 1918 it was 12.9. The purity of juice of the poor Java canes is usually very low, falling to 75 to 77 and in exceptional instances below 70. The factories working on such canes usually produce sugar by the ordinary defecation process. On the other hand most factories work on good cane of high purity as is shown by the tables we give in Appendix III.

12.50 parts of sucrose per 100 parts of cane may be taken as the average sucrose content of Java cane, and 10.3 parts of sugar and 3 parts of molasses are obtained from 100 parts of cane with this sucrose content. In 1915 the sucrose content of Java cane was 11.63 parts per 100 parts of cane, or less than the 12 parts which our enquiries have shown may be assumed as the average for Indian cane. From cane with this sucrose content Java factories recover 9.75 per cent. of marketable sugar against an average of 6.85 per cent. in Indian factories. These figures show their immense superiority. That superiority has not been obtained by the adoption of any processes which are not to be found in India, but, in the main, by careful planning of the factory, by the use of the best and most up to date machinery and, above all, by careful supervision of all branches of factory work. The largest factory in the island has eighty European assistants in the factory and plantations. This is, of course, exceptional but the number of European assistants, in other words, of trained officers employed by an average factory with 1,200 bouws under cane is about twenty as compared with not more than six in India. A word should be said in regard to the net work of tramways and roads which has been laid out by the factories themselves and enables them to bring in canes from distances of eight or ten miles, although they do not hold an acre of plantation land in absolute ownership.

Labour.

32. The labour question in Java is greatly simplified by the density of the population. Java, though only about 50,000 square miles in extent, has a population of over 34 millions. The Province of India to which it most nearly corresponds in size is Assam, but it has five times as many inhabitants. The labour required on the factory lands is voluntarily furnished by the villagers who are paid at fixed daily rates which, at the present time, are equivalent to 8 annas a day for men, 5½ annas for women and 4 annas for children. In one case, which came under our notice, the labour required to start the plantation and factory had been obtained from the neighbouring island of Madoera, but this was exceptional. Villagers who are temporarily landless have an opportunity, therefore, of obtaining in addition to a reasonable rent per acre sufficient continuous employment to give them the income which they would receive if they cultivated the land themselves. During the milling season those who cultivate their own lands have a market for their labour at their own doors, and can work on the factory plantation every day that they can spare from their own fields. In the factories Chinese labour is usually employed under European supervision at the evaporators and vacuum pans, the Javanese being only entrusted with the minor operations. The wages of skilled labour in the factories vary from 10 annas to Rs. 2 per day and those of unskilled from 7 annas to 9½ annas. Skilled labour is often trained in the factory itself, children of the factory employees entering the factory to learn the work. The best of it, however, is obtained from machine shops and technical schools. Housing is

provided for imported labour, and often for skilled labour, but when it is a small rent is usually charged. Attempts have been made by some factories to promote model villages, but on the whole have not been very successful. Hospitals have also been established and free medical attendance can always be obtained from Government institutions.

Indigenous methods.

33. This Chapter would be incomplete without some reference to the cane grown by the indigenous population. The area under this is small and the outturn compares most unfavourably with that of the factory plantations. No exact figure can be given of the yields obtained, as neither the cane nor the raw sugar is ever weighed; but we were informed that the outturn of cane is from 500 to 600 picols per bouw (about 470 to 570 maunds per acre) which, as is shown by the table on page 21, is almost exactly half that obtained from factory lands. The cane is not bought by the factories, but is crushed by the people themselves in small wooden mills worked by buffaloes. The juice is limed and boiled in open iron pans in which it is concentrated, and is then cooled in bamboo baskets, the process being thus very similar to that employed in making gur in India and equally wasteful. The amount of raw sugar obtained from it is estimated at 30 to 40 picols per bouw (28.3 to 37.8 maunds per acre).

General conclusions.

34. Whilst there can be no doubt that, as the result of the traditions of the forced culture system, the Java sugar industry has had exceptional advantages in securing land and labour for cane production, it is equally unquestionable that these alone would not have been sufficient to ensure it the commanding position it at present holds. This has been secured by an admirable organisation for mutual assistance in all directions, above all in regard to research, generous expenditure on which is recognised to be a most profitable investment, and by the adoption of methods of cultivation and manufacture on which it would be difficult to improve, carried out under highly trained and well paid supervision. The sugar industry of Java was certainly not in a more favourable position for commanding land and labour in 1918 than in 1894, but whereas the outturn of sugar in 1894 was 2.81 tons per acre, in 1918 it was 4.34 tons. In 1919 it fell to 3.86 tons, but owing to prolonged drought the circumstances of the latter year were exceptional. The result is, as Mr. Keatinge, Director of Agriculture, Bombay, stated in 1914, that Java sugar dominates the Eastern markets and that, not only is the industry able to dispense with any protection, subsidy or assistance from Government, but it successfully forces its way through hostile tariffs and pays high dividends on invested capital.

We have endeavoured to give as accurate a picture as possible of the present conditions of the Java sugar industry. It must, however, be remarked in conclusion that many of these conditions are undergoing rapid and material change. Costs both of cultivation and manufacture are rising, labour difficulties are increasingly felt and political developments threaten to affect the hitherto amicable relations between the factories and the land holders. The industry is thus not entirely secure in the position it has so successfully established; and its difficulties and problems appear likely to multiply rather than to diminish in the years that lie before it.

Part I—Agricultural.

CHAPTER III.

THE UNITED PROVINCES.

Climate and soil.

35. The United Provinces of Agra and Oudh lie between 23° 52′ and 31° 18′ N. and thus fall entirely outside the tropics. As is shown by the statistics given in the following paragraph, the acreage under cane in the Provinces is more than half the total acreage under cane in India. Although cane is grown in every district with the exception of Almora and Garhwal, the principal cane-growing tracts are the Meerut and Rohilkhand divisions in the west and the Gorakhpur division in the extreme east, which between them contribute nearly two-thirds of the total cane area of the Provinces. Cane is a crop of some importance in the Benares division and in Oudh. The area under it in the Jhansi and Kumaun divisions is negligible and no district in the Allahabad or Agra division, with the exception of Farrukhabad, returns as much as 20,000 acres. The monsoon in the United Provinces sets in usually in June and the air is more or less completely saturated with moisture till the close of September. The rainfall during this period varies with the locality, the variations in the most important cane-growing tracts being in the Meerut division from 26 inches in Bulandshahr to 38 inches in Saharanpur, in the Rohilkhand division from 33 inches in Budaun to 50 inches in Pilibhit, and in the Gorakhpur division from 40 inches in the Azamgarh district to 48 in Gorakhpur. Nearly the whole of this is received during the monsoon, the rainfall between October and February averaging from one to five inches in different years. From March till June such rain as occurs is chiefly received from local thunderstorms. Frost is known, but is rarely severe enough to injure the indigenous canes. A few imported varieties and Coimbatore seedlings have been found unable to withstand the low temperatures which are liable to occur in Rohilkhand between December and February. The variations in rainfall are reflected in the percentage of irrigated cane to the total crop returned by the different divisions. For the Provinces as a whole the average percentage for the five years ending 1918-19 was 71.41. In the Meerut division it was as high as 88.83. In the Gorakhpur division it was 72.31, whilst in Rohilkhand it was only 41.9. The percentage of the irrigated area under cane on the canals to the total area under cane in the Provinces was 23.79.

The soil of the main cane-growing tracts is the alluvial soil of the Gangetic plain. Its chemical composition shows little variation and, though certain differences in structure and the average size of the particles exist, these differences are not pronounced. Even the soils classed locally as clays and stiff loams are found on analysis to contain a considerable proportion of what are conventionally known as "coarse sand" and "fine sand." The great bulk of the alluvium contains adequate quantities of lime and potash but is deficient in phosphoric acid, whilst the amount of nitrogen present at

any one time is small. The classification of soils recognised by the agricultural community is sand, loam and clay. These, it need hardly be stated, vary greatly in quality, but, speaking generally, the loam soils of the United Provinces are excellent soils for cane. A cross classification of soils depending on the distance from the village site is recognised over the greater part of the Provinces, the thoroughly manured home lands near the village on which the thick canes mentioned in paragraph 37 below are grown being distinguished from the outlying fields. In some localities a middle zone is also distinguished. The short period during which cane is on the ground, the limitation of the period of vigorous and active growth to the warm, moist, monsoon months and the occurrence of low temperatures in the northern districts, all of which result from the situation of the Provinces outside the tropics, render their cane problems of great complexity.

Statistical.

36. The average area of the United Provinces excluding Native States during the five years ending 1918-19 was 68,237,212 acres. The net area actually cropped during the same period averaged 35,421,128 acres, of which 1,336,854 acres were under sugarcane. The percentage of the area under cane to the net area cropped was 3.77, and to the total area under cane in India was 48.9. The average yield of gur for the quinquennium was returned at 0.94 of a ton to the acre.

Varieties of cane.

37. The varieties of cane grown in India, more especially in the northern Provinces, are extremely numerous. Each of these has its own local name, and the result is most confusing. The botanical study of Indian sugarcanes and their classification into families is very far from complete, though much work has been done on it by Dr. Barber, late Sugarcane Expert, Coimbatore. The subject is of a highly technical character and we consider that it will be sufficient for the purpose of our Report if we refrain from entering into more detail than is necessary to enable our recommendations to be understood. The broad division of the canes of India into thin, medium and thick is perhaps the most important from our point of view and is the one adopted by the cultivators for agricultural purposes. In 1898 the canes of the United Provinces were classified by Mr. S. M. Hadi, Assistant Director of Land Records and Agriculture, into these three divisions and into sub-divisions according to colour ; and in the absence of later work on the subject we have in what follows adopted Mr. Hadi's classification. The great bulk of the cane of the United Provinces is thin cane, and is known locally as Ukh or Ikh cane. The characteristics of this class of cane, which is reed-like in form, are medium height, hard rind and a high percentage of fibre. The internodes are of short or medium length. These canes survive conditions which would be fatal to the medium and thick varieties and suffer much less from attacks of animals. The Ukh canes again fall into two main classes, the red and the white. The former is mainly found in the Meerut division and comprises the Saretha group which, according to Dr. Barber, includes in addition to Saretha itself the varieties known as Chin or Chunni, Raksi, Ramui, Burra Chunni and Baraukha. The canes of this group suffer less from flooding than the white varieties and are early ripeners, being harvested in December and January. They are poorer in juice because more fibrous than the white Ukh canes, but the juice has a higher sucrose content. Of the white Ukh canes the most important varieties are those which are known as Hemja, Mungo, Bhurli, Kuswar, Matna, Reora and Dhaul or Dhaur. Mungo, Hemja and Bhurli are found chiefly in the Gorakhpur division. They ripen later than the Saretha group and are

on the ground till March. Reora is the favourite cane in the Benares division, whilst Matna is principally found in Rohilkhand. Kuswar, which is a very brittle cane, is mainly grown in the eastern districts of Oudh. Dhaul or Dhaur is the most common variety of cane grown in the United Provinces and was very largely substituted for the medium cane, Agaul, in the Meerut division when the latter disappeared owing to red rot. In the United Provinces it is a hardy variety and can be grown with less water and manure than the canes of the Saretha group. It is found side by side with the latter in tracts where the irrigation facilities do not permit of the cultivation of Saretha only. In Rohilkhand it is the usual custom to sow a mixture of white and red canes, the Dhaul-Chunni mixture being the one most commonly used. A cane which forms part of the mixture not only in Rohilkhand but also in Kheri district is Rehra or Rakhra. This cane, which, according to Dr. Barber, belongs to the Sunnabile group, is a tall, thin cane of erect habit which yields well and has good tillering powers. A single plant culture was isolated at Shahjahanpur some years ago and has given excellent results when tried on a field scale. It ripens in November. It is estimated that the Ukh canes give a yield of 10 tons of cane per acre.

The medium canes of the United Provinces are known as Ganna canes. The most common of these are the varieties known as Agaul, Dikchan, Pansahi and Katara. Their cultivation is decreasing owing to their liability to attack by red rot, but they are still grown to some extent in the Meerut, Gorakhpur, Rohilkhand and Benares divisions, mainly for the manufacture of gur but occasionally for chewing when the thick Paunda cane is not available. Taller and thicker than the Ukh canes, they have as hard a rind. As a rule they yield more juice, but the juice is not so rich in sugar. They require better cultivation than the Ukh canes to produce a satisfactory yield. The yield of this class of canes is estimated at 14 tons per acre.

The thick cane of the United Provinces known as Paunda, which is undoubtedly an introduction from the tropical parts of India, is grown almost exclusively for chewing in the neighbourhood of big towns where town refuse and poudrette are available. The area under this variety, the estimated yield of which is 20 tons per acre, is stated to be about 75,000 acres.

History of work on sugarcane.

38. The history of the Agricultural Department's work on sugarcane in the United Provinces commences with 1907 when Mr. G. Clarke on his appointment as Agricultural Chemist was directed, in addition to his other duties, to take up the investigation of certain problems connected with cane cultivation. From 1907 till 1912 Mr. Clarke's investigations were carried on at the Partabgarh farm. In the latter year they were transferred to Shahjahanpur. Some 120 varieties of cane obtained from most of the cane growing countries of the world have been under experiment. These fall roughly into two groups, thick canes of the Paunda type, of which Ashy Mauritius and M-16 are good examples, and medium canes, of which the Natal and Java canes are the most typical. In addition 22 of the new canes produced by Dr. Barber at Coimbatore have been received. Some of these are medium canes and others are thin canes resembling the indigenous canes of Rohilkhand from which many of them were derived by cross fertilisation with canes containing a higher percentage of juice and sugar. Most of these have been selected for extended field trials to ascertain the outturn of cane and gur and their sucrose content under conditions obtaining in the United

Provinces. Five have been found to require intensive cultivation and three have proved suitable for cultivation under cultivator's conditions. At Shahjahanpur Mr. Clarke by deep tillage, heavy manuring and an ample supply of water for irrigation has successfully grown exotic varieties of cane. The average yield obtained at Shahjahanpur with nine selected varieties from 1914 to 1919 was 838 maunds or 30.8 tons of cane per acre. The average percentage of sucrose in the cane was 11.1, which is equivalent to a sugar content of 93 maunds or 3.4 tons per acre. This is estimated by Mr. Clarke to represent a yield of about 100 maunds or 3.7 tons of gur per acre. The average yield of gur in the United Provinces for the same period was, as stated above, 0.94 of a ton per acre. The area on which the experiments have been conducted at Shahjahanpur is approximately 10 acres. The demand for seed from the farm now exceeds the supply, and has been accompanied by a demand for instruction in intensive methods of cane cultivation. During recent years, considerable quantities of the seed of medium sized canes, mostly J.-33, Mauritius and Uba, and especially the first of these, have been distributed both from the Shahjahanpur farm and from the other Government farms in the United Provinces. On the whole they have done well when grown by zamindars and large tenants who have been prepared to put the necessary capital into their cultivation. Ashy Mauritius has, however, been found to be somewhat too delicate a cane for general distribution, though it has been popular as a chewing cane. In the North-Eastern Circle J.-33 has proved a total and Ashy Mauritius a partial failure on account of red rot. In 1919, however, the latest selections of Java canes have given better results at Gorakhpur than at Shahjahanpur.

Agricultural practice.

39. In the United Provinces cane is an annual crop grown in rotation with other crops. Ratooning is practised only in rare cases, and hardly ever outside the Gorakhpur division. There is no established system of rotation in any part of the Provinces, each locality and individual cultivator growing the crop he thinks will pay him best. All that can be said is that, as a general rule, cane is grown on the same plot about every fourth or fifth year. In the Gorakhpur and Rohilkhand divisions, where wells are the chief source of irrigation, a full year's fallow before cane is the usual practice. But elsewhere the fallow is limited to the half year period following a *kharif* (or monsoon) crop. More rarely fallowing is entirely dispensed with, the cane sets being put into the ground immediately after a *rabi* (or cold weather) crop has been taken off it.

The agricultural practice of the United Provinces is, as in many other parts of India, very backward, and the cultivator still uses the primitive implements that have been handed down to him for many generations. His method of cultivating medium and thin canes is much the same. When a full year's fallow is given, the land is thoroughly irrigated in March or early April and then receives frequent ploughings throughout the year, the number varying from 15 or 20 in the western districts to 30 or 40 in the eastern districts. Where the fallow is limited to half a year or dispensed with altogether, the number of ploughings has to be reduced in view of the shorter time elapsing between the harvesting of the previous crop and the planting of the cane. In the Gorakhpur division a preliminary irrigation is often omitted as unnecessary; in Rohilkhand also, whenever the winter rains are sufficient irrigation previous to planting is dispensed with. The land having been prepared, the sets are sown. These are generally obtained from the cultivator's own previous crop or are purchased in the immediate locality, no attempt being made at selection further than to reject obviously diseased canes. In the Meerut and Rohilkhand divisions tops only are planted, while in Allahabad, Lucknow and Gorakhpur, whole canes are used as sets. When whole canes are used, they are left standing in the fields till wanted. When tops are used, they are collected into bundles at the time of harvesting, covered with a layer of moist earth and left till sowing time.

Outside Rohilkhand the usual method of planting cane is to lay the sets flat in the ground behind the plough, the rows being about a foot apart. If it is considered that there is insufficient moisture in the soil for germination, the field is then irrigated. In Rohilkhand no plough is used, the sets being planted by small gangs of men using *kalsis* (short-handled, heavy hoes). The period of planting extends from mid-February to the end of April, the number of sets used varying from 16,000 per acre in the Allahabad and Lucknow divisions to 26,000 in the Fyzabad and Benares divisions.

After-cultivation is practically confined to irrigation and hoeing, principally during the period of germination. The number of irrigations varies from two to seven and of hoeings from seven to fourteen; but there is a tendency in the canal irrigated tracts to dispense with hoeing. Certain varieties of cane, *e.g.*, Saretha, are tied up towards the end of the monsoon to prevent lodging.

In Rohilkhand the cane is frequently not manured at all. Elsewhere village sweepings and farm-yard manure are generally applied at the rate of 200 to 300 maunds (7.3 to 11 tons) per acre, the bulk of which is ploughed in before the cane is sown, though further dressings are applied later in the season. The use of cake manures is as yet very restricted, while concentrated artificials and green manuring are practically unknown. The general impression, which is endorsed by officers of the local Agricultural Department, is that the indigenous canes do not respond to high manuring.

The crop remains on the ground from nine to eleven months, according as it is an early or late variety, and harvesting begins towards the end of December and continues in some parts into March.

The foregoing account refers only to thin and medium canes. In the case of Paunda, or thick canes, which are almost entirely grown for chewing, a much more advanced system of cultivation is followed. The land is dug to a depth of 12 inches before planting, in order to obtain a good seed bed and to destroy white ants and other insects. The sets are sown in trenches two or three feet apart, two inches being left between sets, and are immediately irrigated after being covered with earth. The crop is heavily manured with as much as 500 to 800 maunds (18.4 to 29.4 tons) of poudrette or cattle dung, and sometimes 30 to 40 maunds (1.1 to 1.5 tons) of oil cake are also applied. The crop is hoed after the second watering has dried off, and then the ridges are split and the field is levelled and laid out in irrigation beds. Hoeings and waterings continue till the monsoon is established, some 12 to 17 waterings being given and 5 to 7 hoeings; and the canes are finally earthed up in July or August. The whole system is one of specialised agriculture and has apparently been imported into the United Provinces with the Paunda cane. It is absolutely dependent on water and manure and is, therefore, confined to localities where both are abundant.

Prospects of the extension of sugarcane under existing irrigation systems.

40. As has already been stated, 23.79 per cent. of the sugarcane crop of the United Provinces is irrigated from Government canals. We propose very briefly to consider the present position of cane under the different canals. One of the obstacles to the extension of

ıe under canal irrigation in the United Provinces is that such irrigation ely extends over the whole of the village. Only a part of the village area ı therefore be put under cane and irrigated from the canals. It is, of course, .e that in the remaining area cane is grown to some extent under wells ; l we make recommendations in paragraph 49 below which we trust will vē the effect of increasing this area. It should perhaps be mentioned that the United Provinces, owing to the restricted supply of water, all canals ₹ designed to work on a system of rotations, *i.e.*, they are designed to run th a full supply for one week and to bē closed the following week. In this ₃pect they differ from the canals in the Punjab and Sind, thē channels from ıich are designed for constant flow and are worked in rotation only during riods of short supply.

41. The Upper Ganges canal takes off from the right bank of the Ganges near Hardwar. It commands a tract in the Meerut and Agra divisions 5,350,500 acres

(a) The Upper Ganges canal.

extent, the normal annual rainfall of which is 28.67 inches and in which ıeat, sugarcane and cotton are the principal crops in order of acrēage. ıring the ten years ending 1918-19 the area under cane averaged 173,646 acres, e highest figure reached being 198,138 acres in 1917-18. The area annually ₹igable by thē system is estimated at 1,541,800 acres; the largest area actually ₹igated has been 1,412,661 acres in 1918-19.

42. The Lower Ganges canal takes off from the right bank of the Ganges at Narora. It commands a tract in the Agra and Allahabad divisions 6,765,000

(b) The Lower Ganges canal.

₹res in extent, the normal annual rainfall of which is 30.85 inches and in hich wheat, other food grains, cotton and rice are the principal crops in order acreage. The average area under cane for the ten years ending 1918-19 ıs 31,972 acres, the highest figure reached being 51,147 acres in 1918-19. The ₹ea annually irrigable by the system is estimated at 1,267,000 acres; the largest ₹ea actually irrigated has been 1,199,918 acres in 1913-14.

43. The Eastern Jumna canal, which takes off from the left bank of the Jumna near Fyzabad, commands a tract in the Meerut division 1,341,800 acres in

(c) The Eastern Jumna canal.

ₓtent, the rainfall of which averages 30.13 inches. Cane is the second most nportant crop under this canal, the area on which it is grown being only exceeded ₹ that of wheat. The average area under cane for the ten years ending 1918-19 ıas 70,845 acres, the highest figure reached being 80,048 acres in 1913-14. The ₹ea annually irrigable by the system is estimated at 390,000 acres; though the ₹rgest area actually irrigated has been as much as 403,009 acres in 1918-19.

44. Cane is also only second in importance to wheat on thē Agra canal, which takes off from the Jumna eight or nine miles below Delhi, and commands a tract

(d) The Agra canal.

n the Muttra and Agra districts and also in thē Gurgaon district of the ₹unjab 1,397,200 acres in extent, the average rainfall of which is 25.18 inches. The average area under cane for the ten years ending 1918-19 was 13,506 ıcres, the highest figure reached being 27,972 acres in 1917-18. The area ınnually irrigable by the system is estimated at 390,300 acres; the largest area ıctually irrigated has been 306,406 acres in 1915-16.

As we have stated above, the supply in the canals in the United Provinces s much less satisfactory than in the Punjab, and for this reason we doubt whether any appreciable increase under cane on these four canals, with the exception of the Upper Ganges canal, is to be expected. New permanent headworks for the Upper Ganges canal are under construction and will shortly be completed. Hitherto the diversion of the river to the canal head has been effected by means of temporary weirs which are built annually when the river is low and are washed away when it rises in the monsoon. This method of control has been found very unsatisfactory, since the canal supply is generally inadequate when there is a long break in the rains or an early winter demand. The new headworks will give complete control over the river supply at all periods of the year; this should lead to an increase in cane cultivation in the Meerut division, as the cultivators will then be certain of adequate supplies of water throughout the hot weather.

45. The canal systems in the Rohilkhand division—the Bijnor and Rohilkhand canals—are of much less importance than those already described. The area under

(e) The Bijnor and Rohilkhand canals.

cane on the Bijnor canals averaged 7,341 acres for the ten years ending 1918-19, the highest figure being 10,455 acres in 1918-19. That on the Rohilkhand canals averaged 17,335 acres for the same period, the highest figure reached being 22,592 acres in 1918-19. There is no prospect of any extension of canal irrigation in the Bijnor district ; but present conditions in the Rohilkhand districts of Bareilly, Shahjahanpur and Pilibhit and throughout the Lucknow division of Oudh would be entirely altered by the construction of the Sarda canal.

46. This project consists of two branches, the Sarda Kichha feeder canal and the Sarda Oudh canal. The Sarda Kichha feeder canal will take off from the Sarda river above Tanakpur in the Almora district and will run in a westerly direction across the Terai, or submontane tract, to the Kichha river. Distributaries will be provided from it to irrigate the Bareilly district and those portions of the Shahjahanpur and Hardoi districts between the Garra and Ramganga rivers. The estimated cost of the project is Rs. 200½ lakhs, and it is anticipated that it will irrigate an area of 345,224 acres and will yield a net annual revenue of nearly Rs. 12¾ lakhs, a return of 6.3 per cent on the capital outlay. The head-works and the first 7½ miles of the main canal are designed also to supply the Sarda Oudh canal which is now under investigation and which it is anticipated will irrigate Pilibhit, the northern part of the Shahjahanpur district and the area between the Gogra and Ganges rivers up to the western borders of the Allahabad, Jaunpur and Fyzabad districts. It will command an area of 6,400,000 acres of which 21 per cent. or about 1,350,000 acres are expected to be irrigated annually, 600,000 acres in the monsoon season and 750,000 acres in the cold weather. It is estimated that the Sarda Kichha feeder canal will irrigate a total area of 62,500 acres of sugarcane, an increase of 50,000 acres over that already irrigated by the existing canals. It is also estimated that from 25 to 30 per cent. of the *kharif* (monsoon) area will be the probable area under cane on the Sarda Oudh canal. This gives an approximate area of 160,000 acres under cane, an increase of 70,000 acres over that at present under cane in the tract commanded by the canal. We are, however, inclined to think that the probable area has been pitched at too high a figure, as the southern portion of the area commanded by the canal is mainly a rice-growing tract. It may, nevertheless, be anticipated that the construction of the whole Sarda canal system will result in an increase of approximately 100,000 acres under cane. We are glad to know that the construction of the Sarda Kichha

Prospects of extension under irrigation projects :

The Sarda canal project.

feeder canal has already been sanctioned by the Secretary of State. From the point of view of our enquiries, it is more important than the Sarda Oudh canal. It will irrigate a tract of country the soil of which is specially suitable for the introduction of improved methods of cane cultivation and in which the principal industry is already the manufacture of gur, but where the cane crop is subject to heavy losses from drought and, owing to the lack of irrigation facilities, the yield of cane is inferior to that of the Meerut division and the profits from its cultivation smaller. The provision of a perennial water supply will enable better varieties of cane to be substituted for the inferior varieties such as Dhaul and Chin at present grown and, as suggested above, should also lead to a very marked improvement in methods of cultivation. We trust, therefore, that the construction of the canal will be pushed on as rapidly as possible.

General recommendations regarding irrigation.

47. Although, as already stated, we do not anticipate any appreciable extension of cane under existing canals with the exception of the Upper Ganges canal when the new permanent headworks are completed, we consider that some small increase in area might be obtained and that the present areas under the crop might be rendered more secure, if means could be devised of modifying the existing system of distribution so as to enable its needs to be met during the hot weather months and during breaks in the monsoon. It must be remembered that failure of supply even for a short period in the critical months of March April and May before the young cane is established results in a complete failure of the crop and not simply in a reduction in yield, as occurs with such a crop as wheat.

A complaint which was made to us by several witnesses was that under the present system of distribution the cultivator is kept in ignorance as to when he will receive his next supply of water. We have not sufficient detailed information before us to justify us in offering an opinion on the validity of the complaint, but would suggest that the matter should be investigated. It is undoubtedly true that, in present conditions, the cultivator frequently uses far more water than is really necessary for his cane crop and that the crop suffers in consequence ; and it seems probable that one of his main reasons for doing so is his desire to make the most of the water when it becomes available, and his fear that he may have to wait unduly long before again getting a supply. In view of the extension of cane cultivation which will undoubtedly follow the construction of the Sarda Kichha feeder canal, the system of distribution of water on that canal should, in our opinion, be worked out from the outset with special reference to the needs of that crop. We would recommend that the Agricultural Department should make every effort to secure that cane should be grown in concentrated areas on the new canal, as this would obviously greatly facilitate the successful working of such a system.

Drainage and water-logging.

48. It is difficult to exaggerate the importance of proper drainage as a factor in the successful cultivation of cane, and it is for this reason that in Chapter we have described at length the system of drainage which is followed in Jav We understand that the question of surface drainage is receiving attention the United Provinces ; and the only specific recommendation we need make this point, the importance of which we would again emphasise, is that a drainage survey should be carried out in the sub-montane districts of the United Province in which from Saharanpur to Gorakhpur, with the exception of Bahraich, the area under cane is large. The question of injury to land from water-loggin in the United Provinces is not at present so urgent as it is in the Bomba

Deccan and some places in the Punjab, but it is important, and we understand that the local authorities are fully alive to this, as is shown by the fact that, although no pecuniary benefit is anticipated, it is proposed to line a length of 50 miles of the Sarda Oudh canal in a section where percolation is probable. We should perhaps mention that the expert opinion we consulted on the general question of lining Government canals and distributaries in the United Provinces was opposed to it on the ground that no benefit commensurate with the expense would be secured either by the resulting economy of water or by the prevention of damage to cultivable land. We would, therefore, only urge that, in view of the importance of a regular supply of water to cane in the critical months of March, April, and May, no scheme whereby loss of water can be prevented should be rejected without careful examination. We have no doubt that the necessity for providing adequate drainage in the area commanded by the new canals has been realised. Such drainage is of special importance in this tract, over a great part of which the subsoil water level is higher than it is in irrigated tracts elsewhere in the Provinces.

Well irrigation.

49. The percentage of cane irrigated from other sources than canals in the United Provinces to the total area under that crop is 47.6, and to the area irrigated by canals 200.2. 70 per cent. of the area of all crops irrigated from other sources than canals is irrigated by wells; so that, assuming the same proportion to hold good for the particular crop of cane, the percentage borne by cane grown under well irrigation to the total area under cane is 33.3 and to the area irrigated by canals 140. The canals in the United Provinces are designed to irrigate some forty per cent. of the area commanded by them which is not irrigated by wells, and no supplies are given to any lands for which well water is available. Wells are consequently numerous both in canal irrigated tracts and in tracts in which they are the sole means of irrigation. The Provinces have some 1,500,000 wells actually in use, and the area under all crops irrigated by them during the five years ending 1918-19 averaged nearly six million acres, which was about $2\frac{1}{5}$ times the average area irrigated by canals. In these circumstances there is a wide field for the development of pump irrigation ; and there is, in our opinion, no crop for which the development of this form of irrigation is as important as it is for cane. In their report the Indian Cotton Committee recommended that the whole question of pump irrigation should be investigated at an early date. No action has, as far as we are aware, yet been taken on this recommendation ; and we would, therefore, express the hope that the subject will now be taken up, as we consider that the investigation is more urgently required for cane than for cotton. The Agricultural Department has during the last few years installed over 70 tube wells, mostly in the cane-growing tracts, in addition to a number of pumps worked by power and has shown that usually a pumping installation can irrigate land far more cheaply than bullock power. Its work in this direction has been greatly hampered by conditions arising out of the war, and we understand that the Agricultural Engineer has a list of over six hundred landholders who have applied for pumping installations as soon as these can be supplied. There is reason to believe that the list would be longer than it is, if there were better prospects of the applications being complied with in the near future. That the applications are so numerous is encouraging evidence of the interest which is being taken in the potentialities of these installations, an interest which it is eminently desirable to encourage in every way. We understand that, hitherto, the work of the Agricultural Engineering Department in the United Provinces has been almost entirely confined to well boring and pumping installations, and it has not yet been found possible to undertake work on an extended scale on improved agricultural implements and the introduction of small

power machinery. In order, therefore, to ensure the development of the activities of the Agricultural Engineering Department in both directions, but more especially in the former, we would strongly recommend that an entirely separate branch of the Department should be formed. We consider it very necessary that the work of this branch should, as far as possible, be concentrated. Tube wells cannot, of course, be installed unless landholders ask for them ; and by concentration we mean that, where applications from a particular tract are at all numerous, priority in disposal should always be given to that tract and that an active propaganda should be undertaken to induce other landholders in it to apply for installations. We suggest this, as we have observed that improvements in the agricultural practice of the localities where installations are at present in existence have been almost negligible and we are convinced that they would not have been, if they had not been isolated. Concentration would enable the Agricultural Department to give advice and assistance more readily in regard to cultivation under the wells, and would also greatly facilitate supervision. We have little doubt that the installation of fifty tube wells within a radius of some seven miles in the Kheri district, to mention a district which seems to us specially suitable for them, would make the intensive cultivation of 3,000 acres of cane of better varieties than any which are grown in it at present a working proposition, and would thus provide sufficient raw material for a factory with a capacity of 8,000 to 9,000 tons of sugar per annum. As stated in paragraph 37 above, the inferior variety of cane known as Dhaul is grown side by side with Saretha in the Meerut division owing to lack of suitable irrigation facilities. An extension of pump irrigation should, therefore, mean a marked extension of the area under Saretha.

Possibility of developing electric power for pumping.

50. The possibility of utilising electric power generated by the falls on the Upper Ganges canal for industrial purposes in this division was suggested to us. This is a matter which has doubtless come under investigation in the hydro-electric survey of India at present in progress, and we need only point out that, as it is the exception for the whole of a village in the canal irrigated tracts to be irrigated from the canals, such power could be used to very great advantage in working tube wells in those parts of the village which are not so irrigated. A far more important scheme which we understand is under investigation is one for generating power from the falls on the Jumna river near Kalsi. The main object of this scheme is to provide power for lighting and industrial purposes to Delhi and other large towns ; but it is probable that there will be a surplus of power available for agricultural purposes. As the transmission lines will pass through the important cane growing districts of Saharanpur, Muzaffarnagar and Meerut, this scheme, if it fructifies, should prove of great benefit to the sugar industry in those districts, particularly as a means of developing tube wells.

With reference to the suggestion which was made to us that tube wells and power pumping formed a promising field for the operation of co-operative societies, we would point out that so far the agricultural side of co-operation has been very little developed in the United Provinces, and that at present there are only four pumping installations which are run by co-operative societies. We are not, therefore, hopeful of any great expansion of their activities in this direction in the near future, and in fact are somewhat doubtful whether these installations can be properly managed by societies except in special circumstances, owing to the difficulty of obtaining efficient supervision. This is a matter which we shall deal with more specifically in the concluding paragraphs of Chapter XV; but for the present are of opinion that the grant of Government loans to individuals on a liberal scale would be more effective in extending pump irrigation where co-operation is as backward as it is here.

Agricultural improvements.

51. Having dealt with the question of irrigational improvements in these Provinces in the interests of the cane crop, we proceed to examine the larger question of general agricultural improvements. These fall naturally under two main heads: the introduction of improved varieties of cane and the spread of improved methods of cultivation. If in what follows we have found it convenient to consider these two lines of work separately, it cannot be too strongly emphasised that they are most closely connected. Some improvement in yield can, it is true, be effected by the application of improved methods of cultivation to existing varieties, but the converse does not hold with cane as it does with such a crop as wheat or cotton ; and it is hardly an exaggeration to say that work done on the dissemination of improved varieties of cane is wasted, unless the improved methods that their successful cultivation requires are simultaneously adopted. In saying this we do not overlook the fact that the work initiated by Dr. Barber at Coimbatore has as one of its objects the evolution of suitable crosses for Northern India which will, even under the average ryot's present system of cultivation, give a better yield than existing indigenous varieties ; but we shall deal with this branch of the cane-breeding operations in Chapter XXIV (paragraph 388), and, in view of what we there say, we have no desire to qualify the above important principle.

Selection and improved varieties.

(a) Pure line cultures of indigenous varieties.

52. The work of the provincial Department of Agriculture on varieties of cane is being conducted on three main lines :—

(1) Selection of the Coimbatore seedlings which appear to be suitable for further trial in the United Provinces and comparative field trials of these selections,

(2) The isolation of pure races of the indigenous canes of the Provinces and

(3) The importation, acclimatisation and selection of varieties from overseas.

All three lines of work are of great importance and should be continued, but we are of opinion that quicker and more definite practical results might be obtained from the second, if the methods hitherto followed were to some extent modified. Dr. Barber's classification of North India canes has placed the many varieties met with into a limited number of groups, the individual members of which, in addition to similar morphological features, possess agricultural and chemical characteristics in common. Although this classification was not made with special reference to the United Provinces, many of the varieties commonly cultivated there fall into one or other of Dr. Barber's groups ; and it is now possible to undertake a more systematic agricultural and chemical examination of them than hitherto. While, therefore, the classification requires to be completed for these Provinces on the lines laid down by Dr. Barber for Northern India as a whole, it is already possible to make single line cultures of the groups that have been definitely classified. This is, in fact, now being done at Shahjahanpur; but its concentration at a single station tends to confusion and overlooks the important fact that certain groups, such as the Saretha in Meerut and the Hemja-Reora in the north-eastern tracts round Gorakhpur, have established their suitability for the conditions of definite areas, and deteriorate when grown outside those areas. Where clearly defined groups have clearly defined areas of adaptability it is, we think, important that the collection of the canes of these groups and the isolation of

pure line cultures should be conducted within their respective areas. Our proposals to this end are set out in paragraph 63 below; and we would here merely emphasise the value of this work, the object of which is to discover such agricultural and chemical differences between varieties as period of ripening, sucrose and fibre content and water and manure requirements, and thus to enable the Agricultural Department to arrange the distribution of varieties more strictly in accordance with varying local conditions.

53. Regarding the other two lines of improvement in cane varieties, namely the establishment of suitable crosses and the importation of exotics, we have only to urge that the work already in progress should be greatly extended and the field trials carried out on a larger scale. We would also advocate the opening of a station in the foot-hills for the supply of hill sets on the lines already followed in Java, as described in paragraph 22 of Chapter II above. The work already done in this direction in the Government gardens at Jeolikot in the Naini Tal district shows that hill sets can be successfully grown. It should constantly be borne in mind that, if the outturn of thick and medium varieties of cane is to be maintained without deterioration, the sets must be changed periodically. This presents no insuperable difficulty, if the necessity is realised from the outset and arrangements are made accordingly to bring down sets from the hill nursery to the Circle farms at regular intervals and to multiply them there for distribution. In the selection of the site and the determination of the area of such a nursery we hope that consideration will also be given to the needs of Bihar, which will probably be unable to provide a suitable hill breeding station within its own administrative borders and will therefore be dependent on the station here proposed for its supply of hill sets. We would add here a caveat against the distribution of sets of improved and imported varieties to persons who are not in a position to give them the care and cultivation they require.

(b) Importations of Coimbatore crosses and exotics.

54. We propose to consider first what improvements are possible in the cultivator's methods with the indigenous varieties of Ukh canes without any great departure from existing practice. The increase in yield of cane and sugar obtainable by the adoption of such methods is limited, and it is not possible to approach the high yields given by medium and thick varieties under trench cultivation with adequate manuring. But the extensive distribution of such varieties and the demonstration of their proper methods of cultivation must take time; and for years to come many cane growers will not be in a position to adopt them. As an average estimate, it may be taken that the improved cultivation of *desi* canes is capable of increasing the present average outturn of 25 maunds of gur per acre by 8 to 10 maunds. We need make no apology, therefore, for considering the means necessary and practicable to secure such an increase. By *desi* canes we mean varieties indigenous to the Province under discussion, as distinct from exotic and other Indian varieties. Needless to say, these are, in the United Provinces, practically all thin canes.

Improvements in cultivation:

(a) Improved cultivation of desi *canes.*

55. The introduction of pure races of indigenous varieties best suited to particular tracts instead of the mixture of good and bad at present sown should be pushed forward wherever possible. As examples we may give the extension of Saretha in the Meerut division, Hemja and Reora in the eastern and north-eastern districts and Rehra in the Rohilkhand division. Pure sets of these varieties should be maintained at the respective Circle farms. Also as progress is made with the isolation of pure line cultures referred to in paragraph 52 above, it should be possible to isolate early ripening Ukh varieties and to arrange for the cultivation

(i) Introduction of pure races of Ukh canes.

of such varieties in a manner that will extend the total period of the cane harvest by advancing the date of its commencement.

56. The first essential is improvement in the preparation of land for sowing the cane. The present shallow ploughing with the wooden country plough should be replaced by fewer ploughings with the turnwrest plough; and a summer fallow should be given before the cane crop is sown, thereby preserving the soil moisture and increasing the supply of plant food.

(ii) Improved preparation of land.

57. In the Meerut and Rohilkhand divisions, where cane and wheat are two of the principal crops, the following rotation is a good one:—Cane, wheat, fodder crops, gram, fallow, cane. But a rotation often followed in some of the older canal areas in the west of the Provinces is cane, cotton, a *rabi* crop (*e.g.*, wheat or barley), cotton, cane. This gives no time for the proper preparation of the land for cane. In these areas cane is not one of the principal crops, and it is doubtful whether cane growing should be encouraged in tracts where cotton is the principal and more profitable crop. In any event cane should not follow a cotton crop. Nor would we advocate, as a general rule, the practice of ratooning. The cane grower's present avoidance of it appears to us, so far as we were able to judge, to be justified by the poorness of the ratoon crop which indigenous canes give and by the liability of ratoons to harbour diseases and carry them over from year to year.

(iii) Rotations and ratooning.

58. The number of sets sown by the cultivator is excessive, amounting in some cases, as already stated, to as many as 26,000 per acre. Even with a moderate germination this is far too close together for the full development of each stool. 15,000 sets per acre of thin Ukh canes are ample for a full crop, if sown in lines two feet apart. Early demonstration of the advantages of sowing a smaller number of sets in lines by *kalsis* should be made. At the present time, while great pains are taken to preserve the soil moisture by hoeing at the time of sowing and until germination is assured, subsequent intercultivation is often rendered extremely difficult, if not impossible, by the manner in which the canes are sown. Sowing in lines two feet apart would make intercultivation possible after each irrigation and thus reduce the amount of water required. Frequently as many as six irrigations are given to thin (Ukh) canes. With better intercultivation this could be reduced to two, or at the most three.

(iv) Number of sets per acre.

59. It has been clearly demonstrated that heavy manuring of Ukh canes with nitrogenous manures gives rise to excessive vegetative growth and delays the ripening until the time when crushing operations become impossible owing to the claims of the *rabi* harvest and the advent of the hot weather. Ten to fifteen maunds of castor-cake meal (36 to 54 pounds of nitrogen) per acre is the limit beyond which the Ukh canes will not profitably respond. The use of oilcake meal should be encouraged and arrangements made for supplying it from seed depots. It is important, however, that instructions regarding the correct amount to use should be given at the same time.

(v) The use of manures.

60. We have already drawn attention to the large area of land under cane in the United Provinces, the miserable yield of sugar at present obtained and the necessity for increasing the outturn of sugar on the existing area under cane. The fact that 75,000 acres of thick canes are already grown in the Provinces shows

(b) Improved cultivation of medium and thick canes

(i) Scope for its adoption.

that the conditions of soil and weather do not impose any serious obstacle to the extended growth of canes of better quality. The real obstacles are to be found in the lack of manure and water, the supply of which even in the canal irrigated areas is often irregular. We hope that the recommendations which we have already made for the extension of tube wells and those which we shall make for the supply of manures in our later Chapter regarding agricultural work in general will do much to remove these obstacles. Certainly their removal is a condition precedent to the successful application of the improved methods of cultivating thick and medium canes which we now proceed to describe. Those methods involve a great change in the agricultural practice of the Provinces and, for this reason, we recognise that their introduction will be a slower process than the introduction of the methods which we have suggested above for the improvement of the cultivation of the indigenous Ukh varieties. It must, however, be borne in mind that, if our purpose of increasing India's outturn of sugar sufficiently to supply her own needs at least is to be achieved, great changes are required. That such great changes will be rewarded with proportionately greater yields can, we think, be confidently predicted from the results of the important experiments conducted at Shahjahanpur since 1912, where the replacement of the present poor varieties with their limited possibilities of improvement by canes of better quality properly cultivated under competent supervision has trebled the yield per acre of sugar ordinarily obtained. The introduction of better methods of cultivation and better manuring of cane will, moreover, promote a general rise in the standard of agricultural practice throughout the cane areas; while Shahjahanpur experience has shown that the residual effect on the soil of intensive cane cultivation is so great that the yield of a following crop like wheat is increased to at least thirty maunds per acre, or nearly three times the average yield of the United Provinces, and that even the yield of a gram crop following the wheat crop is improved. With these possibilities before us, we would, therefore, recommend that the improved methods of cultivation which have been worked out at Shahjahanpur as suitable for the United Provinces should be adopted where facilities for irrigation and manure are assured, particularly around tube wells and in the neighbourhood of existing and proposed central factories and that the spread of these methods should form one of the principal duties of the staff of supervisors and field-men whose appointment we shall suggest below for the demonstration of better sugarcane cultivation. The profits of central factories largely depend on the quality of the cane they handle, and it is impossible to obtain the high extraction of sugar yielded by medium and thick canes from the Ukh varieties which contain as much as 16 to 18 per cent. of fibre. There are now, in addition to the local Paunda, several varieties of medium and thick canes suitable for the United Provinces such as 247-B, Barbados-1529, Ashy Mauritius, Mauritius No. 16, Uba and the medium Java canes. We anticipate that the number will be increased in the near future both by medium Coimbatore seedlings which are now under field trial and by fresh importations.

(ii) Description of system of cultivation recommended.

61. The best and most certain results with medium and thick canes, both as regards germination and yield per acre, are obtained by sowing carefully selected sets in shallow trenches 2 feet wide, 6 inches deep and 4 feet from centre to centre in a manner similar to that practised in Java, which, as we have explained in Chapter II, has given such remarkable results. The method of sowing in trenches is more necessary in the case of thick than medium canes, but is worth adopting for the latter wherever possible. Where trenching is adopted, it should be preceded by a summer fallow during which the land should be worked at intervals and the

trenches should be made in November as soon as the cultivator is free from sowing of his *rabi* crop. Failure to secure adequate results by this method is often traced to attempts to make the trenches too late before planting. In a normal season the trenches should be irrigated as soon as they are made. With careful cultivation of the trenches, the moisture thus given should be sufficient to last until the cane is sown. A second irrigation will be required about ten days after sowing and about four additional irrigations before a normal monsoon. It has been ascertained that the cost of making trenches in Rohilkhand and Gorakhpur is Rs. 15 per acre when the labour rate is four annas a day. The method, however, requires a large and constant supply of labour, and is, therefore, at present difficult to adopt where labour is scarce or irregular. A wide extension of this method will become possible as mechanical means of trenching are developed. Medium canes such as P. O. J.-33-A and Uba will give a good stand of canes when sown on the flat in rows four feet apart without trenching, if deep cultivation is given to the land preparatory to sowing. This method is also to be recommended in preference to trenching, wherever, although a summer fallow has been given, it has not been possible to make trenches by November.

Whichever method of planting is adopted, thorough earthing up of the young canes should be done before the rains, preferably in two operations. The importance of keeping the cane standing by earthing up cannot be overestimated. Heavy crops of cane, such as those produced by these methods of cultivation, nearly always fall down during the monsoon months, if this is not done, and the purity of the juice and the sucrose content are adversely affected. The quantity of manure which gives the best results under the above conditions requires working out for the different cane tracts. In Rohilkhand the latest experiments show that it is 35 maunds (1.3 tons) of castor cake meal per acre (equivalent to 126 pounds of nitrogen), or the nitrogen equivalent in some other form of oil-cake meal or manure. In the case of farm-yard manure this would average about 300 maunds (11 tons). The economic optimum for other soils of the Provinces will not differ greatly from this. On the Shahjahanpur farm the manure is dug into the trenches in one dose a month or six weeks before sowing.

The rotations practised at Shahjahanpur are given below. It is recognised that these may be modified with advantage to meet local conditions.

1. When cane is grown every fourth year :—

Sugarcane, wheat, fodder crop, gram, fallow, sugarcane.

Where land is available this has proved an excellent rotation and gives heavy yields of wheat and gram as well as cane. Where cane every fourth year would not meet requirements, for example, on a limited area of land owned by a central factory, the following rotation can be used.

2. When cane is grown every third year :—

Sugarcane, wheat, fallow, sugarcane; a fodder crop and gram taking the place of wheat every third rotation.

Development and organisation.

62. We are now in a position to consider how far the detailed recommendations we have made above for the improvement of cane cultivation in the United Provinces necessitate any reorganisation or expansion in the local Agricultural

Department. The form of our proposals is inevitably affected by the wider scheme for an all-India organisation with its own cane research stations under centralised control which we shall elaborate in a later Chapter of this Report ; but substantially those proposals can be stated in terms of local needs and their justification can be found in the description of local conditions recorded in the preceding paragraphs of the present Chapter.

(a) Research stations.

63. At present the research work on sugarcane is centred in the Shahjahanpur station, the only agricultural farm in the Provinces which is devoted exclusively to cane work. On the Circle farms cane must take its chance with other crops of a share in the limited area available and of a claim on the attention of an already fully employed Deputy Director. The unsuitability of such an arrangement for a crop which requires the close and constant attention and chemical analyses that cane requires we discuss in Chapter XXIII below : and we would merely state here our conclusion that, while the co-operation of the ordinary Circle farms will always be necessary in promoting improvements worked out at the cane stations and in the multiplication and distribution of sets, the establishment of farms devoted exclusively to research work on cane is an urgent need in all Provinces in which cane is, or is likely to become, an important crop. In no Province is it so important as it is in the United Provinces, and, though this has been recognised by the local authorities in the opening of the Shahjahanpur station, we are convinced that much requires to be done, if the Provinces are to realise the full benefit of their preponderating share in the cane crop of India. We have already indicated the need for a hill nursery ; but an equally urgent need is, in our opinion, the opening of at least two more cane research stations like Shahjahanpur, one in the Meerut and one in the Gorakhpur division. We have drawn attention to the importance of conducting the isolation of pure line cultures within the areas to which each group of canes has proved its natural adaptability, and we cordially endorse the view expressed by the Local Government in paragraph 6 of their Resolution on the Report of the Agricultural Department for the year 1918-19 that the marked effect of local variations in soil and climatic conditions rendered experience gained in one part of the cane growing tract of doubtful value for another. The Meerut and Gorakhpur tracts possess such marked characteristics of their own, and the need for local research in these two areas should, we think, be immediately recognised. But it would be unfortunate if the work were handicapped, as it threatens to be at Shahjahanpur, by lack of room for the conduct of the numerous comparative and other tests that will be required on a field scale, and we hope that it will be found possible to secure sites for the two new research stations we propose with an area of not less than 200 acres of suitable land each, as well as to enlarge the existing station at Shahjahanpur, the area of which is at present only 50 acres, to the same extent. We are confident that the acceleration of definite and reliable results which will thus be secured will repay many times over the comparatively small extra outlay involved.

(b) Demonstration.

64. The need for demonstration on the cultivator's own field of improvements both in varieties and agricultural practice, and the division of functions between the research and the demonstration staffs are again matters which we deal with generally for all India in Chapter XV. The question of a special demonstration staff to work on sugarcane only is, however, one that we there leave for determination in accordance with the needs of each Province.

Such a special staff can be justified by (1) the outstanding importance of improved cultivation for cane, if any substantial increase in yield is to be obtained, (2) the fundamental nature of some of the changes in agricultural practice required, and (3) the fact that, cane being a crop which is on the ground all the year, its proper cultivation and care call for constant supervision at all seasons. In those Circles in which sugarcane is a leading crop, therefore, *viz.*, the Meerut, Rohilkhand and Gorakhpur divisions, we recommend the appointment of a demonstration staff specially trained for and specially employed on sugarcane work, the training being furnished at the cane research stations and the constitution of the staff being fieldmen working under officers of the Provincial (or Class II) Service of the local Agricultural Department. The numbers required will naturally depend on the number of demonstration plots it is found advisable to work in each year ; but we suggest as a suitable standard which should provide full employment without relaxing essential supervision one fieldman to six plots and one Class II officer to ten fieldmen.

(c) Superior control.

65. Hitherto, the control of the Shahjahanpur research station and of all special research work on cane in the Provinces has been undertaken by our colleague, Mr. Clarke, in addition to his own duties as Agricultural Chemist, with more recently those of Principal of the Agricultural College, Cawnpore, and Professor of Agriculture. We realise that this multiplication of charges is due to abnormal causes, and we are glad to learn that the sanction of the Secretary of State has recently been obtained to the creation of a new post of Assistant Agricultural Chemist, primarily with the object of allowing the Agricultural Chemist to devote more time to the development and improvement of cane cultivation in the Provinces. But, though this is a step in the right direction, we feel strongly that it is not enough, and that the time has come when all research work, both chemical and agricultural, on cane in the United Provinces should be definitely placed under the undivided control of an officer whose whole time will be devoted to it. It will then, and only then, be possible for him to direct the cane work not only at Shahjahanpur but at the two new stations the constitution of which we have proposed above, as well as to take charge of the cane breeding station in the foot-hills. As will be seen from Chapter XXIII below, we contemplate an all-India scheme of organisation for cane research under which all these research stations would eventually be absorbed by and controlled from a central institution to be called the Sugar Research Institute, and the expert officer in charge of them would pass under the same control and be transferred to the same organisation. Meantime, however, we regard it as important in provincial interests that immediate steps should be taken to complete the unification of the control of cane work in the Provinces and to free the officer in charge of it from all other responsibilities.

This unification of control, however, though it will relieve the executive staff of the local Agricultural Department of the main research problems of cane growing, will in no way interfere with their existing interest in the practical spread of improvements in the crop within their own Circles ; and, whatever be the future of the organisation we propose in Chapter XXIII, the staff at the research stations must, as we there show, continue largely to rely upon the Deputy Directors of Agriculture to multiply their improved varieties of seed, to check and report on variations in the results of the research stations when applied to particular localities and to popularise the improved varieties and methods there recommended. This is our justification for venturing to offer a suggestion regarding the redistribution of Deputy Directors' Circles which we understand is now being considered. The intention is, we

believe, eventually to split up the existing four Circles into eight, though for the present only two new posts of Deputy Director have been created, and the number of Circles will for the time being presumably be increased to not more than six. We are given to understand that one Circle will comprise practically the whole of Oudh including Kheri and Sitapur, two important cane districts where the conditions and problems in regard to cane are very similar to those in the adjacent Circle of Rohilkhand. We are not in a position to say whether more important interests affecting other crops or facility of administration outweigh the material advantages which the fusion of these two districts with the Rohilkhand Circle would secure for the cane crop, but, if not, we would draw the attention of the Local Government to the advisability of this comparatively small rearrangement.

Summary of Conclusions and Recommendations.

(1) *The United Provinces furnish more than half the acreage under cane in India; but sub-tropical conditions render their cane problems of great complexity.*

(2) *Existing canals here, unlike those in the Punjab, are designed for an intermittent discharge only; and there is no prospect of a material extension of cane on any of them except the Upper Ganges canal, which has new permanent head-works under construction.*

(3) *The execution of the Sarda canal project, one part of which, the Sarda Kichha feeder canal, has now been sanctioned, should, however, give an increase of 100,000 acres under cane, besides creating great possibilities of introducing improved varieties and methods of cultivation.*

(4) *A small increase under existing canals might be obtained, if the system of distribution of water could be modified to enable the needs of cane to be met during the hot weather months and breaks in the monsoon.*

(5) *The feasibility of giving more reliable notice to cane growers of the supply of canal water should be investigated.*

(6) *The system of distribution on the Sarda Kichha feeder canal should be worked out with special reference to the needs of cane; and the Agricultural Department should try to secure concentration of the cane areas in the interests of efficient irrigation.*

(7) *The provision of adequate drainage is of great importance and should be constantly borne in mind; and a drainage survey should be carried out in the submontane districts.*

(8) *Wells are a most important source of irrigation; and the development of pump irrigation would confer great benefit, especially to cane.*

(9) *There is already a fair demand for such installations; and an entirely separate branch of the Agricultural Engineering Department should be formed to deal with well boring and pumping installations only.*

(10) *The work should be concentrated in selected tracts, e.g., the Kheri district, and combined with active propaganda.*

(11) *If electric power is generated from the falls on the Upper Ganges canal, it might well be used to work tube wells in the areas not irrigated by the canal.*

(12) *Surplus power from the falls on the Jumna might be used for the same purpose in the Saharanpur, Muzaffarnagar and Meerut districts.*

(13) *The grant of loans to individuals for the installation of tube wells and power-pumping is preferable to encouraging co-operative societies to undertake them.*

(14) *The separate consideration of the two main branches of agricultural improvement should not obscure the fundamental principle that in Upper India improved methods of cultivation must accompany the introduction of improved cane varieties.*

(15) *The Agricultural Department's work on the isolation of pure races of indigenous varieties should be decentralised in recognition of the adaptation of particular groups to particular tracts.*

(16) *The work on Coimbatore crosses and importation of exotics should be extended and field trials should be carried out on a larger scale.*

(17) *A station should be opened for the supply of kill sets and should provide for the needs of Bihar as well as the United Provinces.*

(18) *Though the enhancements of yield obtainable by the application of improved methods of cultivation to local canes are limited, they are still appreciable, and improvement in this direction is likely to be more rapid than in the direction of introducing better varieties.*

(19) *Instances of such improvement are the dissemination of pure races of the best indigenous varieties, better ploughing, a summer fallow, more scientific rotations, planting fewer sets in rows, and the use of oil cake manures.*

(20) *Superior thick and medium varieties with the greatly improved system of cultivation they require must, however, be introduced if India is to supply her own sugar requirements.*

(21) *The feasibility of their successful introduction, given adequate supplies of water and manure, has already been demonstrated at Shahjahanpur; and a great improvement in general agricultural practice will be promoted thereby.*

(22) *The suitability of several thick and medium varieties for the Provinces has already been established.*

(23) *The best system of cultivation is the trenching system adopted in Java, but until trenching by mechanical means is adopted it requires a large and reliable labour supply.*

(24) *For medium canes and wherever labour is not plentiful sowing on the flat in rows four feet apart after deep cultivation may be adopted.*

(25) *Whichever method is adopted, earthing up of the young canes is essential.*

(26) In addition to Shahjahanpur, which should be enlarged to 200 acres, two new stations of similar size devoted exclusively to research work on cane should be immediately opened in the Meerut and Gorakhpur divisions.

(27) Demonstration parties of fieldmen under Class II officers of the Agricultural Service should be trained at the cane research stations and posted solely for demonstration work on cane in the Meerut, Rohilkhand and Gorakhpur divisions.

(28) All cane research work, both chemical and agricultural, should now be placed under the undivided control of a whole-time officer, without awaiting the constitution of the Sugar Research Institute.

(29) In the interests of the cane crop it is suggested that, when the impending redistribution of the Circles of Deputy Directors of Agriculture is carried out, the Kheri and Sitapur districts should be included in the Rohilkhand Circle.

CHAPTER IV.

BIHAR AND ORISSA.

66. The Province of Bihar and Orissa lies between 19° 3′ and 27° 31′ N. Orissa occupies the most southerly position in the Province and is thus entirely within the tropics, whereas Bihar proper is entirely sub-tropical; the intervening tract known as Chota Nagpur lying half north and half south of the Tropic of Cancer. In acreage under cane Bihar and Orissa stands third of the Provinces in India, but the cane growing tracts are concentrated in the Patna and Tirhut Divisions of west Bihar, the principal cane growing districts, according to the official statistics, being Saran north of the Ganges and Gaya and Shahabad south of that river. Outside these divisions the only district which returns an area of more than 10,000 acres is Bhagalpur in the eastern half of north Bihar in which the area under cane in 1919-20 was 17,400 acres. The monsoon in Bihar and Orissa sets in somewhat earlier and lasts longer than in the United Provinces. In the cane growing districts the rainfall is more intermittent than it is further east and is due mainly to cyclonic disturbances which develop at short intervals of two or three weeks in the north-west angle of the Bay of Bengal. These invariably move westward and in passing over the western districts of the Province cause heavy rainfall for several days at a time. From November to February the weather is fine and dry and there is an almost total absence of cloud and rainfall except for an occasional disturbance proceeding from the north-west of India. From March onwards until the break of the monsoon dry westerly winds with increasing temperatures prevail, and the only rain is that from hot weather storms which varies between one and three inches on an average. The annual rainfall in south Bihar, that is, the districts lying between the Ganges on the north and the Chota Nagpur division on the south, is about 42 inches and there is very little variation between the different stations. The variations in North Bihar are much greater. In the submontane tracts the annual fall is from 50 to 55 inches, but nearer the Ganges it is very little higher than in South Bihar It is worthy of mention, in view of the fact that practically all the cane in North Bihar is unirrigated, that the rainfall in the Saran district was as low as 24 inches in 1896-97 and as high as 65 inches in 1899-00. North Bihar is a level plain falling gradually from the foot of the Himalayas but with a belt of fairly high land along the bank of the Ganges. The soil consists mostly of the older alluvium or *bangar* of the Gangetic plain, which is a yellowish clay with frequent deposits of *kankar* (calcium carbonate); but in many parts this has been cut away by the torrents which rush down from the Himalayas, and the lowland through which these rivers have at one time or another found their way to the Ganges is composed of more recent deposits of sand and silt brought down by them in flood. These latter soils have a remarkable capacity for retaining moisture, a specially valuable feature in view of the capricious character of the rainfall. In South Bihar the presence of new alluvium is less marked.

Climate and soil.

67. The average area of Bihar and Orissa excluding Native States during the five years ending 1918-19 was 52,956,150 acres. The net area actually cropped during the same period averaged 25,370,280 acres of which 268,800 were under cane. Of the latter, 47,894 acres were irrigated from Government canals. The percentage of the area under cane to the net area cropped was 1.1 and to the total area under cane in India was 9.8 . The average yield of gur for the quinquennium was returned at 1.04 tons per acre. It must be remembered, however, that most of the Province being under permanent settlement, that is, with a fixed land revenue demand not liable to periodical revision, it has no revenue staff ; and that its agricultural statistics of area are furnished by the police. It is impossible therefore to place the same reliance on these figures as on the corresponding returns of all other Provinces except Bengal, where the same defects exist as here and for the same reason.

Statistical.

68. Bihar and Orissa is specially interesting botanically in that it is a transitional region between tropical and subtropical India, that is, between the region of thick canes and of the thin, indigenous canes. In these circumstances, it is unfortunate that more work has not been done on the classification of canes in this Province. Pure line cultures of some of the most prominent indigenous varieties have been made at Sabour with a view to the more extended study of their chemical and agricultural characters. Owing to the limited area available for sugarcane work and the smallness of the staff, however, this work has not been followed up ; and a complete account of the cane varieties still remains to be made. This is especially necessary in the case of the thick canes which are now grown on a fairly large scale by planters and others. Many varieties of such canes have been introduced in the past, but their history has become hopelessly confused. Mauritius varieties, for example, are common but their original names or numbers have seldom survived. One of the Tanna varieties of Mauritius cane, which were probably introduced into Bihar and Orissa from Western Bengal, is stated by Woodhouse, Basu and Taylor* to be exactly similar to a cane known in Bihar as Red Java, and to be probably the same cane with a different name, whilst the canes known in Bihar as Patli Khajle, Sada Khajle, etc., which are said to have been introduced from Assam, are not known to the officers in that Province.

Varieties of cane.

The varieties of cane mostly grown in Bihar, more especially north of the Ganges, are the dwarf, bushy canes of the Mungo group, and correspond to the white Ukh canes of the United Provinces. This group is represented in Bihar and Orissa by Hemja (also known as Bhurli), Reora and Mungo, all canes which tiller well and have for indigenous canes a sucrose content of high test and purity when ripe, but they ripen late. Of these Hemja is now the most popular variety, as it has been found to suffer comparatively little from drought and waterlogging and, owing to its hard rind, is not attacked by jackals and pigs. It is also more resistant to red rot and borer than the other members of the group. The canes of the Nargori group, which is represented in Bihar by Baraukha, Kewali and Nargori, are tall and reed-like but poor in sucrose content. The points in their favour are that they ripen earlier and suffer less from floods than the Mungo group. The medium canes of the Pansahi group —the Ganna canes of the United Provinces—are more popular in the irrigated lands of South Bihar than in North Bihar where cane is almost entirely grown without irrigation. The principal members of this group, the characteristics of which are medium thickness, erect habit, and good tillering, but high glucose content, are Pansahi, Maneria and Chinia. Maneria is spreading in South Bihar, as it is not subject to attack by borer to the same extent as the other varieties of the group, and as it is found to develop sufficiently on waterlogged land to admit of an early harvest and thus to meet the needs of the early gur market. Pansahi, on the other hand, is very liable to red rot and borer and is unable to withstand waterlogging. Chinia, which has a poor sucrose content, is mainly grown on lands liable to flood in the Darbhanga district of North Bihar. Of varieties which do not fall into any of the groups mentioned above, Khari, which is an important cane in South Bihar and appears to have been introduced from Bengal, is a tall, thin, hardy variety which withstands drought and waterlogging well and gives a good yield and an excellent quality of gur for a cane grown under such conditions. It is, however, peculiarly liable to smut. Sewari, which is an early ripening cane, with a very high fibre but with juice of high sucrose content, is frequently found on lands liable to flood. Paunrah, a tall erect cane also early ripening and with juice of high sucrose content, is said to have been recently introduced from the United Provinces, although there is no cane known by that name in those Provinces, and is spreading in the neighbourhood of Sipaya. Lalgerah is a medium variety which has recently been introduced in the Shahabad district of South Bihar and has so far given good results.

*Memoirs of the Department of Agriculture in India, Botanical Series Volume VII, No. 2, paragraph 31.

69. Reference has already been made to the work on the isolation of pure line cultures which has been done at Sabour. A number of the local varieties of cane which were isolated by the late Mr. Woodhouse, Economic Botanist, are still being tested together with a number of seedlings from Coimbatore, but the work has not progressed sufficiently to enable sets to be given out. The chemical work at Sabour carried out by Mr. C. Somers Taylor on the character and quantity of fibre in different varieties of indigenous and imported canes has afforded interesting information regarding the behaviour of the various canes in the mill, and has further pointed to some radical differences in the structure of the compound celluloses (or fibre) of each group which may ultimately prove of material value in selecting suitable canes for factory work. Chemical work has also been done on the effect of different manures on the period of ripening and has proved that heavy dressings of nitrogenous manure at Sabour delay the ripening for a fortnight. In 1913-14 a cattle breeding farm was started at Sipaya in the Saran district of North Bihar. It was originally planned that this should be combined with a sugarcane station, but within six months the Local Government had abandoned this intention ; and for the next five years, while frequent changes in the proposals for the location and control of the cane station were made, it was consistently intended that it should be provided with a site elsewhere than Sipaya. Such work as was done there on cane selection meanwhile was merely regarded as a breaking of the preliminary ground pending the creation of a special cane station under fully qualified direction. In the autumn of 1919, however, it was decided that Sipaya was, after all, the best place for the station and arrangements are now being made for its permanent location there. The work done, as at Sabour, has so far been almost entirely confined to varietal tests, but a small quantity of the variety known as D-1135 has been distributed to planters in the neighbourhood. On the Ranchi farm special attention has been paid to the cultivation of cane on drained land, and the experiments have shown that it is possible to grow large crops with heavy manuring provided that the drainage is sufficient. Mention should also

History of work on sugarcane in Bihar.

be made of the varietal tests and the experiments with improved methods of cultivation which have been carried out at the Imperial Research Institute at Pusa, the results of which should prove of value in North Bihar.

Agricultural practice (a) on ryots' holdings.

70. Bihar differs from other Provinces in India not only in the possession of a considerable industry for the manufacture of white sugar direct from the cane but also in that a large area of cane is grown by European planters on their home farms under their own supervision. On these estates the cultivation is of a comparatively high order and differs so markedly from that of the ordinary cultivator as to call for separate description. To take the Bihar ryot first, he has, like the ryot in the United Provinces, no established system of rotation. Except in the irrigated tract of South Bihar, where cane generally follows rice, cane follows either autumn rice (harvested in September), or peas or, less commonly, a whole year fallow succeeding a *rabi* (cold weather) crop. As cane in Bihar is usually planted in February, the fallow with the first of these rotations is from October to February, and with the third from March to February; whilst after a crop of peas there is no fallow at all. A fallow in North Bihar, where little or no manure is applied and cane is almost entirely grown without irrigation, is of the greatest importance, not only as a means of restoring fertility but also as a means of conserving the necessary moisture to carry the crop through the hot weather. It follows, therefore, that cane gives the best results when grown after a *rabi* crop, and this rotation is usually followed on the best land.

In the preparation of land the practice in no way differs from that followed in the east of the United Provinces. The number of ploughings varies from 3 or 4 to 15 or 20, according to the length of the fallow. Whole canes cut into sets are used as seed, the worst corner of the standing crop being usually kept for that purpose. No examination of the sets in order to ascertain whether any are diseased is made, and the cultivator is content to see that the sets have buds. They are sown after the plough and covered with earth by a *hanga* (wooden beam) except in Saran, where cane is planted in pits for making which a *kodali* (long handed hoe) is used. The cultivator in Bihar sows cane thickly, as many as 25,000 sets to the acre being not uncommon, as he believes that the land is not strong enough to enable the cane to tiller freely.

After cultivation is confined to working the land with a *khurpi* (trowel) before the cane germinates, to weeding with the same implement and to working the land with the *kodali* when the cane is above the ground. On land under wells in Saran the wells are only used to help the cane through the hot weather, when two or three irrigations are given.

As a general rule no manure is used except on land under wells and canals, where village sweepings and farm-yard manure are applied to a limited extent.

As in the United Provinces, the crop remains on the ground from nine to eleven months, according as it is an early or late variety, and harvesting begins towards the end of December and continues in some parts into March.

(b) on planters' estates.

71. The cultivation on planters' estates is of a much higher order than that on the land of the ordinary cultivator. On these estates, cane is usually grown on high land, that is, on land not subject to floods. A definite rotation is usually followed, the most common one being—

First year :—Cane, planted February, 1918, cut December, 1918 and January, 1919.

Second year :—Maize, sown June, 1919, and cut September, 1919, followed by oats, or some other *rabi* crop sown in November, 1919.

Third year :—The land is fallowed after the reaping of the *rabi* crop in March, 1920.

Fourth year :—Cane again

ractically a whole year's fallow thus intervenes between the harvesting of ıe *rabi* crop and the planting of the cane crop. Indigo is frequently grown ıstead of maize in this rotation, and its seeth forms a valuable manure. Weedıg is efficiently done and the land is thoroughly worked with the *kodali* when the ıne is well above the ground. Indigo seeth and oil cake are applied fairly liberlly. Although, as a general rule, cane is sown, as on the ordinary cultivator's ınd, after the plough, the yields obtained are much higher than those got by ıe cultivator owing to the longer fallow, the more thorough cultivation and the se of manure. It should perhaps be mentioned that a few planters adopt the ·ench system of cultivation for exotic canes, but that in such cases the trenches re often made too late. It should be remembered that under this system the ınd is opened up to a greater depth than it is with ordinary cultivation, and ıe newly exposed soil requires aeration combined with a suitable amount of ıoisture to bring it into a suitable condition for the decomposition of organic ıanures and the development of the young cane.

Prospects of the extension of sugarcane ınder irrigation.

72. Bihar and Orissa has only two large canal systems, the Orissa canal and the Sone canal systems. The area under cane on the Orissa canals, which irrigate ıearly 350,000 acres, is negligible, 824 acres in 1913-14 being the highest figure ·eturned, and we consider that Orissa may be ruled out of consideration as a ·ane growing tract; since the climatic conditions render it in every way much nore suitable for rice. The position is quite different on the Sone canal system. That system takes off from both banks of the Sone at Dehri; the left (or west) ›ank canal having three main branches known as the Buxar, Dumraon and Arrah ›anals, and the right (or east) bank canal having only one main channel, known ıs the Patna canal. The system commands a tract 1,586,900 acres in extent, of which the area irrigable annually is estimated at 850,000 acres; though the are actually irrigated has never exceeded 639,400 acres. The annual rainfall is about 42 inches. Rice and cane are the only two crops of importance; but, as the average area under cane for the ten years ending 1918-19 was 41,293 acres as against 398,443 acres of rice, it will be seen that rice is at present nearly ten times as important as cane. There is, in our opinion, no part of Bihar and Orissa which offers better prospects for the development of cane cultivation than the area under the Sone canal system. The tract which it commands is not subject to river floods, and there would be no difficulty in meeting the needs of the cane crop during the hot weather, since the canal supplies could be supplemented, as they are at present, from wells which can be sunk at trifling cost. The obstacle which has hitherto prevented the extension of cane cultivation and the introduction of better varieties is the lack of drainage. As the main branches of the canal run due north to the Ganges, into which the whole area drains, it will be obvious that the distributaries run across the line of natural drainage. The drainage problem is rendered still more acute by the fact that the main line of the East Indian Railway runs across the north of the tract parallel to the Ganges and that its embankment holds up water to a large extent. The result is that in the monsoon the cultivators of cane find it impossible to get rid of the surplus water from their

cane fields, which suffer not only from the rise in the subsoil water but also from surface flooding due to their situation in the middle of rice fields which have been embanked to hold up water. In consequence, although this tract is capable of growing excellent varieties of cane giving heavy yields, the energies of the cultivators have so far been devoted to raising an inferior class of cane which will stand waterlogged conditions. It was suggested to us that, if drains could be made along the centre of each hollow between the distributaries and could be opened out into the natural water courses which could then be turned into drainage channels, excellent crops could be grown close to the latter and the area under such crops could be gradually extended by opening smaller drains. It was also suggested that the drainage of the tract could be improved if more outlets were provided under the East Indian Railway. We do not feel competent to offer an opinion on the feasibility of these suggestions ; but we are convinced that the first essential to any development of cane cultivation in this tract is proper drainage and that the tract is in other respects so suitable for cane that every effort should be made to provide this. We, therefore, recommend that a drainage survey should be carried out at an early date with a view to the provision of a remedy for the present unsatisfactory state of affairs.

Drainage in North Bihar.

73. The drainage problem in North Bihar is not as important as that south of the Ganges. Nevertheless, owing to heavy monsoon rains combined with torrents from the Himalayas, there are large areas in North Bihar which are so liable to floods that they are unable to produce any crops of value. Here, as in South Bihar, a line of railway—in this case, the Bengal North-Western Railway—runs across the natural drainage line of the country and its presence accentuates the difficulty, as does, though to a much less extent, that of the Tribeni Canal. Attempts to prevent floods in some places by constructing embankments along the river banks at certain points merely resulted in the flooding of large areas and greater damage lower down. We understand that some ten years ago the Local Government found it necessary to take control of certain embankments in the western districts of North Bihar and to prohibit the construction of any new embankments or additions to any existing embankments ; and that this has to some extent lessened the intensity of floods. In spite of this there are still large areas in North Bihar in which, owing either to the entire lack of natural drainage channels or to the fact that these have become blocked up or have been diverted as a result of erosion, silting or similar causes, it is impossible to get rid of the flood water sufficiently quickly to make cane a safe crop. The diversion of the water courses has meant that their position in relation to the outlets provided when the railways and roads were originally built has changed ; and that either the railways and roads are frequently breached or else they hold up water over a large area to the detriment and often to the total destruction of crops. We hold, therefore, that in North Bihar, not only could better varieties of cane be grown and better outturns be secured, but also a considerable extension of cane cultivation might result, if a drainage survey were carried out with a view both to the enlargement of the existing watercourses and the removal of obstructions in them and to the provision where necessary of fresh drainage channels and of outlets under railways and roads.

Agricultural improvements.

74. It follows from what has been said in the foregoing paragraphs that we have no recommendations to make regarding the improvement of cane cultivation in Orissa. The serious obstacle to the introduction of improved

varieties and methods which is offered by the waterlogged condition of the land in the main cane growing tract of South Bihar renders it impracticable for us to make any constructive proposals for that area pending the completion of the drainage survey we have recommended and the elaboration of a thorough drainage scheme. Meanwhile we must be content to advocate the more general lines of improvement we recommend in Chapter XV below, particularly the organisation of supplies of sulphate of ammonia and other artificial manures. In so far as we have special recommendations to make for the Province, therefore, we shall confine ourselves to that part of Bihar which lies north of the Ganges and is generally known as North Bihar.

Ryot's cultivation.

(a) Selection and improved varieties.

75. Before the ryot's education in the adoption of pure and improved varieties can be started, the pure lines have to be isolated and the improved varieties established which will respond to such cultivation as he can reasonably be expected to give them in the near future. With regard to pure lines of indigenous canes, we have indicated in paragraph 68 the large variety of canes at present grown in the Province and the early stage at which the work so far done on their identification and classification has been interrupted owing to shortage of expert staff. We trust that this work will now be systematically resumed without further delay on the lines already adopted and now proposed by us for extension in the United Provinces. Whether this work will ultimately require to be distributed over several research stations, as we have recommended for the United Provinces, is a matter upon which we are not prepared to dogmatise. In the event of the solution of the drainage problem in South Bihar, it seems probable that a separate station for that area will be required. On the other hand, the facts that particular cane groups do not appear to have established their special adaptability to particular localities in North Bihar so clearly as in the United Provinces, and that the more compact area of the former is on the whole more homogeneous than the extensive area of the latter, lend support to the view that the work for North Bihar might well be concentrated in a single research station ; though, as will be seen below, even here we think more certain results are likely to be obtained, if two stations are established forthwith. But this does not mean that, until the classification of all important indigenous varieties and the isolation of pure line cultures of the best variety in each group have been completed, all work on the promotion of improved varieties should be held in abeyance. Certain indigenous canes, and particularly Hemja, have definitely established their superiority to other varieties now extensively grown ; and steps should at once be taken to propagate pure sets of these varieties in large numbers and to distribute them widely among cane growers. The complementary work of introducing new canes which are an improvement on the varieties at present grown is one which, so far as we can judge, the local Department of Agriculture is not yet in a position to undertake. It has yet to establish the superiority of new varieties under Bihar conditions ; but its main line of work, so far as the ordinary ryot is concerned, should be to test indigenous varieties of other Provinces and those of Dr. Barber's crosses which have been evolved with the object of attaining an improved yield under conditions of improved cultivation which the ryot can be reasonably expected to adopt in the near future. A special point to be borne in mind in carrying out these tests is the importance of discovering an early ripening cane, the need for which will be increased in proportion as the Department is successful in spreading the cultivation of so late a ripener as Hemja. It is true that in making this point we have particularly in mind the extension of the factory season ; but we trust that the

recommendations we shall make in Part II of our Report to secure reasonable prices to the cane grower who sells his cane to a factory will result in the grower finding his best market in the factory and thereby consulting his own best interests in consulting theirs. We have no desire entirely to rule out the possibility of introducing exotic varieties among ryots in Bihar; but as the main prospect of advance in this direction is offered by the larger landholders, whose position corresponds more closely with that of the European planters than that of the ryots, we deal with this subject in paragraph 79 below.

(b) Improved agricultural methods.
(i) Rotations and fallowing.

76. Although the most suitable rotations for cane in North Bihar have yet to be worked out, it can be said at once that cane should follow a *rabi* (cold weather) crop, and thus secure the great benefit of a practically full year's fallow; or alternatively that it should be preceded by a green manure crop grown during the previous monsoon. Early steps should be taken to demonstrate to the ryot that these practices more than repay themselves in the improved outturn of the cane crop. The introduction of a fodder crop into the cane rotation is also, in our opinion, an important need which would indirectly improve the cane yield by benefiting the cattle and enabling them to do deeper ploughing. Speaking generally, the cattle in Bihar are distinctly inferior to the cattle of the United Provinces, being both smaller and weaker. The same animals are usually employed both for crushing the cane and for ploughing the land with the result that, underfed and exhausted at the end of the crushing season, they are incapable of drawing anything but the primitive country plough with its limit of depth of four inches. Attempts to improve the Bihar breed are being made in the cattle farms at Sipaya and Bettiah; but the Bettiah herd, which was transferred from Pusa in 1909-10, has, we were informed, very seriously deteriorated as the result of in-breeding; while the work at Sipaya is still in an experimental stage. The possibility of establishing a superior breed for Bihar is, therefore, still problematical; and for some time to come the practical question before us in Bihar will be how to make the most of the existing breed. Better ploughs and deeper ploughing are essential if a more general use of manures is to be advocated; and without these two improvements it is idle to expect any material increase in the yield of indigenous canes. Hence the great importance for improved cane cultivation of securing for the cattle of Bihar better food and less work. Of these the second can only be secured by means which will relieve them of the duty of crushing the cane, that is, by the spread of sugar factories and the introduction of small power plants for the manufacture of gur, a matter we shall discuss in Chapter XVIII. It is with a view to securing the first that we advocate the inclusion of a fodder crop in the cane rotation, and the institution of early and active propaganda to this end.

(ii) Cultivation.

77. There is much more scope for effecting immediate changes in the ryot's practice of selecting and planting his sets. The short-sightedness of his policy of keeping the worst patch of his cane crop for planting should be demonstrated to him; and he should be taught to select his sets with intelligence and care. It is largely owing to his present practices in these respects that he is compelled to go to the otherwise unnecessary expense of planting as thickly as he does; for it is inevitable that a large proportion of the sets so obtained will fail to germinate, and thick planting is mainly an insurance against this. A further economy in sets can be effected by the introduction of planting in lines

which will facilitate after-cultivation and promote better tillering. The popularisation and provision of cheap manures, particularly oil-cake manures, is another urgent problem; and we suggest a possible means of solving it below. The warning we there give against the practice of over-manuring indigenous canes applies of course with equal force here; but the almost complete absence of manuring among ryots at the present time and their lack of capital render the danger more remote with them than with the planters.

Planters' cultivation.
(a) The need for improved varieties.

78. The line of development on planters' estates is clear. We have here a body of men alive to the advantages of scientific agriculture and, as a whole, able to furnish the capital necessary for its adoption. They control areas the extent of which renders the introduction of power machinery an economic possibility, their general standard of cultivation is already comparatively high and the adoption of the trenching system proves that some of them at any rate are prepared to adopt the most advanced methods which can be shown to be profitable. There are, in fact, already signs that the planter's system of cane cultivation is in danger of out-running the cane he cultivates. In the comparative absence of work, either by the planters themselves or by the local Agricultural Department, on the introduction and acclimatisation of medium and thick exotic varieties, the planters' more intensive methods of cultivation have been applied to the best of the indigenous canes, with the result that, while very high yields of cane have been obtained, (individual instances of 800 to 900 maunds—29 to 33 tons—of Hemja per acre having been reported) the sucrose content of the cane has been proved in the factory to fall far short of what the same cane yields under less intensive cultivation. In other words, the cultivation given has passed the limit beyond which the thin, indigenous canes are unable profitably to respond, and they lose in sucrose what they gain in mere vegetative growth. It is, of course, easy to argue that, so long as the factory purchases its cane by weight, this is no concern of the cane grower's; but the answer to this contention is that in the long run the price a factory can afford to pay for its raw material must be proportionate to the true factory value of the material; and that the cane grower will either have to agree to some other system of payment than payment by weight, or be content to look elsewhere than the factory for the disposal of his heavy crop.

(b) Steps necessary for improvement.

79. The urgent need, therefore, so far as the Bihar planter is concerned, is the introduction of improved canes which will respond in sucrose content as well as in weight per acre to the intensive cultivation he is prepared to give them. The co-operation of the planters themselves in the discovery and multiplication of such canes should of course be enlisted, but they do not possess the scientific training and equipment necessary to conduct research of this kind; and it is, we think, the clear duty of Government to undertake it and to provide locally the machinery for the purpose. Simultaneously the solution of problems which have been, or are now being, worked out for the United Provinces at Shahjahanpur should be undertaken, such as the most remunerative rotations, the spacing of the cane rows, the value of green manuring, and the right quantities of manure for each of the three main classes of cane, thin, medium and thick. Nor have we here the interests of the planters only in view, or of the larger zamindars who may be expected to adopt the planters' methods. It must be remembered that the planters do not cultivate the whole of their estates, and that many of them lease large areas to tenants. They are directly interested in improving the agricultural practices of these tenants and so

enhancing the letting value of the land ; and it is to the planters that we look to secure the first initiation of the ryot of this Province in the adoption of the improved methods of cultivation without which they can never hope to grow better varieties of cane with success. It is with the planter's tenant that we expect this important development to begin ; and it is through the planter himself that it must be promoted. By the success of this propaganda will be gauged the possibility of promoting similar methods among the ryots elsewhere.

Co-operation of the planters in the supply of oil-cake manures.

80. There is one respect in which the co-operation of planters in the spread of improved methods of cane cultivation is specially important, and that is in the supply of cake manures. Recent developments have shown that they are fully alive to the value of the cane crop to them ; but it is obvious that the maintenance of that value depends on the prosperity of the sugar factory industry of the Province. That in its turn depends upon a large assured supply of cane from concentrated areas ; and it is, therefore, evident that intensive cultivation of the best varieties of cane gives the greatest promise of success. For this large supplies of manure will be required ; and oil-cakes are the most obvious source of supply in Bihar. One sugar concern in Bihar has already recognised this need by setting up its own oil-mill ; and every effort should be made to enlist the assistance of planters, if not in the establishment of such mills themselves, at any rate in the supply of oil seeds for their use. This need not involve any large extension in the area under oil-seeds in the Province, for that area is already large ; but the planters could do much to divert these seeds from their present export channels to the supply of local mills.

Development and organisation.

(a) The urgent need for work in the Tirhut division.

81. Hitherto the cadre of the provincial Department of Agriculture has included only three Deputy Directors of Agriculture, whose Circles have coincided with the Commissioners' divisions of Patna, Chota Nagpur and Orissa. North Bihar, which consists of the Tirhut division and a part of the Bhagalpur division, thus falls entirely outside their charges. So far as Bhagalpur is concerned, the arrangement has been that an Assistant Director of the Provincial (or Class II) Service has held charge of the Circle with the co-operation of the Professor of Agriculture at the Sabour Agricultural College. For the supervision of the Tirhut division, which is from our point of view by far the more important, no special organisation was created ; the Superintendent of the combined cattle breeding and sugarcane farm at Sipaya having originally been expected to perform the functions of its Deputy Director in addition to his other duties ; and, when this proved impracticable, the officer in charge of the Patna Circle having exercised such control as he could over such departmental activities as there were. The lamentable result of this arrangement is only too patent. Nothing has been done for the improvement of agriculture in the division. Outside Sipaya itself it has no longer a departmental farm, the one at Bettiah having long since been closed, and the only Agricultural staff it can boast is a solitary Inspector at Muzaffarpur. The Imperial Agricultural Institute at Pusa, with its estate of 1,500 acres, is, it is true, situated in the heart of the division ; but the expert officers of the Institute are neither mainly nor primarily concerned with local problems ; and even in so far as their work tends to the solution of such problems they have at their command no agency for the demonstration of their results, a fact which the local authorities did not, unfortunately, realise till 1915, when the war precluded the possibility of strengthening the superior staff of the Department to meet the admitted need. We have no desire, however, to dwell further on past neglect.

more particularly as the Local Government has now obtained sanction for the creation of two additional posts of Deputy Director, one of whom will be given the charge of the Bhagalpur division and the other the charge of the Tirhut division excluding the cane selecting station at Sipaya, for the charge of which another post of Economic Botanist has been created. This opens up a prospect of great improvement in North Bihar, and we can more usefully consider how far the new organisation now sanctioned appears to be suitable and adequate. On the whole, we are, at any rate for the present, inclined to accept it as adequate, it being understood that each Deputy Director will be provided with a strong subordinate staff ; and in particular that a net-work of Circle farms in accessible and otherwise suitable localities will be established at a very early date with adequate areas of land for the working out of local problems and the multiplication of improved seed. Of course we recognise that these farms will deal with the staple crops of their locality generally and not only with cane ; but, considering the hopeful prospects of developing the sugar industry in North Bihar and the great value of the crop, we hope that cane will occupy an important place on all farms ; and particularly on farms opened in the Saran, Champaran, Muzaffarpur and Darbhanga districts. But there is so much lee-way to make up that it is essential that there should be no more delay, and we trust that the Local Government will now give pride of place in its development programme to the organisation of agricultural work in North Bihar, and that the Government of India will render it every assistance in securing recruits for the new posts.

(b) Criticism of the organisation proposed.

82. We are less confident regarding the suitability of the new scheme in all respects. In the first place, the proposal to put the new cane selecting station under the control of an Economic Botanist appears to us to overlook the paramount importance of chemical investigations in the selection of cane varieties and the evolution of proper methods of cultivation ; and we trust that the Local Government will on reconsideration agree to substitute a second Agricultural Chemist for the second Economic Botanist now sanctioned for the control of this station. But the choice of Sipaya as its site is, we think, open to still more serious criticism. We are aware that this is a question which has only now been decided after a prolonged and not always profitable discussion extending over the best part of eight years ; and with so little done and so much to do for sugarcane in North Bihar we are most reluctant to take any step that might again defer the establishment of this much needed station. The objections to Sipaya, however, seem to us so clear and strong, that we have no alternative but to present them.

(c) Origin and object of the scheme for a cane station in North Bihar.

83. To justify our conclusion it is necessary to go into the matter at some length. The scheme originated in a resolution of the Board of Agriculture in India of 1911, which emphasised the importance of locating sugar stations in sugar tracts and suggested to the Government of Bengal (in which Bihar was then included) the establishment of a sugar station north of the Ganges as most desirable in the interests of the industry. Which particular industry was referred to is not precisely stated ; but it is clear from the note prepared for the Board by the then Inspector General of Agriculture and endorsed by them in a separate resolution, as well as from the relevant discussion of the whole subject, that the factory industry in white sugar was primarily intended. In any case the point is finally settled by the explicit statement of the Agricultural Adviser (as the Inspector General of Agriculture had by then been renamed) in his note forwarded by the Government of Bihar and Orissa in February, 1913 in support of their first choice of a site for this sugar station north

of the Ganges, that "the object of this farm is to aid the Central Factories which are now cropping up in the sugar tracts of Bihar." With this view we emphatically concur. In the seven years since 1913 North Bihar has become more pronouncedly than ever the centre of white sugar manufacture direct from the cane in Upper India. Nor is the limit of expansion even now in sight. New factories are in process of erection or are in contemplation ; old factories are being extended. The circumstance that North Bihar is also the home of the European planter is, to our mind, a factor of great and growing importance in this development.. With the collapse of natural indigo, the recovery of which during the war appears unlikely to be maintained in times of peace, the planter's attention is being attracted more and more to the opportunities of cane replacing indigo as a crop which will liberally repay the intensive cultivation he is in a position to give it. Contracts with planters for the supply of cane on a large scale are already being entered into by more than one Bihar factory ; and we have indicated above that improvements in ryots' cultivation of cane may be expected to make more rapid progress on planters' estates than elsewhere. In assisting the factory industry, therefore, the station will be also serving the best interests of the cane-grower both large and small.

(d) Reasons for the selection of a site in Saran district.

84. Yet the site selected in 1913 with this object in view was in the same neighbourhood as Sipaya ; and our objections to the one must have equally been sustained against the other. It is relevant, therefore, to consider what reasons weighed with the authorities in 1913 in selecting a site which, like Sipaya, was near the northern border of the Saran district on the western edge of North Bihar. Subsidiary reasons put forward were that in Saran there was a possibility of demonstrating the value of irrigation to the cane crop, a prospect which the abandonment of the Saran canals has falsified, and that a station in that district might also serve the needs of the important cane tract in the neighbouring United Provinces district of Gorakhpur, an argument which will lose its force, if our recommendation in Chapter III is adopted that the Gorakhpur cane tract should now have a research station of its own. But the main reason on which the selection was based was that Saran was regarded as the main sugarcane tract of North Bihar, and the site chosen was inferentially considered well suited to serve the interests of the other cane districts, namely, Champaran, Muzaffarpur and Darbhanga. This also is, and must be, the main justification for the later choice of Sipaya, the additional facts that Government controlled land is already available and that preliminary work can be started there at once in anticipation of the appointment of an expert officer to take charge of it being of little or no validity, unless this main justification is substantiated.

(e) The main reason regarded by the Committee as invalid.

85. And it is here that we join issue. No doubt the official statistics of cane area support the predominance of Saran, the returns for 1919-20 crediting that district with 46,800 acres against 21,000 in Champaran, 20,000 in Muzaffarpur and only 15,500 in Darbhanga. We were informed also that recent surveys indicated the actual cane area in Saran to be as much as 61,245 acres. But the admitted unreliability of the official statistics does not apply only to Saran ; and it is the opinion of many planters that their inaccuracy is far more serious in the more easterly districts. The fact that, according to the official statistics, the cane area in Darbhanga has not increased at all in the last ten years during which an important central factory industry has come into being there affords strong corroboration of this opinion. It is, indeed, on the factory aspect of the question that we would chiefly rely. Of nine cane-crushing factories actually at work in 1919-20 in North Bihar only three are in Saran, and one of these is on the borders of Gorakhpur and draws half its cane from the United Provinces.

Plate 9

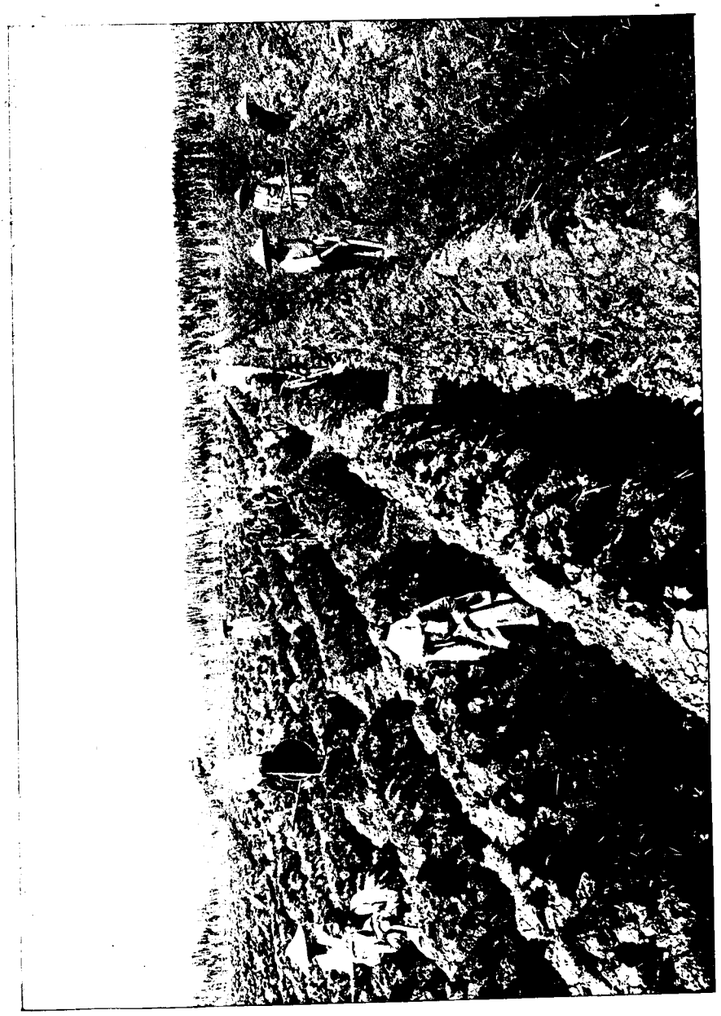


Photo-Mech. Dept. Thomason College, Roorkee.

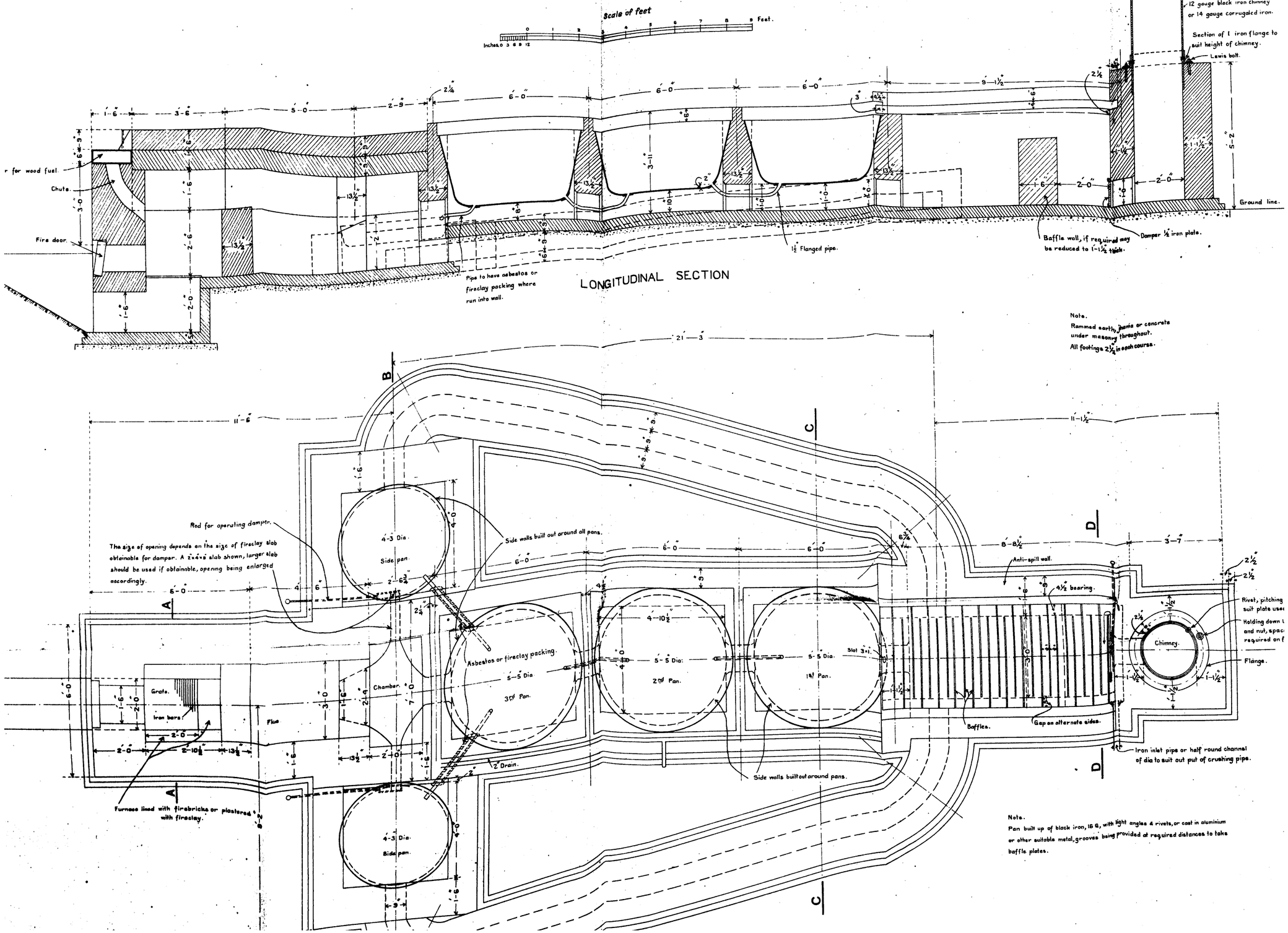
(1). Cane Cultivation in Java—Preparation of the Trenches.

(Reproduced by courtesy of the General Syndicate of Sugar Manufacturers in the Netherlands Indies.)

TAMIL NADU ARCHIVES
No. 1516H

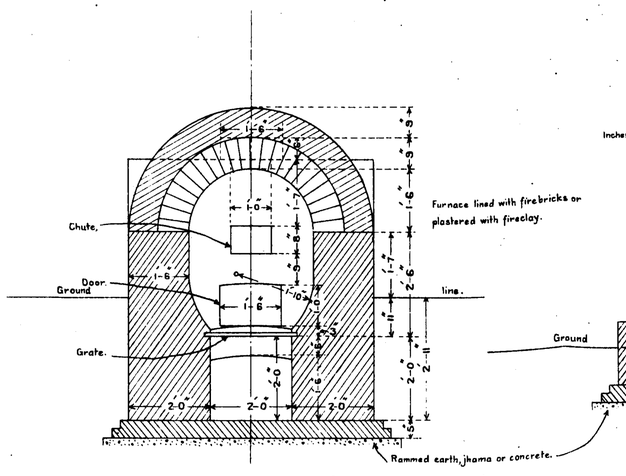
"GUR" BOILING PLANT

Suggested in Chapter XVIII.

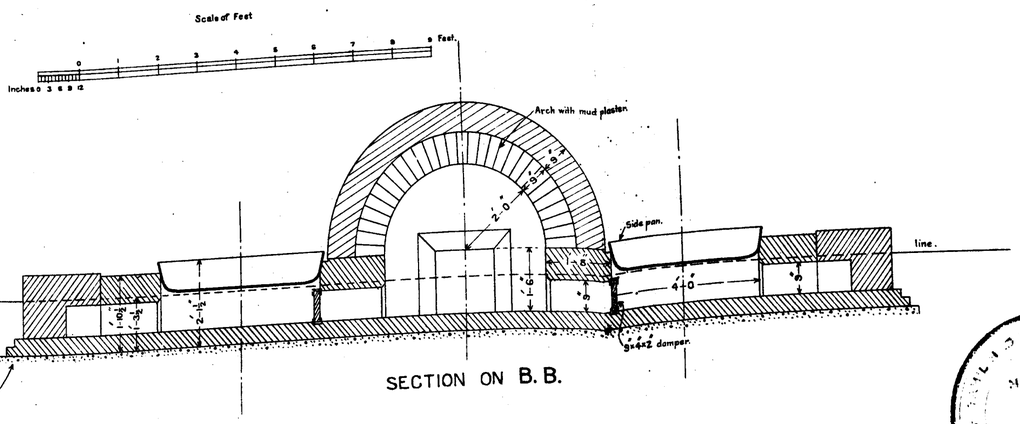


"GUR" BOILING PLANT

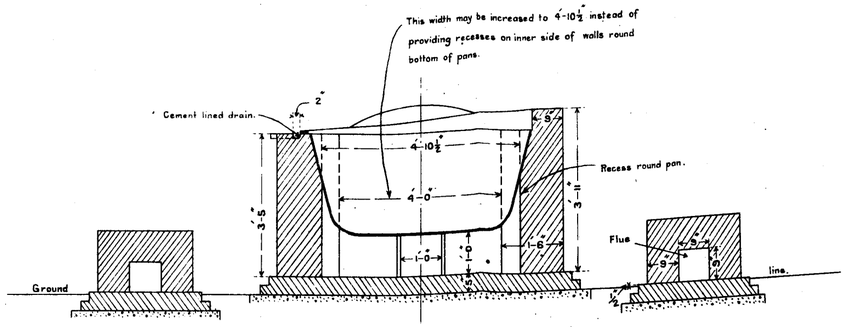
Suggested in Chapter XVIII.



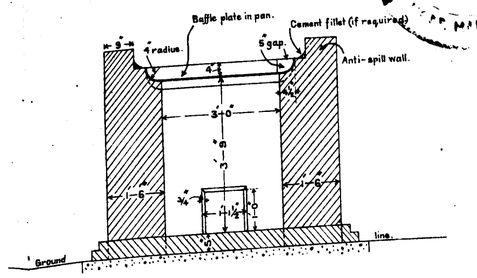
SECTION ON A.A.



SECTION ON B. B.



SECTION ON C.C.



SECTION ON D.D.

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January, 1921.—No.2158-1.2000

CHART SHOWING

PRICE THAT CAN BE PAID FOR CANE

BY FACTORIES OF

HIGH, MEDIUM, & LOW EFFICIENCY

ON THE SLIDING SCALE SUGGESTED IN CHAPTER XIX

MAUND

STANDARD

PER

MAS

CANE TO CULTIVATOR 9% GUR ON CANE RATIO 11:1

AND 9.5 SUGAR EXTRACTED PER 100 CANE.

ACTED PER 100 CANE.

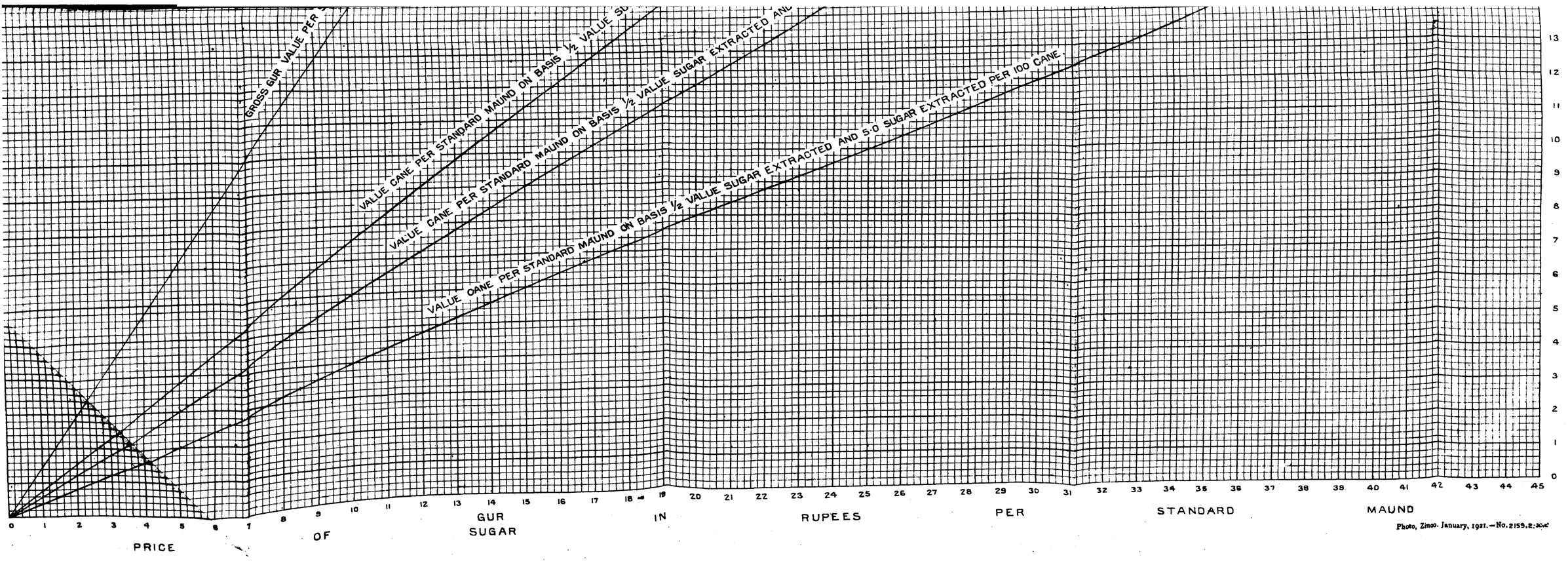
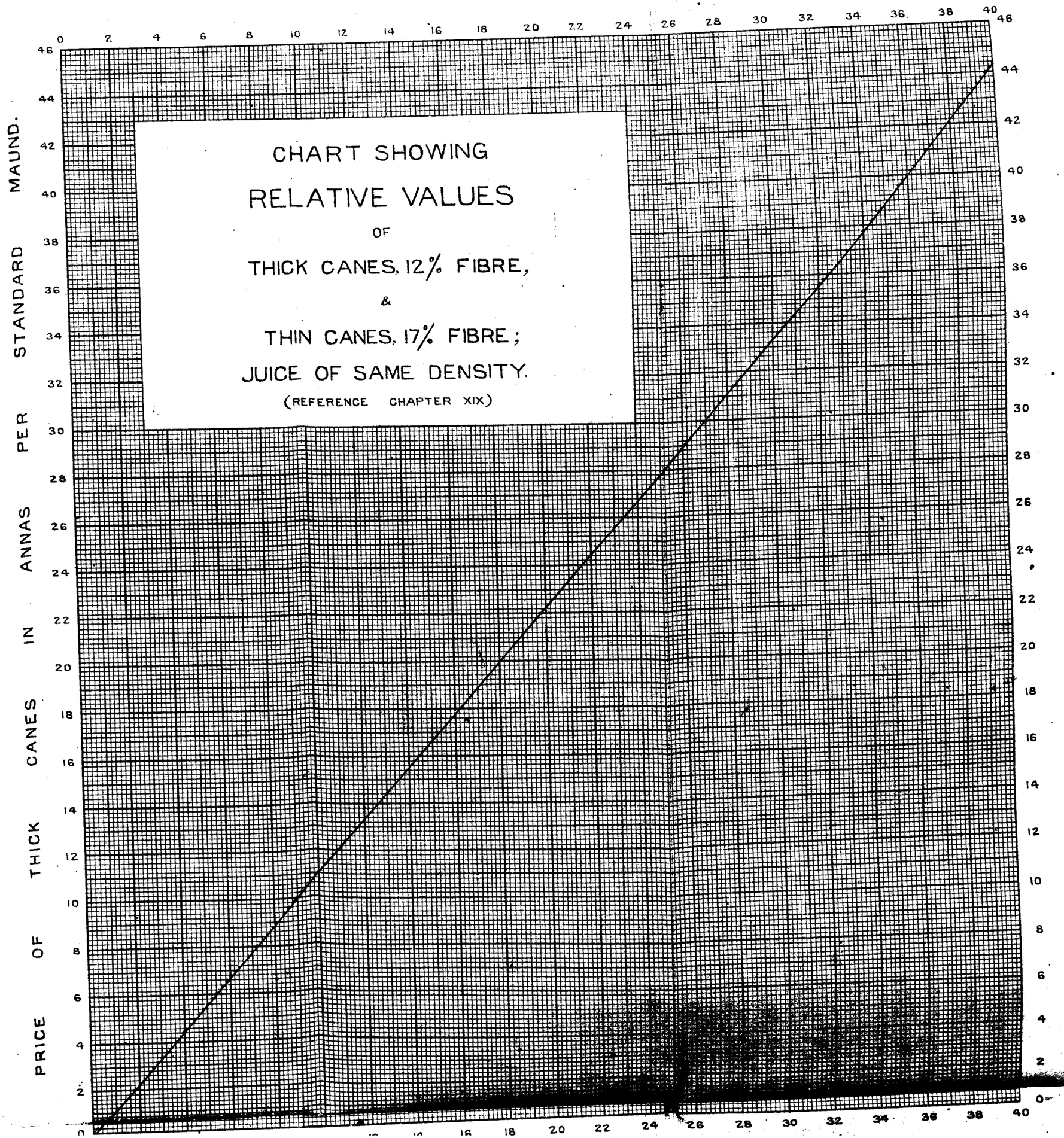


Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Photo, Zinco. January, 1921.—No. 2159.2:2cwt


CHART SHOWING
RELATIVE VALUES
OF
THICK CANES. 12% FIBRE,
&
THIN CANES. 17% FIBRE;
JUICE OF SAME DENSITY.
(REFERENCE CHAPTER XIX)
PRICE OF THICK CANES IN ANNAS PER STANDARD MAUND.
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 46
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46

Six, including the three largest, are in the other three districts, three in Champaran, one in Muzaffarpur and two in Dharbhanga. One of the Champaran factories is now in process of being moved further east to a site in the Bhagalpur district just beyond the eastern border of Darbhanga. From the returns sent us by these factories we find that of the total weight of cane supplied to them by North Bihar $\frac{3}{13}$ came from Saran and $\frac{10}{13}$ from the other three districts. Nor is this all. A large new factory is just about to begin operations in Darbhanga and another is in contemplation in the same district. At least two other factories are proposing to increase their capacity ; and neither of these is in Saran, where no sign of expansion is evident. And the future of cane in North Bihar lies in the central factory industry. The conclusion is inevitable. Whatever the position may have been in 1913, the main sugar tract of this area is not now to be found in Saran; and, if a central situation for the main sugar station is required, it must be sought much further east than Sipaya.

86. It remains, then, to consider whether a central situation is required. We have been told that all that is essential for selection work is widely representative conditions, and that these are supplied by Sipaya. We doubt whether they are. To mention only a single instance, the rainfall in Saran is rather less and considerably more capricious than it is in the more easterly districts ; and it would almost certainly be necessary to verify there the results obtained at Sipaya, involving a regrettable duplication of work. Moreover we cannot accept the assumption on which the above contention is based that the station will be confined to selection work. Our whole object and, we are confident, the object of the Board of Agriculture of 1911 in recommending separate stations exclusively for research work on cane is that all research problems in relation to the crop should there be worked out—problems of soil and of drainage, of manuring and of cultivation no less than of selection. It is our considered opinion that the conditions affecting the solution of these problems in Champaran, Muzaffarpur and Darbhanga must, and in fact do, differ appreciably from conditions in Saran, and that it is only within the limits of the tract in which these conditions obtain that the problems they affect can successfully be attacked. And, although it will be the function of a separate agency to disseminate locally the results obtained at the research station, those results and the methods employed in obtaining them should be open and easily accessible to all at the research station itself. If they are not, the station loses much of its instructional value. An accessible situation is, therefore, important : a central one is indispensable. Sipaya is neither. Saran is the only district of Bihar to the west of the Gandak river ; by which, therefore, it is cut off from every other district. This river is nowhere fordable and is only crossed by two railway bridges, one on the extreme north near the Nepal border, and one on the extreme south near the bank of the Ganges, each as far removed as possible from Sipaya, itself five miles from the nearest railway station on a branch line served by only two slow trains a day. Road bridges the Gandak has none; and we understand that the breadth of its sandy flood bed renders their construction impracticable. All road transport has to be carried across it by ferries which are uncertain when the river is in flood and difficult of access when it is low. The means of communication with Sipaya from any other district in Bihar could hardly be worse.

(f) A central site east of the Gandak river required.

87. Greatly as we regret it, therefore, we are compelled to the conclusion that a cane research station at Sipaya will never serve the interests of the districts east of the Gandak and, since it is in those districts that we see the greatest future for sugar in Bihar, it follows that a

(g) The main station might be located near Pusa, and Sipaya be retained as a substation.

No. 15164

site should be found within their limits for the main station and the headquarters of the expert officer to be placed in charge of the cane work of Bihar. In this view we are supported by a strong body of local opinion which was insistent in its representations of the urgent need of research work for this important factory area. We have not had the opportunity of examining in detail the possibilities of an alternative site to Sipaya ; but we would venture the suggestion that a site in the neighbourhood of Pusa appears to offer many advantages. Pusa is centrally situated within the cane area it would serve ; it possesses a typical soil ; and, though it is six miles from the railway, its road communications are good. Proximity to the Imperial Agricultural Institute would enable the officer in-charge of the station to take advantage of the work already done there and the experience already gained ; while the services of the Agricultural Engineer shortly to be attached to the Pusa staff could be utilised in the conduct of agricultural experiments with power machinery and improved implements. Mr. Sayer would go further than this and, in view of the fact that under our larger scheme dealt with in Chapter XXIII below the proposed station would eventually be absorbed in the central organisation of research stations under Imperial control, would advocate the immediate opening of the station as an integral part of the Imperial Agricultural Institute at Pusa, the officer in-charge being attached to the Institute pending the formation of the Sugar Research Institute. He considers that, if this were done, work on the pressing problems of this area would be started at a much earlier date. The rest of us, however, are averse from this course as creating an undesirable confusion of activities between the two institutions and particularly because we regard the starting of the cane research station for North Bihar under provincial control as of great importance in emphasising the local interests it will serve and in ensuring the active co-operation of the local authorities without which our central organisation for cane research cannot hope to succeed. We trust, therefore, that the Local Government will see its way to take early steps for the opening of a cane research station of not less than 200 acres in the neighbourhood of Pusa, if that locality is on detailed examination found suitable, but in any event in a central and accessible locality within the limits of Champaran, Muzaffarpur or Darbhanga. We do not, however, wish to advocate the complete abandonment of the Sipaya scheme. Saran is still an important cane tract, and its three factories and its many cane growers are as deserving of help as those east of the Gandak. Further, the obstacles to Sipaya proving of benefit to the eastern districts equally preclude a station situated within their limits proving of benefit to Saran. There is, therefore, a good case for retaining a part of the Sipaya farm as a subsidiary station for the study of the parallel problems of cane cultivation in the Saran district, and placing it under the control of the officer in charge of the main station.

Demonstration.

88. It remains to consider whether the creation of a special demonstration staff to work on sugarcane only on the lines we have already recommended for the United Provinces is called for in Bihar. Here again our attention may be confined for the present to North Bihar. The acreage under cane here is considerable and increasing ; while the clear signs of expansion in the local sugar industry open up a great prospect for the crop in the near future. While, however, we think that this area offers a wide field for profitable work in demonstrating new varieties of cane and improved methods of cultivation, which would give full employment to a strong staff, we have to remember that experiment must precede demonstration ; and that at present little is known of the canes best suited to particular localities in North Bihar, and of the methods of cultivation to which they will best respond. Until some progress has been made at the cane research stations now proposed in establishing such results, we do not consider that a special staff for cane demonstration work is required ; and the simpler improvements to which we have already drawn attention can be popularised by the general demonstration staff with whom the two new Deputy Directors of Agriculture in North Bihar will presumably be supplied. But we trust that the great value of a special staff for cane will be constantly borne in mind and that the Local Government will not hesitate to create such a staff as soon as the research work on the crop has sufficiently advanced to warrant it.

Summary of Conclusions and Recommendations.

(1) The special features of Bihar are that its climatic conditions are transitional between the tropical and the sub-tropical, that much of its cane is grown without irrigation and much by European planters and that it is the chief centre of white sugar manufacture direct from the cane in India.

(2) Orissa is essentially a rice-tract and offers no prospects for cane.

(3) The Sone canal system in South Bihar offers the best prospects for cane, if the area can be drained.

(4) A drainage survey of this tract is urgently required ; as, until this problem is solved, no agricultural improvements are possible.

(5) A drainage survey is also desirable with a view to the reclamation of the flooded areas of North Bihar.

(6) Pending action on recommendation (4) above, improvements are only to be looked for in North Bihar.

(7) The Agricultural Department's interrupted work on the identification and classification of indigenous varieties should be resumed.

(8) The propagation and distribution of pure sets of Hemja and other superior varieties among the ryots should now be undertaken.

(9) Dr. Barber's crosses and indigenous varieties of other Provinces should be tested for their suitability to ryots' conditions, and special attempts should be made to secure a good early ripener.

(10) The importance of a prolonged fallow or a green-manure crop before cane is planted should be demonstrated to the ryot ; and he should be urged to introduce a fodder crop into his cane rotation to benefit his small cattle and improve their capacity for agricultural work.

(11) The ryot should be taught to select his sets, to plant them less thickly and in lines, to improve his after-cultivation and to use oil-cake manures.

(12) The great need of the European planters is improved varieties responding to intensive cultivation.

(13) The Agricultural Department should take steps, with the co-operation of the planters, to meet this need and to work out the best methods of cultivation for these varieties.

(14) Through the planters a beginning may be made in introducing these ... and methods to small cultivators.

(15) The co-operation of the planters should be enlisted in obtaining supplies of oil-cake manures.

(16) Work on the improvement of agriculture in the Tirhut division is now of the greatest urgency; and a Deputy Director for this division should be appointed at once with a strong subordinate staff and a net-work of Circle farms.

(17) The substitution of an Agricultural Chemist for an Economic Botanist is suggested to take charge of the cane research station for North Bihar.

(18) The proposal to locate this station at Sipaya in Saran district should be reconsidered.

(19) The future of the central factory industry is in the districts east of the Gandak river; and the main research station should be located in one of those districts, possibly near Pusa.

(20) Sipaya might then be retained as a sub-station for Saran district only.

(21) A special demonstration staff for cane will be required as soon as appreciable practical results have been obtained at the research stations.

CHAPTER V.

THE PUNJAB.

Climate and soil.

89. The Punjab lies between 27° 39′ and 34° 2′ N. Although it is thus well outside the tropics, a point which is of great importance in considering its cane problems, it stands second in point of acreage amongst the cane-growing Provinces of India. Cane is grown in every district with the exception of Simla, but it is of little account in any of the nine districts west and north of the Chenab river. Lyallpur and Gujranwala are, in fact, the only two important cane growing districts in the western half of the Province. The extremes of temperature in the Punjab are very marked, the range being from below freezing point in all the cane-growing tracts in December and January to a maximum at Lyallpur of 116 degrees in May and June. The Punjab has in normal years two well-defined rainy seasons. The first is the period of the cold weather rains which fall between the end of December and the middle of March. The second, in which the greater part of the rainfall is received, is that of the south-west monsoon which extends from the end of June to the middle of September. The total rainfall decreases rapidly with the distance from the hills. In the submontane zone, which includes the cane-growing districts of Sialkot and Gurdaspur, it varies between 30 and 40 inches, whilst at Lahore it is only 18 inches. The eastern cane-growing districts, of which the largest areas under cane are in Karnal and Rohtak, belong to the west Gangetic plain and have a mean rainfall of about 24 inches. The rainfall in the Lyallpur district, which has over 50,000 acres under cane, is only 10 inches. As in the United Provinces, the differences in rainfall are reflected in the percentage of irrigated cane to the total crop. The Lyallpur district grows nothing but irrigated cane, whereas in the Ambala district the percentage of unirrigated cane for the quinquennium ending 1918-19 was as high as 78.4 and in the Hoshiarpur district 74.9. The soil of the Province is an alluvial loam, generally sandy and fairly uniform in character throughout, though local differences occur, the soil of the Lower Bari Doab canal colony being, for example, a heavier loam than that of the Lower Chenab canal colony.

Statistical.

90. The average area of the Punjab, excluding Native States, during the five years ending 1918-19 was 60,391,862 acres. The net area actually cropped during the same period averaged 24,422,081 acres, of which 420,908 were under cane the highest figure reached being 502,836 acres in 1917-18. The average irrigated area under cane was 338,050 acres, of which 199,315 acres were under Government canals, and the remainder mainly under wells. The percentage of the area under cane to the net area cropped was 1.7 and to the total area under cane in India 15.4. The average yield of gur for the quinquennium was returned at 0.79 of a ton per acre.

91. The varieties of cane grown in the Punjab have been classified by Dr. Barber into five groups, of which four are thin or Ukh canes and one a medium or Ganna cane. In the first group he places Katha, Lalri and Kansar, which he considers are closely allied to the Saretha group of the United Provinces. Katha, sometimes called Chan, is the cane most generally found in the Province and is grown equally extensively without irrigation in the submontane tracts where the rainfall, though moderate, is insufficient for other varieties and under irrigation in the canal colonies where it withstands the hot dry climate better than they do. It is a thin, red cane which ripens early, is very hardy and has great tillering powers. It is capable of withstanding drought, floods and, though to a less extent, frost. It has a low percentage of juice owing to its high fibre content, but the juice has a high sucrose content and the gur made from it is said to keep better than that made from other varieties grown in the Punjab. Lalri, which ripens rather later than Katha, is extensively grown on land irrigated by wells and canals in the Karnal, Rohtak, and Gurgaon districts. It is a hardy cane and has been found to resist frost. It is intermediate in height and thickness between Katha and Kansar, the latter of which is a tall, red cane approaching Saretha in thickness. Kansar is most often grown in those parts of the submontane tracts where the water supply and land are specially good. On such lands it gives a heavy yield for the Punjab, a good crop giving forty maunds (1.47 tons) of gur of excellent quality. It is not as hardy as the other members of the group and is only semi-resistant to frost. It ripens about the end of December. Dr. Barber's second group comprises Dhaulu and Tereru of Gurdaspur, canes which are slighty thicker than Katha and only differ from it in a series of minute characters. They require better soil than Katha and a more liberal supply of water and are almost always grown on irrigated land. They ripen later than Katha and have a softer rind and the sets are more liable to be attacked by white ants at planting time. The only cane in Dr. Barber's third group is Dhaulu of Phillaur which is found in the submontane tracts of the Jullundur, Ludhiana and Ambala districts and to a less extent in Hoshiarpur and the north of Karnal. This variety is very like Dhaulu of Gurdaspur in general habit of growth, time of ripening and outturn and quality of gur. Dr. Barber regards it as a connecting link between the primitive Dhaulu of Gurdaspur and the dwarf, thick canes of the Mungo group of the United Provinces and Bihar. The canes of the second and third groups are classified by Dr. Barber as quickly affected by frost and quickly recovering. Dr. Barber's fourth group also comprises one cane only—Kanara of Jullundur—which is very little grown in the Punjab, though it is often seen in small patches in the submontane tracts to the east of the Beas river. It is slightly thicker than Dhaulu of Gurdaspur and ripens to a bright green colour. Owing to its soft rind it is very liable to be wiped out by frost in severe winters. Dr. Barber does not mention Saretha among the thin canes of the Punjab: but it is now grown to some exent in Karnal and Panipat where it has in all probability been introduced from the United Provinces. The only common cane of the Ganna class in the Punjab is Kahu which Dr. Barber considers obviously to belong to the Pansahi group. This cane, which requires more water and better land and cultivation than any other variety in the Punjab, is widely distributed over the Province as a chewing cane near towns, its soft rind making it a favourite for this purpose. As a gur-making cane it is practically confined to the Gurdaspur district where the conditions for its growth are specially suitable. It is a tall, green cane becoming paler on ripening, which it does very late. It yields well and gives gur of excellent quality. It is, however, subject to red rot and is also quickly affected by frost, though it recovers rapidly. Dr. Barber mentions another cane of the

Varieties of cane.

Ganna class, Merthi, which he describes as very similar to Kahu. This is only found in the south-east of the Province and, like Kahu, is grown almost entirely for chewing.

92. Dr. Barber's classification of the canes of the Punjab, much of the material for which was supplied by Dr. Barnes, late Agricultural Chemist, and Mr. Southern, late Deputy Director of Agriculture, has already been mentioned. Work on cane in the Province has been mainly carried on at the Gurdaspur farm where it dates from 1911-12. It has been almost entirely confined to varietal tests and only a small quantity of a medium cane of the Pansahi group from Bihar, P. O. J. 105 and Uba have been distributed to cultivators. Dr. Barber's seedings have been under trial for the last two years. Three of them, CO 202 and 205 which are thin canes and 221 which is a medium cane, are said to be promising and a recent report mentions CO 205 and Dhaulu as the best canes on the farm this season. Mention should be made of the survey of the conditions of cane cultivation in the Amritsar and Gurdaspur districts which was carried out by Dr. Barnes and has been continued in the Karnal and Rohtak districts by Mr. Wilsdon, the present Agricultural Chemist. In the course of this survey Dr. Barnes investigated the frost resisting powers of the different varieties of cane with the results stated in the preceding paragraph.

History of work on sugarcane.

93. The system of rotation followed in the Punjab differs in different parts of the Province, but, speaking generallly, the most common rotation in the central and western districts is (1) wheat, (2) cotton or maize, (3) a *rabi* (cold weather) crop which may be a fodder crop such as *senji* (*Melilotus parviflora*) or a pulse such as *masar* (lentil: *Ervum lens*) and then (4) cane. Where this rotation is followed, the *rabi* catch crop is usually sown either with maize or cotton in the hot weather and is cut and fed to cattle in January. It is, however, often omitted and cane then follows maize or cotton directly. Cane sometimes follows a *rabi* crop after ten months' fallow and is itself followed by a crop of *chari* (*juar* grown as fodder, *Andropogon sorghum*) or cotton sown in May or maize sown in July. On lands on which river floods leave an annual deposit of silt the rotation is either cane, fallow, cane, or cane, wheat, cane. In the east of the Province the most usual rotation is either (1) cane, (2) a mixed crop of cotton and *methi* (a spice, the botanical name of which is *Trigonella foenum graecum*) followed by (3) cane, or (1) cane, (2) a mixed crop of maize and *moth* (a pulse, the botanical name of which is *Phaseolus aconitifolius*) and (3) cane.

Agricultural practice.

The agricultural practice of the Punjab is not in general more advanced than that of the western districts of the United Provinces. Where cane follows a *rabi* crop, *i.e.*, when a ten months' fallow is given, ploughing begins as a rule immediately after the harvest of the *rabi* crop and is continued until cane is sown, the number of ploughings being usually about fifteen, though in some cases it is as high as thirty to fifty. When cane follows maize or cotton, the number of ploughings is less, and when it follows a *rabi* catch crop, is not more than two or three, as the land cannot then be ploughed until shortly before cane is sown. As in the United Provinces, the sets for sowing are usually obtained from the previous crop or are purchased locally, though in the east of the Province it is recognised to be advantageous to obtain sets from Meerut. Whole canes are, as a rule, used for cutting into sets. The canes intended for sets are buried when frost makes its first appearance, as is done in Louisiana where

nilar conditions exist. This is found to secure better and quicker germina-
on. If the cold weather is mild, these canes are allowed to remain standing
the fields until the end of the harvest and are cut as they are required for
wing. This sometimes results in disaster, if frost occurs at the end of the
ld weather.

The usual method of planting is to lay the sets flat in the furrow behind
e plough at a distance of eight to twelve inches from each other. The sets
e pressed down with the foot, six or seven men being employed for this pur-
se to every plough in use. As the furrows are about eight to nine inches
art, the plough does not completely cover the sets in the preceding furrow.
his is done by the *sohaga* (leveller) which is run over the field three or four
nes after the sets have been planted and covers them with a layer of three
four inches of earth, and has the additional effect of bringing up the moisture
the sets. Planting, as a rule, takes place about the middle of March and
e number of sets used per acre is about 25,000. No selection of sets is practis-
l, all that the cultivator does being to see that each set contains at least two
ds.

After the cane has been planted and before it appears above the ground
e field is hoed with a *baguri*, a broad-bladed hoe, the blade of which is set at
angle of 45 degrees to the handle. This hoeing serves the double purpose
improving the texture of the soil and conserving the soil moisture. The
ld is then gone over again with the leveller and, where the land is irrigated,
laid out in beds for that purpose. Where canal water is available, these
ds are of the roughest type. The land is merely flooded and no attempt is
ade to irrigate by furrows or to use the water as economically as possible
is done when the land is irrigated from a well. The number of irrigations
ven varies from eight or ten on the western Jumna canal, where the rainfall
comparatively good and the soil retentive of moisture, to sixteen or eighteen
the Lower Chenab Canal, where the rainfall is scanty and the soil relatively
y. The cultivation after the cane has appeared above the ground is con-
ed to weeding and hoeing. At least four hoeings and weedings are consi-
red necessary and more are frequently done. The hoeing is done with an
n blade fastened to a wooden handle at an angle of about 60 degrees and the
eding by means of a hand implement in shape very like a trowel. After
cane has reached a few feet in height it is impossible to penetrate into the
p and further cultivation ceases. In the Hoshiarpur district the leaves of
dhak tree (*Butea frondosa*) are laid on the young plants to protect them
m the sun. It is a common practice in the Province, when the crop is heavy,
tie two or three canes together by their leaves in order to prevent lodging.

Throughout the Province farm-yard manure is the principal manure
though crude saltpetre, and village refuse are applied when they
available. The usual rate of application of farm-yard manure is about
to 14½ tons per acre, but in the Gurdaspur district, where cane follows
ize and *senji*, this is not applied to the cane crop but to the preceding crop.
e residual effect combined with the ploughing in of the *senji* stubble leaves
land just rich enough for cane. The manure is usually applied in February
veek or two before the cane is sown. In the cane growing tracts the value of a
uminous fodder crop such as sann hemp (*Crotalaria juncea*) or *mung*
haseolus mungo) is widely recognised, and in the Jullundur district sann
np is frequently grown solely for the purpose of being ploughed in previous
a cane crop. As in the United Provinces, the cultivator believe that the in-
genous canes do not respond to high manuring and that this leads to a falling
in the quality of gur.

Cane in the Punjab is sown about the middle of March. Harvesting begins early in December and continues till February, so that cane is on the ground for about a month less than in the United Provinces.

Prospect of the extension of sugarcane under irrigation.

94. As stated in paragraph 90 above, of the average area of 420,908 acres under cane in the Punjab 308,050 acres are irrigated, 199,315 by canals and the remainder mainly by wells. Almost exactly four-fifths of the cane in the Province is, therefore, grown under irrigation, and in these circumstances it becomes necessary to examine the prospects of an extension of cane under irrigation. This is specially necessary in the case of canals in view of recent and prospective irrigation developments. Before doing this we wish to make our position in regard to the possibility of such an extension clear.

In our Chapter on the United Provinces we have pointed out that the short period during which cane is on the ground, the limitation of the period of vigorous and active growth to the warm, moist, monsoon months and the occurrence of low temperatures in the northern districts render the cane problems of the Provinces of great complexity. Conditions are even more unfavourable in the Punjab, where the monsoon period is shorter and the extremes of temperature are greater. In spite of this serious handicap, the area under cane in the Punjab is greater than it is in Java. The crop is undoubtedly a profitable one and, though the outturn of cane and sugar per acre compares badly with that of more favourably circumstanced parts of India, the relatively low costs of cultivation in the Punjab as compared with Southern India and Burma leave the cultivator a margin of profit which, even if prices were considerably below those prevailing at present, would be greater than he could obtain from any other crop. There is every reason to believe that the area under cane in the Province will expand, whether in consequence of the stimulus of high prices, the construction of new irrigation projects or the expansion both of population and cultivation in the normal course of events. Whilst, therefore, the climatic and other conditions of the Province are such that cane must always occupy a subsidiary place to that of wheat and cotton, and there would be no justification for any efforts to secure an increase in acreage at the expense of those crops, its importance is such as to deserve that a much greater degree of attention should be paid to it than has been paid in the past. In spite of the disadvantages under which the cane crop labours in the Punjab, we see no reason for doubting that an improvement in the present varieties is possible, and that a marked increase in outturn can be obtained by applying improved methods of cultivation both to these and to the varieties now grown ; and we make recommendations to this effect in paragraphs 108 and 109 below.

(a) Existing canals.

(i) The inundation canals.

95. The figures in the preceding paragraph have shown that nearly half the cane grown in the Punjab is irrigated by canals. As the conditions of both climate and water supply differ considerably in the cane-growing tracts, we propose to deal very briefly with the prospects of cane in the areas commanded by the more important canals. We may state at once that we see no prospect of any extension of cane on the numerous inundation canals in the Province. An inundation canal is one which has no weir at its head and is, therefore, entirely dependent for its supply on the rise and fall of the river from which it takes off. For this reason, the areas irrigated by the inundation canals in the Punjab fluctuate enormously, but a supply of water cannot be depended on with certainty before May, whereas cane is sown in March.

The rainfall in all the tracts served by such canals in the Province is very scanty. These conditions, in our opinion, preclude any expansion of cane cultivation.

96. It will be convenient to take the perennial canals of the Province in order from east to west. The Western Jumna, which takes off from the river Jumna at Tajewala, commands a tract in the Ambala, Karnal, Hissar and Rohtak districts, as well as in the Delhi Province and the Native States of Patiala and Jind, 2,735,000 acres in extent of which the greatest area irrigated in any one year is 876,000 acres. The annual rainfall varies from 42 inches in the north-east of the tract to 11 inches in the south-west. Wheat, cotton and cane are the principal crops in order of importance, the average area under cane for the five years ending 1918-19 being 65,681 acres, though in 1917-18 it was as high as 85,345 acres. This is the largest average area returned by any canal in the Punjab, though in 1916-17 there were 9,000 more acres under the Lower Chenab than there were under the Western Jumna. The river Jumna has a comparatively small catchment area in the Himalayas, and is, therefore, more dependent on rainfall than any other river in the Punjab. The supplies in the river are, in consequence, liable to be short in the cold weather, and this shortage is prolonged into the hot weather, if the snowfall in the Himalayas is poor or if there is no rain in March and April. In consequence the rise in the river is on an average about six weeks later than elsewhere in the Province and the canal does not give a steady supply up to its maximum capacity until the beginning of June. As cane land requires water from the beginning of March, it will be seen that the irrigation conditions on this canal cannot be regarded as very favourable to the cane crop. This is borne out by the fact that, notwithstanding the recent stimulus of high prices, the area under cane on the canal in 1913-14 was higher than it has been in any year since except 1917-18. We consider, therefore, that the area under cane directly irrigated from the canal has, in all probability, reached its limit.

(ii) The Western Jumna canal.

97. The Sirhind canal, which takes off from the river Sutlej at Rupar in the Ambala district, irrigates both British territory in the Ludhiana and Ferozepore districts and that of the Native States of Patiala, Nabha and Jhind. It commands an area of 4,526,000 acres of which the greatest area irrigated in any one year is 1,609,000 acres. Prior to 1917-18 the highest area under cane on this canal had been 6,800 acres as long ago as 1909-10. The years 1917-18 and 1918-19 showed large proportional increases to 10,225 acres and 17,781 acres respectively; but we were informed that this expansion must be ascribed to a purely temporary boom and that the 1919-20 area shows a distinct decline. The main factor operating against the cultivation of cane here is not so much the water supply as the quality of the soil. This is especially poor in the western and southern portions of the commanded area which are very sandy and subject to severe sandstorms in May and June. We agree, therefore, that the cane area on this canal is more likely to shrink than to expand beyond its present limits.

(iii) The Sirhind canal.

98. The Upper Bari Doab takes off from the river Ravi at Madhopur in the Gurdaspur district. It commands a tract in the Gurdaspur, Amritsar and Lahore districts 1,783,000 acres in extent which is thickly populated and contains several large towns. The greatest area it has irrigated in any one year is 1,201,000 acres. The normal annual rainfall is 24.5 inches. There has been a marked increase in the

(iv) The Upper Bari Doab canal.

area under cane on this canal in recent years. For the five years ending 1918-19, it averaged 40,124 acres against 30,328 acres for the previous quinquennium. We understand that there is no possibility of any extension of irrigation under the canal owing to the shortage of supplies in the Ravi river during the cold weather months. Any increase in the area under cane can only be obtained, therefore, at the expense of some other crop; and the increase in the cane acreage in recent years appears to show that the cultivator is willing to make such a substitution, if prices provide a sufficient stimulus. On the whole, therefore, whilst some small extension of cane, up to perhaps 10,000 acres, seems possible on this canal, it will come as the result not of any improvement in irrigation facilities but of economic conditions such as the continuance of prices high enough to induce the cultivator to plant cane in preference to other crops.

99. The remaining five perennial canals in the Punjab,—the Upper and Lower Jhelum, the Upper and Lower Chenab and the Lower Bari Doab—are interdependent in the matter of water supply and it will therefore be convenient to treat them together. As their name implies, the Upper and Lower Jhelum canals take off from the river Jhelum and the Upper and Lower Chenab canals from the river Chenab. The Lower Bari Doab canal is supplied by the Upper Chenab canal. Although the Upper Jhelum canal irrigates the tract through which it passes, its main function is to carry the surplus water of the Jhelum river (after due allowance has been made for the needs of the Lower Jhelum Canal, which takes off from the river some twenty miles below Jhelum city) to the head works of the Lower Chenab canal in order to replenish the supply in the Chenab river. This it does by replacing in it for use in the Lower Chenab canal the equivalent of the water taken out by the Upper Chenab canal. As in the case of the Upper Jhelum canal, the irrigation of its own commanded area is not the main function of the Upper Chenab canal. This is to carry such supplies as may be available from the Jhelum and Chenab rivers with their canal systems to the river Ravi for utilisation by the Lower Bari Doab canal. The five canals thus depend for their supplies on the Jhelum and Chenab rivers. The Upper Jhelum, Upper Chenab and Lower Bari Doab canals have only recently been opened. The Lower Jhelum and Lower Chenab canals have been working for several years and the irrigation under them is fully developed.

(v) The five linked canals.

The position and magnitude of the five linked canals and the absolute and relative importance of the cane crop under them can be gathered from the information given in the following table:—

1	2	3	4	5	6	7
Name of Canal.	Districts served.	Gross commanded area acres.	Maximum area irrigated acres.	Average annual area under cane 1918-19 acres.	Average annual area under cane 1914-19 acres.	Highest area under cane and year acres.
Upper Chenab ...	Gujranwala, Lyallpur and Jhang.	3,385,000	2,339,000	41,630	59,706	74,139 (1917-18).
Lower Jhelum ...	Shahpur and Jhang	1,368,000	834,000	4,582	7,109	10,749 (1917-18).
Upper Chenab ...	Sialkot, Gujranwala and Lyallpur.	1,613,000	*437,000 (648,000)	Not opened till April 1918.	5,982	7,695 (1916-17).
Lower Bari Doab ...	Montgomery and Multan.	1,664,000	*678,000 (879,000)	Not opened till 1913.	3,592	5,777 (1918-19).
Upper Jhelum ...	Gujrat, ...	594,000	*247,000 (317,000)	Not opened till December 1915.		5,353 (1918-19).

*Not yet fully developed. The lower figure in brackets is the area which the completed project is expected to irrigate annually.

In normal years, there is ample water in the Jhelum and Chenab rivers from the middle of March to the end of October to fill the five canals to the maximum capacity for which they have been designed. The figures we have given above show, in our opinion, that an appreciable extension of the area under cane on these canals, more especially on the newer canals, the Lower Bari Doab, the Upper Chenab and the Upper Jhelum, may be anticipated. The prospects of an extension on the two latter canals are perhaps more favourable than on the other canals of the group, as they irrigate submontane tracts in which, if the supply of water in the canals is deficient in February and March, the rainfall or even the moisture in the soil is sufficient to permit the planting of cane. The factor which limits the extension of cane on all the canals of the group is not so much the water supply as the competition of cotton and wheat. Cane is on the ground so long that it not only competes with cotton during the *kharif* season but also with wheat both at the beginning and end of the *rabi* reason. It requires far more water than either wheat or cotton and the cultivator therefore prefers to use his supplies for these crops. Another factor which militates against an extension of cane is the heavy expenditure on labour its cultivation requires in comparison with other crops and the scarcity of the labour supply in the canal colonies. On the whole, however, if the stimulus of high prices continues and other economic conditions remain as at present, an expansion of the area of cane on the linked canals may be anticipated with some confidence. It is impossible for us to offer any opinion of value as to the probable extent of this expansion, but we would mention that an estimate placed before us gave the ultimate area under cane which might be expected on the Lower Bari Doab canal as 25,000 acres, on the Upper Chenab canal as 32,000 acres, on the Lower Chenab canal as 100,000 acres, on the Upper Jhelum canal as 16,000 acres and on the Lower Jhelum canal as 14,000 acres, a total of 187,000 acres. This represents an increase of 87,000 acres over the area under cane on these canals in 1917-18, the largest so far recorded. The conditions of water supply on the linked canals are so much more favourable than they are elsewhere in the Province, and the consequent possibility of introducing improved varieties is so much greater that, if this extension could be secured, it would undoubtedly represent a valuable adition to the sources of sugar supply in India.

(b) Canal projects.

(i) The Sutlej Valley canals project.

100. There are at present three important irrigation projects under consideration in the Punjab which, if carried out, may result in a considerable increase in the area under cane in the Province. The most important of these from the point of view of our enquiries is the Sutlej Valley canals project which will utilise the water of the Sutlej to improve the inundation system on both banks of the river and will protect a considerable area of land at present unirrigated. The land on the right bank of the river is entirely in British territory, namely, the Lahore, Montgomery and Multan districts, whilst that on the left bank lies mainly in the States of Bahawalpur and Bikanir. The project provides for three weirs on the Sutlej below its junction with the Beas, and one weir on the Chenab below its junction with the Sutlej ; from which twelve, and possibly thirteen, canals in all will take off. It will, in addition to extending irrigation to new tracts the gross commanded area of which is some 3½ million acres, take up all the irrigation done by the Upper and Lower Sutlej inundation canals and by the inundation canals in the Bahawalpur State as well as half that under the Grey canals in the Ferozepore district. Altogether 1,600,000 acres of existing inundation irrigation will thus be benefited. Cane, when grown on these inundation canals, has to be irrigated by wells at the beginning and end of the season. Though the total area under it in the tracts commanded by the existing canals is very

small, there is reason to believe that the provision of a supply controlled by weirs would be followed by a considerable expansion ; as even at present in some localities the proportion of cane grown to the total cropped area is as high as 11 per cent. The tracts on the left bank of the river which will come under irrigation for the first time, if the project is carried out, are not suitable for cane owing to the sandiness of the soil, but we were informed that there is a very large area of Crown waste land on the right bank the soil of which is in every way as suitable for cane as that of the Lower Chenab and the Lower Jhelum canal colonies. This is a matter which should, in our opinion, be further investigated ; as, if this information is correct, the tract might prove a suitable one for the location of a central factory. We have throughout our report emphasised the desirability of factories controlling their own cultivation when possible and though, as we have already pointed out there are many parts of India which are in other ways more favourably circumstanced for the location of a central factory than any part of the Punjab, the control of its own cultivation is of such great importance in contributing to the success of a factory as to counterbalance somewhat serious disabilities in such matters as the varieties of cane grown.

In these circumstances we consider this pre-eminently a case in which the possibilities of growing improved varieties of cane with intensive methods of cultivation might well be ascertained by the grant of land on terms similar to those on which grants have already been made on the Lower Bari Doab canal, where two estates are held on condition that the grantees grow improved varieties of cotton under the supervision of the Agricultural Department which takes over the seed. If it were established in this way that the conditions were suitable for cane growing, factories would undoubtedly follow at a later stage, and the grants, the produce of which until the factories eventuated would be converted into gur, might well serve as the nucleus of their source of supply. We consider this course preferable to the grant to a factory at the outset of a block of land sufficient to make it independent of other sources of supply ; as if such a grant were made before the local conditions had been investigated in the way we propose, the project might result only in failure.

(ii) The Bhakra Dam project.

101. The Bhakra Dam project is also a project for utilising the waters of the river Sutlej. It is proposed to construct a dam at the Bhakra Gorge some 40 miles above the point at which the Sirhind canal takes off from the river. The height of the dam will be 260 feet and the full capacity of the reservoir is estimated at 2½ million foot-acres. The water thus made available will be mainly utilised in extending irrigation into the arid tracts of the Rohtak and Hissar districts to the west and south-west of the area commanded by the Western Jumna canal, where extension of cane cultivation is possible, and to part of the Bikanir State. The project will also irrigate part of the area at present commanded by the Sirhind canal. As we have already mentioned, the tract commanded by the latter canal is not very suitable for cane ; and it does not, therefore, seem likely that the Bhakra Dam project, if carried out, will result in any very great increase in the area under that crop. It should perhaps be stated that the increase in the [illegible] area of the Province which will result from the completion of this and the Sutlej Valley canals project is estimated at 5½ million acres annually, the increase in the area irrigated in *kharif* being about 2½ million acres.

(iii) The Thal project.

102. The third of the projects under consideration is the Thal project which provides for a perennial canal taking off from the left bank of the river Indus near Mari and irrigating a large tract in the Mianwali and Muzaffargarh districts and

smaller areas in the Shahpur and Jhang districts. The gross area commanded by flow irrigation will be very nearly five million acres, whilst that commanded by lift irrigation will be about 128,000 acres. The culturable commanded area will be very nearly 2½ million acres exclusive of 64,000 acres which will be irrigable by lift. It is proposed to irrigate annually 75 per cent. of these areas, or about 1,900,000 acres, of which half will be under *rabi* and half under *kharif* crops. The water supply will be ample and the soil is said to be a fair loam and not unsuitable for cane. In the normal course of events, therefore, there should be an appreciable area under cane, if this project is carried out.

(c) Summary of prospects of cane under existing and projected canals.

103. The above summary of the prospects of cane on existing and projected canals, which we realise that we have not the technical knowledge to make as full as could be desired, has shown, we think, that without any special propaganda in favour of cane the area under that crop is likely to expand considerably in the near future, especially if the stimulus provided by the present high prices continues. Whilst the area of cane under the Western Jumna and the Sirhind canals will, in all probability, remain stationary, that under the five linked canals should increase ; and the completion of the Sutlej Valley canals and Thal projects should mean a relatively large addition to the cane area of the Province. We venture to think that the possibilities of expansion we have enumerated add strength to the recommendations in regard to agricultural practice and organisation which we shall make below.

(d) Possibility of concentrating cane in canal areas.

104. We would recommend, as we have for the Sarda canal system in the United Provinces, that the Agricultural Department should make every effort to secure that cane should be grown in concentrated areas under new irrigation systems, as concentration will greatly lessen and may entirely obviate any difficulty in meeting the needs of the crop for water. It has been suggested to us that efforts should also be made to secure the concentration of cane areas on existing canals by giving additional facilities of supply to cultivators willing to grow improved varieties of cane and to adopt intensive methods of cultivation. We do not feel competent to offer any opinion on the feasibility of this proposal, but would point out that the question of providing additional supplies in the *kharif* season was discussed at some length in the Report of the Indian Cotton Committee with the object of promoting long staple cotton. That Committee pointed out that, in addition to the effect an increased supply during the *kharif* season would have on the area under cotton, it would enable more short season fodder crops to be grown and would encourage the cultivation of green manure crops. They considered a greater intensity of cropping desirable agriculturally, so long as it tended to encourage a greater variety of crops, and especially the growing of more leguminous crops. Viewing the matter from this standpoint, they expressed the opinion that the proportion of cereals grown on the Punjab canals was too high but, though an increase in the *kharif* supplies would have a beneficial effect in reducing the proportion as a result of more crops being grown in *kharif*, they did not regard it as likely to decrease the total food production of the canal colonies. They therefore recommended that a large distributary on one of the existing perennial canals should be selected in consultation with the Agricultural Department to which largely increased supplies would be given during the *kharif* season, and that an agricultural officer should be placed on special duty to advise the cultivators on the selected distributary in regard to cropping and rotations. It was emphasised that nothing should be done in the matter of increased supplies which was not capable of being repeated on a much larger scale, should the experiment

prove successful. We understand that it has recently been decided to make this experiment on a distributary of the Lower Chenab canal, the carrying capacity of which will be increased by 50 per cent ; and we would suggest that cane should be included in the experiment. The importance of additional supplies in the *kharif* season in the case of cane lies in the possibilities such supplies would offer not so much of expansion as of concentration. We point out in Chapter XIX below how essential concentration is to the successful working of a central factory, but we are here looking at the matter agriculturally rather than commercially, *i. e.*, from the point of view of securing steady supplies of water which will enable better varieties of cane to be grown with better methods of cultivation over a large compact area.

(e) Drainage and water-logging.

105. We have throughout this Report emphasised the importance of proper drainage as a factor in the successful cultivation of cane. In tracts which become water-logged or in which the subsoil water table rises within a few feet of the surface only very inferior varieties of cane can be grown. The rise of the subsoil water table has thus an important bearing on cane cultivation. Water-logging occurs on nearly all the perennial canals in the Punjab ; but the areas water-logged are at present very small in comparison with the areas irrigated. For many years past the Punjab Irrigation Department has devoted much attention to the question both of its prevention and cure. Experiments with various kinds of water-proof lining for channels have been carried out on the Upper Bari Doab and Lower Chenab canals ; but the work practically ceased at the outbreak of the war, as the advantages gained were not commensurate with the expenditure incurred. An experiment on a big scale is to be carried out on the main line of the Bikanir canal of the Sutlej Valley project, the Bikanir State having requested that the first 71 miles of this canal should be lined. There thus appears no likelihood that this problem, which we regard as of great importance, will be lost sight of.

(f) Well irrigation.

106. Wells in the Punjab, which irrigate one-third of the area under cane, are worked almost exclusively by bullock power at present, but a considerable number of tube wells of the types patented by Captain J. Ashford, O.B.E., Superintendent, Public Works Department Central Workshops, Amritsar, and Mr. T. Miller Brownlie, Agricultural Engineer, have been installed in various parts of the Province. There is no doubt that in the Punjab, as in the United Provinces, there is a wide field for the development of pump irrigation from both tube and masonry wells. Such a development might lead to a considerable expansion of the area under cane especially in tracts commanded by inundation canals, as water would then be available for planting and final waterings, which it is not at present. Authoritative information regarding the comparative cost of irrigation from canals, from wells worked by bullock power and from wells worked by pumps is not yet available; but such evidence on this point as we received showed that, whilst pump irrigation is much more expensive than irrigation by canals, it is cheaper than the present method of raising water by bullock power. One estimate gave the cost of irrigating cane from a tube well as Rs. 33 per acre when the sub-soil water level is 10 feet below the surface and at Rs. 55 per acre when it is 30 to 40 feet below the surface. We strongly recommend, as we have done for the United Provinces, that a thorough investigation of the subject should be carried out at an early date. The further recommendations on this point which we have made for the United Provinces apply with equal force to the Punjab. The comparatively large

recommendation that a separate branch of the Agricultural Engineering Department with a strong staff should be formed to deal solely with well boring and pumping installations. The formation of such a branch will enable the Department to devote more attention to work on improved agricultural implements and the introduction of small power machinery. In this connection we would refer to the remarks we have made in paragraph 49 above on the desirability of concentrating work in particular tracts in order to secure a rapid improvement in agricultural practice and also to facilitate supervision.

The Public Works Department's hydro-electric installation which has been working for some years past at Amritsar has shown the possibility of irrigation from a group of wells worked from a central power station. A much more important hydro-electric scheme which we understand is under investigation is for the provision of power from the Sutlej river. The project is intended to utilise the fall of 400 feet in the Sutlej river which occurs between the village of Maluana, twenty-five miles above the site selected for the Bhakra Dam, and the town of Kiratpur, about twenty-five miles below it. It would furnish 100,000 horse power which could be transmitted as far as Delhi, Lahore and Lyallpur. The completion of the Bhakra Dam would increase the power available to 300,000 horse power. We are not in possession of sufficient details to enable us to pronounce any opinion regarding the possible effect of the scheme on cane cultivation and would, therefore, merely point out that, if any power from it is transmitted to Delhi, the transmission line will pass through the districts of Ambala, Karnal and Rohtak, which have a large area under cane but in which the possibilities of improvement are limited by the lateness of supplies in the Western Jumna canal. The installation of tube wells worked by cheap electric power would enable this difficulty to be overcome.

Agricultural improvements.

107. In the recommendations that we have to make below for the improvement of cane cultivation in the Punjab we propose to confine our attention to areas irrigated whether from canals or wells. The bulk of the 80,000 acres of cane now grown without irrigation is grown as a speculation a fair return in gur being obtained, if the rains happen to be propitious, and the crop being devoted to fodder, if the rains fail, as they often do. Cane grown under such conditions offers no prospects whatever of improving the production of sugar in India: the likelihood of substituting for the existing varieties a better variety which will withstand the adverse conditions of precarious rainfall, extremes of temperature and dry atmosphere being remote and the enhanced cost of better methods of cultivation not being justified by any assurance of increased yields.

(a) Improved varieties.

108. The classification of the Punjab canes has already been carried out by Dr. Barber; but no work has so far been done on the isolation of pure line cultures in each group. We are doubtful, however, whether this is of so great importance in the Punjab as it is in the United Provinces and Bihar and Orissa, where climatic and other conditions vary much more markedly than in the Punjab; and where the consequent variety of the indigenous canes locally grown is also much more marked. Although, therefore, we regard it as a line of work which requires taking up here as elsewhere, we do not consider it an essential preliminary to the local Agricultural Department's work on the improvement of indigenous varieties. Similarly the extensive area over which a cane of such established superiority as Katha has spread renders it less necessary for special steps to be taken for the provision of an adequate supply of sets of this variety. The more important lines of work in this Province, therefore, are those now being followed at Gurdaspur—the importation and testing of pure line cultures of the superior varieties of other Provinces and exotics and the trial of Dr. Barber's crosses on a field scale. This work requires to be extended and the number of experiments to be multiplied, particularly by the inclusion of experiments on Paunda, the main object being to ascertain the improved methods of cultivation necessary for the successful adoption of these varieties; a point on the importance of which we have laid particular stress in paragraph 51 of Chapter III. As progress is made, moreover, in the adaptation of improved varieties to Punjab conditions, it will become necessary to establish a separate station for the supply of hill sets to meet the demand which the inevitable deterioration of such varieties creates. There is no lack of suitable sites for such a station, which should, of course, be within reasonable distance of a railway line, and the selection of a site may be left to the officer to whom we recommend below that the sugarcane work of the Province should be entrusted. It is, in any case, not an immediate requirement.

(b) Improved agricultural methods.

109. Much the same defects are noticeable in the cane cultivation of the Punjab as in that of the cane grower in the United Provinces and Bihar and Orissa. His cattle, it is true, are distinctly superior, with the result that he is able to use a better type of plough, and to plough more efficiently and to a greater depth. Also a fodder crop of *senji* (*Melilotus parviflora*) frequently finds a place in his cane rotation; but this is probably due rather to the greater need for fodder created by his heavier type of cattle than to a desire to improve the following cane crop. In respect, certainly, of his failure to select his sets with care, of the excessive number of sets he plants per acre, of his wasteful use of canal water, and of the inadequacy of his after cultivation, he has still much to learn; and, though no experiments have so far been carried out in the Punjab to prove whether existing yields of gur can by the same methods be enhanced to the extent of the eight to ten maunds attainable in the United Provinces, there is no doubt that an appreciable increase can be effected by their adoption, and this should be actively and widely advocated. In particular, the advantage of planting in well spaced lines, with the consequent economy in sets and possibility of continuing after cultivation throughout the growing period of the crop, should be demonstrated and the practice of earthing up the canes introduced. The more advanced system of trenching which we have described in paragraph 61 of our Chapter on the United Provinces, is difficult to adopt in the Punjab where the supply of labour is more limited and therefore more dear than it is in the United Provinces, nor is it economically justified with the thin canes at present grown. When the local Department of Agriculture, however, has succeeded in establishing improved varieties of thick and medium canes, there will, we think, be an opening for the adoption of the trench system in the canal colonies where there are comparatively large estates owned by men of considerable means and trenching by mechanical power, such as steam or motor tractors, is possible. In the Punjab also, where such a large proportion of the cane crop is irrigated and where it certainly requires far more water than in the more easterly Provinces, the solution of the problem of the proper water requirements of cane is of special importance; but the question itself is a general one, and we shall deal with it in Chapter XV below. We would, however, invite special attention to the important experiments on windrowing and clamping of cane as a protection against frost which have been conducted at the Tarnab farm in the North-West Frontier Province and an account of which will be found in our next Chapter. Frost is a hardly less pressing problem of cane cultivation in the Punjab that it is in the Frontier Province, and no time should

be lost, we think, in initiating experiments to see how far similar methods can be relied on to overcome the difficulty of frost in the Punjab.

110. Research work on cane in the Punjab is at present practically confined to the Gurdaspur farm which is controlled by the Deputy Director of Agriculture of the Gurdaspur Circle, an unwieldy charge including no less than 15 districts, though his work is in effect, we understand, confined to only seven of them. The farm, which was started with the primary object, of improving the sugarcane crop of the district, has gradually diverged from the original line of work, until it now pays considerably more attention to wheat than to cane. Elsewhere cane is practically neglected. This has been more or less inevitable with a Department which has included only three Deputy Directors of Agriculture in addition to four expert officers at the Lyallpur College, and the time of which has been almost entirely taken up with the more important crops, cotton and wheat. At the same time we trust that, when the impending expansion of the Department materialises, cane will receive the attention which its existing area, its great present and still greater potential value, and the special difficulty of its successful cultivation demand. The first step in this recognition should be the restoration of the Gurdaspur farm as a sugarcane station, the work on wheat and other crops being transferred elsewhere. This is preferable to the transfer of the cane work to a new site, both because the experiments on cane have covered a longer period and because continuity is perhaps a greater essential in the conduct of cane experiments than it is with other crops. The present area of the farm is, we believe, approximately 160 acres, and the whole of this is required if the solution of cane problems on a field scale is to be effectively carried out. In addition to Gurdaspur, also, we recommend that a second cane research station of some 200 acres should be established in the interests of the cane growers in the canal colonies. We have not had an opportunity of investigating locally or in detail the question of an appropriate site ; but we would suggest that, in order to spread research work in the canal colonies as far as possible, the station should not be located in the neighbourhood of the Lyallpur farm. Conditions in the most easterly districts of the Province differ to some extent from the conditions in the sub-montane and canal tracts which the Gurdaspur and canal colony stations here proposed will respectively serve. Nevertheless we do not consider a third station for these districts to be necessary, since their problems approximate closely to those of the Meerut division of the United Provinces, and it should be possible to deal with them from the research station we have already recommended for that area. Two cane stations will, therefore, suffice for the Punjab; and, though, as in other Provinces, these should ultimately pass under the control of the central research organisation we recommend in Chapter XXIII, we trust that they will be organised as cane research stations exclusively without delay, the new station proposed, like that already existing at Gurdaspur, being established under provincial control.

Organisation.

111. With the very large area already under cane in the Punjab, with the prospects of considerable extensions, particularly in the new canal colony areas and with two cane research stations and a station for the propagation of hill sets, there will be strong justification for placing an officer of the Indian Agricultural Service in wholetime charge of the research work, both chemical and agricultural, on cane in the Punjab. Nor need we repeat here the reasons already given in earlier Chapters for our view that this control should be centred in an Agricultural Chemist rather than in Economic Botanist or a general

Staff.

agricultural officer. The present cadre of the Department includes only one post of Agricultural Chemist; and we hope that the Local Government will now see its way to apply for the creation of a second such post, and to place one of the two officers, when the second is obtained, in sole charge of the cane research work of the Province. This officer would later be absorbed in the Imperial research organisation together with the stations under his control. With regard to demonstration work, we understand that the increase of the number of Deputy Directors from three to six has already been sanctioned; and when these posts have been filled, it will be possible to conduct a properly supervised demonstration propaganda on a greatly extended scale. Moreover, research work on cane has here, as in Bihar and Orissa, not yet proceeded far enough to produce any large volume of practical results for demonstration. Here also, therefore, we consider that a special demonstration staff devoted solely to cane is not at present required; but that it will be required when substantial progress begins to be made with the solution of the various cultural and varietal problems at the research stations.

Summary of Conclusions and Recommendations.

(1) The short monsoon period and the extremes of temperature must always be a serious handicap to cane in the Punjab ; and it will remain of less importance than wheat and cotton.

(2) Nevertheless the cane area is large and likely to expand and lower costs of cultivation compensate for lower yields than in tropical India.

(3) The importance of the crop therefore warrants much greater attention being paid to it.

(4) Given the stimulus of high prices, there are prospects of considerable extension on the Upper Bari Doab and the five linked canals.

(5) A considerable extension may be anticipated also, if the Sutlej Valley canals project is carried out.

(6) Large areas of Crown waste land suitable for cane are said to exist in the commanded area on the right bank ; and this should be investigated with a view to the location of a central factory controlling its own cultivation.

(7) The possibilities should be ascertained by the grant of land for cultivation of improved canes by intensive methods on the lines of grants already made for the growth of improved varieties of cotton.

(8) There should be a further appreciable increase in the cane area, if the Thal project is carried out.

(9) The Agricultural Department should promote concentration of the cane areas under new irrigation systems.

(10) Cane should also be included in the experiment shortly to be carried out on the Indian Cotton Committee's recommendation with a view to promoting concentration on existing canals by means of increased water supplies to selected distributaries in the kharif season.

(11) The comparative cost of irrigation from canals, from wells worked by bullock power and from wells worked by power pumps should be investigated.

(12) A separate branch of the Agricultural Engineering Department should be created to deal solely with well boring and pumping installations.

(13) Hydro-electric schemes may provide the means of tube well irrigation worked from central power stations.

(14) It is useless to suggest improvements in the cultivation of unirrigated cane.

(15) The work on trials of superior varieties from other Provinces, exotics and crosses from Coimbatore should be extended; and Paunda should be included in the experiments.

(16) A station for the supply of hill sets will be required, but is not an immediate necessity.

(17) Greater care in the selection of sets, the adoption of planting in lines, economy of canal water and the practice of earthing up should be advocated.

(18) There should be a future for the trench system of cultivation in the canal colonies.

(19) Experiments should be initiated to test the advantages of clamping and windrowing as a protection against frost.

(20) Gurdaspur should be restored as a research station for work on cane only; and a second such station should be opened in one of the canal colonies, preferably some distance from Lyallpur.

(21) The research station recommended for the Meerut division of the United Provinces should deal with the problems of the eastern districts of the Punjab.

(22) A whole-time post should be created for the supervision of all cane research work in the Province and a second Agricultural Chemist should be recruited to fill it.

(23) A special demonstration staff for cane is not immediately required.

CHAPTER VI.

THE NORTH-WEST FRONTIER PROVINCE.

112. The North-West Frontier Province lies between 31° 4′ and 36° 57′ N. It is thus well outside the tropics; and it is worthy of mention that the Peshawar District, which grows about four-fifths of the cane in the Province, lies further north than Louisiana, the northern boundary of which lies along the 33rd parallel of latitude. The only district other than Peshawar which returns more than a negligible area under cane is Bannu, which has an area of about 6,000 acres. The extremes of temperature are even more marked than in the Punjab, the normal variation at Peshawar being from 30 degrees in December to 120 degrees in May and June. Four degrees of forest are, however, the maximum which has been recorded. The Province has two rainy seasons, the monsoon season and the season of the winter rains. The Peshawar valley, which is the principal cane growing tract, receives an approximately equal amount in the two seasons. Both sources of supply are, however, precarious and, although the annual rainfall at Peshawar averages 13.29 inches, it is sometimes little more than 10 inches. The Peshawar valley has light, porous soil underlain by strong, retentive clay. The soil of the Charsadda Tahsil is a rich alluvium. In the Bannu district, the soil on which cane is grown is a heavy loam.

Climate and soil.

113. The average area of the North-West Frontier Province, exclusive of Native States, during the five years ending 1918-19 was 8,571,614 acres. Of this the net area actually cropped during the same period averaged 2,289,173 acres, of which 32,147 acres were under cane. The percentage of the area under cane to the net area cropped was 1.4, which is only exceeded in the United Provinces and the Punjab. The percentage of the same area to the total area under cane in India was 1.2. The average yield of gur for the quinquennium was returned at 1.02 tons per acre.

Statistical.

114. It is a very remarkable fact that the only cane grown in the principal cane growing tract in the most northerly Province of India, in which, as the figures given above show, the extremes of temperature are very marked, is a thick cane—a soft, white Paunda which has very long internodes and a high percentage of juice. The history of the introduction of Paunda varieties into the North-West Frontier Province is interesting. In 1853, Captain Coke, the Deputy Commissioner of Kohat, brought in a hard, red Paunda which continued to be cultivated until about 1867, when it was discarded in favour of the present variety which rapidly supplanted the local varieties except in the Bannu district, where a thin cane which has not been identified is still grown. It cannot be said that the reason why the North-West Frontier Province is able successfully to grow a variety of cane which is very much superior to the varieties generally

Varieties of cane.

grown all over Northern India has been satisfactorily explained, but it appears to be connected with the high degree of humidity which prevails in the Peshawar valley, even in the hot weather.

History of work on sugarcane.

115. Valuable work both on cane and beet has been done by Mr. Robertson Brown, Agricultural Officer, during the last ten years on the main agricultural station in the Province, that at Tarnab near Peshawar. Reference to the work on beet will be found in Chapter XVI below. The work on cane has consisted not only of varietal tests but also of experiments to ascertain the value of the practices of clamping and windrowing. A description of these practices and of the conclusions which may be drawn from the results obtained at Tarnab will be found in the following paragraphs. The varietal tests have established that D-74, Assami Red and Barbados 246 ripen earlier than the local Paunda. These are now being propagated with a view to tests on a field scale under cultivators ' conditio

Agricultural practice.

116. The area of cane in the North-West Frontier Province outside the Peshawar District is so small that the agricultural practice of that district alone need be described. It is worthy of description in some detail, as the cultivation is of an unusually high order. That the cultivator understands the needs of his cane crop is shown by the fact that his rotation almost always includes a leguminous fodder crop of clover (*Trifolium resupinatum*) locally known as *shaftal*. The most common rotations are (*i*) clover, cane, chillies, wheat and (*ii*) clover, cane, maize, wheat. Clover is planted in October and supplies fodder for cattle from the middle of November to the middle of May. Another rotation which is not unusual is barley (or less often wheat) with cane planted in the growing crop, chillies, wheat ; but when cane is planted in growing barley or wheat towards the end of March, it is the result of special circumstances. It is avoided as far as possible, as it is realised that much heavier manuring is then required.

In regard to the provision of sets, the problem before the cultivator in the North-West Frontier Province is to preserve the canes intended for sets through the winter months when, if they were left standing in the fields, all the buds would be destroyed by frost. He solves this by resorting to clamping, a method similar to that used in Europe for preserving roots or potatoes. The canes which will be used for sets in March and April are taken out of the ground with roots, leaves and tops intact about the end of November, when the first touch of frost appears. A pit is dug to receive them and they are placed in it in a neat, flat heap in which they lie parallel to each other. The heap is then covered with six inches of earth. The work at Tarnab has established conclusively that cane can be preserved in clamps until the end of March without suffering any appreciable injury. The pits are opened at the end of March or the beginning of April and, whilst the clover crop is still green and vigorous, shallow furrows about three feet apart are made through it by the country plough. The sets, which are about 14 inches long and contain three sound buds, are placed end to end in the furrows. They are not covered with soil, but a handful of soil is applied to each end of them. A liberal watering is given to the clover crop when the cane is planted. Whole canes are used for cutting into sets, but the root joints are specially preferred. About 40 to 50 maunds of sets (about 5,000 to 6,000) are used to the acre. Sets which are badly affected by red rot are discarded; but the cost of sets is so great, that those which are slightly diseased are used.

In April a cutting of the clover crop is taken and laid alongside the cane to rot and enrich the soil. The clover crop is finally cut for fodder about the middle of May when the cane is from 18 inches to 2 feet high. The space between the lines of cane is then hoed and the remains of the clover crop are ploughed in. At the same time a handful of well-prepared farm-yard manure is applied directly to each plant. The second hoeing is given about six weeks later, when manure is more liberally applied. In July the soil between the lines is dug over and all the manure the cultivator can afford is then piled round the plants. Earthing up is done in August. This prevents the crop from lodging, and no wrapping or tying of plants is necessary. Ratooning is not practised. Twenty to thirty waterings in all are given, from the middle of March to the middle of November.

Well rotted farm-yard manure is the only manure used. It is highly valued, and, as stated above, it is seldom, if ever, ploughed into the land, but is doled out in sparing handfuls to each plant. The manurial value of the clover crop considerably reduces the necessity for other manure.

Cane in the North-West Frontier Province is planted about the end of March. It begins to ripen early in November and as soon as frost appears the cultivator starts cutting it. Harvesting lasts till the middle of February, so that cane is on the ground from eight to eleven months.

Windrowing.

117. Experiments in windrowing have been in progress for some years on the Tarnab farm. Windrowing merely consists in pulling up the canes and laying them on the ground in rows, the leaves of one row overlapping the canes of the previous row. Occasionally, however, the canes are stacked like sheaves of corn. Both the name and the practice come from Louisiana, where windrowing has been found an effective method of preserving cane during periods of frost. Its effect on canes from the chemical point of view in the North-West Frontier Province has been carefully investigated by Mr. J. W. Leather and Dr. W. H. Harrison, Imperial Agricultural Chemists. Their investigations have shown that cane can be successfully preserved by windrowing in the Peshawar valley. Whilst windrowing causes the purity of the juice to deteriorate, it leads to a concentration of the juice with the result that the amount of crystallisable sugar per unit weight of juice remains approximately constant, though there are obviously fewer units. The weight of crystallisable sugar contained in a crop of windrowed cane increases rapidly at first. A period then follows during which it remains practically constant, and thereafter deterioration sets in. The period during which canes can be preserved without deterioration varies in different seasons, but in any particular season varies with the incidence of heavy rains. It would appear that a month is the longest period during which cane can be preserved by windrowing without deterioration, but that, even when it is kept for three months, the loss is very small compared with that which results when the cane is left standing during frost followed by ran and a rise in temperature, conditions which frequently occur in the Peshawar valley during the cold weather.

Prospects of the extension of cane under irrigation.

(a) Public Works Department canals.

118. No cane is grown in the North-West Frontier Province except under irrigation. Of the 32,147 acres under cane an average of 9,464 acres was grown on canals in charge of the Public Works Department, the remainder being mainly on district canals which are managed by the revenue authorities, the distribution

of water being in the hands of the cultivators themselves. Only a very small amount of cane is grown under wells. The irrigation systems in charge of the Public Works Department are four in number, the Upper and Lower Swat canals, the Kabul River canal and the Paharpur inundation canal. It is unnecessary to describe these in detail, as there appears little prospect of an extension of cane on any of them with the possible exception of the Kabul River canal. The limiting factor on the Paharpur canal, which takes off from the Bilot creek of the Indus and irrigates part of the Dera Ismail Khan district, is the great uncertainty of supplies in September and October. On the Upper and Lower Swat canals, which irrigate the northern sub-division of the Peshawar district, it is the scantiness of supplies from September to November. The Swat river commences to fall about the beginning of September and reaches the cold weather level about the middle of October. Practically all the supplies available at the head of the Upper Swat canal in September and October are required for the irrigation of rice in the Swat valley, whilst the supplies at the head of the Lower Swat canal, which, it may be noted in passing, returns about two-thirds of the total area of cane on canals in charge of the Public Works Department, have to meet the demands not only of the canal itself but also of the many district canals which take off from the river lower down. On both canals there is also a keen demand for water for the irrigation of the *rabi* crop which commences at this period. The Kabul river canal, which irrigates the Peshawar valley in the southern part of the district, has an ample supply of water all the year round. It is, however, a small canal, its culturable commanded area being returned at 34,913 acres only. The total area irrigated by the canal during the five years ending 1918-19 averaged about 46,000 acres, of which approximately 24,400 acres were irrigated in the *kharif* season and 21,600 in the *rabi* season. As the average area under cane for the same period was 2,551 acres, the percentage of cane to the *kharif* cultivation is over 10, which is distinctly high. There is, however, reason to believe that it might be still further increased, if the cultivators could dispose of their cane directly instead of being compelled to convert it into gur, a point to which we have made further reference in dealing with the district canals below.

We would mention that we inspected a large area of land at the tail end of this canal which had become so badly waterlogged that it had completely gone out of cultivation, but which appeared as suitable for cane as any other land on the canal, if it were properly drained. We were informed, however, that, even if it were drained, it would be necessary to remodel the canal in order to provide water for it. We regard it as a matter for regret that so large an area should have been allowed to pass out of cultivation through preventible causes, and would recommend that the possibilities of draining it and providing water for it should be investigated.

(b) District canals.

119. No exact information as to the area of cane on the district canals in the Peshawar district is forthcoming, but a comparison of the figures for the canals in charge of the Public Works Department with the total figures for the cane area of the district appears to show that it is at least 12,000 acres. The greater part of this is on canals which take off from the Kabul river. There is no difficulty of supply in these canals, the distribution of water from which is, as already stated, arranged by the cultivators themselves. The factor limiting the extension of cane in this area is not, therefore, the character of the water supply but the difficulty in disposing of the produce. Our enquiries showed that the cultivators are desirous of growing more cane than they do at present, but are prevented from doing so by the difficulty in obtaining

the labour supply necessary to convert it into gur and also in disposing of the gur when made. This difficulty would be overcome by the establishment of a central factory for which the tract appears a suitable one, more especially as, if beet were grown, a possibility which has been demonstrated by the experiments at Tarnab to which we refer in greater detail in Chapter XVI, and if the question of providing fuel for working up beet at an economic rate were solved, such a factory would have an exceptionally long working season. We are fully aware of the desirability of making the Province self-contained in the matter of foodstuffs to a greater extent than it is at present, but we would point out that the work at Tarnab has shown that the excellence of the rotation of which cane forms a part and the high cultivation it requires have a marked effect in increasing the outturn of the food crops in the rotation.

Agricultural improvements.

120. As we have already stated, the cultivation of cane in the North-West Frontier Province is of an unusually high order. There is, in consequence, little that the local Agricultural Department can do in the way of improving it. The importance of selecting sets for planting which are free from disease should be insisted on, and efforts should be made to induce the cultivators to adopt the practice of windrowing. The advantages of this practice have been established on the Tarnab farm, but it would appear that so far it has not been taken up outside the farm. We are inclined to doubt whether the very useful work which has been done at Tarnab has made as great a difference to the agricultural practice of the Province as it would have made, had there been a stronger demonstration staff. We do not know how far the special political difficulties arising in this Province preclude the possibility of any material expansion of demonstration work beyond the neighbourhood of Peshawar and would, therefore only say that, if they do not, an increase in the subordinate staff of the Department is very desirable in order that the advantages of such practices as that of windrowing may be demonstrated to the cultivator on his own lands.

In regard to the introduction of improved varieties, the great need of the Province is an early ripening cane, but such a cane must not be inferior to the local Paunda. The successful introduction of an early ripening variety would obviously afford a more satisfactory solution of the problem of preventing loss from frost than the spread of windrowing. The tests which have been carried out at Tarnab have shown that D. 74, Assami Red and Barbados 246 ripen earlier than the local Paunda, but it has yet to be established that they are superior or even equal to it when grown by the ordinary cultivator. Further work will be necessary before a definite decision on this point can be reached, and the question arises whether such work should be carried on at Tarnab or at a separate station directly under the Sugar Research Institute. We do not consider the area under cane in the Province or the importance of the crop in its agricultural economy sufficient to justify us in recommending a separate substation for work on cane, and are of opinion that such work can be carried on by the local Agricultural Department to which the Sugar Research Institute would give all the assistance possible. We understand that no difficulty has hitherto been experienced in carrying out the chemical work required at Tarnab, as the Imperial Agricultural Chemist has been able to lend a man for this purpose during the crushing season. This arrangement may not always prove feasible, and we consider that it would be an advantage both for cane and other crops if the Province had a chemist of its own, who might be an officer of the Provincial (or Class II) Service. If this recommendation is accepted, the Tarnab farm will require increased laboratory accommodation.

Summary of Conclusions and Recommendation s.

(1) It is remarkable that the chief cane grown in the North-West Frontier Province, despite its northerly latitude, is a thick cane. This is apparently connected with the high humidity in the Peshawar valley.

(2) Cane cultivation here is of an unusually high order, especially in respect of rotations and green manuring and the preservation of sets by clamping.

(3) Experiments in windrowing show that it preserves cane from deterioration for a maximum period of one month, but that it involves comparatively little loss of sucrose up to as much as three months.

(4) There is little prospect of extension of cane under the Public Works Department canals except under the Kabul river canal.

(5) The limiting factor on the district canals is not the water supply but the lack of labour for making gur and of markets for selling it.

(6) The tract commanded by these district canals seems suitable for the establishment of a central factory, particularly if it could combine beet and cane sugar manufacture.

(7) The Agricultural Department should demonstrate the importance of care in selecting sets and windrowing.

(8) Unless political objections exist, the subordinate staff of the Department should be increased to admit of more widespread demonstration work.

(9) The great need of the Province is an early ripening cane.

(10) A separate cane research station is not justified; and cane work should continue under the control of the local Agricultural Department.

(11) An appointment of Agricultural Chemist should be created, and a Class II officer should be appointed to it.

CHAPTER VII.

BENGAL.

Climate and soil.

121. The Presidency of Bengal lies between 20° 35′ and 27° 13′ N. and is almost entirely sub-tropical. In acreage under cane it now stands fourth amongst the Provinces of India, though twenty years ago it was easily second. The causes of the great decline in cane cultivation are referred to later in this Chapter. Cane is grown in every district of the Province, not excepting Darjeeling, but is a crop of small importance in the Presidency and Chittagong divisions. The district with the largest area under cane is Dinajpur in the Rajshahi division which returns about 30,000 acres. The area under cane in the Pabna district in the same division, which in 1900-01 was returned at 60,000 acres, had in 1919-20 fallen to 4,600 acres. In the Dacca division the most important cane growing districts are Dacca and Bakarganj, each with an area of over 20,000 acres. In the Burdwan division the Burdwan district returned an area of about 18,000 acres in 1919-20. Owing to the absence of a revenue staff in Bengal the district figures can only be regarded as approximations.

Climatically, Bengal consists of two fairly distinct tracts divided by a line joining Khulna and Darjeeling. Whilst all over the Province the total rainfall is heavy, varying from about 55 inches in Western Bengal to well over 100 inches in parts of Eastern Bengal, rainfall in March and April west of the line just mentioned is comparatively rare and the first showers of the year are often received as late as May. The monsoon in this tract ends somewhat abruptly and the rainy season is consequently confined to the five months from May to September. East of the line, on the other hand, rainfall in March and April is common and the monsoon lasts into October, giving a rainy season of some eight months' duration. In this area vast tracts in the Dacca, Bakarganj Faridpur, Tippera and Mymensingh districts are more or less deeply submerged during the monsoon period. The village sites only are left above water and boats are the sole means of communication. It need hardly be pointed out that these conditions suit jute and rice very much better than they do cane ; and it is mainly for this reason that, except in the neighbourhood of Dacca city and in parts of Bakarganj, where a considerable area of cane is grown for chewing purposes, there are only a few tracts in Eastern Bengal where more than small scattered crops of cane are to be found. It should be mentioned that the whole Province suffers severely from cyclones and that in 1918 the cane crop in the neighbourhood of Dacca was destroyed by one of these.

The soil of the Province is throughout the alluvial soil of the Gangetic plain, but there are considerable local difference in quality. The old alluvium of the Rajshahi and Burdwan divisions is a stiff and intractable soil not very retentive of moisture, whilst the alluvial land in Western Bengal beyond the reach

of floods, which is the most important class of land on which cane is grown, is usually loamy and consequently fairly easy to work. Throughout the districts of the Dacca and Rajshahi divisions there are vast tracts of alluvial land which are annually submerged and enriched with silt.

Statistical.

122. The average area of Bengal, excluding Native States, during the five years ending 1918-19 was 50,469,937 acres. The net area actually cropped during the same period averaged 24,625,880 acres of which 222,660 acres were under cane. The percentage of the area under cane to the net area cropped was 0.9 and to the total area under cane in India 8.1. The average yield of gur for the quinquennium was returned at 1.08 tons per acre.

Varieties of cane.

123. Nowhere in India is a careful survey from the botanical and chemical points of view of the canes grown more necessary than it is in Bengal. The range of canes grown in Bengal is wider than it is in any other part of India, and nowhere, as Dr. Barber points out, is it more difficult to distinguish the three classes of Ukh, Ganna and Paunda canes. This is mainly due to the presence of a number of varieties which appear to be intermediate between Ganna and Paunda canes and which Dr. Barber considers are the descendants of introductions which have taken place during many centuries from the tropical parts of India. As in Bihar, matters are still further complicated by the introduction of exotic varieties in recent years. Many of the Mauritius varieties which have been brought in have not only lost their original names and numbers but have been given entirely wrong names, the Tanna varieties being now known as Java canes in Burdwan. The necessity for the survey suggested above will thus be clear and it will be understood why the description of the canes of Bengal which follows is even less complete than that given for the Provinces already dealt with. Khajli, for example, was described to us both as a thin, tall, hard-rinded cane and as a soft, thick cane, presumably owing to the fact that the same name is used for entirely different varieties in different parts of the Province. Of the canes which fall under the class of thin or Ukh canes, the most important is Khari, a thin, very hardy variety which is grown all over the Province and is specially resistant to both drought and water-logging. It gives a good yield and an excellent quality of gur. Khagri and Ikri are mainly grown in the flooded lands of East Bengal, Khagri being said to survive even when grown in six feet of water for three months. The gur made from Khagri is considered inferior to that from Ikri. Khala (or Lata) in Eastern Bengal and Chinia in Western Bengal are the thinnest canes of this class, their thickness being no more than that of a man's finger. Khala is grown on poor, flooded land which will grow no other variety. The crop is frequently used only for fodder and, when gur is made from it, it is of such inferior quality that the only purpose it serves is for curing tobacco. The canes which may be considered as falling in the class of Ganna or medium canes are Khajli, Dhalsunder, Magi and Puri. Khajli is a purple cane which Dr. Barber considers an introduction from the tropical parts of India and both it and Dhalsunder are mainly grown in Eastern Bengal. Dhalsunder produces excellent gur, whilst that from Khajli is of inferior quality, though this variety gives a good yield. Puri is considered one of the richest canes in juice grown in Bengal, but is liable to break readily and hence is not popular. Magi is only grown on a small scale in Eastern Bengal, mainly for gur. The remaining varieties, which are either indigenous to Bengal or have been grown so long in the Province that they may be so regarded, appear to fall rather under the Paunda than the Ganna class. Of these the most important are Shamshara and Vendamukhi. Shamshara,

which is largely grown in Western Bengal, is an excellent cane, easy to crush and capable of yielding 50 to 60 maunds of gur of good quality to the acre. Vendamukhi, which is the favourite cane of North Bengal, has much the same characteristics as Shamshara, and like it yields gur of excellent quality which keeps well in the rains. It is, however, being replaced in some parts, especially in the Dinajpur district, by Khari, as owing to its soft rind it is particularly susceptible to attack by jackals. Bangla, a cane which resembles Shamshara, has a high percentage of juice and is consequently grown on a small scale for chewing. Dacca Gandari Bombai is the thickest and best cane of this class. Its juice has a high sucrose content, but it is very susceptible to disease and to the effects of excessive water, and its cultivation is dying out. Of the varieties of exotic canes introduced by the Agricultural Department, the only ones which are grown on an appreciable scale are the Tanna varieties.

History of work on sugarcane.

124. Work on sugarcane in Bengal has been mainly carried on at the agricultural stations at Dacca, Rajshahi, Burdwan and Chinsura. It has been practically confined to varietal tests which, however, have been in progress sufficiently long to establish the suitability for distribution of the Mauritius variety known as Yellow Tanna. This, though its juice has not as high a sucrose content as many other exotic varieties, is resistant to disease and to attack by jackals and has hitherto given the highest yields of gur on the Government farms. There is now a considerable demand from cultivators for sets of this variety and arrangements are being made to meet it from the new farms which are being established at the headquarters of the cane-growing districts and at other centres. 247 B (as J 247 should more correctly be called), has done well in some years on the Dacca farm, but its economic value has not yet been sufficiently established to justify its distribution to cultivators.

Agricultural practice.

125. The great difference between the climatic conditions in Bengal and those of the Provinces which have so far been discussed is reflected in the agricultural practice. Throughout Bengal the problem is to avoid water-logging and, in many districts, cane is grown only on land which has been artificially raised. There is no established rotation of which cane forms a part, but the most common is sugarcane, jute, a *rabi* (cold weather) crop, *aus* paddy (*i.e.*, paddy which is harvested in September), cane. The *rabi* crop in this rotation may be either potatoes, turmeric, mustard, or a pulse or grain crop. Ratooning is not common.

When, as usually happens, cane follows a *kharif* crop, which is almost invariably *aus* paddy, the preparation of the land commences after the harvesting of the crop in September. The land is then given as many ploughings and harrowings as possible. In many districts it is also dug over with the *kodali* (long-handled hoe). Planting proceeds from December onwards, though some of the early varieties are planted in November. In Western Bengal, when irrigation facilities are scanty, as they usually are, planting has to be postponed until showers in April and May have moistened the land sufficiently. This involves the sets being first planted in nurseries and subsequently transplanted to the field. Where irrigation is available one watering is given when the cane is planted. Throughout the Province, except in parts of Eastern Bengal, only tops of cane are used for planting. There is no difficulty about this, as harvesting and planting proceed simultaneously. In the Faridpur and Bakarganj districts, however, where there is an interval between harvesting and planting, part of the crop is reserved for sets, the whole of the cane being

used for cutting into sets. Although, as a rule, the tops for planting are obtained from the cultivator's own crop, there is often some exchange of cuttings, and, if necessity arises, cuttings are imported freely. The selection of sets appears to be no more carefully done than it is elsewhere. The number of sets used per acre is said to vary from 10,000 or 12,000 for the soft, thick canes to 20,000 for the thin varieties.

In West Bengal, as already mentioned, the sets are generally planted in nurseries where they sprout. They are transferred to shallow trenches in the fields as soon as water becomes plentiful. Elsewhere, thick canes are planted in shallow trenches which have been made by the *kodali* and thin canes behind the plough in shallow furrows. The trenches are ridged up as the season advances. The better cultivators understand the advantages of laying out trenches and furrows in the direction of the slope of the land in order to carry off the surplus water. The distance between the sets in the rows varies from 12 to 18 inches, whilst the rows themselves are usually 18 inches apart, though in Western Bengal the distance between them is as much as three feet.

Once the cane has been planted, practically no intercultivation except a little weeding is done for thin canes. For thick canes weeding and hoeing continue until the cane is four or five feet high. No further irrigation is necessary except in Western Bengal, where, when facilities are available, waterings are given two or three times monthly till April and occasionally also in October and November. In Central Bengal, if April and May are exceptionally dry, the cane is watered by hand. As the season advances thick canes are tied together by their leaves for mutual support and in addition the whole row is frequently supported by a bamboo framework.

Thin canes are not generally manured, nor is manure applied to lands which receive an annual deposit of river silt. On other lands which grow thick canes farm-yard manure is the principal manure, the amount used being said to vary between 60 and 360 maunds (2.2 to 13.2 tons). In Western Bengal this is supplemented by a dressing of castor or mustard cake, the usual application being 12 maunds (0.44 of a ton) of oil-cake and 150 maunds (5.5 tons) of farm-yard manure. Where farm-yard manure is not available, the dose of oil-cake is increased proportionately, and may even go as high as 20 maunds (0.73 of a ton). In Eastern Bengal silt obtained from the tanks and *khals* (water courses) is often used as manure. No direct use is made of cane trash as manure, but the ashes from the gur-making furnace are often applied to the land. Green manuring is not a general practice, but sometimes a fibre crop of sann hemp (*Crotalaria juncea*) is grown previous to a cane crop, as it is generally recognised that the growing of this crop improves the land.

The time for which cane is on the ground in Bengal differs greatly according to the locality. Cane is planted from December to April and is, as a rule, harvested between December and February, though in parts of Eastern Bengal thin canes which have ceased their growth on account of prolonged submersion are harvested as early as October. Cane in Bengal is thus on the ground from eight to twelve months.

126. The cane position in Bengal may be briefly stated. The crop has never recovered from the set back which it received from the spread of jute some fifteen years ago and, for the nine years 1911-20, its area has remained practically stationary in the neighbourhood of 220,000 acres. The percentage of the area under cane to the net area cropped (0.9) is now lower than it is in any of the four Provinces already dealt with; and, though the percentage

Prospects of extension.

isa is only slightly higher, *viz.*, 1.1, we have in Chapter IV given our reasons for regarding the returns there as seriously underestimated; and in any event there is in Bengal no such concentration of the cane grown in any particular area as there is in the four western districts of North Bihar. It must moreover be frankly admitted that we see little prospect of any considerable revival or expansion of cane in Bengal in the near future. Whilst the problem of successful cane cultivation in Bengal varies in different parts of the Province, everywhere the problem is more obvious than its solution.

127. In the districts west of the line between Khulna and Darjeeling it is the shortness of the rainy season combined with the liability of the uniformly low-lying lands to inundation by river-floods that is the main obstacle to expansion. Both difficulties must be simultaneously removed before any material advance can be made; and this involves the raising of the lands otherwise suitable for cane above flood level and the provision of perennial irrigation. The former is an expensive operation calculated to cost several hundred rupees per acre, and is thus beyond the means of all but the most wealthy cultivators. There is some reason to fear that the latter can be provided only by canals: for, although trial borings for tube-well installations have only been made on a tentative scale in Bengal, there is a general absence of coarse-grained sand in the water-bearing stratum in these delta tracts far removed from crystalline rocks which renders tube well pumping a doubtful possibility. We trust that further experiments will be made to see how far adverse conditions are present before tube-well irrigation is finally abandoned in this area as impossible; but in the meantime canal irrigation appears to be the only practicable source of a perennial water-supply. We are, however, not in a position to say whether a suitable alignment for such canals could be found; and it is certainly out of the question for us to hazard any prophesy that the opening of a canal would be followed by such an extension of sugarcane cultivation in the area commanded by it as would economically justify its construction. We must content ourselves with saying, therefore, that no part of Bengal offers such natural advantages for the growing of cane as the western districts if the two great obstacles to development we have pointed out can be removed; but that for the present we see little prospect of their removal.

(a) West Bengal.

128. When we turn to other parts of the Province we find that successful cane cultivation involves a constant struggle with adverse circumstances. In the northern districts the water-logged conditions of North Bihar are reproduced in an intensified degree and the prospects of a successful drainage scheme being evolved are more remote. Tea is a formidable rival in Jalpaiguri, and further south cane begins to come into collision with jute. Eastern Bengal, again, is the scene of jute's most signal victory over cane, and there is small hope of retrieving the position so long as jute remains practically a monopoly of North-East India, and retains its present hold on the fibre markets of the world. The Bengali cultivator is both shrewd and industrious; and his acquaintance with cane cultivation is of long standing. Yet it is significant that the stimulus of high gur and sugar prices in the last one or two years has had little or no effect on him; and there is no such tendency to extend the area under cane in Bengal as is so marked a feature of the situation in North Bihar.

(b) North and East Bengal.

129. In Bengal, therefore, cane appears likely to remain a very scattered crop; and this fact combined with the exceptional difficulty of communication in almost every district renders it improbable that a factory industry will be

Agricultural recommendations.
(a) Improvements in cane varieties.

developed in the Province in the future. The question of agricultural improvement, therefore, here resolves itself into one of improving cultivators' cane grown in small and isolated patches. Even here the scope for improvement is limited, as there is little prospects of effecting any material improvement in low-lying lands on the thin canes with low sucrose content which have so far proved to be the only varieties able to survive the water-logging to which such lands are liable. It is consequently on lands which are above flood level that the work of the local Agricultural Department should be concentrated. Such lands have proved capable of taking thick canes of select varieties and the Department has already done something to meet this need. We consider, however, that steps should at once be taken to carry out the botanical and chemical survey of the different canes now grown (which, as we have pointed out above, is specially required in Bengal), with a view to their classification and the isolation of pure line cultures. It is probable that here, as in other Provinces, particular varieties will then establish their superiority in particular localities and point the way to a more appropriate distribution. Meanwhile, the trials already initiated with superior exotic varieties should be continued until it is definitely proved which, if any, of them can be acclimatised in Bengal without losing their original superiority to the best indigenous canes.

(b) Improvements in methods of cultivation

130. The description of present agricultural methods already given indicates that the efficiency of the Bengali cane grower is on the whole fairly high. His chief need is demonstration of the importance of care in the selection of his sets and of the extent to which improved varieties of cane will respond to nitrogenous manures ; and, though the heavier crops thus grown may in their turn demand a higher standard of general cultivation, there should be little difficulty in inducing him to rise to it. Simultaneously with the testing and dissemination of improved varieties, therefore, manurial experiments should be made and the best dose for each variety should be ascertained ; so that the Department may be in a position not only to demonstrate the right treatment of the canes it distributes but to organise local supplies of the manures found most suited to Bengal conditions.

Organisation.

131. The importance of sugarcane to Bengal in comparison with other crops not being so great as it is in any of the four Provinces we have already dealt with, and the chances of its establishing in the future a more prominent position than it now holds being remote ; it seems doubtful whether we can reasonably recommend the creation of any special organisation to promote the cultivation of cane in Bengal. There is little prospect of a factory industry and even the local concentration on any large scale of the cottage industry of gur making appears out of the question. While these conditions obtain, it would, we think, be uneconomical to propose the establishment in Bengal of a sub-station for research work on cane under the Sugar Research Institute we recommend in Chapter XXIII below. And, since the " raison d'être " of these substations is to serve local interests, it follows that for the same reason we cannot urge the Local Government to undertake such a station on its own account. It is the less incumbent upon us to do so, because already as much work is done on cane at the existing Circle farms in Bengal as at those of any other Province. Early steps will, we trust, be taken to expand and improve that work on the lines we have suggested above ; but, though we recognise that the Deputy Directors in charge of these farms will not be able to complete the survey of the local canes as

quickly as could an officer employed solely on cane and working at a station devoted specially to that crop, we must be content in all the circumstances with the slower progress which the existing organisation can maintain. The policy of multiplying the Circle farms of Bengal until ultimately there will be at least one in each district is, we understand, being steadily followed but, as it proceeds, the need for effective supervision will in proportion be more acutely felt ; and we cannot but regret that the Local Government has agreed to defer, as not being of immediate urgency, the creation of the two additional posts of Deputy Directors of Agriculture which it had advocated so long ago as 1917. These appointments will become still more necessary as the establishment of pure line races and improved varieties enables a more active demonstration propaganda to be undertaken, although we do not think that the interests of the cane grower in Bengal would justify the creation of a special demonstration staff for cane only. We shall be glad, therefore, if the Local Government can see its way to revive the proposal for the increase of the cadre of Deputy Directors to five, for we are convinced that the need for them is not only obvious but urgent.

Nurseries for the supply of sets.

132. While we have not felt justified in proposing that research work on cane in Bengal should be directly linked up with the Imperial organisation we advocate in Chapter XXIII, there is one way in which Bengal might, we think, well co-operate in the work of that organisation. We have described in paragraph 22 of Chapter II the excellent system followed in Java of expediting the rate at which new varieties of cane are multiplied for planting. The system involves the cutting and replanting of the young canes at six months old, and is, therefore, only possible where local conditions permit of a very extended planting season. In Bengal the cane planting season extends from November to April, but in a limited area around Dacca, cane is planted for chewing purposes as early as September, the final monsoon showers of October being sufficient to secure germination, and the natural humidity of the atmosphere tiding the crop over to the spring rains which this tract receives in March and April. Here, therefore, a planting season of as much as seven months is possible ; and the area would seem to be admirably suited to the rapid propagation on a large scale of sets of new varieties the superiority of which has been definitely established at the central research station or at one or other of its sub-stations. The matter doubtless requires detailed local investigation before a final pronouncement can be made ; and this will be one of the questions with which it will naturally fall to the Sugar Board with the advice of its expert officers to deal. Should the Board, however, endorse our suggestion, we hope that it may count upon the good offices of the Bengal Government in obtaining suitable land for such a station. Whether the station should be directly under the control of the Sugar Research Institute or should be run by the local Agricultural Department on its behalf is a question we would leave for decision between the authorities concerned in the light of future developments.

Summary of Conclusions and Recommendations.

(1) *There is little prospect of any considerable expansion of cane in Bengal or of the development of a factory industry.*

(2) *Work on agricultural improvements should be concentrated on lands which are above flood level.*

(3) *The first requirement is a botanical and chemical survey of the canes at present grown.*

(4) *Trials of superior exotic varieties should be continued.*

(5) *The importance of care in the selection of sets should be demonstrated.*

(6) *Experiments should be made to ascertain the proper applications of manure for each variety of cane grown or recommended.*

(7) *The establishment of a special research station for cane cannot be justified.*

(8) *The proposal to increase the provincial cadre of Deputy Directors of Agriculture from three to five should be revived.*

(9) *There is reason to believe that parts of Bengal might be well adapted to the rapid propagation of sets of new varieties on the Java system.*

CHAPTER VIII.

ASSAM.

133. The small Province of Assam lies between 22° 19′ and 28° 16′ N. and is thus almost entirely sub-tropical. The Province falls into three natural divisions, the valley of the Surma river, the valley of the Brahmaputra, usually known as the Assam Valley, and the intervening range of hills. The cane-growing tracts of the Province lie in the two valleys, the principal cane-growing districts being Cachar and Sylhet in the Surma Valley and Kamrup and Sibsagar in the Assam Valley. None of these districts, however, returns an area of more than 7,500 acres. The climate of Assam is characterised by coolness and humidity. Its most distinguishing feature, which has a very important bearing on cane cultivation in a Province where cane is always grown without irrigation, is the copious rainfall between March and May at a time when rainfall over Upper India is at its minimum. The year is thus roughly divided into two seasons, the cold season and the rains, the dry hot weather of the rest of India being completely absent. Goalpara and Lakhimpur districts at the two ends of the Assam Valley receive about 110 inches of rain during the year ; but in the central districts of the valley, which are protected to some extent by the high plateaux of the Khasi and Jaintia Hills, the mean rainfall ranges from 70 to 83 inches. The rainfall in the Lanka tract of the Nowgong district, to which we refer below, is only 45 inches. In the Surma Valley the average rainfall is 158 inches at Sylhet, and 125 inches at Silchar, the headquarters of the Cachar district. The soil of both valleys is an alluvial soil which, in the Surma Valley, where the rivers are sluggish, is enriched with silt when they overflow. In the Assam Valley, where there is usually a strong current in the rivers during the rainy season, it is only the heavier portion of the matter held in suspension, that is, the sand, which is deposited during floods. The soil of this valley, in consequence, consists of a mixture of clay and sand in varying proportions, and ranges from pure sand to a clay so stiff as to be hardly fit for cultivation. Cane is usually planted on the high lands near the village sites in the broad belt of permanent cultivation on both sides of the rivers; whereas in the Surma Valley it is often grown on low land where it gives a poorer outturn than on the fertile river banks of the Assam Valley.

Climate and soil.

134. The average area of Assam, exclusive of Native States, during the five years ending 1918-19 was 31,310,566 acres. The net area actually cropped during the same period averaged 5,829,031 acres, of which 35,689 acres were under cane. The percentage of the area under cane to the net area cropped was 0.6 and to the total area under cane in India 1.3. The average yield of gur for the quinquennium was returned at 0.82 of a ton per acre.

Statistical.

135. Information regarding the varieties of cane grown in Assam is scanty; but, as they are few in number, a botanical and chemical survey, though desirable, is not so necessary as in most of the Provinces with which we have already dealt. Thin canes of the Ukh class are seldom met with. The most common cane in the Province is a medium (Ganna) cane known as Magh, a soft cane and therefore a favourite for chewing and easy to crush. Mojara, a variety which is only met with very occasionally, deserves mention, as Dr. Barber considers it the thickest indigenous cane he has seen in India and regards it as a "super-Ganna" type. Thicker than Magh and falling rather under the Paunda than the Ganna class are Kalapura or Teli, a purple cane, and Bogapura, a yellowish green cane. These, like similar canes grown in Bengal, appear to be descendants of introductions from the tropical parts of India. Other thick varieties are met with which are lumped together under the general designation of Bombai or Paunda, names which are usually applied to any thick variety of exotic origin whose original name and history are unknown. All the thick varieties are more susceptible to disease and to attacks by jackals and white ants than Magh, which is consequently growing in popularity at their expense. They are also being supplanted by the exotic varieties which are being distributed from the Agricultural Farm at Jorhat, more especially by Striped Mauritius and B.-376.

Varieties of cane.

136. Work on cane in Assam has been carried on at the agricultural stations at Jorhat, which was established in 1906, and Kamrup, which was established in 1914-15. The work at Jorhat has followed the usual lines and has consisted in varietal tests and experiments with improved methods of cultivation. The varietal tests have established the superiority of Striped Mauritius, B.-376 and B.-147 to the local varieties and their suitability to local conditions when given the better cultivation and manuring they require ; and in 1918-19 some 3½ lakhs of sets of these varieties were distributed from the Jorhat and Kamrup farms. In 1919-20 the average yield of plant cane on the Jorhat farm was 39.5 tons per acre on land treated with phosphatic manures and 37.5 tons on land not so treated. The whole area had previously received a heavy dressing of lime. The average yield of the ratoon crop was 22 tons of stripped cane. Some of the newer importations gave very heavy crops, more especially Barbados A, B.-3412 and P. O. J.-33-A. The highest yield of sucrose in juice extracted per acre, 11,000 pounds, was returned by B.-147, Striped Mauritius and P. O. J.-33-A. being next in order. Of the new varieties which have been grown for observation and preliminary analysis several are said to show exceptional promise. Amongst these is one of the Coimbatore seedlings, CO.-9. The most suitable rotation for cane as worked out on the Jorhat farm has been found to be :—

History of work on sugarcane.
(a) Jorhat.

1st year—plant cane,
2nd year—ratoon cane,
3rd year—(*kharif*) a green manure crop, (*rabi*) oats.
4th year—(*kharif*) another green manure crop, (*rabi*) a catch crop of mustard.

The green manure crops are ploughed in. The mustard crop is sown early in October and ploughed in about the middle of November, after which the land is left fallow until cane is planted in March. This rotation has given the heaviest crops of cane yet obtained on the Jorhat farm, but it is obviously very expensive and we doubt whether it will prove a practicable rotation for large estates.

137. The work on the station at Kamrup has been of a different character and has had a different object. It is necessary to give the history of this station in some detail, as it has an important bearing on the recommendations we make below in regard to the development of the sugar industry in Assam. The station was the outcome of a recommendation of the Board of Agriculture held at Pusa in 1911 that, in view of the large imports of sugar into India, provincial Departments of Agriculture should examine and report on the existence in their Provinces of large blocks of waste land suitable for growing sugarcane in sufficiently large areas to supply large central factories. Early in 1912 Mr. B. Coventry, C.I.E., then Agricultural Adviser to the Government of India, visited Assam and was greatly impressed by the possibility of developing cane cultivation in the Assam Valley. A rough survey of large areas of waste land in that valley was accordingly made, and a tract in the north of the Kamrup district was finally selected as suitable for an experiment in cane-growing on a large scale with the object of ascertaining whether cane could be grown at a profit when cultivated with steam tackle. The reasons which led to the selection of a site in the Kamrup district, 17 miles from a railway station with very indifferent road communications, were the absence of heavy jungle over a large expanse of level land and the open character of the soil which admitted of free drainage, an important point in a tract of heavy rainfall. An additional reason was the fact that the local authorities restricted the choice of a site to districts in which tea was not grown, in order to avoid competition with tea-estates for labour. It was estimated that the experiment would last three years and would cost Rs. 2 lakhs. It is worthy of mention that at this stage it was believed that there were some 200,000 acres of waste land suitable for cane cultivation in the neighbourhood of the selected site, of which 50,000 acres could be made immediately available.

(b) Kamrup.

Work on the Kamrup station commenced in 1914-15, when 20 acres of cane were planted. The growth of the cane was adversely affected by lack of drainage; but planting material was provided for about 70 acres in 1915-16, of which, however, only 40 acres survived. A ratoon crop was obtained from these in 1916-17 and 230 acres were also put under plant cane. The drainage difficulties had by this time been largely overcome and the crop obtained was, in the circumstances, a satisfactory one. No weighment was done either for plant or ratoon cane; but it was estimated that an average of 20 tons an acre was obtained over the whole area, the ratoon crop giving a yield of 15 tons, whilst the yield of plant cane varied between 18 and 30 tons. At the meeting of the Board of Agriculture held at Pusa in February, 1916, a resolution was passed urging that the operations should not be brought to a close in March, 1917, as had been originally intended, but should be continued until it had been definitely established whether cane could be profitably grown at Kamrup on a commercial scale. The Assam Administration accepted this view and, in order to secure the disposal of the crop grown on the farm, entered into an arrangement with the late Mr. W. Maxwell under which he undertook to erect crushing machinery and to manufacture gur, the Local Administration on its part agreeing to carry on the farm until the end of the crushing season of 1919. Owing mainly to delay in the arrival of machinery, only 775 tons of the cane grown on the farm in 1916-17 were dealt with in the factory, the remainder of the crop being thrown away or distributed for planting. In 1917-18 there were 260 acres of plant cane on the farm and 250 acres of ratoon. The gur factory, which had been established the previous year, was in process of conversion into a sugar factory, and in consequence only 390

tons of cane were dealt with, although the average yield of cane on the farm was estimated at 15 tons an acre. In August, 1918, a new agreement was entered into with Mr. Maxwell under which the Local Administration undertook to work the farm until March, 1924, the cane grown to be purchased by the factory at a price based on its sucrose content. Although the area under cane on the farm in 1918-19 and the following year was only slightly lower than it had been in 1917-18, difficulties in regard to machinery prevented the factory from dealing with more than a fraction of the crop, the actual figures being 1,855 tons in 1918-19 and 1,157.5 tons in 1919-20. The average yield of plant cane in 1918-19 was estimated at 18.4 tons per acre, but that of the ratoon crop was not more than 4 tons, the low yield being attributed to the late removal of the plant cane of the previous year. In 1919 the crop was severely damaged by beetles and the average outturn was not more than 6 tons of stripped cane per acre, though two blocks which escaped yielded 15 to 20 tons. In view of the heavy expenditure involved in the continued maintenance of the station, it has recently been handed over by the Assam Administration to the Assam Sugar Estates and Factories Company, Limited, to which Mr. Maxwell transferred his rights and obligations in March, 1919. The total cost of the experiment has been about Rs. 5½ lakhs.

Agricultural practice.

138. The cultivator in Assam is not ambitious and is satisfied to exist on comparatively little, provided he can thereby live a leisured existence. This accounts to a large extent both for the small area under cane in the Province and for the distinctly primitive character of its cultivation. No definite rotation is followed; but when it is decided to put land under cane the soil is dug over with the hoe in the early autumn and then left till the spring, when it is worked to a fine tilth by hoeing or ploughing. Tops only are planted, the number used to the acre being estimated at 11,000 to 14,000. No selection of any kind is practised, and the result is that what was described to us as the most miserable rubbish is often planted. The tops first germinate in a nursery and sooner or later, but almost always too late to give the best results, they are transplanted to the field where they are planted in shallow holes in lines about two feet apart. This is too close to admit of proper interculture ; and such after-cultivation as is practised usually consists merely in surface hoeing to keep down weeds followed by manuring, where manure is available, and a light earthing up. Even this is often badly neglected and the cane has, in consequence, to compete with weeds almost throughout its life. The only manure used is cattle manure, the average application being from 100 to 150 maunds (3.6 to 5.5 tons) an acre. The value of this is largely minimised by careless conservation, so that it is generally insufficient in quantity and often of low manurial value. Ratooning is common, though the ratoon crop is even more neglected than the plant cane. It is a common practice in parts of Assam to follow a crop of plant cane by two ratoon crops and then to abandon the land for some years before cropping it again. This practice is carried to extreme lengths on the virgin soils of Upper Assam, where as many as five successive crops of cane are taken before the land is abandoned. Cane in Assam is planted in March in the nurseries, the transplanting being frequently delayed till May. It is harvested from February till April, so that it is on the ground from eleven to thirteen months.

Prospects of extension.

139. The cane problems of Assam differ widely from those of any of the five Provinces we have so far dealt with, although it possesses certain features in common with the North-West Frontier Province. Its situation is remote and

almost the whole of it is cut off by the Brahmaputra from through railway communication with the rest of India. Its incidence of population is low, being only 137 to the square mile, and the people themselves are indolent and unenterprising. The Province is in consequence exceptionally undeveloped. Less than one-fifth its total area is cultivated against over a fourth in the North-West Frontier Province, two-fifths in the Punjab, nearly a half in Bengal and Bihar and Orissa and over a half in the United Provinces ; while its area returned as culturable waste is proportionately far greater than that of any other Province in British India. Of the area cultivated, moreover, the Assam ryot devotes an even more diminutive fraction to cane than the ryot of Bengal ; and his cane plots are probably smaller and more scattered. They are also more liable to attack by wild animals. In these circumstances we see little prospect of improvement on present lines. The distribution of improved varieties of cane to the small growers is useless, unless they are prepared to improve their cultivation correspondingly ; and so far they have shown no indication of such a response. The research work on cane at Jorhat, which we consider to be already proceeding on right lines, is thus well in advance of the ryot's practical requirements ; and so far as he is concerned, we have no special recommendations to make for its expansion or even for its continuance. On the other hand the experiments at Jorhat have proved (and those at Kamrup have to some extent corroborated the fact) that superior varieties of cane can be grown with marked success in Assam ; and that, where improved methods of cultivation are adopted and local conditions are suitable, very high yields can be obtained. Vast areas of unoccupied land are available and the Local Administration has long since recognised the necessity of developing these areas by means of large agricultural grants to capitalists, as is indicated by the existence of the numerous tea estates in the Province, and by the extensive concessions recently granted to certain enterprising firms for the cultivation of other crops, such as jute and sugarcane. All these circumstances are distinctly favourable to the development of a central sugar factory industry relying for its raw material on land under its own continuous control, probably the most valuable asset this industry can acquire. It is along these lines, therefore, that we must look for the advancement of cane sugar production in Assam ; and, since the obviously favourable conditions for such advancement are counterbalanced by no less obvious difficulties and disadvantages, it is to the solution of these difficulties and the removal of these disadvantages that the attention of the local authorities should now be mainly directed.

Need for a local survey.

140. In the first place we would sound a note of warning against the too facile assumption that, because cane can be made to give excellent yields in Assam, excellent yields can be obtained in all or even in most parts of the Province. Cane is apt to be an exacting plant, and the better the variety of it grown the more exacting does it tend to become. Favourable atmospheric conditions and a well-distributed rainfall may be nullified by an unfavourable soil or the impracticability of drainage ; and, since there is no organisation of the sugar industry which requires such a large capital outlay as the combined sugar estate and factory, it is of the first importance that all possible information should be made available regarding the local incidence of the conditions requisite for a successful venture of this kind. We are convinced, therefore, that a careful survey of all the areas which seem to offer a provisional prospect of supplying these conditions, (and we would mention North Mangaldai, the Lakhimpur Frontier Tract and the Lanka plain of the Nowgong district as

typical instances) is here the first and most urgent necessity of the problem. The survey need not be very elaborate or detailed ; but it should certainly be careful enough to preclude the possibility of repeating the mistake made at Kamrup of reporting the area available and suitable for the cultivation of cane as being several times greater than it ultimately proved to be. It should not be conducted with an eye solely to the agricultural aspect of the problem. The feasibility of drainage and the provision of communications are questions which an engineer is required to answer ; while the suitability of an area from the practical business point of view can only be correctly gauged by a man of experience in the management or control of large estates employing a considerable labour force. We are of opinion, therefore, that, if reliable results are to be obtained, the survey should be conducted by a committee of three, namely, a member of the Agricultural Department who has already done practical work on cane in Assam, an officer of the Public Works Department, who should preferably possess experience of drainage as well as of land survey work, and a non-official expert in plantation management. The Committee would be asked to examine all areas considered to offer prospects of concentrated and intensive cane cultivation on a factory scale and to report on the suitability of each area and the extent of suitable land available for the purpose. On receipt of their report the Local Administration would, we trust, proceed to reserve the areas definitely recommended as suitable, and to invite applications from individuals or companies who are in a position to take up large blocks of land for the cultivation of cane and to establish sugar factories with a crushing capacity of not less than, say, 500 tons a day.

Terms on which cane-growing concessions should be granted.

141. Grants of this kind would, of course, come under the provisions regulating concessions for the purpose of "special cultivation" embodied in the provincial Settlement Rules ; and the concessions would thus take the form of leases in perpetuity, with a purchase premium of Re. 1 per acre, but free of land revenue for not less than two and not more than ten years, with privileged rates thereafter on a gradually ascending scale till the conclusion of the first 30-year period of the lease. The standard form of lease (Form 2) adopted in such cases, however, appears to us defective in two respects, namely, that no restriction is placed upon the lessee's right to transfer the lease as a whole, and that there is no provision to secure that the land is brought under the special cultivation for which it was granted within any specified period of time, nor even for penalising the lessee if he fails to cultivate the land at all. If Government concedes permanent rights in land to capitalists for the cultivation of crops in a manner which is beyond the means of the ordinary cultivator, it should be in a position to enforce the fulfilment of his contract by the capitalist within a reasonable period of time, and thus to check the operations of mere land speculators whose sole object in taking up such leases would be to hold the land for a remunerative price against later and more desirable applicants. In all leases for the special cultivation of sugarcane, therefore, we trust that provision will be made requiring the previous sanction of Government in writing to any form of alienation or encumbrance of the lease ; and for the bringing of the whole of the leased area classed as suitable for cane under cultivation with cane (or in a cane rotation) within a specified term of years and at a specified rate per year, varying of course with the particular circumstances of each concession. Breach of either condition should render the lease liable to immediate revocation; but for breach of the second we think an alternative penalty in the form of a fine or an enhanced assessment on the area which the lessee has failed to cultivate should be provided.

Agricultural improvements on large estates.

142. We have little doubt that, if the survey we have recommended above is carried out and prompt action is taken on it, the interest in cane cultivation on a plantation scale of the existence of which there are already unmistakeable signs will be greatly stimulated ; and the number of such estates may before long be considerable. The management of these estates will be in a position to take full advantage of any variety of cane and method of cultivation the superiority of which has been demonstrated by the local Agricultural Department ; and it is, for this reason, important that the work now centred at Jorhat should be not only continued but extended. Of particular urgency are the evolution of what is commercially (and not merely ideally) the best cane rotation and the establishment of a cane or canes that will ratoon freely and for several years ; for a good ratooner is of the first importance in a Province like Assam where labour has to be imported at great cost. We doubt, however, whether Jorhat is really a suitable situation for this work ; although we were informed that results obtained there had been found in practice to be valid for Kamrup. Jorhat is situated in the middle of a tea tract and no considerable development of cane cultivation is to be looked for in its neighbourhood. A suggestion was, it is true, put before us that the management of tea estates should be induced to grow cane on uncultivated land on their estates and that in this way raw material could be provided for a sugar factory in a tea area. The main assumption on which this proposal was based, however, was that surplus labour was available on tea estates in the months of February and March and could thus be utilised for the planting of cane. We have satisfied ourselves that this assumption is incorrect and that there is little prospect of inducing the tea planters to undertake the growing of cane. The Jorhat farm, moreover, is only 60 acres in extent, and not more than ten acres per year are devoted to cane experiments. We think, therefore, that it should only be maintained as a sugar research station on its present lines and under the existing control until such time as the new station or stations are opened the establishment of which we now proceed to consider.

Organisation.

143. In dealing with this question of cane research stations for Assam we cannot ignore the unfortunate precedent of the Kamrup farm which has now been made over to a private company. The history of that experiment which we have outlined above indicates that it was instituted with the object of establishing certain commercial, and not merely agricultural, results but that no provision was made for obtaining any commercial results whatever. Even when a belated attempt was made to attach a factory to the farm, the object appears to have been rather to reduce the cost of the agricultural experiment than to make the factory an integral part of the experiment itself. At the same time we cannot help feeling that it was inequitable for Assam with its very limited resources to be called upon without assistance from Imperial revenues to conduct such a large and costly experiment in Imperial rather than provincial interests. It was, therefore, doomed to failure from the start and, while we cannot but regret that the opportunity has been lost of conducting it on right lines to definite and valuable conclusions, we have no desire to advocate any fresh experiments of the same dimensions and with the same objects as Kamrup. Circumstances have altered since 1912. The use of steam tackle for cultivation on a large scale is no longer a novelty in India ; and the grant of large concessions to several Calcutta firms in the Kamrup area and the number of enquiries now being made for similar concessions elsewhere are a proof that

the commercial possibilities of such ventures are already realised. It is in respect of the purely agricultural problems of cane cultivation that Government assistance is required in Assam, and for the solution of these problems—both varietal and cultural—it is not necessary to take up so large a block as a thousand acres, while it is positively detrimental to its real objects to treat such a station on the lines of a private estate and to require it to show commercial results on its operations as a whole. There is, therefore, no reason why any cane research station in Assam should exceed in area the 200 acres we have suggested as suitable in other Provinces and, while we are convinced that at least one such station is required, we would suggest that the committee we have recommended above should be asked to advise whether a second station is called for and to indicate the most suitable site or sites. Should more than one station be proposed, however, it should be borne in mind that both will have to be under the control of a single research officer, so that an excessive distance between the two stations is to be deprecated. As, however, any research station for work on cane only in Assam will for a long time to come be working in the interests mainly of large financial concerns from outside the Province, we do not feel justified in asking the Local Administration to undertake the institution of them; and in this instance we think it will suffice, if the opening of such stations awaits the establishment of the Sugar Research Institute we advocate in Chapter XXIII below, when the Assam station or stations could be inaugurated forthwith under Imperial control. In the meantime we trust that the cane work at Jorhat will be actively continued and that the Local Administration will freely recognise its obligations to open up suitable communications in newly exploited areas and, in particular, will lose no time in constructing road bridges adequate to carry the heavy machinery required for large sugar factories. Delay in the delivery of its plant at the factory site may mean the loss to the factory of a whole season's work, and involves considerable risk of damage to the machinery itself. It is, therefore, of the first importance that the Government's programme of road construction in these areas should be drawn up and put into execution well in advance of the demands that will inevitably be made on it.

Labour.

144. Labour will always be one of the greatest difficulties in the way of cane cultivation in Assam on a plantation scale, though the discovery of a suitable ratooning cane and the extensive use of labour saving machinery may do much to mitigate it. A suggestion was made to us that recruitment of labour for sugar estates should be placed outside the operation of the Assam Labour and Emigration Act (VI of 1901) under which all imported labour for Assam is at present recruited. But not only can we substantiate no claim to such exceptional treatment for the sugar industry in Assam: in our opinion, it would not be in the best interests of the industry itself that it should be so exempted. After all, the main object of the Act is the prevention of abuses both in original recruitment and in enticement from one concern to another and under its provisions a recruiting organisation has grown up, under the direction and control of the Assam Labour Board, which should be of material assistance in putting new concerns into touch with the likeliest sources of a labour supply. Whether the management of sugar estates would be better advised to appoint their own local agents under the Act to recruit their labour for them than to employ the Tea Districts Labour Association is a matter which must be left for individual decision; but we see no reason to press for the relaxation of the Labour and Emigration Act in its applicability to sugar planters and manufacturers. Similarly

each estate must be left to work out its own salvation in the matter of popularising itself with its own labour force. Fortunately the experience already acquired on tea estates is available for the sugar planter to profit by, and its lesson is obvious that there are no synthetic substitutes for personal interest, sympathy and effort on the labourer's behalf. The health as well as the comfort of his employees is the employer's concern, and power is taken by the Local Government under sections 135 and 163 (2) (q) of Act VI of 1901 to enforce the provision upon estates of suitable hospital accommodation and medical treatment; but we regard this as a matter in which the employer is entitled to the advice and help of Government, particularly in the supply of cheap anti-malarial remedies and in obtaining medical assistants of the right stamp. In fact we consider that the Local Administration should be prepared to depute members of its Medical Department for a term of years as medical officers to individual estates or groups of estates at the latter's cost.

Seed supply and demonstration.

145. It follows from the view we have taken above regarding the small prospects of improvement in the ryot's cultivation of cane that we have no immediate recommendations to make for expanding the existing organisation either for the supply of selected sets or for the dissemination of improved methods of cultivation. Both may await the results of the cane survey we have recommended; but, with the opening of the cane research station or stations under the control of an officer of the central research organisation which we contemplate, it will, we think, be necessary to establish a nursery in the foot hills for the supply of hill sets under the same control. There is no lack of choice for a site for such a nursery; but this again is a matter on which the cane survey committee should be asked to advise. It seems likely also that parts of Assam will lend themselves admirably to the rapid propagation of sets of new varieties in the manner we have suggested for Bengal in paragraph 132 of Chapter VII. This, however, like the constitution of special cane demonstration staffs, can only be anticipated as a development of the future; and it must be left for the officer in charge of the cane research work in Assam in consultation with the officers of the local Agricultural Department to advise when the time is ripe for either the one or the other.

Summary of Conclusions and Recommendations.

(1) *The climatic advantages of Assam as a cane growing tract are the absence of dry hot weather, the humidity and the copious rainfall between March and May.*

(2) *The inefficiency and indolence of the small grower, the scattered nature of his cane cultivation and his failure to adopt new methods render improvements in ryots' cultivation unlikely.*

(3) *Progress must be along the lines of promoting a central factory industry controlling its own cultivation, and the possibility of growing heavy s of superior varieties of cane, the large extent of waste land available, the prevailing policy of developing agriculture by capitalist grants are all urable to such progress.*

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(4) A Committee of three should be appointed to survey likely areas for development on these lines, and selected areas should be reserved for allotment in large grants.

(5) The standard provisions regulating concessions for special cultivation should be amplified to prevent alienation or encumbrance without previous sanction in writing and to prescribe for bringing the concession area under cane cultivation within a specified term and at a specified rate.

(6) It is in the interests of large estates that the cane research work now centred at Jorhat should be continued and extended.

(7) The evolution of the commercially best rotation and the discovery of good ratooning varieties are of special importance.

(8) Jorhat is not, however, the best centre for the work which should only be continued there till a new research station is opened.

(9) So large a station as Kamrup is not required, nor should the attempt there made to establish commercial as well as agricultural results be repeated.

(10) One or two stations of 200 acres each should suffice; and the question of number and location should be referred to the proposed survey committee.

(11) The establishment of them should, however, await the creation of the Sugar Research Institute recommended in Chapter XXIII, as they should form an Imperial and not a provincial charge.

(12) Meanwhile the Local Administration should push on the provision of adequate communications in newly exploited areas.

(13) There is no justification for placing the recruitment of labour for sugar estates outside the scope of the Assam Labour and Emigration Act.

(14) Government should assist estate managers by the provision of cheap anti-malarial remedies and the loan of members of its Medical Department.

(15) With the opening of the new cane research station or stations a nursery for the supply of hill sets will be required, and the proposed survey committee should advise regarding a site for it.

CHAPTER IX.

BURMA.

Climate and soil.

146. The Province of Burma lies between 9° 58′ and an as yet undemarcated line in the neighbourhood of 29° N. and is thus mainly tropical. As the figures in the following paragraph show, the acreage under cane in Burma is insignificant, being less than one-sixth that returned by the single district of Gorakhpur or Meerut in the United Provinces. Over half of it is in two districts, Thaton in Lower Burma and Yamethin in Upper Burma. Pegu, Amherst and Toungoo, all in Lower Burma, are the only other districts which return an area of more than 1,000 acres. It is, therefore, entirely from the point of view of possible future developments of cane cultivation that Burma is of importance. The Province is of such vast extent that it is difficult to give a concise and at the same time accurate description of its climate and soil. It will suffice to say that climatically it falls into four main divisions, the Upper Burma wet, the Upper Burma dry, the Lower Burma littoral and deltaic and the Lower Burma subdeltaic. The varying conditions of rainfall under which cane is grown in Burma are strikingly illustrated by the figures for Pyinmana and Bilin, the principal cane growing centres in Upper and Lower Burma respectively. At Pyinmana in the Yamethin district, which is just outside the dry zone, the rainfall is about 55 inches, whereas at Bilin in Thaton, which is one of the deltaic districts, it is 195 inches. The rainfall in the Mon canal area of the Minbu district, to which we refer below and which is in the dry zone, is about 35 inches. Throughout the Province the monsoon commences about the third week in May and ends with the third week in October. July is the wettest month, except in the dry zone, where the beginning and end of the monsoon give the heaviest rainfall. Rain from November to April is very scanty everywhere. The distinctive characteristics of the climate of Burma outside the dry zone, as compared with that of the great cane growing Provinces of India, the United Provinces and the Punjab, are the much smaller margin between the extremes of temperature in the hot and cold weathers respectively and the absence of scorching winds in the former season.

The nature of the soil is of special importance in considering the possibilities of the extension of cane cultivation in Lower Burma, in which for this purpose we include all districts as far north as Meiktila. Throughout this part of the Province the prevailing soil is old alluvium, that is, soil formed at the bottom of the sea from the silt of the Irrawaddy, Sittang and Salween rivers or their precursors and elevated to form what are now the alluvial plains of Lower Burma. The land in the deltaic districts is rising and the rivers have in consequence to excavate their way to the sea. Such river silt, or new alluvium, [illegible] is therefore confined to a narrow strip of what is known as

with the distance from the sea, probably owing to the overflow of the smaller tributary rivers, the waters in which are banked up by floods in the Irrawaddy and Sittang rivers. The Mon canal area was mentioned to us as one of the tracts in which it is comparatively high. In the Gangetic plain, on the other hand, river silt has been deposited for ages on a large scale over vast areas. The prevailing soil of the great cane growing tracts in that plain is, therefore, new alluvium. This is much less stiff in texture and much more tractable to work than the old alluvium of Lower Burma, on which the experiments carried out at the agricultural station at Hmawbi have shown that cane cannot be profitably grown, although it is a soil which gives very high yields of rice. Whilst the predominance of this soil in Lower Burma is undoubtedly a handicap to the extension of cane cultivation, and, even if all other conditions were favourable, would prevent Burma from becoming as important a cane growing tract as the Gangetic plain, it has to be remembered that, though the proportion of new alluvium is not high, yet in the aggregate the extent of soil suitable for cane must be considerable, especially as the new alluvium is not the only soil on which cane can be successfully grown. Running through the old alluvial plains are various ridges and ranges of hills such as the Pegu Yomas. These consist of Tertiary rocks with a covering of sand and sometimes an apron of laterite abutting into the flat alluvium which surrounds them. Although the soil based on the Tertiary rocks is usually poor, which limits the possibilities of cane cultivation on it, in the neighbourhood of Pyinmana it is a deep, open, sandy loam, rich in humus, which chemical analysis has shown to be one of the richest soils of the Province. The area of cane in Burma north of Meiktila is not more than 900 acres and there has, in consequence, been no examination of the soils from the point of view of cane cultivation. It may, however, be mentioned that the whole of the tracts under the Mandalay and Shwebo canals, which irrigate about 264,000 acres, consist of stiff impervious clay soils on which cane can only be grown with difficulty.

We recommend below that, as a preliminary to any development of the sugar industry in Burma, an agricultural survey should be made with a view to the discovery of suitable localities for cane cultivation. It will be evident from the description of the soils of the Province which has been given above that a soil survey must from an essential part of such a survey.

147. The average area of Burma, excluding Native States, during the five years ending 1918-19 was 109,465,761 acres. The net area actually cropped during the same period averaged 14,534,491 acres of which 18,253 acres only were under cane. Even this represented an appreciable advance on the figures of the previous quinquennium, when the area under cane averaged only 13,735 acres. The percentage of the area under cane to the net area cropped for the quinquennium ending 1918-19 was 0.12 and to the total area under cane in India 0.7. No figures showing the average outturn of gur are available.

Statistical.

148. There has so far been no scientific classification of the canes of Burma, but the need for such a classification has not been great, as the varieties grown are few in number. The indigenous canes of India proper are almost entirely absent, the reason being, in Dr. Barber's opinion, the unimportance of cane cultivation and the absence of land communications with India. A reed-like variety is grown on a small scale for medicinal purposes,* mainly in the Thaton district, and varies in colour from brown, when it is known as Kyannyo, to

Varieties of cane.

black, when its vernacular name is Kyannet. Kaing Kyan, or elephant-grass cane, a tall, thin, white variety, is also found in the Thaton district, its chief use being to act as a sheltering hedge to Bilin cane. Of the medium canes the most important are the Bilin cane just mentioned and the Pyinmana Red. The Bilin cane, also known as Shan cane, which is the only variety grown on a large scale in the Thaton district, has short internodes but a very soft rind and is, therefore, easily crushed in the wooden mills in use in the tract. It lodges badly and it is owing to this weakness that a protective hedge of elephant-grass cane is frequently grown round it. The Pyinmana Red cane, also known as Burmese cane, the vernacular name of which is Kyanni, is a hard and brittle cane of erect habit with short internodes. It suffers much less from drought than any other of the medium or thick varieties grown in Burma and for this reason is chiefly found in the Yamethin and Kyaukse districts. The only other medium cane is Moulmein cane which, as its name implies, is found chiefly in the neighbourhood of Moulmein. Dr. Barber regards this as a member of the great Pansahi group and says that it is so like Uba from Natal that the two cannot be distinguished in the field. He thinks it probable that it is a migrant from Bihar. The only cane grown in Burma which, in Dr. Barber's opinion, shows all the characteristics of tropical canes, and would, therefore, in India proper fall in the Paunda class, is Toungoo cane, a soft, yellow cane of erect habit which is found both in Pyinmana and in the Lower Burma districts of heavy rainfall. Another variety of thick cane which is found on a very small scale in the Amherst district is known as Moulmein Elephant cane.

149. The combination of shortage of staff with an insignificant area under cane has resulted in very little work being done on that crop in Burma. The Agricultural Department has hitherto had no farm organised in such a way as to permit of systematic experiments with it ; and such work as has been done has, in consequence, been somewhat desultory and can hardly be said to have led to any definite results beyond establishing that cane is not a profitable crop when grown on old alluvium. Indigenous and exotic varieties as well as seedlings from Coimbatore have been grown on most of the departmental farms in the Province, but the tests have not yet resulted in any conclusions as to the comparative merits of the different varieties. Mention should be made of the excellent yields which have been obtained on the sub-station at Hopin in the Myitkyina district, small plots of Mauritius and Gillman varieties having recently returned at the rate of 40 tons of cane and 4 tons of gur to the acre. The experiments on the small station at Pwinbyu in the Mon canal tract which were commenced in 1913-14 have proved a disappointment, as, owing to want of staff, the poverty of the colonists and the difficulty in getting irrigation water in the hot season, they have not led to any expansion of cane cultivation in the tract.

History of work on sugarcane.

150. Although the implements in use for the cultivation of cane in Burma are of a primitive character and little attention is paid to the question of suitable rotations, cultivation may, on the whole, be considered fairly good, especially in the Pyinmana tract. In the Thaton district cane is usually grown only in alternate years, the land lying fallow in the interval. Elsewhere in Lower Burma cane follows rice. In Upper Burma the most usual practice is to allow the land to lie fallow after the cane harvest until June when a crop of sesamum is sown. This is harvested in October and cane is again planted in December or January.

Agricultural practice.

In Upper Burma and on the new alluvial soil of Lower Burma cane is [illegible] from December to February except in the Bilin tract where the porous

soil will not retain moisture and the crop has therefore to be planted in September to give it the benefit of the end of the monsoon. For the same reason planting in September or October is the usual practice on the sandy soils of the ridges and ranges of hills which cross the alluvial plains. As a rule the top or the whole upper part of the cane is used for planting and, as cane in the Bilin tract is not harvested till November and planting is done in September, this means that a part of the crop must be cut two months before harvest time, and planted while it is still green. The number of sets planted per acre varies from 6,000 in the Pyinmana tract to 12,000 in the Thaton district. Sets of which the buds are damaged or which show signs of red rot are discarded.

The land is everywhere ploughed and harrowed before cane is planted. Except in the Pyinmana tract, planting is done is treaches from 4 to 8 inches deep. The distance between the trenches varies from 2 or 2½ feet in the Thaton district to 4 feet in the Kyaukse district. In Lower Burma the sets are laid lengthwise in the furrows about 6 inches apart. In Upper Burma, except in the Pyinmana tract, they are generally planted in a sloping position. In the Pyinmana tract they are planted upright in holes which are 6 inches square by one foot deep and are 6 inches apart. These holes are made in parallel rows, the distance between the rows being from 4 to 4½ feet. Two sets are planted in each hole. After-cultivation consists of banking up earth round the growing plant and in weeding or hoeing. This is done thoroughly in the Pyinmana tract alone and elsewhere the land gets very dirty by harvest time. The principal defect of the cultivation in Pyinmana is that insufficient attention is paid to drainage. The banking up of earth round the growing plants results in the formation of high ridges, while the spaces between form furrows which, as a rule, run parallel to the slope of the ground. Drains are not, however, constructed at the ends of the fields and in consequence sets frequently fail to germinate there owing to water-logging. With the exception of the small areas in the Kyaukse district and in the Mon canal tract, cane in Burma is grown without irrigation. In the Kyaukse district the land is given one irrigation before planting and three subsequently. The Mon canal was designed for the irrigation of paddy and the difficulty of getting water before July has proved a bar to the extension of cane. Cattle manure is practically the only manure applied, though crushed sesamum cake is occasionally used in the Thaton district, where the soil is also enriched by the annual deposit of river silt. In Upper Burma, where a crop of sesamum usually precedes cane, the manure is applied before the sesamum crop is planted, so that cane merely gets the residual effect. Cane trash is sometimes left on the ground and ploughed in. Ratooning is rare.

As already mentioned, cane is planted either in September and October or between December and February. In both cases it is harvested between November and January, so that it is on the ground from 10 to 15 months.

Prospects of extension.

151. If cane is at present an insignificant crop in Assam, and yet offers prospects of great development on a plantation scale, it is a still more insignificant crop in Burma and offers prospects of still greater development. Dr. Barber, who did not visit Burma till shortly before he left India, found that there were large areas in Upper, Middle and Lower Burma where thick canes could be quite easily grown and considered that, in view of the great extent of land available for the growth of sugarcane, there was no part of India which could for a moment compare with Burma as a possible area for the installation of sugar-making factories. Without definitely endorsing this view in the extreme form in which it is expressed, we are in full agreement with Dr. Barber's main contention that

Burma offers exceptional prospects for the establishment of a sugar industry on a large scale. The climate is nearly everywhere favourable, and, though the occurrence of suitable soils is more restricted, they undoubtedly exist over large areas. Thick canes are already the usual kind grown; and in the Toungoo Yellow variety the Province possesses, in our opinion, the finest indigenous cane we have seen in India. Again, although the lands classed as culturable waste bear a smaller proportion to the total area of the Province in Burma than in Assam, they cover nearly twice the extent in actual acreage. The Province is, it is true, notoriously backward in the development of its communications, but we understand that, as a result of the large profits accruing from the recent Government control of rice exports, a great advance may confidently be looked for in the near future; and we doubt whether the opening of new roads and railways in most parts of Burma will be so difficult or costly an undertaking as in Assam. Finally, while the policy of the Local Government, as laid down in the Burma Land Revenue Directions (Nos. 19 and 20), is opposed to the introduction of a landlord class and prescribes as a general rule the rejection of applications by capitalists for the grant or lease of large areas of land, it specifically recognises the need for a relaxation of this principle in favour of applicants whose intention is to cultivate special staples, not by letting the land to tenants, but under their own immediate supervision. Fairly large grants for the cultivation of rubber have already been made in the Tenasserim division; and special steps were taken two or three years ago to encourage the opening up of large rubber estates by capitalists, the more important of which, we are glad to observe, are precisely on the lines we have to recommend for the encouragement of sugar estates. We have every hope, therefore, that our recommendations will be sympathetically received.

Need for a local survey.

152. In the first place we recommend the appointment of a committee of three to conduct an agricultural and soil survey of all localities which appear to offer an opening for the establishment of a sugar industry on a factory scale. It is not necessary to repeat here what we have already said in paragraph 140 of our Chapter on Assam regarding the constitution of the committee and the scope of its enquiries; the less so because the rubber survey in Burma was conducted on approximately identical lines; and, though it was eventually found necessary to entrust it to a single officer, the original proposal was that it should be carried out by a committee constituted similarly to the committee we have in view, with the substitution of a Forest Officer for an Agricultural Officer. It might, indeed, be advisable for the cane survey committtee to co-opt a Forest Officer as a fourth member in areas where any question of the relinquishment of reserved forests for cane cultivation arose. Nor is any recommendation required from us to ensure that large grants made for the cultivation of cane shall be developed for that purpose at a specified rate, and shall not be alienated by the grantee without the sanction of Government, as provision already exists to this effect in the revenue rules of the Province. The existing rules regarding initial exemption from assessment to land revenue in the case of newly reclaimed lands and lands granted for the cultivation of certain special crops, with privileged rates on a sliding scale thereafter, also appear to us quite reasonable and merely require to be specifically extended to sugarcane. The only suggestions that we have to make, therefore, are that of the two main forms recognised of devolving rights in land—grant and lease—the former, which is in perpetuity, is preferable to the latter, which is normally restricted to a period of thirty years and that, in fixing the rate at and extent to which the area granted shall be brought under cane, allowance should be made, not only

for land unsuitable for cane cultivation, but for the fact that cane must be grown in an appropriate rotation, and that, since in most localities labour will have to be imported, provision will probably have to be made, as it is in Assam, for the allotment of home plots to the field labourers for the cultivation of food crops. The question of revising the present crop-rate of assessment on sugarcane is one that more immediately affects the small grower, and we, therefore, deal with it in paragraph 156 below.

Development of research work on cane.

153. It is hardly surprising that practically no effective work has yet been done on sugarcane in Burma by the local Agricultural Department, when the insignificant position hitherto held by cane among the staple crops of the Province and the extremely small staff that has been available are considered. Burma is the largest Province in India, yet none, except the North-West Frontier Province, possesses a smaller district agricultural staff. There are only two Deputy Directors actually at work in Burma, although the number of such posts sanctioned was, until recently, four. Fortunately, however, the Province has been fully alive to its own deficiencies, and it is a great encouragement to us in making our recommendations that a comprehensive scheme of departmental expansion has now been sanctioned by the Secretary of State which contemplates the increase in the number of Deputy Directors' Circles from four to eleven and the recruitment of the officers for them at the rate of two a year. As this scheme materialises, it will be possible to take up a considered programme of research work on cane. Here, as elsewhere, we think it will be found advisable to open separate research stations for cane, and not merely to devote a part of the experimental or demonstration farms of each Circle to it. The number and location of these stations, which should not be less than 200 acres each in extent, would be decided on the advice of the cane survey committee we have proposed above, for it is hardly open to doubt that it is in so far as a sugar factory industry is successfully built up that cane will establish its importance as a commercial crop in Burma. The committee would no doubt consider the suitability of sites in the Bilin township of the Thaton district, in the Pyinmana sub-division of the Yamethin district and in the Namyin valley of the Myitkyina district, all of which we are provisionally inclined to regard as likely areas for the purpose in view, and the local conditions of which are widely divergent. The Mon canal area, which some of our members visited in the course of our Burma tour, may, we think, be finally left out of account. Whatever the prospects may have been as long ago as 1911, when a scheme for the establishment of a sugar factory in that area was first mooted, they are hardly favourable now, when the canal has been completed in accordance with a design for the irrigation of paddy and water is only supplied from July to November. In the last year for which figures are available (1918-19) nearly 56,000 acres of paddy were grown on the less than 60,000 acres actually irrigated by the canal, and the bulk of the commanded area has now been taken up by small colonists of very limited means who have so far evinced great reluctance to grow cane at all. The provision of permanent means of communication between this area and the Irrawaddy, moreover, which is vital to the success of a sugar factory in the neighbourhood, is a matter of peculiar difficulty owing to the vagaries of the river in this part of its course, and the heavy floods to which the intervening stretch of land is liable. Unless, therefore, the means of irrigation in this tract are largely extended, we consider that the possibilities of cane cultivation are now too doubtful and too limited for further consideration. Another small matter that might be referred to the cane survey committee is the location of the sites for the stations which the Province will require for the supply of its hill sets (*vide* paragraph 22 of Chapter II above). These are easy to establish and very inexpensive, and should in time,

as the demand for hill sets develops, show a clear profit on their operations. We trust, therefore, that the Local Government will be prepared to open some three or more of these stations to meet the needs of different parts of the Province, for it is neither safe nor economical to carry sets over very great distances.

Superior control.

154. In view of the paramount importance of chemical control in all research work on sugarcane, we should have liked to recommend that all cane research stations in Burma should be placed under the control of an Agricultural Chemist. The cadre of the local Agricultural Department, however, includes only one such post and no provision has been made for another in the recently sanctioned scheme of expansion. The present Agricultural Chemist will also be Professor of Chemistry in the Agricultural College now under construction at Mandalay and it is clearly out of the question to make him responsible for the control and direction of all cane research work in the Province. Yet the possibilities and prospects of early development are so great that no time should be lost in opening these cane research stations as soon as sites have been selected for them. Pending the establishment of the Sugar Research Institute we recommend in Chapter XXIII below, therefore, it will be necessary for the Deputy Directors of Agriculture to superintend the work at the stations in their respective Circles. Cane is, however, so comparatively unknown a crop in Burma that the Local Government would, we think, be well advised to require the Deputy Directors under whose control these stations are opened to visit at least one of the cane research stations in Provinces where work on cane is most advanced, namely the United Provinces, Assam and Bombay. Of these stations, Jorhat and Manjri are working under conditions which approximate more nearly to those of Burma. We make this suggestion, however, with a view to the assimilation rather of the broad principles of cane research work, such as methods of control, the order in which various lines of work should be undertaken, the most suitable areas for field trials and the like, than of such details as the local adaptability of particular varieties or agricultural methods, and, for the former purpose, we consider that a visit to Shahjahanpur would be in no way less instructive than a visit to either of the other two stations. On the establishment of the Sugar Research Institute, the cane research stations in Burma would, of course, be taken under Imperial control and a whole-time officer would be placed in charge of them. As in Assam, particularly urgent and important lines of work will be the evolution of the best cane rotation for large estates to adopt and the discovery of a cane that will ratoon freely, and thus economise labour. We have already expressed in our Chapter on Assam our views regarding the obligations of Government to lose no time in providing adequate means of communication in newly exploited areas and to assist the management of plantations and factories in safeguarding the health of their labour, and it is not necessary to repeat them here.

Improvements in ryots' cultivation.

155. Although we have in this Chapter reversed the order we have hitherto followed, and dealt first with the question of cane cultivation on a plantation scale, because we regard this as obviously the main line of advance in Burma, we have no desire to ignore the possibilities of improvement and extension of the cultivation of cane on small holdings. The prospects of improvement in this direction may be limited, but within their limits we regard them as distinctly bright. The best of the cane-growers in Burma have already proved themselves capable of raising surprisingly good crops, considering the primitive implements they have at their disposal. The absence of caste and purdah restrictions among the Burmans and their natural tolerance and sociability have rendered possible an

unusual degree of intimacy between them and the authorities , and the high percentage of literacy in the Province and the encouraging response which has been evoked in some districts to the propaganda of the Agricultural and Co-operative Departments indicate that Burma is a promising field for improvement. Both on the cane research stations, therefore, and on the ordinary experimental farms of the agricultural Circles room should be found for the solution of the ryot's problems and the meeting of his needs. The best methods (within his capacity to adopt them) of preparation of the land, of selecting sets, of spacing the rows for planting and of planting the sets in the rows, of manuring, of drainage and of after-cultivation should all be worked out and then actively demonstrated, while the varieties of cane which will best respond to these methods should be ascertained and multiplied. Already the Toungoo Yellow variety has established its superiority on well-drained soils with adequate rainfall and Pyinmana Red its suitability in less favourable areas where the rainfall is more precarious Pure line cultures of these varieties should be made and multiplied on Government seed farms.

Land revenue assessment on cane.

156. Another method by which Government might directly encourage the cultivation of cane by small holders is by the reduction of the present rates of assessment to land revenue. While the main system of assessment in Burma is an acre rate varying according to the classification of the soil with reference both to fertility and situation, in certain cases a crop-rate is levied on the land, that is, still a rate of so much per acre, but the rate itself is fixed according to the particular crop grown. Cane is one of the crops to which this system applies ; and the rate is now fixed almost uniformly in all districts at Rs. 10 per acre. This, we were informed, is more or less a conventional rate, the insignificance of the area under cane in each district not having warranted its reconsideration. It is distinctly higher than the prevailing rates for un-irrigated rice-lands, which in most districts vary between Rs. 2 and Rs. 4 per acre and nowhere exceed Rs. 6. It is true that the profits on cane should be so appreciably greater than the profits on rice that by any comparative test the existing rate for cane might be fully justified, but we have had several representations made to us that it is regarded as a hardship ; and, if the encouragement of cane cultivation is desired, it is more important to recognise that this feeling is entertained than to consider whether it is really well grounded. The simplest step would be to exclude cane from the crop-rate system altogether and to leave each field on which a cane crop is raised to bear the assessment attached to the class in which it was included at the last land revenue settlement, and the loss of present revenue involved would be very small. Should, however, our hopes of the development of cane cultivation in Burma materialise, the loss of prospective revenue might be appreciable, nor is it necessary for the purpose of popularising cane-growing that a light assessment should be permanently imposed. Moreover, we would ourselves advocate a specially low rate on a ratoon crop of cane with a view to the spread of the practice of ratooning and this necessitates the retention of the crop-rate in any event. On the whole, therefore, we would prefer the alternative of a general, but temporary, reduction in the crop-rate from Rs. 10 to the prevailing rate in the neighbourhood on first class paddy land in the case of a plant crop and on second class paddy land in the case of a ratoon crop. The reduction might be sanctioned in each district for the remaining period of the current land revenue settlement, and be reconsidered as each settlement came under revision, the criterion for the reimposition of a specially high rate for cane being the extent to which cane had established itself in the locality as a particularly profitable crop. These proposals do not of course

ffect large estates taken up for the purpose of cane cultivation on a factory cale, the rates of assessment applicable to which will in each case have been xed in the original instrument of grant or lease.

As will be seen from Section X of his Supplementary Note, Mr. Padshah ssents from the recommendations made in this paragraph ; but we are bound o point out that his main contentions are based on experience derived from ther Provinces and have a very limited application to Burma and that his roposal to assess land according to the value of the most remunerative crop will grow is a direct discouragement of the all-important agricultural practice f rotation.

Summary of Conclusions and Recommendations.

(1) It is solely from the point of view of possible future developments that urma is important as a cane-growing country

(2) The old alluvial soil of Lower Burma is unsuitable for cane, and its redominance prevents Burma from becoming as important a cane tract as the angetic plain.

(3) Nevertheless, the occurrence of other more suitable soils is in the ggregate extensive and the abundant rainfall in many districts and the absence f extreme temperatures render the climate generally favourable.

(4) These features, and the facts that excellent thick canes are already own wihout irrigation, that there are vast areas of culturable waste land, and at the Local Government already recognises the need for capitalist grants in e case of special staples are highly favourable to the development of sugar ltivation on a plantation scale.

(5) A committee of three should be appointed to conduct an agricultural d soil survey of likely areas for this purpose.

(6) The existing rules for initial exemption from land revenue and a scale privileged rates of assessment thereafter on certain special crops should be plied to cane.

(7) Grants are preferable to leases, and allowance should be made for tations and home plots for field labourers in fixing the rate at and extent to hich the concession should be brought under cane.

(8) Separate research stations specially for cane will be required and that oposed survey committee should advise regarding the number and location of em, as well as of the stations for the supply of hill sets.

(9) Bilin, Pyinmana and the Namyin Valley are likely areas for the location research stations, but the Mon canal tract should be finally rejected as suitable.

(10) These stations should be opened without delay and placed initially under e Deputy Directors of Agriculture of the respective Circles, who should be quired to visit at least one of the main cane research stations in the United ovinces, Assam and Bombay.

(11) On the creation of the Sugar Research Institute the cane research work should be concentrated under a single whole-time officer.

(12) Important lines of work in the interests of large estates are the evolution of the best commercial rotations and the discovery of a good ratooning cane.

(13) There are good prospects of improving the small grower's cane cultivation.

(14) These improvements should be worked out both on the cane research stations and on the ordinary Circle farms.

(15) Pure line cultures of the Toungoo Yellow and Pyinmana Red varieties should be made and multiplied for distribution

(16) With a view to popularising cane cultivation among small growers it is suggested that the present rate of assessment on cane might be temporarily reduced, a specially low rate being fixed for a ratoon crop.

CHAPTER X.

MADRAS.

157. The Madras Presidency lies between 8° 4′ and 20° 26′ N. and is thus entirely within the tropics. Although nowhere in India are the climatic conditions more favourable for the successful cultivation of cane than they are on irrigated land in Madras, the area under that crop in the Province is both small and scattered. Its total area is less than in either the Gorakhpur or Meerut district of the United Provinces, despite the fact that cane is grown in every district. The only districts which normally return an area of 10,000 acres or more are Vizagapatam and Godavari in the north and Chittoor in the centre. As a result of the configuration of the Province, which consists of a narrow strip of land between the Western Ghats and the Indian Ocean, a broader strip between the Eastern Ghats and the Bay of Bengal and an elevated tract lying midway between the two, cane is perhaps grown under a greater variety of conditions than in any other Province in India. The two west coast districts of Malabar and South Kanara enjoy a heavy and unfailing rainfall of over 100 inches. Bellary, on the other hand, the driest district in the Presidency, has an average rainfall of only 22.54 inches. Whilst all districts get rain during both monsoon seasons, that of the south-west monsoon which lasts from June 1st to September 30th and that of the north-east monsoon which lasts from October to December, the bulk of the rain except in the south is received during the south-west monsoon. In the south the position is reversed, Tinnevelly getting only 3.17 inches of rain in the south-west monsoon months, or nearly 4 inches less than in the non-monsoon months, January to May, and 16.57 inches from the north-east monsoon. Except in Malabar and South Kanara, cane is very rarely grown in Madras without irrigation. It is therefore grown either on " wet " land, that is, land irrigated from a Government source of irrigation such as a canal or tank, or on " garden " land, that is, land irrigated by a well. " Wet " soils are chiefly formed of the mixed alluvium washed from the hills and uplands. " Garden " land is not only naturally fertile owing to its position but has been laboriously improved by tillage and manure.

Climate and soil.

158. The average area of the Madras Presidency, excluding Native States, during the five years ending 1918-19 was 89,581,077 acres. The net area actually cropped during the same period averaged 33,856,889 acres of which 106,801 acres were under sugarcane. The percentage of the area under cane to the net area cropped was 0.3 and to the total area under cane in India 3.9. The average yield of gur for the quinquennium was returned at 2.32 tons per acre, an outturn which was only exceeded by Bombay.

Statistical.

159. In Dr. Barber's opinion, the Madras Presidency has only one indigenous cane, Naanal, a white cane which is grown in the south of the Province. It belongs to the Sunnabile group and is, therefore, a member of the same family as

Varieties of cane.

Dhaulu and Tereru of the Punjab, Rakhra of the United Provinces and Mojorah of Assam. Naanal is, however, considerably thicker than the first three of these, but is thinner than Mojorah. Hullu Kabbu, which is grown in the Bellary district, belongs to the Saretha group and is considered by Dr. Barber to be possibly a migrant from Bombay. It is, however, much thicker than any other member of the Saretha family and, like Naanal, may be regarded as a medium cane. Both Naanal and Hullu Kabbu furnish evidence that the thickness of canes of the same family varies with the locality in which they are grown. The remaining canes of the Province are thick canes which have been introduced at various periods. The number of varieties is so large that it is impossible to give a detailed description of them. Most of them have been in the country a very long time and have greatly degenerated. The varieties which are specially mentioned by Dr. Barber as showing marked deterioration are Yerra Valu, Mogali, Poohen or Peovan, Namalu, Rastali, Kaludai Boothan, Chittan, Bonta, and Palabonta. Bonta, a dwarf cane which is grown on a fairly large scale in the northern districts, was in fact described to us as a thin cane. Vellai, on the other hand, which was introduced some eighty years ago, is still a good cane. Dr. Barber considers that Poohen or Poovan, Keli and the cane grown as a mixture with Hullu Kabbu in the neighbourhood of Hospet in the Bellary district which has no special name, (being merely known as Javari or indigenous cane), are all probably identical with Paunda canes. The work of the Agricultural Department in Madras which is described in the following paragraph has resulted in the replacement to a large extent of the local canes by Mauritius varieties.

History of work on sugarcane.

160. At the end of the last century, Namalu and Keli, the two varieties then most largely grown in the Godavari delta, were severely attacked by red rot. The diminution in the area under cane which resulted was so serious as to threaten the sugar industry of that part of the Province with extinction; and an agricultural station was therefore established at Samalkota in the Godavari district in order to deal with the problem. The work done on that farm, as just mentioned, speedily led to the replacement of the local canes by Mauritius varieties. The situation may be said to have been saved by the introduction of Red Mauritius, a hardy variety but comparatively poor in sucrose, which was obtained from Bombay. Other Mauritius varieties were obtained from Vizianagram in the Vizagapatam district, where a collection of Mauritius canes had been grown for some years by the late Mr. H. F. W. Gillman, C.S.I., when Trustee of the Vizianagram Zamindari. Red Mauritius and Striped Mauritius spread very rapidly in the Godavari delta, but the latter succumbed to disease after a few years. Red Mauritius has also deteriorated and Purple Mauritius is now the favourite cane in the tract, though a red sport of Striped Mauritius known as the Gillman Sport has been very successful on small areas. B.-3412, B.-6450, B.-208 and J.-247, the correct name for which is 247-B., are also grown to some extent. 247-B. has proved a very suitable cane for deltaic conditions, though its hard rind, which makes it somewhat difficult to crush, and the fact that it is comparatively low in sucrose militate against its popularity. B.-3412 and B.-6450 give heavy yields and gur of excellent quality, but the cost of cultivation of the former is high, as it is a tall cane which requires stronger props than other varieties. B.-208 also gives good gur, but in Madras it is a dwarf cane and is not therefore a heavy yielder. As regards other cane growing tracts, Red Mauritius is still the cane principally grown in South Arcot, although Fiji B. is spreading as the result of the work done by the East India Distilleries and Sugar Factories Company on their leased lands at Nellikuppam. Red Mauritius, the first cane introduced by the Agricultural Department in Malabar

and South Kanara, where cane cultivation has increased appreciably in recent years, is still the favourite variety. In addition to the work at Samalkota, work on cane has been carried on at Anakapalle in the Vizagapatam district, Palur in the South Arcot district, Taliparamba in the Malabar district and Coimbatore. Apart from the varietal tests, the most important result of this has been to show that the practice of planting cane in lines effects a very marked reduction in the number of sets required for planting. The experiments at Samalkota to test whether the local practice of propping and wrapping canes is worth the extra expenditure it involves have not so far given any conclusive results. The work at the Coimbatore cane breeding station, which was established in 1912-13, is Imperial rather than provincial in character and is described at length in Chapter XXIV. Seedlings from the station were first tried on the provincial agricultural stations in 1918-19, and the opinion pronounced on them was distinctly favourable.

Agricultural practice.

161. The scattered nature of the cane cultivation in Madras and the diversity in the local conditions under which it is grown make it almost impossible to give a brief and at the same time accurate description of the agricultural practice of the Province. Almost everywhere cane is usually rotated with rice on wet lands, though the appearances of cane in the rotation vary greatly in the different districts. In the Bellary and Kurnool districts a rice crop usually breaks a sequence of cane crops every third or fourth year. In the Godavari delta, on the other hand, it is cane which breaks a sequence of rice crops every fourth or fifth year. In other tracts the practice varies between these two extremes, and cane follows rice either every alternate year or once in three years. Ratooning is not common except under the big Cumbum tank in the Kurnool district, where as many as four to six ratoon crops are sometimes taken. Elsewhere, when cane follows cane for a series of years, it is planted afresh every year. *Ragi* (*Eleusine coracana*) is sometimes rotated with cane on wet lands, especially where irrigation facilities are not satisfactory, and is the crop most usually rotated with it on garden lands, though groundnuts or *kumbu* (*Pennisetum typhoideum*) often take its place.

Whatever the crop which precedes cane, ploughing, as a rule, commences immediately after harvest, that is, usually in November or December. The number of ploughings varies greatly in different districts and is said to depend to a large extent on the means of the individual cultivator. The minimum number reported is three in the Bellary district, where a big plough is used to which five or six pairs of bullocks are attached for the first ploughing, four for the second and three for the third. The clods are then broken by a big harrow which also levels the field. Elsewhere the ordinary country plough is used, the mst usual number of ploughings being 10 to 20, though in the North Arcot district it is as high as 30 to 40. In the Godavari delta a rice crop of short duration is sown before cane. This is harvested at the end of October and is followed by a pulse crop or by sann hemp. The land is then worked over with a crowbar in January or February, the crowbar being preferred to the plough as it works the land to a greater depth and removes deep rooted weeds such as *hariali* (*Cynodon dactylon*) and *nuth* (or spear) grass which prove very troublesome in land which is ploughed. Wet land is also prepared for cane by means of crowbars in the South Arcot district. The ridge and furrow system of planting is common except in the Godavari district and parts of the Ganjam and Vizagapatam districts, the distance between the furrows varying from one foot to 2½ feet according to the number of sets used. In the Godavari district, after the fields have been flooded, the sets are sown broadcast and are then

crampled in flush with the ground. In Ganjam a system of raising cane from plants grown in nurseries is almost universal and in Vizagapatam is very common. Under this system there are three stages. The first seed bed is planted in July, the number of sets used being said to be at the rate of some 600,000 to the acre. After two or three months the sets from this bed are transplanted to the second seed bed which supplies the sets used for the regular crop. Where this system is adopted, the cultivator crushes all his own cane and buys his sets from the nurseries. In the Godavari delta the cultivators show an increasing preference for sets obtained from the upland parts of the Peddapuram taluk of the district. With these exceptions cane is usually grown from sets obtained from the cultivators' own previous crops. The use of sets obtained from the whole cane would appear far more common in Madras than that of tops, though the Nandyal valley in the Kurnool district and the South Arcot district are mentioned as tracts in which tops are planted. The number of sets planted to the acre varies greatly. The lowest rate given us was 7,500 to 12,000 for the Bellary district, whilst in Ganjam it is said to be as high as 50,000. In the Godavari delta it varies from 20,000 to 30,000.

After cultivation consists of weeding and hoeing. Throughout the Province care is taken to keep the land free from weeds. Except in parts of the Godavari delta, where weeding is done entirely by hand, the usual number of hoeings is three or four. The first watering is usually given from three to twelve days after the sets are planted, though in the Godavari delta it is often delayed for three weeks. The number of waterings varies according to the nature of the soil and the irrigation facilities. In North Arcot, for example, where for eight months in the year cane depends upon well irrigation, waterings are given every week, and in the Coimbatore district the number is as high as fifty. Cattle manure is the most usual manure, but in Godavari its place is taken by castor cake. About twenty maunds (1,646 lbs.) of this are applied in June and July, the cake being placed in small pits at a distance of six to nine inches from the young plants. The use of castor cake is also spreading in the Ganjam, Vizagapatam and South Arcot districts. In all the districts just mentioned *pongam* (*Pongamia glabra*), *neem* (*Melia azadirachta*), gingelly (*Sesamum indicum*) or groundnut cake is occasionally substituted for castor cake. Indigo seeth is also used as manure when available and sheep-penning is not uncommon.

The practice of wrapping cane is far more common in Madras than it is elsewhere. It has reached its greatest development in the Godavari district where abundant irrigation and rich soil coupled with forcing heat cause the canes to grow to a great height, and where violent cyclonic storms during the growing season often cause severe damage to the crop. Dr. Barber mentions a field in this district in which the average height of the cane was 25 feet, and we ourselves saw fields in which the cane was well over 20 feet high. The method of wrapping adopted is as follows. Several of the older but still firmly adhering leaves of the cane are twisted to form a band with which it is tied to its neighbours while still quite small. In a well grown field as many as seven successive wrappings are done, the last two or three being carried out from the tops of tall three-legged stools. The operation at this stage is very expensive on account of its comparative slowness. Even this is not the whole process. The bunches of cane shoots thus brought together are fastened to upright bamboos sunk in the ground. These bamboos are of three sizes. At first small thin bamboos support the canes of a single clump. Later on larger and thicker bamboos bring several clumps together and, ultimately, tall thick bamboos complete the work and unite several full grown clumps. The bamboos last

for several years and are carefully stacked at harvest time, but the practice adds very appreciably to the cost of cultivation. On the basis of data obtained on the Samalkota farm, Dr. Barber estimates the cost of wrapping a fairly good crop at Rs. 37-12-0 per acre in addition to an expenditure on bamboos of Rs. 100 per acre for a freshly started plantation and a recurring charge of about Rs. 20 per acre for replacements. Nowhere else in Madras is wrapping as elaborate as in the Godavari delta. In the Bellary and Kurnool districts, except in the Nandyal valley, it is not practised at all.

The most usual time for planting cane in Madras is March and April, though in Bellary, Ganjam and the upland tracts of Godavari planting is delayed till May and June. Whether planted in March or June, cane is harvested in February and March and is thus on the ground for ten to twelve months. The Coimbatore district has a second planting season which lasts from July to September, and the cane planted during this period is on the ground for fifteen months.

Prospects of extension.

(*a*) *The present position.*

162. We must frankly confess to a feeling of disappointment that, in the only major Province in India which lies entirely within the tropics, the prospects of any appreciable extension of cane cultivation cannot be regarded as at all hopeful. The area under cane in Madras has responded to some extent to the stimulus of high prices but the effects of that stimulus appear to be wearing off. In 1914-15 Madras had 74,000 acres under cane. By 1918-19 the acreage had increased to 123,000 acres, but in 1919-20 it fell to less than 93,000. The fall was attributed to shortage of water at the planting season owing to the abnormally low rainfall in 1918. The high price of oil cakes and the deficiency of indigo refuse were also ascribed as subsidiary causes. Although it might appear from this that an extension of cane cultivation in Madras is largely a matter of the extension of irrigation facilities, that inference is, in reality, not justified. The area under cane does not expand to any great extent even when prices are high because, where water is available, the cultivator prefers to use it for other crops, and especially for rice. The extent of his preference for rice can be gauged by a few statistics. In 1919-20 the total area irrigated from all irrigation sources in the Province—canals, tanks, wells and other sources—was a little over ten million acres. Of this total rice accounted for more than 8½ million acres, or some 85 per cent. ; whereas cane only claimed 78,631 acres, or 0.8 per cent. On the more important irrigation systems the disproportion is even more pronounced. The total area irrigated by Class I and Class II Works, (that is, " Major Productive and Protective Works " and " Minor Works for which capital and revenue accounts are kept ") in 1918-19, the latest year for which statistics are available, was 3,909,000 acres ; and of this 3,441,000 acres were under rice (86.7 per cent.), as compared with 11,081 acres under sugarcane (0.3 per cent.). Of this meagre area more than half was contributed by the Godavari delta system, namely, 6,262 acres; but, as this is the largest irrigation work in Madras, even here the proportion of cane was no more than 0.6 per cent. of the total area irrigated, namely, 1,064,000 acres. On the other two great systems cane may be said practically not to exist, the Kistna delta system in the same year returning only 47 acres out of 724,000 irrigated and the Cauvery delta system only 673 acres out of 925,000 irrigated. It is obvious from these figures that the bulk of the cane grown in Madras is grown either under " Minor Works for which capital and revenue accounts are not kept," such as river channels and small tanks, or under wells and other sources of private supply. In other words, where the cultivator is assured of a regular and abundant supply of water, he generally uses it for rice and hardly ever thinks of devoting it to cane.

163. The main reason given us for the preference shown by the cultivator for rice is the absolute certainty of the crop and the ease with which it can be grown and marketed. Light would have been thrown on the question how far the preference is justified by the comparative costs of cultivation of rice and cane and of the profits obtained, had trustworthy statistics regarding these been forthcoming; but, in any case, conclusions drawn from such statistics would have been vitiated by the immense disparity in the areas under the two crops. Whatever the relative position of rice and cane which might be revealed by figures of costs and profits, there can be no question that there is no part of India, except possibly the Deccan canals tract of Bombay, in which cane can be grown with greater profit than in Madras. Another reason which was given us as militating against an extension of the area under cane in Madras was lack of capital. This, however, is a condition which is not peculiar to Madras, and seems a reason of doubtful validity when applied to the deltaic tracts where laffdholders are certainly not less prosperous than they are in the Bombay Deccan canals tract where cane is much the most popular crop.

(b) The difficulty of promoting cane in competition with rice.

The problem is, therefore, almost entirely an economic one. Now that red rot has practically disappeared from the Godavari delta as the result of the work of the Agricultural Department, the agricultural difficulties in the way of the extension of cane are small compared with those in most other parts of India; nor is there any evidence to show that irrigation difficulties form any bar to expansion. The ingrained preference of the cultivator in Madras for rice has thus to be recognised in any discussion of the prospects of cane in that Province. It has been recognised by the Madras Agricultural Department which has made no efforts to promote the cultivation of cane, but, as far as its other activities have permitted, has always been willing to give the cultivators all the assistance in its power. Its action saved the cane of the Godavari delta from extinction, and in more recent times, when the cultivators of the South Kanara district showed a desire to extend their cane area, its ability to give them a better cane than they were already growing led to marked extension of the cane area in the district. Whilst, as will be seen from what follows, we think that more might be done by the Agricultural Department to assist the cane cultivator, we cannot but admit that the policy of the Department has been the right one in the circumstances.

164. Our conclusion, therefore, is that any appreciable extension in the area under cane in Madras can only come about as the result of an extension of the factory system. Greater facilities in obtaining capital for cane cultivation from co-operative societies or the manures required for it at cheaper rates than prevail at present, the introduction of power crushing plants and improved furnaces, the formation of co-operative societies for selling gur, all matters with which we deal in detail in other Chapters, may lead to some expansion, but the process will be slow. The problem before the factory in Madras is entirely different from that which confronts it in Upper India. In Upper India the supplies of cane already exist. The question there is whether they can be obtained from a sufficiently concentrated area to enable a factory to work successfully. In Madras the factory will have to create its own supplies. In other words, there is little hope for a factory, unless it can obtain sufficient cane from land under its own control to make it almost independent of other sources of supply. There is thus no part of India to which our suggestions for the leasing of land are more applicable than they are to Madras. That the difficulties in securing such leases

(c) Expansion only possible through the central factory system.

are not insuperable has, in our opinion, been shown by what has been accomplished by the East India Distilleries and Sugar Factories Company at Nellikuppam in the South Arcot district. The Company started with 40 acres of leased land. It has now 1,800 acres. Its success has been very largely due to its realisation of the value of the oil engine for pumping purposes. The high rents charged for wet lands caused the factory to turn its attention to the large tracts of dry land in the neighbourhood of the factory which had previously yielded a comparatively poor return to their owners and which the introduction of the oil engine made it possible to irrigate. What has proved feasible at Nellikuppam should not be beyond attainment elsewhere in Madras. In the deltaic tracts, as in South Arcot, the high rents for wet lands would almost certainly render leases out of the question, but there are other parts of the Province where this obstacle would not be met. We have naturally not had the opportunity of making detailed investigations on this point, but the northern districts—Ganjam and Vizagapatam—appear to us to offer possibilities of successful imitation of the example set at Nellikuppam. We can do no more than point the way. It is for private enterprise to decide whether to travel along the road.

165. Whilst we have expressed our general approval of the policy which has been followed by the Madras Agricultural Department in regard to the expansion of the area under cane in the Presidency, we have stated that, in our view, more might be done to assist the cane cultivator. Madras, as we have said, has only one indigenous cane of no special merit; and the line of advance does not, therefore, lie in the introduction of pure lines of indigenous canes but in that of exotics. The work of the Department in this direction has been mainly confined to the Godavari delta. There experience has shown that red rot is an ever present danger, and the great essential is that the Agricultural Department should always have a cane ready to take the place of existing varieties which are attacked by this disease or show signs of deterioration owing to the water-logged conditions under which they are commonly grown. This necessity has been recognised in the work on the Samalkota farm; and the work on that farm has, in our opinion, been carried out on sound lines. Outside the Godavari delta little progress has been made in spreading improved varieties, except perhaps in South Arcot and South Kanara. The Ganjam and Vizagapatam districts, which between them have nearly one-third of the total area under cane in the Presidency and in which the comparatively poor varieties, Bontha and Keli, are almost the only ones grown, offer great scope for work of this character. The Bellary district, which has perhaps a more concentrated area under cane than any other district outside Godavari, is another promising field of activity.

Agricultural improvements. (a) Varietal.

166. The most urgent improvement in agricultural practice in Madras is a great reduction in the number of sets planted. We have mentioned that in the Ganjam district the rate is said to be as high as 50,000 to the acre. Even with the thin, indigenous canes of North India the highest rate is only about 26,000 to the acre; and it will, therefore, be evident that, where nearly twice this number of sets are planted, full development of each stool is impossible. The Bellary district reports the lowest number of sets to the acre for the Madras Presidency—7,500 to 12,000—but this is considerably higher than the 6,000 sets which experience at Manjri has shown are sufficient for the thick canes of Southern India, given proper cultivation and drainage. We describe the Manjri method of cane cultivation at length in the following Chapter and dwell upon its advantages in saving water, sets, labour and manure. The

(b) Cultural.

similarity in climate and other conditions between Madras and Bombay would make it peculiarly applicable to the former Province, especially to such tracts as the Godavari delta, were it not for the smallness of the plots on which cane is grown and their scattered situation, usually in the midst of rice fields where drainage is often impossible. But the value of these methods has been so evident in Bombay that we trust that the Madras Agricultural Department will not lose sight of the possibility of introducing them in Madras in tracts in which there are sufficiently concentrated areas under cane to render their adoption feasible. We need not emphasise the advantages the planting of sets in lines has over the present haphazard method followed in the Godavari delta, as this is an improvement the adoption of which the Agricultural Department is doing its best to promote. The Department has yet to solve the problem whether the results of wrapping and propping cane justify the expenditure the practice involves. The latest available report of the Samalkota farm, that for 1918-19, states that the increased outturn of 1¼ candies (625 lbs.) of gur obtained from the plot on which wrapping and propping were done did not cover the cost of these processes. The propped and wrapped cane was, however, somewhat easier to crush and yielded gur which was slightly lighter in colour. It was added that the question of profits did not appeal to the cultivator in the delta and that he could never be convinced that wrapping and propping could safely be discarded. We are inclined to question the accuracy of this statement. It has yet to be established on the Samalkota farm that propping and wrapping can be dispensed with. We have little doubt that, if this were proved feasible on the farm and subsequently demonstrated to the cultivator on his own land, little difficulty would be found in convincing him on the point. We are, therefore, of opinion that the experiments on the Samalkota farm should be continued until a definite conclusion is reached.

Development and organisation.

167. In the main, therefore, the assistance which can be given to the cane cultivator by the Agricultural Department in Madras lies in the introduction of superior varieties of cane and in bringing home to him the advantages of those improvements in agricultural practice which have already been worked out by the Department. This brings us to the question of the organisation necessary for this purpose. We have reiterated, we fear somewhat tediously, throughout this Chapter that the great obstacle to expansion and improvement in Madras lies in the scattered nature of the cane cultivation. Fortunately, in the matter of organisation, this obstacle can be overcome to some extent owing to the existence in the Province of one or, if our recommendations on the point are accepted, possibly two cane breeding stations which can combine research work for the whole of India with work on the cane problems of Madras. Hitherto the work of the cane breeding station at Coimbatore has been almost entirely directed to the evolution of suitable canes for Northern India. In Chapter XXIV we suggest that more attention should be paid to the needs of the Peninsula for improved varieties of thick canes and that the station should serve as a research station for the southern districts of the Presidency. We also suggest that the obstacle to cane breeding work which arises from the fact that some of the canes of Northern India do not flower at Coimbatore should be overcome by the establishment of a second cane breeding station which might be located in one of the Madras districts bordering on Mysore, if a suitable site could be found. Such a station when established should, as at Coimbatore, combine research work for all India with work on the local cane problems of the tract in which it is situated. If located where we have suggested, it should specially serve the needs of the Chittoor district which has the third largest area under cane in the Presidency.

Both these stations will naturally form part of the all-India scheme of organisation which we contemplate in Chapter XXIII below. In view of the special needs of the Godavari delta and of the valuable work which has been done on the Samalkota farm, we consider that that station should also become definitely a cane research station and should be enlarged to 200 acres, the area we have suggested for similar stations in other Provinces. Our description of conditions in Madras will have shown that the cane problems of the Ganjam and Vizagapatam districts differ considerably from those of the Godavari delta. In these circumstances, and so large a proportion of the cane area of the Presidency is already contributed by these districts, a proportion which, as will be seen from paragraph 164, we regard as possible of increase in the future, we are of opinion that the establishment of a separate research station for this tract is advisable. The Vizagapatam district has, it is true, an agricultural station at Anakapalle where some work on cane has been done. The area of this station is, however, only forty acres, of which not more than three are under cane. We do not recommend the enlargement of the Anakapalle farm to serve as a research station, but would suggest that this should continue as a Circle farm and that a new station should be established further north where it will be better able to serve the needs of the Ganjam district than can Anakapalle. We consider that the establishment of this station can await the establishment of the Sugar Research Institute, and that then both it and the Samalkota station should be placed under the control of an officer working directly under the Sugar Research Institute.

Provision for the needs of outlying districts.

168. We thus recommend the establishment of four research stations for cane in the Madras Presidency. This may appear somewhat liberal for a Province which has only an average of 107,000 acres under cane, but it must be remembered that much the most important part of the work on two of the four stations will be Imperial in character. Even with four stations, there will still be cane tracts of some importance, such as the Bellary and South Kanara districts, where the problems differ, though not greatly, from those of the tracts in which the research stations are located. The establishment of separate research stations for these tracts is obviously out of the question, and they must be left to adopt as far as practicable the improvements in agricultural practice worked out on the main stations. Though this involves some departure from the organisation we have recommended for other Provinces in which cane is of importance, the testing of varieties suitable for them must be done on the Circle farms with the advice and assistance of the officers in charge of the research stations. In this connection we would mention that we are greatly impressed with the need for Circle farms in the Ganjam and South Kanara districts, and trust that the Local Government will be able to establish such farms in these districts at an early date. The establishment of a Circle farm in the western part of the Bellary district through which the spread of the improvements worked out at the research stations could be promoted and sets multiplied and distributed would also be advantageous, though it cannot be regarded as so urgently required as the farms in the districts just mentioned. We should draw attention to the fact that, owing to the great interest in cane cultivation which has been taken by Mr. J. W. Neilson, the Manager of the East India Distilleries and Sugar Factories Company's factory at Nellikuppam, the factory has served virtually as a research station for the South Arcot district. The possibility that this personal interest may disappear at some future date when Mr. Neilson's connection with the factory ceases cannot be overlooked, and we are,

therefore, of opinion that work on cane in the Palur farm in this district should be carried out in close co-operation with the authorities at Nellikuppam, and that the farm should be in a position to take up, at any time, the multiplication and distribution of sets of improved varieties.

Demonstration.

169. In concluding this Chapter we would refer to our suggestions in Chapter XV on the subject of demonstration staff. We have pointed out above that there is much work to be done in Madras in demonstrating the advantages both of improved varieties of cane and of improved methods of cultivation. Whilst there are not, in our opinion, sufficient reasons for proposing a special demonstration staff for work on cane in Madras, we are emphatically of opinion that, in such tracts as the Godavari delta and the Vizagapatam, Ganjam and Bellary districts, work on cane must form an important part of the work of the general demonstration staff organised on the lines we suggest in Chapter XV, and that it is specially necessary that the staff should be trained at the nearest research station.

Summary of Conclusions and Recommendations.

(1) *Despite its tropical advantages Madras offers very limited prospects for cane.*

(2) *This is mainly due to the widespread preference for rice wherever supplies of irrigation water are assured, and to the very scattered area on which cane is now grown.*

(3) *Material expansion can, therefore, only be expected along the line of developing a factory industry growing its own cane on leased lands.*

(4) *Ganjam and Vizagapatam are likely districts for such a development.*

(5) *Work on the introduction and acclimatisation of exotic varieties should be continued and extended into the Ganjam, Vizagapatam and Bellary districts.*

(6) *Reduction in the number of sets planted per acre is of special urgency.*

(7) *The possibility of adopting the Manjri method of cultivation should be tested wherever there is sufficient concentration of cane.*

(8) *The experiments with the wrapping and propping of cane on the Samalkota farm should be carried to a definite conclusion.*

(9) *The cane-breeding station at Coimbatore should become a cane research station for the southern districts of Madras.*

(10) *If a second cane-breeding station is opened in the Chittoor neighbourhood, it should also serve as a cane research station for that locality.*

(11) *The Samalkota farm should be enlarged to 200 acres and become purely a cane research station for the Godavari delta.*

(12) *Another cane research station should be established north of Anakapalle for the Ganjam and Vizagapatam districts.*

(13) *This station and Samalkota should be placed in charge of an officer working directly under the Sugar Research Institute.*

(14) *The needs of other districts must be met by the ordinary Circle farms working in conjunction with the research stations.*

(15) *Circle farms are specially required in Ganjam, South Kanara and western Bellary.*

(16) *Cane work on the Palur farm should be conducted in close co-operation with the management of the Nellikuppam factory.*

(17) *Cane should form an important part of the work of the general demonstrtion staffs in the Godavri delta, Ganjam, Vizagapatam and Bellary.*

CHAPTER XI.

BOMBAY.

170. As the agricultural problems of Sind are entirely different from those of the remainder of the Bombay Presidency, of which it forms a part for administrative purposes, it will be convenient to treat Sind separately, and we do so in paragraphs 187-189 below. The Bombay Presidency proper lies between 13° 53′ and 24° 43′ N., and is thus almost entirely within the tropics. Although higher outturns of cane and gur are obtained from irrigated land in Bombay than anywhere else in India, the area under cane in that Province is, as in Madras, both small and scattered. Cane is grown in every district; but the only districts in which the area is usually more than 10,000 acres are Nasik, Ahmadnagar, Poona and Satara in the Bombay Deccan and Belgaum in the Karnatak, and none of these returns as much as 20,000 acres. Of the four great natural divisions of the Province, Gujarat, the Deccan including Khandesh, the Karnatak and the Konkan, the Deccan, returning as it does nearly two-thirds of the total area under cane, is much the most important from the point of view of our enquiries. This tract is a plateau varying in height from 800 to 2,000 feet above sea level. The average annual rainfall over the greater part of it varies between 20 and 30 inches, and there is perhaps no part of India which is more liable to famine. Cane is grown entirely under irrigation, a large and increasing proportion being under the canal systems which are described in detail below. The soil of the region is almost wholly of volcanic origin and is formed from the weathering of trap rock. At a distance varying from a few inches to as much as six feet below the surface is a substratum of what is known as *murum*, which is a secondary deposit from the disintegration of the trap rock. This is porous, and, if it is within two or three feet of the surface, excellent under-drainage can be assured. Where it is at a greater depth than this, drainage is often poor and cane can only be cultivated successfully, if the water supply is carefully controlled. The rainfall of the Karnatak, except in the east where climatic conditions differ little from those of the Deccan, is more certain than that of the latter, the average at Belgaum being about 50 inches. This part of the Province receives more rain from the north-east monsoon, *i.e.*, between November and January, than any other. The soils of this tract, like those of the Deccan, are formed mainly by the weathering of the trap rock ; but, as the debris from primitive rocks is mixed with basaltic material, they are more varied in character than those of any other part of Bombay. Cane cultivation here, as in Gujarat, is almost entirely under wells. Rather more than three-quarters of the 4,000 to 5,000 acres under cane in Gujarat are in the Surat district, the mean rainfall of which is about 52 inches annually. The soil is a heavy clay, but there are patches of excellent loam and it is on these that the cane of the tract is cultivated. The Konkan, comprising the coast districts of the Province below the Western Ghats, has a rainfall of between 100 and 150 inches

Climate and soil.

which is all received during the five months of the south-west monsoon. Except for a narrow strip along the coast varying from 16 to 50 miles in width, which consists of recent sandy deposits on which excellent garden crops can be grown, if fresh water is available for irrigation, the soils of this part of the Presidency are various forms of disintegrated trap and range from light and shallow soils to heavy clays where water has been held up by the embankments of the rice fields. The cane of this tract, which is mainly grown in the Kanara and Ratnagiri districts, suffers from the heavy rainfall, unless attention is paid to drainage. It cannot be grown entirely without irrigation and requires watering from wells, tanks or river channels between planting and the break of the monsoon.

171. The average area of Bombay, exclusive both of Native States and of Sind, during the five years ending 1918-19 was 48,679,650 acres. The net area actually cropped during the same period averaged 26,025,889 acres of which 74,976 acres were under cane. The percentage of the area under cane to the net area cropped was 0.3 and to the total area under cane in India was 2.7. The average yield of gur for the quinquennium, including that of the 3,867 acres in Sind for which separate figures are not given, was returned at 2.6 tons per acre, a yield which is more than twice as much as that returned by any other Province in India with the exception of Madras. It should be mentioned that the average area under cane in Bombay exclusive of Sind, for the five years ending 1918-19, according to the 'Estimates of Area and Yield of Principal Crops in India,' (revised figures) was 109,533 acres. This, however, included Native States, so that there are some 34,500 acres under cane in the Native States within the limits of the Presidency, mainly in Kolhapur and Kathiawar.

Statistical.

172. Some work on the classification of the canes of Bombay has been done by Mr. Mollison and others, but it is far from complete. Dr. Barber classes Kalkya or Hullu Kabbu, a tall, thin, hard cane which is found in the Karnatak, as a member of the Saretha group. As mentioned in the preceding Chapter, this variety is grown in the Bellary district of Madras, where, however, it appears to be a thicker cane than in Bombay. Khadya, Bansi or Vansi and Sunnabile are included by Dr. Barber in the Sunnabile group, the best known members of which in other Provinces are Dhaulu in the Punjab, Mojara in Assam and Naanal in Madras. Sunnabile is the thickest of these. It is found in the Belgaum and Ratnagiri districts and is said to tiller freely and ratoon well. Khadya, which is grown in the Deccan and Karnatak, and Bansi, which is grown in the Surat and Belgaum districts, are tall, thin, hardy canes, Khadya being especially rich in sucrose. As in Madras, the thick canes are numerous and it is unnecessary to give a detailed description of them. Paunda, generally known in Bombay as Pundia, though susceptible in some localities to red rot which has almost put an end to it in Gujarat and the Konkan, is undoubtedly the best of them and is grown on a far larger scale than any of the others. Dr. Barber considers it obviously an introduction which has, however, been a very long time in the country. A striped variety of Paunda known as Khabirya is grown in some parts of the Satara and Sholapur districts. It is said to be hardier than Paunda and to require less irrigation. Amongst the varieties of thick cane mentioned by Mr. Mollison are Khajuria, Malabari, Bhuri, Phojhuri, Songadi and Kalijadi in the Surat district, Deogadi in the Ratnagiri district, Rasdali and Ramrasdali in the Kanara district and Karekabbu in the Belgaum and Dharwar districts. Other thick varieties not mentioned by Mr. Mollison are Tambola and Newalya which are found in parts of the Nasik district but are being

Varieties of cane.

replaced by Paunda. It appears probable that in Bombay, as in Madras, all the thick canes are introductions, many of which have been in the country a long time and have greatly degenerated.

History of work on sugarcane.

173. The Manjri farm near Poona, which is the centre of the activities of the Bombay Agricultural Department in regard to cane, was established in 1894. The varietal tests which have formed an integral part of the work have merely established that for tracts where irrigation is available and disease is not prevalent no better variety exists at present than the local Paunda. An unnamed Java variety introduced by the Agricultural Department and called by it Manjav is increasing in popularity in the Deccan owing to the fact that it ripens in ten months, whilst Paunda is on the ground from twelve to fourteen months. Red Mauritius, which, when it was first imported by Mr. Mollison in 1893, was found low in sucrose but has since improved in that respect, is spreading with some rapidity in the Konkan, where Paunda has been found unsuitable to the local conditions owing to its propensity to lodge and its inability to withstand red rot. The valuable work which has been done at Manjri by Mr. J. B. Knight, Professor of Agriculture at the Poona Agricultural College, has been much more fruitful in other directions than in that of the introduction of new varieties. It has established the possibility of obtaining heavier yields of cane than those secured by the ordinary cultivator with less water and manure and with smaller expenditure on sets and cultivation. Special attention has been paid to manurial questions : the advantages of growing sann hemp (*Crotalaria juncea*) as a green manure crop have been demonstrated ; and the optimum amount of nitrogenous top dressings has been worked out. An unusual line of work recently taken up by the Department is the organisation of a special party for the destruction of pigs in the Deccan canals area, particularly in the Nira Valley. Guns and hunting dogs are employed, and in 1919 out of 286 pigs seen 134 were killed. To the experiments with furnaces for gur making which have resulted in the evolution of a furnace which is far more efficient than any previously in use in the Presidency reference is made in Chapter XVIII below.

Agricultural practice.

174. Throughout Bombay, except in the canal tracts of the Deccan, cane is grown in very small patches. In the Konkan it is usually rotated with rice except in the Thana district. In that district and elsewhere in the Province outside the canal areas it forms one of a series of garden crops and, therefore, follows such crops as plantains, ginger, turmeric, chillies, onions or other vegetables in no definite sequence. In the canal areas, where it is cultivated in large blocks, it is grown on the same land as frequently as possible, though as a rule not oftener than once in three years. When no ratoon crop is taken, the most common rotation is—

1st year, cane,
2nd year, *juar* (*Andropogon sorghum*) followed by a fallow,
3rd year, *bajra* (*Pennisetum typhoideum*) and gram.

Spelt wheat (*Khapla*), or "*Sal*" rice followed by gram, or *bajra* and *tur* (*Cajanus indicus*) often replace *juar* in the second year ; and sann hemp (*Crotalaria juncea*) is sometimes grown instead of *bajra* and gram in the third year. When ratooning is practised, a common rotation is—

1st year, plant cane,
2nd year, ratoon cane,
3rd year, a fodder crop followed by groundnuts or *bajra*,
4th year, a green manure crop followed by a fallow till cane is planted again.

Cane in this rotation is grown two years out of four, the other three crops occupying the land for the remaining two years.

Where iron ploughs are in use, as they are in the greater part of the Presidency, three ploughings only are given. In North Gujarat, where light wooden ploughs are still common, the number is as high as 15 to 20. After ploughing the land is worked to a fine tilth by a blade or log harrow and is then levelled. In the canal areas, in order to facilitate irrigation, the land is ridged up with the plough, the ridges being about 2½ feet apart and the furrows as deep as possible. Water channels 10 feet apart are then made by the plough at right angles to the ridges, so that the field is laid out into beds about 10 feet square. The sets are placed in the bottom of the furrows and are trampled in to a depth of three or four inches by the feet. The distance between the sets is about four inches. In the Karnatak and the Konkan no beds are made. The sets are planted in furrows which, in the Konkan, are made from twelve to eighteen inches deep in order to facilitate earthing up later on and so prevent lodging. In Surat whole canes are passed through a peculiarly constructed plough which buries them from four to six inches and frequently destroys buds in the process. No selection of sets is practised beyond a cursory examination to see if the buds are undamaged. The number of sets used varies from 16,000 to 20,000.

After-cultivation consists of weeding and earthing up. Three weedings are given before earthing up and two after. A small sickle-shaped implement is used for the purpose. The number of irrigations is as high as 35 to 40, and it is estimated that careful cultivators in the canal areas use 112 inches of water and careless cultivators as much as 136. Cane is always wrapped and tied in the Konkan. In other parts of the Presidency canes are only tied together when lodging appears likely to prove troublesome.

Farm-yard manure is everywhere the principal manure used except in parts of the Konkan, where its place is taken by fish manure, and in the canal areas of the Deccan, where poudrette takes its place to some extent. When farm-yard manure is used in the Konkan, a small dressing is applied when the cane is planted and is supplemented by three dressings of castor cake. Elsewhere the amount of farm-yard manure used varies from 30 or 40 cart loads in Surat, where a crop of sann hemp often precedes cane, and under well irrigation in the Deccan, to from 60 to 100 cart loads in Northern Gujarat. This is supplemented by sheep-folding in the latter tract and in the Karnatak. In the canal areas, where the quantity of farm-yard manure or poudrette used ranges from 30 to 80 carts loads, heavy dressings of oil cake, which may be either castor, groundnut, *karanj* (*Pongamia glabra*), niger (*Guizotia abyssinica*) or Safflower (*Carthamus tinctorius*), are also applied to the extent of as much as 3,000 lbs. to the acre. Farm-yard manure is always ploughed in and the dressings of cake are worked into the soil either when weeding is done or when the cane is earthed up. Trash, when not required for fuel, is burned on the land.

Ratooning is not practised in Gujarat or the Konkan. One ratoon crop is often taken in the Karnatak and from land under wells in the Deccan. On the newer canals in the Deccan the number of ratoon crops is often as high as four or five; but on the older canals, such as the Nira Left Bank canal, not more than one such crop is grown.

The most usual time of planting in Bombay is between January and April, though in the Surat district it is done as early as October and in parts of the Satara and Thana districts in November. In Northern Gujarat, on the other hand, and in other parts of the Thana district it is delayed till June. The time of harvesting varies according to that of planting from September till May ; but it

may be stated that, as a general rule, cane in Bombay is on the ground from twelve to fourteen months, though when Paunda is planted late this period extends to eighteen months.

Prospects of extension.

(a) The Deccan canals.

(i) The present position.

175. For the five years ending 1918-19 the area of cane in Bombay irrigated from Government sources of irrigation averaged 23,595 acres. That there has recently been a rapid expansion in the area is shown by the fact that in the last year of the quinquennium figure was 29,742 acres. Practically the whole of this area is under the Dec canals ; and, as it is on these canals and their projected extensions that the m hopeful prospects for an expansion of the cane area of the Bombay Preside exist, it is necessary to give a brief description of them. The number of Gove ment irrigation works in the Bombay Deccan is large, but the area under majority of them is insignificant and we shall confine ourselves to the main ca systems. It will be convenient to take these in order from south to north.

The Gokak canal, which was opened in 1884, takes off direct from the Gha prabha river. It irrigates a small area in the north of the Belgaum district ; is at present entirely unimportant from a cane-growing point of view, as highest acreage under cane hitherto has been 338 acres in 1918-19. It is, h ever, under contemplation very greatly to extend this system, and the constr tion of a reservoir at Daddi on the Ghataprabha river has been sanction When this is completed, it is anticipated that the canal will irrigate 132, acres.

The Krishna canal which is the oldest of the Deccan canal systems, havi been opened between 1865 and 1870, is also a small canal. It takes off from Krishna River, as its name implies, and irrigates part of the Satara distri Of its irrigable area of 12,320 acres an average o. 1,949 acres was under ca during the quinquennium ending 1918-19, which was not far short of half t area actually irrigated.

The Nira Left Bank canal, which was opened in 1884, receives its supply partly from the Nira river and partly from Lake Whiting, a reservoir on a tributary of that river. This canal commands an area of 274,447 acres in the Poona district of which 113,280 acres are irrigable, though the area actually irrigated in 1918-19 was less than one-half of this. The average area under cane for the five years ending 1918-19 was 9,133 acres, the highest figure recorded being 11,600 acres in 1918-19.

The Nira Right Bank canal is not likely to be completed until 1928. A dam 180 feet high and 4,300 feet long is at present under construction on the Yalwandi river and it is anticipated that, when it is completed, 114,000 acres in the Poona, Satara and Sholapur districts and the Phaltan State will be irrigable from it.

The Mutha canal, which was opened before 1880, is a small canal in the Poona district capable of irrigating 16,800 acres only. The average area of cane under it for the five years ending 1918-19 was 4,903 acres, and it should be mentioned that the cane area in 1917-18 was almost exactly half the area actually irrigated. The Manjri farm is situated in this tract.

The Pravara River Works consist of a right and left bank canal with a masonry dam on the Pravara river in the ghats at Bhandardada. The Right Bank canal has been completed and is in operation. The earthwork on the Left Bank canal has also been completed and the masonry works are making rapid progress. The dam has not yet been carried to its full height, but it is

xpected that the whole scheme will be finished within the next two years, and will hen be capable of irrigating 75,000 acres in the Ahmadnagar district. The area nder cane on the Right Bank canal had expanded from 23 acres in 1910-11 to ,421 acres in 1917-18, (it fell somewhat in the following year) but that on the eft Bank canal is still insignificant.

The Godavari Left and Right Bank canals, which depend for their supplies n Lake Beale, a storage reservoir on the Godavari river, have been practically ompleted. They command an area of 220,000 acres in the Ahmadnagar and Nasik districts of which the acreage actually irrigated in 1918-19 amounted to 5,893 acres. The area under cane has expanded from 2 acres in 1910-11 to ,084 acres in 1918-19, of which nearly two-thirds were on the Right Bank canal.

(ii) Future prospects.

176. The maximum area of cane which has been cultivated on the Deccan canal systems, during the last ten years has been some 27,750 acres. It is anticiated that, when the Godavari canals are fully developed and the works providg additional storage for the Pravara and Nira canals are completed, this figure ill rise to 66,200 acres, the Godavari canals providing 3,000 acres of the addiional area and the Pravara and Nira extensions some 36,000 acres. The okak canal extension is the only important work in the Deccan which as been sanctioned but not yet commenced ; and we were informed hat this, when completed, might add another 24,000 acres to the area nder cane and bring the total up to 90,200 acres. The possibilities f expansion, however, by no means end there. The question of proiding still further storage for the Godavari, Pravara, Mutha and Nira anal systems has already been investigated, and it is estimated that this addiional storage would permit another 58,300 acres of cane to be cultivated. The aximum area under cane in the Deccan canal tracts would then be 148,500 acres. here are certain other projects under consideration into the details of which it s unnecessary to enter, as it is unlikely that any of them will be undertaken ntil all the other works mentioned above have been fully developed. Should hese eventuate, they would add still another 45,000 acres to the cane area of the Deccan. The limit of the possibilities of the Deccan canal tracts in regard to cane ay, therefore, be placed at 193,500 acres ; and the area which may not improably be reached in the near future at very nearly 150,000 acres, or more than ive times as large as it is at present. This may seem a small figure when compared with the $1\frac{1}{3}$ million acres under cane in the United Provinces ; but, when t is remembered that the average outturn of gur per acre in the Bombay Presidency, even in present conditions, is almost three times as large as it is in he United Provinces, it will be realised that the importance of this additional rea under cane cannot be measured merely in figures of acreage. At the same ime, we feel bound to utter a warning against a too hopeful view of the prospects f cane in the Deccan. A very disquieting feature of the situation is the extent o which water-logging is prevalent in some of the Deccan canal areas, and this uestion we now proceed to discuss.

(iii) Water-logging in the Deccan canal areas.

177. We ourselves in the course of our tour saw evidence of the damage done to canal irrigated areas from this cause ; and some idea of the extent of it can be athered from the statistics given us regarding the Nira Left Bank canal, on which three experimental schemes for reclamation by drainage have already been ndertaken. Of the total commanded area of 81,000 acres in the perennial ection of this canal, we were informed that 9,100 acres had already gone comletely out of cultivation as a result of water-logging or salt-efflorescence proluced thereby ; while the area appreciably damaged in the same way was

estimated at 27,000 acres. The extent of the damage caused or threatened o the Godavari and Pravara canals has not been so carefully investigated as yet but the ascertained rise of the sub-soil water-table justifies the apprehension tha if remedial and preventive measures are not speedily taken, the situation on thes canals may shortly become as serious as it is on the Nira Left Bank canal. O that canal, at any rate, there is no doubt that the water-logging is largely due t seepage ; and it was stated in evidence before us that proposals were und consideration for lining some of the softer portions in the tail of the syste where leakage is at present especially serious. We are handicapped i expressing our views on this problem by the fact that our Committee does no include an irrigation expert among its members ; but the deterioration of the soi in some of the canal commanded areas is already so marked and so extensive, a the reasons for it are so obvious that we feel bound to bring the existence of th evil into prominence and to express the hope that the Local Government wi give the most careful consideration to the question of lining not only the old canals, where seepage has already inflicted appreciable damage, but also th newer canals, and particularly projected extensions, where the problem is one o prevention rather than of cure. We realise that the paramount consideratio in this matter is the question of cost ; but it must be remembered that agains the cost of lining has to be set off the money equivalent not merely of the wate saved thereby but also of the deterioration of land in the commanded area prevented by the stoppage of water-logging. Moreover we trust that the Loca Government will not lose sight of the fact that these Deccan canals have bee designed as protective works in the interests of a tract peculiarly liable t famine and that the securing of a remunerative return on the capital outla should not, therefore, be either the first or the preponderating consideration And certainly there is no part of India which we have visited where the lining of canals would confer more direct and substantial benefit than in the cana irrigated areas of the Bombay Deccan.

178. It has been represented to us, however, that lining alone will not com

(iv) Drainage schemes and the problem of redistribution of holdings.

pletely eradicate the evil ; and that com prehensive drainage schemes are required to supplement the effects of lining, unless perennial irrigation is to be abandoned altogether. The necessary legal machinery for the execution of such drainage schemes is provided by section 15 of the Bombay Irrigation Act (VII of 1879) ; but several witnesses who appeared before us have contended that the fragmentation of existing holdings and the unsuitable shapes and scattered positions of the plots at present put down to crops requiring perennial irrigation render the evolution of practicable schemes an impossibility. Exponents of this view, therefore, (with whom it will be seen from Section VIII of his Supplementary Note that our colleague, Mr. Padshah, agrees) maintain that, if any improvement is to be effected, the concentration of the areas under cane and crops with similar water requirements is essential and that for this purpose compulsory acquisition followed by redistribution of existing holdings in the area selected for perennial irrigation at least must be enforced, the new holdings to be reallotted subject to specific conditions regarding the crops to be grown and the economic use of the canal water. We were informed, in fact, that the Bombay Government had under consideration a Bill for the acquisition and redistribution of the whole area commanded by any canal which may be constructed in future. This opens up a large question involving drastic interference with existing rights both legal and customary. It is a question for the decision of which most careful and special investigations are required, and close familiarity with the laws and customs affected is indispensable. We have had neither the time nor

e opportunity for such investigations ; nor has any of us more than a super-ial familiarity with the salient facts of the problem. For these reasons all us except Mr. Padshah refrain from expressing any opinion on it either one ay or the other, realising, as we do, that its solution must depend on far wider id more fundamental considerations than the interests of a particular crop, of hatever potential value. In one small and special case, however, we would pport the advocates of redistribution, namely when land has gone entirely out cultivation in canal-irrigated areas through water-logging. On the Nira Left ank canal, we were informed, small blocks of abandoned land have already been quired for the purpose of the reclamation experiments already referred and the latest results of those experiments appear to have been very couraging. Should experiments on a larger scale confirm the provisional nclusion that the solution of the drainage problem in these areas is the open-g up of the deep subsoil with the object of discovering and utilising the d natural drainage lines, we recommend that Government should proceed to quire all blocks of land which have been abandoned from this cause, to reclaim em and then to reallot them to the original owners, if they are prepared to ke them up again subject to the three conditions that they will accept redistri-tion of the block into holdings of suitable size and shape, that they will repay Government the cost of reclamation and that they will undertake to co-operate a definite scheme of intensive irrigation by the cultivation in concentrated eas of sugarcane and other valuable crops requiring a perennial water supply.

179. Representations were also made to us by a number of agricultural wit-

(v) The agricultural population and the Irrigation Department.

nesses regarding the administration of the Irrigation Department, notably re-arding the intervals at which canal water is supplied to each field and the pro-sion requiring the construction on all irrigated fields of bunds of a specified eight. These again are questions into the technical merits of which we are not mpetent to enter ; but we have been strongly impressed with the importance of ose and intimate relations between the officers of the Irrigation Department id the cultivators whose fields they serve, in order that the latter may under-and the difficulties of equitable distribution and the real objects of the various ficial regulations, and that the former may appreciate the indirect and often foreseen results when the Department's rules are put into actual operation. is for this reason that we welcome the present movement in Bombay towards e formation of Irrigators' Associations, with the members of two of which e held informal meetings during our tour, for it seems to us that these ssociations can do much in the way not only of the collective and efficient presentation of the cultivators' views but also of enlightening their own embers regarding the essential community of interests between themselves nd the Irrigation Department. The formation of these Associations should, e think, be actively encouraged ; and we hope that in the future they will be lued by no-one more than the Canal Officer himself as a reliable source both information and advice.

180. Any substantial extension of the area under cane outside the Deccan

(b) Well irrigation.

will depend entirely in the Karnatak and Gujarat and partly in the Konkan on an crease in the number or an improvement in the type of wells used in those acts. In the year 1918-19 the cane area irrigated from wells in the Presi-ency proper (29,505 acres) was almost as great as that irrigated from Gov-nment canals (29,742 acres). The scope for improvement is, therefore, reat, particularly as the existing wells in Western India are generally nall, and in many areas are very expensive to sink. Appreciable

progress, considering the small staff at his disposal, has, we understand, already been made by the Agricultural Engineer in the sinking of tube wells ; but the work has latterly been impeded by the shortage of plant and the multiplicity of other duties devolving upon the Agricultural Engineer. It is now time that a systematic campaign was opened ; and we trust that the outstanding importance of the work will be recognised by the early formation of a separate branch of the Agricultural Engineering Department for the sinking of new wells and the improvement and deepening of old ones, as well as for the installation of power pumps in connection therewith, a matter of special importance in Bombay where fodder famines from time to time make great inroads on the available cattle supply. Here no less than in the United Provinces and the Punjab the campaign of improvement should be concentrated as far as possible ; and combined with an active propaganda in selected areas. As progress is made in extending the popularity of the improved plants, the work will sooner or later demand whole-time supervision, when the separate branch for well boring will, we hope, be given an Agricultural Engineer of its own, whether the head of the Department himself or the second officer working under his general control will depend upon the comparative importance of the two branches which future developments may establish.

Agricultural improvements.

181. The most important problem of improvement in cane cultivation in Bombay differs in a marked degree from that in other Provinces. In its yields of cane and sugar per acre Bombay stands an easy first among all the Provinces of British India, crops of 50 tons to the acre being not unknown and crops of 40 tons being commonly obtained under canal irrigation ; but these yields are only obtained at a remarkably high cost which is without parallel elsewhere. This has been estimated, even before the war, to be sometimes as much as Rs. 600 per acre ; the main items contributing to this large figure being manure and labour. It is one of the chief merits of the excellent work done on cane in the Presidency that economy in the cost of cultivation was early recognised as a more pressing question than any other, and the experiments conducted on the Manjri farm have been mainly directed to its solution. They have resulted in the evolution of a system of cultivation, popularly known as the Manjri method, for which its author, Mr. Knight, claims only slightly better yields than those obtained by the ordinary local method, but which undoubtedly obtains these yields at a considerably reduced cost and with large savings of irrigation water. We are indebted to Mr. Knight for the four photographs illustrating some of the main features of the method which we reproduce at the end of the Report (Plates 17-20).

(a) The Manjri method.

182. So far as the actual system of cultivation is concerned, the object of the Manjri method is to economise labour by the substitution of bullock labour for manual labour as far as possible. This is secured by the spacing of the furrows in the cane-field 5 feet apart instead of only 2½ feet, and erecting crossbunds for irrigation purposes at right angles to the furrows at intervals of not less than 100 feet instead of 10 feet. Not only does this arrangement allow most of the ridging to be done by cattle-power, but it enables the subsequent operations of weeding and banking up of the young cane to be done by the same means ; while there is also an incidental reduction in sets sown (from 16,000 to 6,000) and in the labour employed in distributing them, as it is now possible to distribute the sets along the furrows direct from carts instead of carrying them from the field boundary by head-loads. The volume of irrigation water required by the Manjri method is said to be as low as 63 inches against a minimum of 84 inches required by the local method, while commonly far more than this is used by the ordinary cultivator. The chief reasons for this saving are that, by the improved method, the superficial area requiring saturation in the early stages of cultivation and the number of plants to be irrigated are reduced by half, and that the upper layer of earth between the cane-rows is left as a dry soil mulch and loss by evaporation is thereby minimised. Special care is also taken to admit the irrigation water into the rows at a slow rate (about 100 feet per hour) ; and this, combined with the deep ploughing and thorough tillage the field has already received, enables the soil to absorb and hold in a capillary state some ten inches of water without seepage.

This careful irrigation also contributes largely to another main source of economy which has been worked out at Manjri, namely economy in the use of manure. There is a tendency in the trap soil of the Deccan for the finer particles of clay to settle into the spaces between the soil granules and to impede the free circulation of water and air in the soil. The proper manuring of cane within the trap area, therefore, requires the maintenance of a suitable physical state of flocculation in the soil no less than the supply of adequate quantities of plant food. It is owing to their failure to appreciate the importance of the former factor that the cane-cultivators of the Deccan have gradually increased their applications of manure till they have long since passed the limit of economic response. The lengths to which this excessive application has gone can be gauged from the facts that in the canal irrigated areas of the Deccan the cane cultivator frequently applies some fifty to eighty cart-loads of farm-yard manure (approximately 225 to 360 lbs. of nitrogen) and three tons of oil cake (500 to 600 lbs. of nitrogen) to an acre of Paunda ; whereas by the Manjri method it has been found possible to obtain equally good yields with the application of only twelve cart-loads of farm-yard manure (about 54 lbs. of nitrogen) and less than half a ton of oil cake (under 100 lbs of nitrogen). Manuring experiments are still in progress at Manjri with the object of ascertaining the minimum loss of nitrogen actually applied to the soil in the form of manure which must be regarded as unavoidable ; but the results so far obtained indicate that the most suitable method of manuring is to supplement a green manure crop of sann hemp (*Crotalaria juncea*), which has been estimated to contain some 75 lbs. of nitrogen by a top-dressing with approximately the same nitrogen content, that crops of over 40 tons to the acre can thus be obtained, and that, beyond this, increased applications of manure do not increase the yield in any degree proportionately to their cost.

(b) Demonstration of the Manjri method.

183. We have described the Manjri method at some length, because we are impressed with its thoroughly practical value, and because we consider that the active promotion of the method throughout the canal irrigated tracts of the Deccan is now the most urgent and important need for the improvement of cane cultivation in Bombay. It requires more intelligence and careful supervision than the local method, but less water, less sets, less labour, less manure and, consequently, less money ; the cost per acre of cane cultivation by this method having been Rs. 361 before the war against the local cultivator's costs of about Rs. 600. It is not, therefore, faced with the main difficulty which impedes the spread of improved methods elsewhere, that they involve a further demand upon the energies and the resources of the cane cultivator to which he may not be ready or able unaided to respond. Properly demonstrated, therefore, the method evolved at Manjri should attain a speedy popularity ; and we would urge, as the first of our recommendations, the importance of constituting a special demonstration staff for work solely on sugarcane in the Deccan canal areas, whose main duty would be the thorough

demonstration and popularisation of the Manjri method. In view of the excellent crops of cane already grown in this tract by the local cultivators, there is perhaps no part of India where it is more imperative that the special demonstration staff should be most intimately familiar with the technique of cane-growing and with every detail of the method it will be their chief duty to demonstrate. It is, therefore, essential that every member of the special staff should undergo a thorough course of training on the Manjri farm before he is allowed to take up his duties in the field ; and that the whole of the demonstration work should for the present be conducted under the direct control of the officer whose appointment we propose below for the charge of all the research work on cane in the Presidency. The same basis might be adopted for the organisation of this special staff as we have proposed for the United Provinces, namely, that it should consist of parties of field-men under Provincial (or Class II) officers of the local Agricultural Department, the strength being calculated at the rate of one field-man to every six demonstration plots and one Class II officer to every ten field-men.

On this basis we think that the Local Government might well create two such parties and initiate their training forthwith ; one for work on the Godavari and Pravara canals, where there are already some 8,000 acres of cane and an appreciable extension may be anticipated in the immediate future ; and one for work on the Nira and Mutha canals, where the cane area is as much as 16,500 acres and again there is a prospect of large extensions. A proposal to institute a campaign involving some 60 plots a year in an area of only 8,000 acres of cane implies a far greater concentration of demonstration work than we have contemplated in any other Province; but the value of the work to be demonstrated and the exceptional prospects of success for a well-conducted campaign in this exceptionally favourable tract are our justification for it. Moreover, this appears to us to be the only part of the Presidency which offers any present prospect of the establishment of a factory industry ; and it is hardly necessary to point out that the almost inevitable result of the spread of the Manjri method with its saving in cost and its consequent enhancement in the margin of profit, will be greatly to stimulate the cultivation of cane on the Deccan canals. The work of these demonstration staffs should be specially concentrated on new canals or extensions as soon as they are opened, for it is of the greatest importance that a method of cultivation which involves the most sparing and economical use of water should be adopted from the outset for a crop like cane, the irrigation of which by the ordinary methods has probably contributed even more largely than percolation to the water-logging of existing canal areas. We do not suggest the creation of a similar staff for demonstration work on cane in other parts of the Presidency, as their conditions and problems have not yet been investigated so exhaustively as have those of the Deccan canals tract, nor are their prospects of development as yet in any way so bright. In them, therefore, demonstration must await the results of the research work the local initiation of which we advocate below.

Selection and improved varieties.

184. Except in certain tracts, such as the Konkan, no cane has so far been discovered which could be definitely recommended as superior to the local Paunda in Bombay. Paunda possesses a number of good qualities. It tillers very freely, is moderately free from lodging, exhibits for a thick cane a remarkable immunity to disease in the areas in which it is now extensively grown, has an average sucrose content of 15 per cent. on cane, and mills easily because its fibre content is usually below 10 per cent. It has also, of course, been long established in the country, and has hitherto shown no signs of deterioration. It is not safe, however, to rely too exclusively on a single variety of cane; and with the spread of improved methods there is always a possibility of introducing new varieties which will give as high a tonnage as Paunda and possibly a richer juice. Again, as a factory industry develops the need for an extended ripening season will be accentuated, and this can only be met by the establishment of varieties ripening earlier and later than Paunda. The experiments now being conducted at Manjri, therefore, with thick exotic varieties and with Coimbatore crosses should certainly be continued and extended; and we consider that a special attempt should be made at the cane-breeding station to evolve a good, thick, disease-resisting cane for Bombay which might replace the local Paunda in the event of its failure. Arrangements should also be put in train at Manjri for the propagation of pure line sets of varieties the superiority of which is established. The rapid multiplication of sets on similar lines to those followed in Java (*vide* paragraph 22 of Chapter II), is not an immediate necessity in Bombay, but its practicability has already been demonstrated during the recent famine of 1918-19, when, owing to the impossibility of obtaining water for planting cane in February, 1919, the problem of maintaining the necessary supply of sets on the Manjri farm was solved by carrying over a part of the standing cane till June, cutting it and planting it in seed-beds in that month and cutting the young cane so grown for sets again in February, 1920. A subsidiary line of work that requires to be taken up, also, is that of completing the classification of the indigenous cane varieties and the isolation of pure line cultures of each.

Organisation and control.
(a) The Deccan.

185. Although the area under cane in the Bombay Presidency is at present comparatively small, the excellent crops obtained, especially under canal-irrigation, the very considerable prospects of extension and the interest already being taken in the Deccan as a suitable area for the location of sugar factories, in our opinion, fully warrant us in recommending that all research work on cane in Bombay should be placed under a single officer whose whole time should be devoted to it. The obvious centre for this work is Manjri where it is already being carried on; and the obvious officer to place in charge of it is Mr. Knight, who is so largely responsible for the practical results already obtained. Mr. Knight, who has been Professor of Agriculture and, latterly, Principal, of the Poona Agricultural College, has hitherto supervised the work at Manjri in addition to his other duties; but the existing staff for demonstration and propaganda is entirely outside his control. We recommend that the Manjri farm should be extended from the 62 acres it at present comprises to the 200 acres we have adopted as our standard for main cane research stations in all Provinces, and that Mr. Knight should be relieved of his other duties as soon as possible and placed in whole-time charge of it as well as of all cane demonstration work on the Deccan canals. One of his first duties will be the selection and training of the special cane demonstration staff we have just proposed and that staff should work in the field entirely under his guidance. It is true that we contemplate the absorption of this post in the Imperial scheme outlined in Chapter XXIII below for a Sugar Research Institute with its own substations in the main cane-growing Provinces and that under that scheme we intend that demonstration work on cane should remain under the direct control of the local Department of Agriculture in each Province. The present case is, however, exceptional. The main object of the special staff we have proposed is the demonstration within a strictly defined area of a method of cultivation which is entirely Mr. Knight's own work; and which has been evolved by him as an officer of the provincial Department. His name is already closely associated with the method in local opinion; and he possesses distinct personal qualifications for the active demonstration of its merits. While, therefore, the special

demonstration staff for cane must always remain a provincial organisation, we trust that the Local Government will have no objection to the control of it remaining under Mr. Knight even after his post of Cane Research Officer for Bombay has been taken over by the Imperial Research Institute ; it being, of course, understood that, as soon as he vacated the post, the control of the special staff would be transferred to the Deputy Director of Agriculture in the provincial Department within whose Circle it might from time to time be employed.

(b) Gujarat and the Konkan.

186. If the research work of the special officer for cane is to be of benefit to other parts of Bombay than the Deccan, it must not be confined entirely to Manjri. Conditions in the tracts irrigated by wells in Gujarat and in an area with such a heavy annual rainfall as the Konkan are so diverse that they require local stations for the solution of their problems. We consider them of sufficient importance to justify the establishment of such stations; but, until the prospects of a material extension of cane improve, we doubt if they need be on anything like such a large scale as Manjri. Areas of 40 to 50 acres each would probably suffice; and the neighbourhood of Amalsar suggests itself as a suitable site for the Gujarat substation. Both stations would be controlled by the special officer for cane, and their main lines of work at the outset would be the isolation and classification of local canes and varietal tests with exotics. We should be glad to see both stations started at an early date; but, should the Local Government find itself unable to adopt all our proposals in anticipation of the opening of the Sugar Research Institute which would ultimately take charge of all these stations, we are of opinion that the substations for Gujarat and the Konkan are of less immediate importance than the extension of the Manjri farm, the freeing of Mr. Knight entirely for work on cane, and the creation of a special demonstration staff for cane, action on all of which will, we trust, be taken at once on provincial initiative and in provincial interests.

SIND.

Climate and soils.

187. Sind lies between 23° 35′ and 28° 29′ N., and is thus just outside the tropics. It is entirely separated from the rest of the Bombay Presidency by the sea, the vast salt water waste known as the Rann of Cutch and the desert at the south-west corner of the Rajputana State of Jodhpur. It consists of the valley of the lower Indus and comprises three distinct tracts—the Kohistan, or hilly country, on the extreme west, the central alluvial plain watered by the Indus and the Thar, or desert, on the eastern border. Practically the whole Province lies outside the path of both the south-west and the north-east monsoons, and the rainfall is thus scanty and irregular, the annual average for all recording stations being not more than 6.4 inches. The climate is consequently arid and temperatures are very variable, the thermometer occasionally recording a few degrees of frost in the winter, and rising to as much as 120 degrees in the summer. At Jacobabad on the Upper Sind Frontier a temperature of 126 degrees has been recorded. Cultivation is, in these circumstances, almost entirely dependent on irrigation. The alluvial soil of the central plain is of the same general type throughout, varying only from a sandy loam to a clay loam, and is of great potential fertility. When irrigation water is applied, it develops into a rich mould ; without water it degenerates into a desert. There are numerous irrigation canals to which the Indus river is the main source of supply ; and with few exceptions they receive water only from June to September during the inundation of the river. Even during this period, their flow is very variable, since it is dependent on the height of the water in the river itself. The small area under cane is at present practically confined to the three southern districts of Karachi, Hyderabad and Thar and Parkar.

Statistical.

188. The average area of Sind, exclusive of Native States, during the five years ending 1918-19 was 30,099,954 acres. The net area actually cropped during the same period was 3,911,181 acres of which no less than 3,495,596 acres or almost 90 per cent. were irrigated, 2,963,675 acres (75 per cent.) from Government canals. Only 3,867 acres were under cane. The percentage of the area under cane to the net area cropped was 0.1 and to the total area under cane in India 0.1. We have already stated in paragraph 171 that separate figures for the yield of gur per acre in Sind are not available.

Prospects of development.

189. The area under cane in Sind is, therefore, insignificant. What there is, is mainly on the Jamrao canal in the Thar and Parkar District, where it is grown by Punjabi colonists, and on the Fuleli canal in the Hyderabad District. In the circumstances it is not surprising that the Bombay Agricultural Department has done no work on cane in Sind and that no information in regard to the varieties grown was forthcoming. Cane can obviously not be grown without irrigation in a tract the average annual rainfall of which is about six inches ; but it is unnecessary to describe the irrigation systems of Sind in detail, as on none of the existing canals are the conditions of supply such as to render the successful cultivation of cane possible. Until perennial irrigation is assured, there is thus no prospect of any extension of the area under cane. The situation will, however, be entirely changed by the construction of the Sukkur Barrage and its connected canals. This well known project provides for a barrage across the Indus near the Sukkur-Rohri Gorge, for canals on the right and left banks of the river and for improvements in the Jamrao canal and the canals of the Eastern Nara canals district which will remain outside the tract directly commanded by the proposed right and left bank canals. Although the project has not yet been sanctioned, we understand that sanction is not likely to be long delayed and that, in all probability, the work on it will commence in the near future. The total cultivable area under the system is estimated at 6,529,700 acres, of which it is anticipated that 81 per cent. will be irrigated annually. Whether any appreciable proportion of the latter area will be under cane depends on the policy which is decided on in regard to that crop. We understand that, in order to ensure the economical use of water and so to prevent water-logging, it is proposed to limit the cultivation of rice to the areas in which it is at present grown, and that for the same reason it may be necessary to prohibit or curtail the cultivation of cane. The water requirements of the latter crop have not, however, yet been worked out, and the first essential, therefore, is that these should be ascertained. The Indian Cotton Committee in their Report recommended that three agricultural stations with pumping installations should be established in the tract which will be commanded by the proposed left bank canal in order that the Agricultural Department should be in a position to deal with the new conditions which will ensue when the Sukkur Barrage project is completed. We were informed that these stations will shortly be established, and we would recommend that an investigation into the water requirements of different varieties of cane should be included in the programme of their work. The comparative requirements both of the superior varieties of other Provinces, more especially of the Katha variety which has established its superiority to other indigenous varieties in the neighbouring Province of the Punjab, and of exotics would be worked out. If it were found as a result of this investigation

that the same objections applied to the cultivation of cane as to that of rice all further work on cane would be abandoned. If, on the other hand, a contrary conclusion were reached, it would then be for the Agricultural Department to proceed to further work to decide on the variety or varieties which should be distributed when perennial irrigation is assured. We are obviously not in a position to make any more definite recommendations than this, but would point out that experience gained in the Punjab should prove particularly helpful to the Agricultural Department in its work on cane in Sind in view of the close resemblance between the climatic conditions of Sind and the adjacent parts of the Punjab.

Summary of Conclusions and Recommendations.

A.—Bombay proper.

(1) The Deccan canals and their projected extensions afford the brightest prospects for the extension of cane in Bombay.

(2) It is not improbable that nearly 150,000 acres of cane will be grown under these canals in the near future.

(3) Water-logging is, however, a serious problem on some of these canals and is partly due to seepage.

(4) The possibility of lining the canals should, therefore, be carefully considered; and the fact that they were originally constructed as protective rather than productive works should not be lost sight of.

(5) The Committee prefer to express no opinion on the general contention that redistribution of agricultural holdings should be undertaken to enable drainage schemes to be carried out.

(6) They do, however, support compulsory acquisition, redistribution after reclamation and enforcement of intensive irrigation in concentrated areas in the special case of land which has gone out of cultivation through water-logging.

(7) The movement towards the formation of Irrigators' Associations should be encouraged.

(8) Outside the Deccan there is great scope for the improvement of well irrigation, and a separate branch of the Agricultural Engineering Department should be created for the purpose.

(9) Ultimately this branch will require an Agricultural Engineer of its own.

(10) The main problem of agricultural improvement here is to reduce the high cost of cane cultivation.

(11) Much has been done to solve this problem by the improved method of cultivation worked out at Manjri.

(12) The active promotion of this method throughout the Deccan canal areas is of the most urgent importance.

(13) A special demonstration staff of two parties should be created and trained at once to popularise the method, one on the Godavari and Pravara canals, and one on the Nira and Mutha canals.

(14) Similar demonstrations should be organised on new canals as soon as they are opened.

(15) Experiments should be continued with a view to discovering new thick varieties to supplement or replace the local Paunda, and the cane breeding station at Coimbatore should co-operate to this end.

(16) Pure line sets of superior varieties should be propagated at Manjri, and the classification of indigenous canes should be completed.

(17) The present high yields, the prospects of extension and the possibility of a factory industry developing in the Deccan canals tract justify the creation of a whole-time post for the supervision of cane research work.

(18) Mr. Knight, Professor of Agriculture, Poona Agricultural College, should be appointed to this post, and the Manjri farm should be extended to 200 acres and form the centre of his work.

(19) As a special case Mr. Knight should control the demonstration staff recommended above (item 13).

(20) Subsidiary cane research stations of 40 to 50 acres each should be opened in Gujarat and the Konkan under the cane research officer.

B.—Sind.

(21) There is no future for cane in Sind until the Sukkur Barrage project is carried out.

(22) Even then it may be necessary to restrict the cultivation of cane under it in order to economise water and prevent water-logging.

(23) The decision of this question depends on the water requirements of cane.

(24) An investigation of the water requirements of different varieties should be undertaken at the agricultural stations shortly to be opened in pursuance of the recommendations of the Indian Cotton Committee.

(25) The need for further agricultural work will depend on the result of these investigations.

CHAPTER XII.

CENTRAL PROVINCES.

190. The Central Provinces including Berar lie between 17° 47′ and 24° 27′ N. and are thus almost entirely within the tropics. Cane in these Provinces is a crop of small and until recently of diminishing importance. The district in the Province which returns the largest area under cane is Bilaspur with an average of approximately 4,000 acres in the last five years. The only other districts which have returned an area of more than 2,000 acres in recent years, are Raipur, Betul, Chhindwara and Chanda. The area under cane in Bhandara, which was formerly one of the principal cane-growing districts of the Provinces, was in 1919-20 only 854 acres. The area under cane in Berar is insignificant. Of the districts mentioned above, Raipur and Bilaspur lie in the great plain of Chhattisgarh, and Chanda and Bhandara in the Nagpur plain, whilst Betul and Chhindwara are on the Satpura plateau. Here, in comparison with other parts of the Provinces, the climate is fairly cool and during the cold season the temperature sometimes falls below freezing point to the detriment of the cane crop. Chanda, on the other hand, is the hottest district in the Provinces and a shade temperature of 119 degrees has been recorded there. The average annual rainfall in the cane-growing districts ranges from 41.52 inches in Betul to 53.17 inches in Chanda. The mean annual rainfall of the Central Provinces excluding Berar is 49 inches. Of this amount over 35 inches are received during June, July and August, 10 inches in September and October and the remaining 3½ inches in the other seven months of the year. The rainfall during the hot season is, as a rule, seldom more than an inch. The soils of the Provinces are as diversified as their scenery and vary from the heavy "black cotton" soil of Berar to the light sandy and stony up-lands of the Vindhyan and Satpura ranges. Cane is, however, mostly grown in the rice tracts of the east of the Provinces, the yellow and sandy soil of which, formed from metamorphic or crystalline rocks, is of little natural fertility, though it responds readily to manure and irrigation.

Climate and soil.

191. The average area of the Central Provinces and Berar, excluding Native States, during the five years ending 1918-19 was 63,969,780 acres. The net area actually cropped during the same period averaged 24,663,471 acres of which 23,511 acres were under cane. In 1914-15 the area was only 19,000 acres, but in 1918-19 it had increased to 30,000 acres. Even the latter figure represents a very great decline from that recorded during the first settlement of the Provinces between 1864 and 1869, when the total cane area was over 95,000 acres, and the Bhandara district alone had 11,000 acres. Moreover the latest returns for 1919-20 show that the area had dropped again in that year to 19,000 acres. The percentage of the area under cane to the net area cropped averaged 0.1 for the five years ending 1918-19 and to the total area under cane in India 0.8. The average yield of gur for the quinquennium was returned at 1.15 tons per acre.

Statistical.

192. The varieties of cane grown in the Central Provinces are not numerous, but the range is very wide. Little work has so far been done on classification, and the information regarding some of the varieties found in the Provinces which was furnished to us was very meagre. Of the varieties which undoubtedly fall in the class of thin or Ukh canes, Dr. Barber considers that Sararoo or Saradi and Kathai, thin, hardy canes with a very hard rind which are grown in the northern cane-growing districts of the Provinces, often as a protecting hedge round soft, thick varieties, belong to the Nargori group. He regards them as strange migrants from North Bihar and very primitive. Barhai and Barahi he places in the Saretha group. These he considers migrants from the Punjab and adds that it is a mystery how they reached the Central Provinces, as this is the most southerly part of India in which these "thin, useless canes" are found. Other canes which appear to fall in the Ukh class are Kala, a dark, red cane of no great value grown mainly in the southern districts, Bangla, grown in the Chhattisgarh division, and Ledi, grown in Balaghat and Bhandara. Bangla and Ledi are said to be popular as they produce a good quality of gur. In the Ukh class also fall Khari and Sunnabile, two varieties which have been introduced into the Central Provinces by the Agricultural Department during the last ten years from Bengal and Bombay respectively. As mentioned in the Chapter on Bengal, Khari is a thin, very hardy variety. In the Central Provinces it has been found to germinate well and to give a heavy yield, whilst its hard rind renders it comparatively immune to attacks by pigs and jackals. It gives a better ratoon crop than any other variety yet tried and has been grown continuously on the Telinkheri farm at Nagpur as a ratoon crop for seven years without showing signs of deterioration. The gur produced from it is slightly inferior to that produced from Sunnabile, but the latter does not ratoon so well. Of canes which appear to fall in the class of medium or Ganna canes the most important is Pachranga, a purple and yellow striped cane, the origin of which is unknown and which is found throughout the Provinces. Its juice content is fairly high and the gur produced from it is of good quality, though dark in colour. Malyagar or Dhaur, a greenish yellow cane which is found mainly in the Bilaspur and Balaghat districts, is placed by Dr. Barber in the Sunnabile group and is considered by him a fine specimen of that group. Of medium exotic varieties introduced by the Agricultural Department 247 B is spreading to some extent. It has a good stand and gives a very heavy yield and has been found to suffer comparatively little both from excess and deficiency of water. Its remarkably hard rind renders it immune from attacks by wild animals, but makes it difficult to crush which militates somewhat against its popularity. The only thick cane which has been grown in the Provinces for any length of time is Paunda, known locally as Engrezi or Poundhi, which is said to have been introduced by Colonel Sleeman and is found mainly in the Betul, Chhindwara and Chanda districts. As elsewhere in India, it has a high sucrose content but a soft rind. Ashy, Striped and Red Mauritius, which are recent introductions by the Agricultural Department, have been found to give heavy yields of cane and gur of good quality, but, like all exotic canes, require better cultivation, more manure and more water than the local varieties, whilst they are more subject to red rot when grown on water-logged areas.

Varieties of cane.

193. Work on cane in the Central Provinces has been mainly carried on at the Tharsa farm in the Nagpur district, the Sindewahi farm in the Chanda district and the Adhartal farm in the Jubbulpore district. The varietal tests carried out on these farms have demonstrated the superiority of Khari, Sunnabile, 247 B and

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the Mauritius canes to the local varieties ; and, as mentioned in the preceding paragraph, appreciable progress has been made in spreading them. Khari has now to a large extent ousted the local Kathai, whilst Ashy and Red Mauritius have become distinctly popular amongst the cane cultivators of the Betul district. In addition to improved varieties the Agricultural Department has introduced the Nahan mill for which there is now a keen demand, especially in the Chanda district, and also the Poona method of making gur. A more efficient furnace designed by Mr. J. McGlashan is now, however, in use on the Government farms. Another matter to which the Department has devoted attention, but in regard to which its efforts have been hampered by the difficulties of supplies resulting from war conditions, has been the introduction of patent woven wire fencing, a very necessary improvement in the Central Provinces where the depredations of wild animals are specially severe and constitute a serious obstacle to the introduction of the softer rinded exotic varieties. It should here be mentioned that the work of the Agricultural Department on cane has been greatly handicapped by the difficulties in regard to irrigation facilities which we refer to below. At one time great hopes were entertained of the successful establishment of a central factory in the area commanded by the Ghorajheri tank in the Chanda district, and with that object in view a concession was granted to Mr. McGlashan. The impossibility of guaranteeing a satisfactory water supply prevented these hopes from being realised.

Agricultural practice.

194. Excluding Berar, which is predominantly a cotton tract and has since 1909-10 had less than 2,000 acres under cane, the Central Provinces may be roughly divided into a wheat tract, comprising most of the districts of the Jubbulpore and Nerbudda divisions on the north and west and a rice tract, comprising the Nagpur and Chhattisgarh divisions on the south and east. In the former tract cane is most frequently grown in alternate years as follows :—

November 1918—April 1919 a *rabi* (cold weather crop, such as wheat, gram or another pulse crop ;
May 1919—January 1920, fallow ;
February 1920—January 1921, cane ;
February 1921—October 1921, fallow, and then another *rabi* crop.

In the latter tract cane is usually rotated alternately with rice, rice being sown in June and harvested in October to December, according to the variety grown, and the following cane crop being planted in February or March. The period of fallow between the two crops is thus often very short. Chillies and vegetables sometimes take the place of rice in this rotation ; while in parts of the large and thinly populated district of Chanda, where only one seventh of the total area is cropped annually, land is fallowed for as much as three years before cane is grown. Ratooning is seldom practised by the ordinary cultivator the only varieties of cane which have been found to yield satisfactory ratoon crops being Khari and Uba.

Cane is grown in the Central Provinces on black cotton soils, unless there is an assured water supply, when a sandy loam is preferred. The land is ploughed and cross-ploughed some ten or twelve times with the country plough. It is then given a couple of harrowings and levelled, if necessary, with a heavy log. The resulting tilth is from nine to twelve inches deep. Sets as a rule are obtained locally and, since crushing usually takes place before the next year's crop is planted, small plots of the previous crop are left standing for sets. Where cultivation is more advanced, however, as it is in parts of the Balaghat and Bhandara districts, tops are stored at the time of crushing and planted out later. Selection of disease-free sets is not frequently practised.

The commonest and most efficient method of planting is the furrow system. Furrows are made by the country plough, about 18 inches apart, and after irrigation the sets are pressed to a depth of two or three inches into the soft mud. Other methods are:—

(1) that of laying the land out into flat beds in which the sets are planted in lines after the soil has been softened by irrigation,

(2) that of planting whole canes by means of a special type of country plough known as the *bawan,* through a large hole running downwards through the sole of which the canes are passed and pressed into position as the implement is moved along. Irrigation is not usually employed in this method, which is peculiar to the Bilaspur district,

(3) that of placing the sets into small holes dug by hand, after which the field is ploughed and levelled, but is not irrigated till the young shoots are well above ground. The land is ridged up before the rains break.

The number of sets used per acre, whatever system of planting is adopted, averages about 20,000 for thick canes and 25,000 for thin canes. No attempt is made to fill up gaps if germination is bad.

No after-cultivation is given till the young shoots are well above ground. The soil is then worked with a *kudali* (a hand tool resembling a small pick-axe), the operation being repeated about once a month throughout the dry season. Just before the rains break in June the earth is ridged up round the stools so as to form drainage channels between the rows. During the rains no weeding or other inter-cultivation is done except by the best cultivators. Throughout its growing period irrigated cane receives some 12 to 15 waterings in the Jubbulpore and Nerbudda divisions and as many as 30 in the Nagpur and Chhattisgarh divisions.

The manure used is generally village refuse consisting of ashes mixed with some cattle-dung. The manurial value of the mixture is low, the nitrogen content being less than 0.3 per cent and the average application per acre is not more than thirty cart loads, or 240 maunds, (8.8 tons), which is ploughed into the soil. In some districts sheep are folded on the cane-field and rarely this is combined with top-dressing, when much larger yields of cane and gur are obtained. Green manuring is practised on a very small scale; cane trash is not used as a manure at all, nor have artificial manures as yet attained any popularity.

Cane is planted between the middle of January and the end of March, and is harvested from the middle of December to the end of February. It thus occupies the ground for an average period of eleven months.

Prospects of extension.

195. Of the 30,000 acres under cane in the year 1918-19 less than 4,000 acres, we were informed, were grown without irrigation, and it is clear from the restricted and uncertain rainfall between November and May that it is only under irrigation, whether from canals, tanks or wells, that any material improvement or extension is to be looked for. The first question that confronts us, therefore, in dealing with the cane problems of the Central Provinces is that of the most likely sources of irrigation water. In considering such a crop as cane, where the prospects of development depend so greatly upon the degree of concentration attainable, it is natural that we should look first to the larger sources of irrigation which it is beyond the means of private land-holders to provide.

196. The past history and present position of the Government irrigation works in the Central Provinces are, however, peculiar, and have a direct bearing on the future of sugarcane cultivation within their commanded areas. Government works for irrigation purposes are here of very recent origin. In the quarter of a century between 1871 and 1896 not only had a failure of the monsoon been unknown but a long, wet cycle within that period had caused serious and widespread injury to crops. The result was that, as the Irrigation Commission of 1901-03 found, the percentage of the area under crops which was irrigated by means of private tanks, wells or field embankments was in a normal year 7½ per cent and in a dry year only 1½ per cent. The situation was gravely disturbed, therefore, when an abnormally dry cycle of years followed between 1897 and 1907, including a critical famine in 1899-1900 involving a total expenditure of public revenues on gratuitous relief and famine works of no less than 437 lakhs of rupees. The necessity for the provision of irrigation facilities at Government expense was then recognised, and some twelve principal schemes are now either completed or in course of construction. Only three of these are canal systems ; in all three cases the river supply is supplemented by a storage system, for there are no snow-fed rivers flowing through the Provinces and the discharge of the few perennial streams is very low during the hot weather months. The bulk of the irrigation supplies is thus provided by tanks, and the important fact to bear in mind is that all these schemes, both in origin and in intention, are essentially protective, whether on their financial results, actual or estimated, they are classed as "productive works" or not. Their object is to secure the more important food crops, namely, rice and wheat, and it is the deliberate policy of the Local Administration only to allow irrigation water for such crops as cane, if a surplus is available after the area under food crops has been fully supplied. The extent to which this limits the cultivation of cane in areas irrigated by Government works can be gauged from the fact that only 1,497 acres were so cultivated in the year 1918-19.

(a) Government irrigation works.

197. We were informed that it was the Local Administration's intention to adhere to this policy for the present until the proportion of the food-crop area secured from failure by the provision of irrigation water was increased to what would be regarded as a reasonable margin of safety. It was, therefore, decided as recently as July, 1919 that, while it was desirable in the interests of revenue to allow irrigation of sugarcane as a temporary measure under a large number of works, it was to be made clear to all cultivators that there was no guarantee of water either to mature the crop sown in any year or to provide for the crop in any succeeding year, and all subordinates were to be warned that the growing of sugarcane should not be encouraged without the special orders of the Chief Engineer. With a view to the most remunerative utilisation of surplus water, therefore, it was decided to classify the Government irrigation works according to the amount of water likely to be available for crops other than rice. The details of the classification need not be considered here; it will suffice to state that in the case of only one out of five classes—that of works in which it is certain that there will be surplus water available in the worst year—has it been decided to encourage cane cultivation, and that out of 75 works so far classified only four have been included in this class. It is perhaps permissible to speculate whether the sharp and unexpected lesson of the opening decade of the century has not converted the local authorities to an extreme devotion to the policy of self-containment which ignores the possibilities of improved communications and the control of food supplies as means of meeting the scarcity

(b) Irrigation policy.

arising from an occasional failure of the monsoon. In other words, it is disputable whether the true interests of the agricultural population would not be better served by a modification of the present policy to the extent of releasing a limited amount of the available water for the cultivation of such a profitable crop as cane and enabling the cultivator to meet by his enhanced purchasing powers the needs of a famine year, than by insisting on the insurance of his local food supplies at the cost of creating a glut in the great majority of years and thereby inevitably reducing the value of his produce. The question is a large one, however, and requires examination from other points of view than that from which it has naturally presented itself to us. It must be left to the Local Administration to decide whether the decision of 1919 should not now be reconsidered; but we cannot refrain from representing that, so long as the present policy is maintained, there is no future for cane in the Central Provinces except to the limited extent to which its cultivation is possible under wells. In present circumstances we are compelled to accept this position ; but we accept it with regret, for climatically and agriculturally the prospects appear to us to be good. As it is, the Central Provinces stand third among the Provinces of India in their yield of gur per acre, despite the small attention given to the crop and the insecurity of the water supply, and the measure of improvement possible is illustrated by the returns obtained on the Government farms, yields of 3 and 4½ tons of gur per acre having been given by the Khari and Sunnabile varieties respectively.

198. Unless and until, therefore, the existing policy regarding the use of water from Government irrigation works is reconsidered, the only prospect of development for cane lies in the promotion of irrigation by wells. So much so, that we feel it necessary to point out that, if Government is not prepared to undertake a regular campaign to this end, they should definitely decide that there is no future for cane in the Central Provinces and exclude the crop entirely from the local Agricultural Department's programme of operations. Such recommendations as we have to make for the improvement of cane cultivation must accordingly be understood to postulate acceptance of the policy of promoting the sinking of wells for the purpose. A post of Agricultural Engineer has now been sanctioned on the departmental cadre, and we regard it as of outstanding importance that the first duty with which he should be entrusted should be the organisation and execution of a scheme for the sinking of tube wells. It would not, in fact, surprise us, if it were found that his whole energies were taken up with this work, and a second Agricultural Engineer were required for the development of such other lines of activity as improved agricultural implements and power plants. We have in paragraph 49 of our Chapter on the United Provinces recorded our reasons for holding that the practical results of a well-boring campaign are likely to be far more extensive, if it is concentrated in a selected area or areas which will enable the necessary supervision to be exercised and active propaganda to be combined with the meeting of the existing demand. These reasons are equally valid here and the same policy should be followed. We have no desire to claim that the interests of cane only should be considered in organising the campaign; but we trust that cane will find a prominent place in it, more particularly as the crop has little chance of development elsewhere. A district in which cane is already grown to some extent should, therefore, be chosen, and we venture to think that no better selection could be made for this purpose than the centrally situated Bhandara district of the Nagpur division, which in former years returned a larger area under cane than any other district in the Provinces and where the agricultural practice of the cane-grower is comparatively advanced.

(c) Well irrigation.

199. Even if a considerable extension of the cane area under wells is attained, however, it is unlikely that for some time to come, at any rate, cane will be grown on a plantation scale; all improvements, therefore, both in the varieties grown and in the methods of cultivation adopted require to be worked out with a view to the needs of the local cultivator. The damage done to cane in the Central Provinces by pigs and jackals is so extensive that this must form the first consideration in the selection of a suitable cane variety until it has been found possible to evolve a system of fencing which is at once efficacious and within the means of the cane-cultivator to adopt. We are doubtful whether any solution of this problem will be found until the financial position of the cane-cultivator is improved; and for the time being it will be necessary for the local Agricultural Department to devote their main energies to the distribution of such a proved hard-rinded variety as Khari and to the discovery of other varieties which will improve upon the yield of Khari while retaining its essential quality of resistance to the attacks of wild animals. The chief line of work should, therefore, be, we think, the systematic classification of existing varieties with special reference to their hardness of rind, the isolation of pure line cultures of the most promising varieties, and the subsequent multiplication and distribution of pure sets of those varieties. Simultaneously, and with the same object in view, trials of the Coimbatore crosses should be made ; but, while we have certainly no desire to exclude work on improved exotics altogether, we must point out that there is little prospect of their successful introduction outside areas where adequate fencing is practicable. This work should accordingly remain of subsidiary importance until the fencing problem is solved, for it is unlikely that pig-killing campaigns on the lines of those now being attempted in the canal areas of the Bombay Deccan will be successful in a tract with such extensive jungle areas as the Central Provinces. A specific exception must, however, be made in the case of the medium Java variety 247B, the particularly hard rind of which renders it eminently suitable for distribution in districts where it has established its adaptability.

Agricultural improvements.
(a) Improved varieties of cane.

200. Work is already in progress, notably on the Tharsa and Sindewahi farms, on the reduction in the number of sets sown per acre, (the optimum rate of 16,000 per acre so far ascertained seems to us to be still too high) on the practice of sowing in rows and the best spacing of the rows for good tillering and to enable effective after-cultivation to be done, on the correct use of manures and on the introduction of improved ploughs and other implements. It is, in our opinion, being conducted on right lines, and we have only to advocate its continuance and its concentration in the area selected for the promotion of well irrigation, for an assured water supply is essential, if the full benefits of improved agricultural practice are to be reaped.

(b) Improved methods of cane cultivation.

201. It is, in fact, the wide distribution of the present experimental work on cane which we regard as its chief defect. Such work is at present being conducted on no less than four farms—Tharsa in the Nagpur district, Sindewahi in the Chanda district, Chandkhuri in the Raipur district and Adhartal in the Jubbulpore district, and there appears to have been a certain degree of duplication in the experiments carried on at the various farms. This is, no doubt, the natural outcome of the fact that cane is at present an unimportant crop everywhere and, while it was too profitable to ignore altogether, in no particular locality was special concentration on it held to be justified. If our proposal for the organisation of a well-sinking campaign in a selected district is accepted,

Organisation and control.

this reason will no longer be valid, and we have no hesitation in recommending that the main research work on cane should then be centred at a single agricultural station within or in the neighbourhood of the selected district. Possibly the Tharsa farm could serve the purpose of the Bhandara district, which we have suggested above for this selection, or should one of the more northerly districts, such as Betul or Chhindwara, both of which have appreciable areas of cane under wells, be preferred, the Betul farm might be utilised. On the other hand it might be found more convenient to open a new station specially for the purpose. This is a matter which must depend on local circumstances and the lines on which the well-sinking operations develop, and we must be content to urge that, whatever station is chosen for the centralisation of research work on cane, cane should be declared the chief crop with which it will be concerned. Thereafter the cane work on the other farms would be mainly confined to the multiplication of approved varieties and to collaborating with the main station in the classification of the indigenous canes, and the isolation of pure line cultures of varieties which have established a definite local sphere of adaptability.

With the limited prospects of development which are all that we can at present contemplate in these Provinces, it is clearly out of the question to consider the linking up of their cane work directly with the Imperial scheme for central research which we contemplate in Chapter XXIII below. The results which appear likely to be attained do not justify the appointment of any special staff as yet, whether for research or demonstration, to deal exclusively with cane problems. The special station for research work on cane, therefore, should, in our opinion, be controlled by the Deputy Director of Agriculture within whose Circle it is located, though we trust that the Local Administration will so far recognise the possibilities as to place the station under the whole-time and immediate charge of a reliable officer of the Provincial (or Class II) Agricultural Service, and not merely under an ordinary Farm Superintendent. It must be remembered that, while the main lines of research will be dictated and controlled by the Deputy Director in consultation with the Director of Agriculture, neither of these officers will have the time to spare for detailed supervision, and that, should the recommendations we have made in this Chapter be adopted, the whole future of cane as an important crop in the Central Provinces will depend upon the initial success of the experiment in well-sinking on a concentrated area of which this cane research station will form an integral and fundamentally important part.

Summary of Conclusions and Recommendations.

(1) Cane is at present an unimportant crop in the Central Provinces, and the area grown is less than one-third what it was 50 years ago.

(2) It is and will always be grown almost entirely under irrigation.

(3) All Government irrigation works are protective in character and the present policy is against encouraging the cultivation of cane under them until a larger proportion of the food-crop area has been secured against failure.

(4) So long as this policy is pursued, there is no future for cane except under well irrigation, despite the excellent yields obtainable.

(5) Unless, therefore, the Local Administration is prepared to undertake a well-sinking campaign, all agricultural work on cane should be stopped.

(6) The newly appointed Agricultural Engineer should be entrusted with the organisation of such a campaign as his first duty.

(7) The work should be concentrated in selected areas, preferably in the Bhandara district, and cane should be accorded a prominent place in the scheme.

(8) Given this campaign, the agricultural work on improved varieties should be devoted to meeting the needs of the small cultivator.

(9) Until fencing can be generally introduced hard-rinded varieties should be preferred, and indigenous varieties should be classified and Coimbatore crosses tested with special reference to this quality.

(10) Meanwhile the introduction of exotics, other than 247B, should be held in abeyance.

(11) The present lines of work on improved methods of cultivation should be followed up, but the work should be concentrated.

(12) It should be centred at a station in or near the area selected for the well-sinking campaign, and cane should be declared the chief crop at that station.

(13) Other farms should then confine themselves to the multiplication of improved varieties and to co-operation in classifying local canes.

(14) Prospects of development being limited, the special station proposed for research work on cane must be left under the control of the Deputy Director of Agriculture of the Circle, but he should be given a reliable officer of the Class II Service to hold whole-time charge of the station.

CHAPTER XIII.

HYDERABAD.

Climate and soil.

202. The Hyderabad State lies between 15° 10′ and 20° 40′ N. and is thus entirely within the tropics. It falls into two well marked and nearly equal divisions if a line is drawn due north and south through the Capital city of Hyderabad. The area east of that line is known as Telingana and that to the west as Mahratwarra and the Canarese country. Cane is a crop of very small importance in Telingana and the Canarese country, the only districts returning more than 1,000 acres being Nizamabad in the former tract and Raichur in the latter with 1,118 and 1,367 acres respectively in 1918-19. In Mahratwarra the most important cane growing district is at present Bidar, where in 1918-19 the area was 11,687 acres. The Bir district in the same year returned 4,407 acres, the Aurangabad district 3,350 and the Parbhani district 3,127. West of the line mentioned above the climate is generally hot and dry from March till the end of May and temperate for the remaining months. In the Telingana districts it is hot and damp from March till the end of September and temperate for the rest of the year. The rainfall varies from about 22 inches in the south-west to 40 inches in the north-east. Over three quarters of it is received between June and September, the remainder practically all falling in October and November, and it may be stated at once that the possibilities of the extension of cane in Hyderabad entirely depend upon the provision of additional irrigation facilities. The soil of Mahratwarra, that is of the only tract in which cane is of importance at present, is mainly the Deccan trap weathered to form the black cotton soil found in the adjoining tracts which, at its best, is a deep, rich, black and very fertile loam, often of great depth, with very thick underlying strata of yellow clay and lime. The Bidar district, however, furnishes an exception, the Deccan trap being here covered with a surface deposit of laterite. The soil of Telingana, which has been formed from the disintegration of igneous rocks, is shallower than that of Mahratwarra. It is mostly reddish brown in colour, with a substratum of *murum* as in the Bombay Deccan.

Statistical.

203. Complete agricultural statistics for the Hyderabad State are not available and that State is not, therefore, included amongst those for which figures are published in Volume II of the Agricultural Statistics of India. We were, however, furnished with figures which showed that the average area under cane for the five years ending October, 1919 was 29,763 acres, an appreciable advance on that of the previous five years, when it averaged 21,614 acres. The high water mark appears, however, to have been reached in 1916-17—37,313 acres—and there has been a distinct tendency to recede in the last two years, the return for 1918-19 being only 27,991 acres. The average cane area of this quinquennium represents 1.1 per cent. of the total area under cane in India. Statistics of the yield of gur per acre are not available.

204. It has not yet been possible to do any work on the classification of the canes grown in Hyderabad and the information available on this point is in consequence very meagre. The cane which is almost universally grown was described to us as a thick, soft, yellow cane and appears to be identical with Paunda. Some striped varieties are said to be grown as a mixture with this, whilst a dark red variety with a hard rind is also found in the Telingana districts.

Varieties of cane.

205. As Hyderabad did not possess an Agricultural Department eight years ago, and as the strength of that Department to-day is only one Director, two Demonstration Superintendents, five Farm Superintendents and one Cotton Superintendent, it is not surprising that the research work so far done on cane has been very limited. It is confined to the experimental farm at Kamareddi in the Nizamabad district; where the work has been mainly directed towards solving the insistent problem of lodging, and so obviating the necessity for the use of props, the doubling in 1915 of the rates charged for which by the Forest Department has made them a heavy item in the cost of cane cultivation in Telingana. The result of the experiments is said to prove that lodging is mainly due to the presence of sodium sulphate in the soil, which causes excessive deflocculation when the land is irrigated and prevents the cane roots from obtaining a proper hold. It is claimed that this effect is largely counteracted by the application of nitrate of potash combined with deeper ploughing and drainage, and that in this way props can be largely dispensed with. The work has, however, been considerably interrupted during the last year or two owing to the occurrence of red rot on the farm. Varietal and other cultural experiments have not yet been made, though it is proposed to try imported seedlings from Coimbatore and sets of some Mysore varieties in the near future.

History of work on sugar cane.

206. In the Mahratwarra districts sugarcane is invariably raised after a crop of hemp, as the decomposition of the hemp roots helps the growth of the cane. In the Telingana districts cane is invariably preceded and followed by a rice crop.

Agricultural practice.

Where cane is grown for crushing the tops are reserved as sets for the next year's crop, but where it is grown for chewing whole canes are cut up into sets. We were informed in evidence that a fresh supply of sets from an outside source is obtained every fourth or fifth year, but we doubt whether this is by any means a general practice. In the Mahratwarra districts comparatively greater care is bestowed on the preparation of land than in the Canarese and the Telingana tracts. The selected plot is ploughed and cross-ploughed eight times. The first ploughing is performed with six bullocks, the second and third with eight and the fourth with ten bullocks. A heavy log of wood is then drawn over the field two or three times to break up the large clods of earth, and lumps that still remain are broken with a pick. After a tolerably level surface has been obtained, about 150 cart-loads of manure are applied to the acre, the manure being well worked into the soil with a country hoe called "*vakhar.*" When this has been thoroughly mixed the field is levelled with a log of wood called "*phullau.*" It is next furrowed in parallel lines a foot or 18 inches apart with a plough drawn by two bullocks and the whole field is divided into a number of little beds by cross furrows five or six feet apart. Water is freely applied till the trenches

become soft and muddy, in which state they are ready for the planting of the new crop in January. In the Telingana districts, after the *abi* or monsoon crop of rice has been reaped, the land is twice ploughed with a two bullock plough first straight and then across. Another heavier ploughing is then given with a four bullock plough and the land is left to dry. If the land has been left fallow in the *abi* season, the ground is first levelled and all clods of earth are carefully broken and the land is then ploughed four times. In either case, after the soil has become perfectly dry and pulverised, about 100 cart-loads of soil collected from the banks of a *nallah* (ravine) or the bed of a tank are thrown on each acre of the land, each cart-load containing about 30 baskets of earth. The last ploughing is now made and the ground finally levelled. The land is then manured twice. First about 600 goats are folded for 25 days on each acre, after which the land is then ploughed three times. Next about 100 cart-loads of cattle sweepings and farm-yard manure to the acre are put in and the land is ploughed up again and laid out in small level beds with the spade and surrounded by deep ridges. In the vicinity of Hyderabad City, however, there are a few more advanced cultivators who drive comparatively deep parallel trenches through the field some two feet apart as is done in Mauritius.

The sets are usually cut from the tops of the previous crop and each set is from a foot and a half to two feet in length and contains at least one leaf bud. Before planting the level beds are well irrigated and in Mahratwarra the sets also are tied in bundles and kept watered for five or six days. After the land has been thoroughly irrigated, the sets are laid contiguously in rows sometimes less than a foot apart and they are then trodden down about two inches into the saturated soil. The number of sets used per acre varies from 25,000 or 30,000 in Mahratwarra to as much as 50,000 in Telingana.

The growing crop is weeded at least three times and earthed up some five or six months after planting. In Mahratwarra subordinate crops such as *mung* (green gram, *Phaseolus mungo*) *val* (field bean, *Dolichos lablab*) and *ambadi* (Deccan hemp, *Hibiscus cannabinus*) are also sown along with the cane. These secondary crops are cut at the time of the second weeding and used as fodder for cattle. In some parts the growing plants are manured with farm-yard manure at each weeding and this is again followed, although in rare cases, by a top dressing of dry fish powder or castor oil cake. When the canes are about five feet high, they are tied together by their lowest leaves in clumps of four or five throughout the field so as to form a support against the high monsoon winds. In parts of the Telingana tract, however, wooden props are stuck into the ground and the canes are tied to them to prevent lodging. The number of props used varies from 5,000 to 15,000 per acre, which considerably increases the cost of cane cultivation.

The crop is frequently irrigated at intervals of about four days until the monsoon breaks. Usually during the monsoon no water is given, unless there is a continued break, when water has to be given about every sixth day. At the latter end of the monsoon and during the hot weather the crop has to be more frequently watered and the interval between successive waterings is accordingly reduced again to about four days.

Cane is usually sown in Hyderabad between the months of January and March and is cut from December to February. It is thus on the ground for about 11 months.

207. It is clear that, unless a considerable increase in the area under cane in Hyderabad is to be looked for, the question of effecting any agricultural or varietal improvements will remain of very minor importance, and that we can hardly press the small Agricultural Department of the State to give it a prominent place in its programme of work. The first essential for any such increase is the provision of irrigation water, and it becomes necessary to consider the possibilities of extending or improving the various sources of irrigation.

Prospects of extention.

208. There are already a few irrigation canals in the State, the more important of which may be briefly described. The Mahboob Nahir canal takes off from the east bank of the Manjra river and runs north through the Medak district and into the Nizamabad district. Its length is 22 miles and it commands an area of 12,000 acres, of which 5,000 are actually irrigated annually. It is now in process of extension to Yellareddipet by means of dams thrown across the Aler river. When this completed, it is hoped to increase the area actually irrigated by some 11,500 acres. The area under cane in this tract is at present small, and it is doubtful whether it is likely to extend appreciably. The Asaf Nahir channel takes off from the south bank of the Musi river and, running in a south-easterly direction, fills a number of storage tanks in Nalgonda district. It need not be further considered, however, as no cane is grown in this district. Finally there are the three canals taking off from the north bank of the Tungabhadra river on the southern border of the State, of which the most important from our point of view is the Gangawati canal irrigating some 8,000 acres in the south-west of the Raichur district, 1,500 acres of which are already under cane. Provisional sanction has, we were informed, been accorded to the extension of the system to irrigate some 16,000 acres, of which we were given so high a figure as 10,000 acres as the area which might be expected to be put down to cane. Of two or three larger projects still under examination, the only one likely to have any effect on cane is a project to dam the Manjra river some distance below, (that is, north of) the Mahboob Nahir canal, to store 32,000 million cubic feet of water, and to run a canal from the east bank past Nizamabad and Armur in the Nizamabad district towards Jagtial in the Karimnagar district. Surveys have already been started, and the canal, if constructed, would be able to irrigate 300,000 acres of which it is hoped that as much as 10 per cent. would grow cane. The project would, however, cost three crores of rupees and take about fifteen years to carry out. For the present, therefore, it appears that very little increase of cane can be looked for under canals, with the small exception of the Gangawati extension.

(a) under canals.

209. Tanks in Hyderabad are practically confined to the eastern tract known as Telingana where the general configuration of the country is undulating and there are natural facilities for storage. The total number of Government tanks is about 20,000 ; but the great majority of them are quite small, there being only about 500 capable of irrigating 100 acres and more and only about 100 irrigating more than 400 acres. And it is under these largest tanks only that cane can be grown without help from supplementary well irrigation. The need of wells for the cultivation of cane, therefore, is not appreciably less in Telingana than it is in Mahratwarra where they are the sole source of irrigation. Wells are, as a rule, privately constructed and owned, though they may have been sunk with the aid of Government loans which are frequently granted for this purpose. In these circumstances, we are inclined to think that the numerous representations made to us regarding the high rates of

(b) under tanks.

assessment on sugarcane irrigated from Government tanks in Telingana deserve careful and sympathetic examination, certainly so far as its two most important cane districts are concerned.

The system of assessment on sugarcane irrigated from Government irrigation sources varies in the three tracts. In the Mahratwarra districts only a garden crop rate is levied ranging between Rs. 4 and Rs. 7 per acre, while in the Canarese and Telingana districts the assessment on cane is based on the assessment on the two crops of rice known as *abi* (monsoon) and *tabi* (summer) respectively, although the proportion it bears to the rice assessment varies in the different districts. For instance, in the Canarese districts of Gulbarga and Raichur the assessment on cane is twice the single crop rate for *abi*, whereas in the Telingana districts of Warangal, Mahbubnagar, Nalgonda and Karimnagar (where there is very little cane cultivation) it is only one and a half times the charge for *abi* and equals the actual assessment levied on land from which two crops of rice are taken in the same revenue year. In the Medak and Nizamabad districts, on the other hand, the assessment on cane is equal to the charge for one *abi* and two *tabi* crops, the principle adopted apparently being that, whereas cane only occupies the ground for 11 months during which not more than two crops of rice could be taken, its water requirements are equivalent to those of one *abi* and two *tabi* crops of rice. This inequality of incidence upon the cane cultivator in Medak and Nizamabad is intensified by the facts that the scale of assessment on rice in these districts is much higher than it is in other districts, and that the second crop charge, *i.e.*, the charge on *tabi* rice, is also higher than the *abi* charge. It is particularly high in the Medak taluk of the Medak district, being as much as twice the *abi* charge. Moreover the remission which is generally allowed in these districts for a double crop of rice is not allowed in assessing sugarcane. Thus in the Medak taluk (where one quarter of the *tabi* assessment is remitted when a double crop of rice is taken), if the *abi* assessment on a piece of land be Rs. 10 per acre and if the same plot were double cropped with rice, the charge for the two successive crops would be only Rs. $(10+20-\frac{1}{4}$ of 20) or Rs. 25 per acre instead of Rs. 30. But if the same plot were cultivated with cane, the charge would be Rs. $(10+20\times2)$ or Rs. 50 per acre. A charge which is not unreasonable for an assured perennial supply of water may legitimately be regarded as excessive for a supply which is both partial and uncertain and which the cane-grower has to supplement from sources of his own providing ; and we cannot help thinking that the existing system of assessment has something to do with the very limited extent of the cane in Telingana. It tends particularly to discourage cane cultivation in the two districts the soil of which appears to be eminently suited for it, and where the keen interest in cane growing evinced by a number of witnesses who appeared before us furnishes, we think, good reason to believe that a reduction of the present rates would be followed by a marked extension of the crop. If, therefore, the Nizam's Government are desirous of encouraging the cultivation of cane in these districts, they would in our opinion, be well advised to reconsider the present rates of assessment on cane irrigated from Government tanks and, in particular, on a ratoon crop, the smaller return from which appears to justify its assessment at a lower rate than a plant crop.

210. Regarding the extension and improvement of well irrigation we have little to say. The policy of the Government is already directed to the active promotion of well sinking ; and loans for the purpose, we were informed, are granted

(c) under wells.

at 6 per cent. interest, with recovery by instalments spread over a period of ten years. Where Government wells are the only source of irrigation, the commanded area is assessed at *garden crop rates varying between Rs. 5 and Rs. 7 per acre instead of dry rates ; but dry rates continue to be levied on lands commanded by wells which* have been sunk by the cultivators themselves. We cordially endorse this system and doubt whether much more can be done so long as the Agricultural Department has no engineer of its own to initiate the construction of tube wells and wells of other improved types.

211. So far as the provision of the essential supplies of water is concerned, therefore, there are prospects of a considerable expansion of the cane area in Hyderabad, if a definite policy of encouragement is adopted. We enter this proviso because we are convinced that the Agricultural Department of the State will have to be expanded and developed, if it is to establish and to popularise improved methods of cane cultivation, and equally that it is not worth while to incur the cost of such an expansion, unless the desire to promote cane cultivation actuates in the same degree the other Departments of Government concerned—namely, the Irrigation Department, the Revenue and General Administration Departments and the Co-operative Department. Given this uniformity of policy, which should be maintained by a constant interchange of views between the officers of these Departments, there is, we think, substantial justification for expanding the Agricultural Department in the interests of cane. The work at present suffers from the fact that the superior expert staff is too small for the exercise of effective supervision over such experimental work as is being carried on and, owing to the lack of an Agricultural Chemist, is operating largely in the dark in respect of one of the most important elements of the cane problem. Under these conditions it is impossible to organise the experiments on the Kamareddi farm on thoroughly scientific lines ; and they are thus inevitably less systematic than they should be, if conclusive results are to be obtained.

Future policy.

212. We venture to suggest, therefore, that an Agricultural Chemist, well qualified to undertake independent research work, should be added to the Department as soon as possible, that he should be given special facilities for studying the work done on cane and the research methods adopted in one or other of the Provinces of British India which have devoted special attention to cane and that he should then be placed in immediate charge of the Kamareddi farm and any other station that may be opened for cane research. The experiments already in progress with a view to the elimination of props should certainly be continued ; for we are disposed to doubt whether it has yet been satisfactorily established that the chief remedy for the tendency of canes in Hyderabad to lodge is the application of nitrate of potash to the soil rather than a system of deeper cultivation and more effective drainage. Once the essential expert control is provided, it will also be possible to initiate work on other lines of improvement, such as the isolation of pure line cultures, the introduction and acclimatisation of exotic varieties, and the carrying out of comparative manurial and other cultural tests. Then, too, we think it will be advisable to open subsidiary cane research stations for the Mahratwarra and Canarese districts, for the former preferably in Bidar, where the cane area is already fairly large, and for the latter in the tract of the Raichur district commanded by the Gangawati canal. The present site of the Kamareddi farm, moreover, is by no means ideal but we understand that it has already been proposed to remove it to a fresh site in the neighbourhood ; and we trust that a sufficiently large area will be taken up and on a sufficiently long tenure to admit of more field experiments and of greater continuity than have hitherto been possible.

Need of an Agricultural Chemist and new centres for cane research work.

213. In the meatime, until definite results have been obtained, it seems advisable to abstain from all attempts at demonstration in the cane-growers' own fields ; and the Agriculutral Department's assistance should be confined to the multiplication and distribution of disease-fee sets, and to co-operation with the Forest Department in introducing a more economical use of props. Quite apart from the work on the prevention of lodging, it seems to us that a large saving might be effected, if the growers of cane could be induced to use stronger and more durable props for the support of their canes, and not to divert them at the end of the growing season for use as fuel in their gur furnaces. The necessity for constant renewal would thus be obviated, as it is by the cultivator of cane in Madras ; but we realise that stouter props would, in the first instance, be more expensive, and would thus enhance the cost of cultivation in the year of their adoption. We would suggest, therefore, that this difficulty might be met by provision for payment by instalments. The rate now charged for the slender props, about one inch in diameter, at present in use is, we believe, 2 pies each in the case of unreserved species of timber ; and it might be arranged that the annual instalments for stouter props should be slightly less than this in order to stimulate a preference for their use. The general question of the correlation of research work on cane in Native States with the central research organisation which we advocate for British India in Chapter XXIII below is one which we shall deal with in paragraph 384, and it is unnecessary to do more here than invite a reference to the relevant discussion.

Lines of demonstration work for the immediate future.

Summary of Conclusions and Recommendations.

(1) The provision of new and improved irrigation facilities is the first essential for the extension of cane in Hyderabad.

(2) Except to a limited extent on the Gangawati canal there is little prospect of extension under canals in the near future.

(3) A considerable extension under tanks in Telingana may be expected, particularly in the Nizamabad and Medak districts, if the prevailing assessment on cane is reduced.

(4) Until an Agricultural Engineer is appointed, no change in the existing system of promoting the sinking of wells is required.

(5) The Committee's recommendations for expansion of cane work presuppose the adoption of a definite policy of encouragement.

(6) The expert staff of the Agricultural Department should be strengthened and an Agricultural Chemist should be appointed to supervise all research work on cane.

(7) Experiments with a view to the elimination of cane props should be continued, and work on other lines of varietal and cultural improvement should be started.

(8) *Substations for research work on cane should be opened in the Bidar district and the canal irrigated area of the Raichur district.*

(9) *For the present, demonstration work should be confined to the distribution of disease-free sets and to reducing the necessity for annual replacement of cane props.*

CHAPTER XIV.

MYSORE.

Climate and soil.

214. The Mysore State, which lies between 11° 36′ and 15° 2′ N. and is thus entirely within the tropics, falls into two very distinct natural divisions, the hill country or Malnad in the west and the more open country or Maidan in the east. Of these the latter is by far the larger, the Malnad consisting only of those parts of the Shimoga, Kadur and Hassan districts which border or rest on the Western Ghats. Cane in this tract, which has a very heavy rainfall, is of small importance, except in the Shikarpur and Sorab taluks of the Shimoga district, which in 1917-18 returned an area of 6,429 acres. Most of the 6,000 acres in the Hassan district lie outside the Malnad area. The various parts of the Maidan differ considerably in character. Neither the level plains of black cotton soil in the north nor the stony and wide spreading pasture grounds of the centre with their somewhat scanty rainfall and insufficient means of irrigation are suitable for cane. The principal cane growing districts lie in the east and south. Kolar, the most easterly district, has an area of about 8,000 acres, whilst Mysore and Bangalore, the two southern districts, return about 5,500 and 4,800 acres respectively. Though the average annual rainfall in Mysore ranges from over 360 inches on the crest of the Western Ghats to as little as 17 inches in parts of the Chitaldrug district in the north, from 25 to 40 inches represent the general average for the greater part of the State and, therefore, for the main cane growing tracts. This, on the whole, is well distributed, as Mysore receives the benefit of both monsoons and its rainy season may be said to last from June to November. Heavy storms are common in April and May, the average rainfall in May for most stations being, in fact, higher than for any other months in the year except September and October. The cold season rains from December to March are insignificant. Outside the Malnad the rainfall is not sufficient to enable cane to be grown without irrigation; and in Mysore, as in Hyderabad, the possibilities of an extension of cane depend mainly upon the provision of additional irrigation facilities. The greater part of the cane grown in the State is grown under tanks, channels from rivers supplying a very small proportion and wells even less. It should be mentioned that, as the Mysore State is from 2,000 to 3,000 feet above sea-level, the extreme high temperatures of other parts of India are absent, and even in the hottest years the temperature rarely exceeds 100 degrees. The soils of the State range from the black cotton soil to a light sandy loam, but cane in the great majority of cases is grown on land which is also used for paddy and is, therefore, a dark clayey or silty loam.

Statistical.

215. The average area of the Mysore State during the five years ending 1918-19 was 17,484,650 acres. Of this, the net area actually cropped during the same period averaged 6,300,779 acres of which 37,423 acres were under cane, a larger

area than that returned by any other Native State. The percentage of the area under cane to the net area cropped was 0.6, and to the total area under cane in India 1.4. The yield of gur for the whole State is returned at 1.3 tons per acre, but the variations in the different tracts are very great, the yield for the Malnad being estimated at 0.5 of a ton and that of the Kolar district at 1.8 tons.

Varieties of cane.

216. Of the indigenous canes of Mysore the one most widely grown is Cheni. Of this there are in reality two varieties, Ganda Cheni and Hotte Cheni, which are classified by Dr. Barber as members of the Saretha and Sunnabile groups respectively. Dr. Barber considers them comparatively giant forms in those two divisions of indigenous canes and in North India they would be regarded as medium rather than thin canes. Both varieties are hard white canes which withstand drought well. They tiller freely and give high yields under good cultivation. It is rare, however, that they receive such cultivation, as they are mainly grown on land which has a precarious water supply and is somewhat neglected in consequence. When grown under these conditions, Cheni is on the ground for eighteen months and gives an outturn of about 27 maunds (one ton) of gur per acre. Of the thick canes of Mysore, the most common is Patta Patti, a striped variety which, although it is said to have been introduced from the Madras Presidency about 150 years ago, shows no signs of deterioration, possibly owing to the altitude at which it is grown. It is now grown on from two-thirds to three-quarters of the total cane area in the State. Its juice has a very high sucrose content, the average being about 19 per cent. in addition to 0.5 per cent. of glucose. It tillers freely and responds well to manure, but tends to lodge under good cultivation and high manuring. It was stated to yield from 117 to 136 maunds of gur (4.5 to 5 tons) ; but this is probably the maximum rather than the average range of yields, as the yield on the Hebbal farm for the last five years has averaged only 95 maunds (3½ tons). Rastali, which is popularly regarded as the indigenous cane of Mysore, is a soft, white cane which does not tiller so freely or give so high a yield as Patta Patti. Its juice has also not so high a sucrose content. It is, however, extensively grown in the Chitaldrug district and to a less extent in Kolar, and is frequently found as a mixture with Patta Patti. Like that variety it is liable to lodge, and its soft rind makes it particularly liable to the depredations of jackals and pigs which the hard rinded Cheni is able to resist. The other canes of Mysore, such as Mara Kabbu amongst thin canes and Mullu Kabbu and Kare Kabbu amongst thick canes, are merely survivals, and none of them is found on a sufficiently large scale to merit description. The Mysore Agricultural Department has now been engaged for some fifteen years in importing and testing exotic canes and two of these have now spread sufficiently to justify mention in this paragraph. Both Red Mauritius and Mysore Java, an unidentified Java variety, were obtained from the Samalkota farm in Madras, though the latter is not now grown anywhere in that Province. Red Mauritius has so far been found more vigorous and a higher yielder than any other variety yet grown in Mysore. It has the further advantages over the local varieties that it does not lodge and that its hard rind protects it from wild animals. It is, however, harder to crush than Patta Patti or Rastali and does not yield as good a quality of gur. None the less, it is increasing in popularity, as the increased yield more than compensates for these defects. Mysore Java, a light coloured cane the juice of which has a high sucrose content and produces an excellent quality of light coloured gur, is replacing Patta Patti in what is known as the semi-Malnad tract in spite of the fact that it does not tiller well nor give a heavy yield of cane. It matures, however, in twelve months, whilst Patta Patti in this tract is on the ground for 18 months, and its hard rind is a great advantage in a part of the State in which jackals and pigs are numerous.

History of work on sugar cane.

217. Mysore is fortunate in the possession of an organised Agricultural Department which is not only unique among Native States but compares favourably with the Agricultural Departments of several Provinces in British India. The research work already done on cane in the State is consequently appreciable both in quantity and quality, and material results have been obtained in several directions. A feature of the work to which we would draw particular attention is the close chemical control which has been maintained throughout. Since 1905 the Department has been engaged in importing and testing varieties from other parts of India and foreign countries. Many of these have failed to adapt themselves to local conditions and the tendency of some varieties to flower freely militates against their introduction, as this is found to reduce the yield of sucrose in the cane. The two varieties referred to in the preceding paragraph, Mysore Java and Red Mauritius, have, however, been successfully established over considerable areas, and the Java variety P. O. J. 33 A shows promise of attaining similar success. Trials are also being made of some of Dr. Barber's crosses from Coimbatore, and since it was discovered in 1913 that fertile seed could be raised in Mysore itself, the Botanical section of the Department has been engaged in the raising and testing of seedlings from various types of canes. About 600 seedling canes are at present being grown, a few of which, including some of the Red Mauritius variety, are being tested in comparison with imported Red Mauritius and local varieties on the departmental farms and on private estates. Experiments to prove the best period for planting cane were discontinued in 1914 after establishing that this period was from December to March. A series of manurial and spacing tests was started in 1915. These are still in progress, but results so far obtained show that, even with the present high prices of oil cakes, it pays handsomely to apply as much as two tons per acre of *honge* (*Pongamia glabra*) or caster cake in addition to the usual applications of farm-yard manure and that, if adequately manured, canes planted in rows four feet apart give a larger yield than canes planted two and three feet apart. Another problem which is now being tackled is that of economising labour by the adoption of bullock power as far as possible for operations at present performed by hand. Very considerable efforts have been made during the war to popularise the use of oil-cake as a manure for cane, and also, though to a lesser extent, ammonium sulphate; but the work has been seriously hampered by the rapid rise in prices for these manures. The work done in Mysore on gur manufacture will be referred to in Chapter XVIII below.

Agricultural practice.

218. Cane is usually grown in comparatively small patches surrounded by extensive paddy fields, and the commonest rotation is, therefore, cane alternating with paddy either every other year or, more frequently, at intervals of two or three years. A crop of garlic, onions or coriander may also be taken on the same land during the first three months after the cane is planted, a practice which is particularly prevalent in the Mysore district. Other rotations are confined to the small area on which cane is grown under wells, the chief of them being cane alternating with turmeric or irrigated ragi (*Eleusine coracana*). Ratooning is almost unknown outside the Malnad, where the heavy monsoon and the shortage of labour are alike in favour of the practice. The crop is occasionally ratooned twice.

The cane cultivator selects his best land for his cane, but, as it is nearly always land on which paddy is also grown, it is usually a dark clayey or silty loam. The preliminary cultivation consists in ploughing or, less commonly, in

digging the land. With the wooden plough, which is still used by the majority of cultivators, six to ten ploughings are required. Clods are also crushed by hand with mallets and levelling is done by the log harrow or large bullock hoe. Cane tops are everywhere preferred to sets for planting, as they are believed to germinate better and to be less liable to attack by white ants, but whole canes have frequently to be used. Little or no selection of sets is practised, nor is any attempt made to import fresh stock periodically. In the Malnad the sets are steeped in water two or three days before planting to induce quicker germination. We were given estimates of the number of sets planted per acre varying between 4,000 and 12,000, but the weight of evidence supported the mean between these two extremes, or 8,000, as being most common.

Two distinct and well recognised methods of planting are followed : in pits and in furrows. The former method is the commoner in the western districts and wherever the supply of water is scanty during the early period of growth. The pits are shallow and are usually arranged in squares three feet apart each way, two sets being planted in each pit. The system is economical in manure and water, irrigation having to be applied to each pit by hand, but it is expensive in labour and difficult to carry out on large fields. The furrow system is practised in the more important sugarcane areas of the eastern districts. The sets are planted end to end in shallow trenches not more than 1½ feet apart, water being run into the trenches for irrigation purposes from the first.

After cultivation consists in weeding, digging, earthing up and wrapping. Digging is usually confined to fields planted on the pit system, but weeding operations are general and comparatively frequent, and are done by bullock hoes in parts of the Shimoga and Hassan districts. Ridging and earthing up are common only in the western part of the State where the heavy monsoon necessitates efficient drainage. Wrapping is practised only on thick canes and chiefly in the areas of more intensive cultivation in the eastern districts. The number of irrigations and the volume of water given to cane vary greatly, but in general waterings are given every five to seven days during the first three or four months and every ten to fourteen days thereafter, the supply under efficient irrigation being estimated at 108 to 120 inches per annum. Except in the Malnad waterings are required during both monsoon periods as well as in the dry weather. On some three-quarters of the cane area no commercial fertilisers are used, the chief manure being cattle dung, of which amounts varying from 15 to 60 cartloads per acre are applied in the Maidan area, and about 25 cartloads in the Malnad. Alternative manures are tank-silt and night soil, while sheep are sometimes folded on the cane fields. The use of green-manures for cane is practically unknown. On the remaining one-fourth of the area *honge* (*Pongamia glabra*) castor, or groundnut cake is applied in greater or smaller quantities. Their respective nitrogen contents vary from 3½ to 4, 4 to 6 and 6 to 8 per cent. As much as one ton per acre is given in the Bangalore and Kolar districts. In the Malnad, where special efforts have been made to popularise oil-cake, the dose is said to be not more than half a ton per acre. A small beginning has been made in the introduction of sulphate of ammonia in the Shimoga district.

The most usual planting season is from January to March, and the crop is then cut about one year later. Rastali, however, which sometimes ripens in ten or eleven months, is frequently sown in April. So also are Cheni and Patta Patti in the Malnad and semi-Malnad areas, where they are on the ground for 18 months. Another fairly common planting season is September and October,

Prospects of extension.

219. Although during the last 20 years the cane area of Mysore has fallen below 30,000 acres and risen above 45,000 acres, the average area over the decade ending 1918-19 has been only 38,957 acres against an average of 39,849 acres in the preceding decade. Despite the efforts made by the Agricultural Department to improve and extend the cultivation of cane, it would thus appear that no real extension has been achieved. Allowance must be made for the fact that many of the Department's results have hardly had time to make their effects felt, while in other directions final results have not yet been obtained. Abnormal causes also have interfered with the campaign for the spread of commercial manures. But, when all has been said, it seems clear that, if progress is to depend on the work of the Agricultural Department alone, progress will be slow, and it will be a question whether the value of the crop to the State is really proportional to the research work which is being done on it. The questions, therefore, arise what are the obstacles, other than agricultural, to the spread of cane cultivation in Mysore, and how far are those obstacles superable. Subsidiary obstacles are, we understand, the scarcity of labour in some areas and the reluctance of the cultivators in others to substitute so troublesome a crop as cane for one so comparatively easy and certain as paddy. But the primary difficulty here, no less than in Hyderabad, is the problem of water supply, since outside the Malnad cane requires irrigation water practically all the year round.

(a) under canals.

(i) The Cauvery dam project.

220. The cane area irrigated by canals from rivers is at present very small, being estimated at not more than 7 per cent. of the total area. The reason for this is that, with one or two exceptions, Mysore has no reliable perennial canals; and it is these exceptions only that we need consider. The largest of these is the Krishnarajasagara project, more commonly known as the Cauvery dam project, which was started in 1912 and is still under construction. It consists of a huge dam, already some 5,200 feet long and from 40 to 107 feet high, across the Cauvery river north of Mysore city for the storage of water with the double object of guaranteeing a largely increased minimum discharge to the electrical power station at Sivasamudram lower down the river and of irrigating a total area of 175,000 acres of land including 25,000 acres now irrigated from tanks. The complete scheme is still in dispute with the Madras Government, who claim that their own prescriptive rights to irrigation water from the Cauvery are affected ; but its first stage is, we understand, not contested, and this is now approaching completion. It provides for storage of water to a depth of 80 feet, which will suffice to provide the necessary minimum power to Sivasamudram and to irrigate 25,000 acres of fresh land. It is anticipated that water will actually be provided for 21,000 acres in 1921. This will, however, be hot weather irrigation only, as perennial irrigation is not possible under the first stage of the scheme. Under the second stage, assuming the dispute with Madras to be satisfactorily settled from the point of view of the Mysore Darbar, a further 150,000 acres would be supplied, some 106,000 acres with hot weather irrigation only, and the remaining 44,000 acres with perennial irrigation. The prospects of cane under this project, therefore, are not bright unless its second stage is carried out. Even then there is reason to believe that the extension of the crop will be only limited and gradual. Every scheme so far proposed by the Darbar for the concentration of the areas under perennial irrigation and to compel the occupants of land commanded by the scheme to devote a portion of their holdings to cane has met with resolute opposition. Cane cultivation in the tract is backward, and for a long time the attempts of the Agricultural Department to improve it, particularly by the introduction of manuring with oil-cake, failed to

is now being successfully overcome is certainly encouraging; but it would be unsafe to infer from this initial achievement the early eradication of the old spirit of conservatism. The alternative of a capitalist enterprise taking up large blocks of land for cane cultivation is precluded by the fact that practically the whole area has been occupied for many years, and the holders would not be willing to part with their land except at prohibitive prices. Conditions do not, therefore, seem favourable at present for any large extension of cane under this project, unless the old order changes more rapidly than appeared likely at the time of our visit.

(ii) The Marikanave reservoir.

221. The Marikanave reservoir is impounded by means of a masonry dam thrown across the Vedavati (or Hagari) river at the point where it passes through a narrow gorge in the range of low, rocky hills which traverses the south-west corner of the Hiriyur taluk of the Chitaldrug district. It was constructed in 1903 and an area of over 30 square miles was submerged above the dam. Two low level canals carry the stored water over a total length of thirty miles and command what was previously a dry crop area of 25,000 acres, of which 15,000 acres are actually irrigable in each year, though the area so far taken up is only 8,000 acres and the area to which a perennial supply can be guaranteed for cane, even under the most efficient system of distribution, is, we were informed, not likely to exceed 5,000 acres. The Babbur farm, which the Agricultural Department opened in 1916, lies in this tract. Cane experiments form an important part of its operations and a beginning has already been made in the sale of sets for local propagation. In view of the high capital cost of the Marikanave reservoir and the limited area it can irrigate, the officers of the Irrigation Department are anxious to intensify the irrigation as far as possible by promoting the cultivation of valuable crops, such as sugarcane, in concentrated and economically irrigable areas. There is also some prospect of an extension of the canal system under the reservoir. The chief difficulties here, however, are the shortage of labour for the cultivation of cane and the salinity of a good deal of the land. Both difficulties are illustrated by experience on the Babbur farm, where the problem of providing even the limited labour force it requires has not yet been satisfactorily solved, and plots affected by salinity have given not more than half the acre-yield of cane that unaffected plots have given under the same cultivation. It was suggested to us in evidence that this was a suitable area for a central sugar factory controlling its own cultivation and that the existing areas of waste land might be supplemented by purchases from the local land-holders, whose holdings are too large for effective cultivation, and who might be induced to sell at reasonable prices. It seems to us, however, after our visit to the area during our tour in Mysore that the limited perennial supply of water available, the shortage of labour, and the prevalence of salinity in the soil constitute in combination too formidable an obstacle to capitalist enterprise; and that, until it has been demonstrated to what extent and within what period the affected lands can be freed of saline matter, development on these lines is unlikely. This is, however, a factor which will retard the spread of cane cultivation by the small holder also, and the problem should, we think, be worked out as soon as possible on the Babbur farm. The extent of the damage to saline lands is, we believe, much less than it is in parts of the areas commanded by the canals of the Bombay Deccan; and the ryot here might accordingly be less willing to accept restoration subject to certain conditions regarding future cultivation. At the same time the advantages of combining land improvement with a scheme, however partial, for the introduction of intensive cultivation seem to us so great that we would recommend that the possibility of action on the lines suggested in paragraph 178 of our Chapter on Bombay should be investigated. In this case it would probably not be necessary or advisable to proceed to outright acquisition of the lands to be improved, for individual holdings in this tract are so large as to render provision for their redistribution unessential to the success of the scheme.

(iii) The Bhadra river project.

222. We were also informed that a project was already under construction with right and left bank canals from the Bhadra river, taking off at a point some nine miles from Benkipura in the Shimoga district. The scheme, which is estimated to cost 16 lakhs of rupees and to be completed in three or four years, will distribute a perennial supply of water over a total commanded area of 15,000 acres of high class land, and we were given 3,000 acres as the probable area under cane within a few years. Here also, however, the problem of shortage of labour would have to be dealt with.

(b) under tanks.

223. The great bulk of the cane in Mysore is grown under tanks of which there are as many as 26,000 in the Maidan tract. Of this number some 20,000 are classed as minor works and provide water only for a part of the year, some for monsoon crops and others for hot weather crops. These are controlled by the Revenue Department, the Irrigation officers being only responsible for repairs and restoration. The remaining 6,000 are major works, many of which provide water throughout the year. These are controlled by the Irrigation Department, and it is mainly under them that cane is grown. We were given to understand that a number of these tanks had silted up in course of time and that their excavation and repair was a matter of funds, the total cost being estimated at two or three crores of rupees. This, in any event, is a matter of general policy affecting all irrigated crops and not sugarcane only, and the Mysore Darbar needs no reminder from us that tanks are and must always be the State's main source of irrigation. We would, however, make a special reference to the Sulekere tank, as the evidence we received was unanimous in testifying that the prospects of successful cane cultivation on a plantation scale were particularly bright in the area that it commands. It receives the drainage of 457 square miles in the Chamagiri taluk of the Shimoga district. It stores water sufficient to irrigate 4,000 acres of land, though only some 2,200 acres are at present irrigated. This is due partly to the wasteful use of water by the cultivators and partly to the fact that they sometimes deliberately restrict their irrigated areas in favour of dry crops. The standard of cultivation is low, but the soil is much better than that commanded by the Marikanave reservoir and is said to be well suited for cane. There was also said to be a considerable area of Government reserved land under the tank, though evidence as to its extent was conflicting. Moreover, the chances of purchasing some of the occupied lands were regarded as good. On the other hand, labour shortage would probably be acute. The main objection, however, in our opinion to the selection of this area for a central sugar factory is the very limited possibilities of irrigation. Even supposing 4,000 acres to be supplied with perennial water, the whole of this area to be available and suitable for cane, and cane every second year to be a suitable rotation, average outturns of 50 tons to the acre would be required to give a season of 100 days to a factory crushing 1,000 tons a day; and this, as will be seen in paragraph 341 of Chapter XX below, we regard as the economic limit for India. It will probably be many years before even half this yield can be attained as an average and, unless other sources of irrigation are available in the immediate neighbourhood, we regret that we cannot recommend the development of this area except with a view to the manufacture of gur. The tract

would probably, though we have not visited it, lend itself well to the establishment of improved small power gur factories of the kind we suggest in Chapter XVIII, and the possibility of development on these lines would, we think, well repay investigation.

(c) under wells.

224. We have little to say regarding wells as a source of irrigation for cane in Mysore. The State comprises a tract which is not suited for this form of irrigation on a large scale. The subsoil is loose in texture and ill-adapted for the storage of moisture. The subsoil water table is frequently as low as 40 to 60 feet and the discharge obtained from individual borings is usually insufficient for irrigation. Over most of the State, we were informed, tube wells are impracticable. Of the million acres of irrigated land in Mysore less than 75,000 are supplied by wells. The extension of cane under wells, therefore, is never likely to be more than insignificant.

(d) under pumping installations.

225. Another possible source of irrigation water might be provided by the installation of power pumping plants on the banks of rivers. Some streams which run throughout the year flow between banks or through tracts which are too high to admit of canal irrigation by flow. Others which have no perennial flow leave deep pools of stagnant water sufficient to irrigate areas large enough for the economic use of power pumps. Efforts in this direction have already been made, so far with little success ; but we are disposed to endorse the view expressed to us that these failures might have been obviated by the exercise of closer cooperation between the Department of Industries and Commerce, which controls the work of installing power pumps, and the Agricultural Department. We are not aware whether the Mysore Darbar has ever considered the advisability of transferring this work to the control of the Agricultural Department, which has an Engineering section of its own, but, whatever the administrative reasons against this course, the need for expert agricultural advice in a matter of this kind is clear. We have, of course, no means of estimating the expansion of cane cultivation possible under this source of irrigation ; but in any event it is not likely to be rapid in the immediate future.

(e) Conclusions.

226. To sum up, there are considerable tracts in Mysore which are, in respect both of climate and soil, undoubtedly capable of giving high yields of cane of good quality (more than 5 tons of gur per acre have been obtained on the Hebbal farm near Bangalore), but irrigation water is indispensable. Rapid progress in the extension of the cane area and the introduction of improved agricultural methods is unlikely so long as cane cultivation remains as scattered as it is now. Concentration under wells is out of the question and under the large irrigation works now in existence or under construction does not, as we have seen, offer any large promise of attainment. Tanks are the main source of supply and tanks are usually small and scattered. It seems to us, therefore, that material expansion can only be expected, if the assistance of private enterprise is enlisted in the development of cane cultivation in conjunction with a sugar factory, and that the first essential for such a development is the concentration of irrigation supplies in areas found otherwise favourable, that is to say, where the soil is suitable for cane, where land can be obtained by the factory for cultivation under its own control, and also, if possible, where a local labour supply exists. Within the brief period of our tour in Mysore it was out of the question for us to undertake the detailed survey necessary for the selection of such areas ; but we would hazard the suggestion that the Goribidnur taluk of the Kolar district

affords an exceptional opportunity for the concentration we have in view. The cane area under tanks in this taluk is considerable. A small sugar factory is already in existence at Goribidnur which has, it is true, had a somewhat chequered career and has hitherto depended on gur rather than cane as its raw material. But a beginning has now been made in the purchase of cane from the local cultivators, and we were informed that there were blocks of virgin land suitable for cane in the neighbourhood which the factory management proposed to ask permission to take up for the cultivation of their own cane. These are all circumstances which are favourable to development and, should more detailed investigations confirm the impression we have formed and establish the possibility of improving and concentrating the irrigation sources of the neighbourhood, we think that the Mysore Government would be well advised, in consultation with its Agricultural and Irrigation officers, to draw up a scheme to that end and to reserve all suitable areas of unoccupied land for allotment as large sugar plantations. Given a concrete scheme of development and the assurance of the Mysore Government that it will be carried out forthwith, if private enterprise is prepared to cooperate in the manufacture of white sugar direct from the cane, we are hopeful that private enterprise will not be appealed to in vain. It is quite possible that there may be other and even more suitable localities for a similar scheme elsewhere, particularly in the Malnad, though we are not in a position to indicate them. Should the Mysore Darbar, however, be disposed to follow up the suggestion, there is one possible source of unoccupied land which we would venture to put before them. Extensive areas are held by the Government, we believe, as Date palm reserves for which tapping licenses are issued to contractors supplying liquor to the toddy shops, and even outside these reserves there is a good deal of waste land at the disposal of the State which is occupied by Date groves. Much of this land is suitable for cultivation with valuable crops; and it seems to us that, if after a detailed survey a compact area of such land were found on which cane could be grown and to which perennial irrigation could be supplied, the interests alike of the people and of the Government would be served by the opening up of the area for the manufacture of sugar. Certainly the agricultural prospects for cane in Mysore appear to us so good as to warrant us in advocating a thorough local investigation on the lines we suggest before it is finally decided that the obstacles, whether irrigational, economic or other, to the establishment of a factory industry are insuperable.

Agricultural development.

227. The Mysore Agricultural Department is already so efficiently organised both for research and demonstration, and is already doing such sound and practical work on the cane problems of the State, that we have little to say beyond advocating the continuance of that work. All scientific sections of the Department—Chemical, Botanical, Mycological and Entomological— are co-operating in the solution of those problems ; and cane occupies an important place on no less than three of the departmental farms—the Hebbal farm near Bangalore, the Babbur farm in the Hiriyur taluk of the Chitaldrug district and the Marthur farm in the Sagar taluk of the Shimoga district. It will soon, also, occupy relatively an even more important place on the Nagenhalli farm which has been recently opened near Mysore City, and on which it is proposed to plant eight acres of cane in 1921. Should the local survey we have suggested above lead to the development of cane growing on a plantation scale in any locality, it would be for consideration whether experiments on cane might not with advantage be transferred from one or other of the existing farms to that locality. This, however, is a question for the future ; and the only suggestion we have to make regarding the work now in progress is that sight should not be lost of the fact

that the provision of commercial manures in sufficient quantities to meet the growing demands of improved cultivation is, as we point out in our succeeding Chapter, likely to prove one of the acutest problems of Indian agriculture for a number of years to come, and that shortage of supplies may impose a policy of reducing the ascertained optima per acre in the interests of cane cultivation considered as a whole. Problems of drainage, of the proper water requirements of cane, and of eliminating the unsatisfactory rotation of cane with paddy, in so far as this is practicable with the present scattered system of cultivation, still remain to be dealt with. These can, perhaps, best be undertaken on the Babbur farm, but we understand that work on these lines is handicapped by the disability under which the farm labours owing to the stipulation that it must be run at a profit. In pursuance of this stipulation, we observe, a statement of income and expenditure is published for this farm regularly in the Annual Report on the work of the Agricultural Department. None of the other farms is similarly handicapped, and we are so convinced that the handicap must seriously detract from the practical usefulness of Babbur as an experimental station, that we cannot refrain from expressing our earnest hope that the Mysore Darbar will now withdraw a stipulation so strangely at variance with the enlightened policy which they have always pursued towards the advancement of agriculture in the State. As in the preceding Chapter on Hyderabad, we must refer the reader to paragraph 384 of Chapter XXIII below for our views regarding the correlation of research work on cane in Native States with the central research organisation there advocated for British India.

Summary of Conclusions and Recommendations.

(1) *The chief obstacle to extension of cane in Mysore is the need for perennial irrigation.*

(2) *Extension under the Cauvery dam project is improbable until the second stage of the project is carried out, and even then is not likely to be rapid.*

(3) *The limited perennial water supply, shortage of labour and salinity in the soil are obstacles to extension under the Marikanave reservoir.*

(4) *The reclamation of saline lands under this reservoir should be undertaken and an attempt made to combine it with a scheme of intensive cultivation on the lines proposed for the Bombay Deccan.*

(5) *The Sulekere tank area is probably too small for development as a central factory area, but the possibilities of introducing small power gur factories there should be investigated.*

(6) *The installation of power pumping plants should be carried out either by or in close consultation with the Agricultural Department.*

(7) *A factory industry must be organised, if any material extension is to be effected and the bright agricultural outlook justifies special efforts to this end.*

(8) *The Goribidnur taluk of the Kolar district appears a favourable tract for development on these lines.*

(9) *The Malnad and some of the State's Date palm groves may provide equally suitable areas for such development.*

(10) *The possibility of concentrating and improving sources of irrigation in such tracts should be investigated, and suitable areas should be reserved for allotment as sugar plantations.*

(11) *If cane growing on a plantation scale is organised in any locality, the transfer of cane research work to that locality should be considered.*

(12) *Limitation of supplies of commercial manures is an important factor in the conduct of manurial experiments.*

(13) *Problems of drainage, water requirements and rotations remain to be dealt with.*

(14) *Withdrawal of the stipulation that the Babbur farm must be run at a profit is recommended.*

CHAPTER XV.

GENERAL AGRICULTURAL RECOMMENDATIONS.

228. In previous Chapters we have described in detail the local conditions in each Province in which sugarcane is a crop of any importance or possesses any possibilities and have made recommendations based on a study of those conditions. In this Chapter we propose to discuss briefly some important questions of general applicability to all Provinces.

Scope of the Chapter.

229. We commence with the question of manures, as we consider that no more insistent problem confronts the Agricultural Department in India. If the urgent demand for increased food production is to be met and the full benefit of extensions of irrigation is to be realised, it is essential that a supply of fertilisers should be available at reasonable prices. This is a matter of such vital importance to the cultivation of improved varieties of cane that we propose to review it in some detail.

Manures.

India depends almost entirely on the recuperative results of natural processes in the soil to restore the combined nitrogen annually removed in the crops. Although, as will have been gathered from the description of the agricultural practice of the different Provinces, the manurial requirements of such crops as cane are given some measure of recognition, it is true, broadly speaking, that the amount of nitrogen returned to the soil in the form of manure and refuse is insignificant. Here India is in striking contrast with the United Kingdom where it is estimated that 37 million tons of farm-yard manure are annually utilised on the land. In India, as is well known, the bulk of the farm-yard manure available is utilised for fuel. The recuperative processes in the soil are more pronounced in tropical and sub-tropical than in temperate regions; and it is for this reason that the standard of yield in India is maintained at the level to which the cultivator is now accustomed. An acceleration of these processes can be effected by improved agricultural methods such as fallowing, adequate soil aeration, more judicious rotations and the growth of green manure crops; but, helpful as these methods undoubtedly are, even their combined effect falls very far short of meeting the complete needs of intensive cane cultivation. As soon as attempts are made to produce yields of cane to the acre at all comparable with those of Java, external supplies of combined nitrogen, and in some localities of phosphoric acid, become of vital importance. We would here make it clear that the use of nitrogenous manures is not profitable in all conditions. Where crop production is limited by a small rainfall, the annual additions of combined nitrogen given to the soil by natural processes are sufficient to meet the needs of a crop whose bulk is determined by the moisture available; and no profitable result follows from the use of nitrogenous manures under such conditions. As soon, however, as moisture

ceases to be a limiting factor and better cultivation is rendered possible by the introduction of canals or wells, an external supply of nitrogen becomes necessary, if the crop-producing potentialities of the soil are to be exploited to their fullest extent and the maximum return, both direct and indirect, obtained from the expenditure incurred on irrigation schemes.

230. The war has brought about a complete change in the conditions governing the supply of nitrogenous manures in India affecting both possible sources of supply and prices. Before the war the use of nitrogenous manures was mainly confined to the planting districts in Bihar, Assam and South India; and their application was limited—as indeed it still is—to crops of high value such as tea, coffee, and to a less extent cane. The sources of supply of combined nitrogen were oil-cake meal and sulphate of ammonia, the former greatly predominating. The quantity of sulphate of ammonia produced in India was small and did not exceed 3,500 tons of which about 1,000 tons were consumed in this country, the remainder being exported to Japan, Java and the Straits Settlements. Chile nitrate was used only on a small scale on a few tea estates. The market rate for oil-cake meal is fixed on the basis of its nitrogen content. That of castor-cake meal, which is perhaps the kind of oil-cake meal most easily procurable in India and the price of which may therefore be taken as a basis of comparison of the prices ruling for combined nitrogen in India, averaged Rs. 1-10-0 per maund in up-country markets, itself a marked advance on the price level of preceding years. The average nitrogen content of this meal is five per cent. and the price of combined nitrogen, calculated on this basis, works out at Rs. 870.6 per metric ton. We adopt the metric ton of 1,000 kilograms or 2,205 lbs., as that is the standard usually adopted for purposes of comparing the price of combined nitrogen in various parts of the world. The following table shows the average market rate in the United Kingdom for 1911-13 for the chief forms of combined nitrogen available, *viz.* Chile nitrate and by-product sulphate of ammonia, and also for calcium cyanamide :—

(a) The pre-war position in India.

Product.	Nitrogen contents.	Price per metric ton of combined nitrogen.
	Per cent	Rs.
Castor cake meal	5	870·6
By product sulphate of ammonia	20·17	991
Chile nitrate	15·6	1,003
Calcium cyanamide	18	871·5

In the last three cases it has to be remembered that cost of freight from the United Kingdom must be added to the figures given above and it will thus be seen that oil-cake meal was the cheapest form of nitrogenous manure available in India.

231. As already mentioned, the war has completely changed the position. Export of sulphate of ammonia from England was prohibited in 1917 and no supplies could be obtained from other European countries. The demand for nitrogen in this form in the Far East is considerable, especially in Java,

(b) The present position in India.

where it is the usual form of manure for cane, and in the Straits Settlements. Prices in those markets rose in consequence to abnormal heights and this reacted on the price of combined nitrogen in India, where the demand for oil-cake meal had increased as its value as a fertiliser became more widely recognised and was stimulated by the high prices prevailing for cane and other valuable crops. Supplies of oil-cake meal continued, however, to be strictly limited and the disparity between supply and demand sent prices in 1918-19 up to Rs. 4 per maund in up-country markets. In 1919-20 they fell to Rs. 3-12-0 per maund. Taking castor-cake meal with a nitrogen content of five per cent., these prices are equivalent to a price per metric ton of combined nitrogen of Rs. 2,143 in 1918-19 and Rs. 2,009 in 1919-20. The great increase in the price of combined nitrogen in the form of oil-cake meal which has resulted from economic changes precludes its application to any crops except those which yield a high monetary return.

The price of sulphate of ammonia produced on the Indian coalfields, that is, the cost of production and packing, was in October, 1920 Rs. 250 per ton of 2,240 lbs. The retail prices in India and the export prices continue to be regulated by the rate prevailing in the United Kingdom *plus* the cost of freight. As we have already mentioned, the greater part of the sulphate of ammonia produced in India is exported to Java and the Straits Settlements. The price paid by the Java plantations in October, 1920 was 28 guilders per picol or Rs. 461 per ton of 2,240 lbs. The price per metric ton of combined nitrogen works out at Rs. 1,219.6 in the case of sulphate of ammonia delivered free on rail at the Indian coalfields in October, 1920 and Rs. 2,248.9 in that of sulphate of ammonia purchased retail on the Java plantations during the same month.

(c) Future requirements of nitrogenous manures for cane.

232. The figures given in the preceding paragraphs show in very striking fashion the necessity for increasing the internal supply of combined nitrogen in India in order to assist the development of the sugar industry. It is, however, obviously impossible to frame any but a most tentative estimate of the probabkle requirements of combined nitrogen and nitrogenous fertilisers which would follow the development of cane cultivation on the lines foreshadowed thrughout our Report. Even a tentative estimate is, however, not without value, if it helps to an understanding of the naure of the problem. If by intensive methods of cultivation the yield of cane per acre could be increased to 30 tons, a factory with a 9.5 per cent. extraction producing 10,000 tons of sugar annually would require 3,500 acres under ane to supply it with ufficient raw material. The amount of nitrogen that would be needed to obtain this yield and leave the land in sufficiently good condition to enable the succeeding crop, which in Northern India would generally be wheat, to benefit by the cultivation given to the crop of cane may be taken as 120 lbs. per acre. Every 10,000 ton factory would thus become a consumer of 190.4 metric tons of combined nitrogen. This is equivalent to 929.6 tons (of 2,240 lbs.) of ammounium sulphate, or 102,066 maunds (3,752 tons) of castor-cake meal. If we assume hat the production of factory ugar in India may ultimately reach 1,000,000 tons per annum and that the cane required to give this result is grown on land on which intensive methods of cultivaion have been adopted, the potential requirements of India for cane alone would amount to 19,041 metric tons of combined nitrogen which is equivalnt to 92,960 tons (of 2,240 lbs.) of sulphate of ammonia, or one-third of the total quantity of that product exported from the United Kingdom in 1913. If the demand were met entirely

by oil-cake meal, the quantity required would be 10,206,600 maunds (375,200 tons). The question therefore arises how this possible demand could be met.

(d) External sources of supply and future prices.

233. Although it is impossible t oforecast the future of the trade in nitrogenous fertilisers with any degree of certainty, there can be no doubt that the present situation will undergo great modifications. Before the war the continuous increase in the demand for nitrogenous fertilisers and the upward trend of prices led to the invention of processes for obtaining them from the air, thus opening up an unlimited source of supply. The enormous requirements of explosives during the war resulted in an extensive development, chiefly by the Central Powers, of two of these processes, the cyanamide process and the Haber process for the production of synthetic sulphate of ammonia. The following table shows the extent of the development :—

	Percentage of fixed nitrogen contributed by each industry.	
	1914	1917
Chile nitrate	53·0	41·1
By product sulphate of ammonia	36·6	30·3
Synthetic processes	10·4	28·3

The rate at which the cyanamide process and the Haber process have developed is shown in the following table :—

	Year.	Production in metric tons.
Cyanamide process	1907 ...	1,700
	1913 ...	156,000
	1916-17 ...	931,000 (estimated).
Haber process	1913 ...	30,000
	1917 ...	500,000 (estimated).

The installations for the manufacture of synthetic products which were erected during the war can now be used for the production of fertilisers and a considerable proportion of their capital cost will be written off as a war charge. A very important additional source of supply has thus been created. The Chile nitrate and the by-product sulphate of ammonia industries have also expanded, and it is estimated that 30 to 40 per cent. more combined nitrogen can now be produced than in 1914. It is, however, anticipated that the increased demand for combined nitrogen for agricultural purposes will provide an adequate market. This anticipation is based on the fact that the consumption of nitrogenous fertilisers doubled between 1903 and 1913, and that the present demand for agricultural purposes is greatly in excess of that in 1913. We do not, however, consider it probable that the high prices now prevailing can be maintained indefinitely. There is no question that the synthetic processes can produce combined nitrogen at a cost which leaves a very considerable margin of profit as compared with the pre-war price, and that the nitrate and by-product sulphate of ammonia industries will in consequence be subjected to

severe competition. Such information as we have in regard to the costs of the synthetic processes shows that they are able to produce combined nitrogen at a cost of Rs. 240 to 245 per metric ton at the factory. This means that, after making allowances for freight and marketing charges, producers of sulphate of ammonia may have to face a market price in this country of Rs. 140 per ton and those of castor-cake meal one of Rs. 1-4-0 to Rs. 1-5-0 per maund. There is, however, little likelihood that the price of combined nitrogen will fall at all rapidly to this level ; as high wages and high costs of production as well as the high returns obtained in other countries by their use for food crops will tend to keep it up. There can be no doubt that there would be a large demand in India for both oil-cake meal and other forms of nitrogenous fertilisers at the rates just mentioned, and that this demand would increase as agricultural practice in India improved. This, however, is a general agricultural problem which is beyond the scope of our enquiry.

(e) Price which the cane grower should be able to pay.

234. The question with which we are immediately concerned is the price at which it should be possible to purchase combined nitrogen in order to make it profitable to apply it to the intensive cultivation of the cane crop. This price must obviously be determined by the price obtainable for cane; and the latter again will, if the sliding scale we propose in Chapter XIX is adopted, be determined by the price of sugar. As we have already stated, an application of 120 lbs. of nitrogen per acre to a field which is given proper cultivation and suitable irrigation should result in an outturn of 800 maunds (about 30 tons) of improved cane per acre in Upper India, an increase of 300 maunds (or 11 tons approximately) over that which would be obtained without the use of concentrated fertilisers. If the price of sugar were Rs. 15 per maund and extraction no more than 7.5 parts of sugar per 100 of cane, the value of the increased outturn of cane, calculated at half the value of the sugar to be obtained from it, would be Rs. 168 per acre. If the price of sugar were Rs. 20 per maund, it would be Rs. 225 per acre. In these conditions it would pay the factory or grower to invest at least one-half this amount, *viz.*, Rs. 84 to 113 per acre, in the purchase of nitrogenous manures for the cane crop. A price of Rs. 84 to Rs. 113 for 120 lbs. of combined nitrogen works out at Rs. 1,543 to Rs. 2,076 per metric ton. If, therefore, the Indian sugar industry is to be in a position to purchase the supplies of combined nitrogen it requires when sugar is not more than Rs. 15 per maund, an adequate supply must be available at not more than about Rs. 1,540 per metric ton, which is equivalent to Rs. 315.5 per ton (of 2,240 lbs.) of sulphate of ammonia and Rs. 2-13-4 per maund of oil-cake meal.

(f) Internal sources of supply and their development.

235. This brings us to the discussion of the internal supplies of nitrogen available in this country and the methods by which these can best be developed. One of the salient lessons which emerged during the later stages of the war was the necessity that every country should develop its resources of combined nitrogen to the fullest possible extent in order to maintain and, if necessary, increase its food production. The important bearing of this question on the Indian sugar industry was impressed upon us by many witnesses amongst whom were the most experienced officers of the Agricultural Department. It is most unlikely that there will be any great increase in the amount of farm-yard manure available, as no solution of the problem of providing for the requirements of fuel for domestic purposes in any other way than by the use of farm-yard manure appears to be in sight. The most promising lines of development in India therefore, are

(1) The increased production of oil seeds and the extension of the oil pressing indust

(2) The development of processes for the by-product recovery of sulphate of ammonia from coal.

(3) The establishment of synthetic processes for obtaining combined nitrogen from the air in forms suitable for use as fertilisers.

An exhaustive investigation into the possibilities of these three lines of development would have occupied the whole of our time to the exclusion of the enquiries for which we were primarily appointed. The subject is one which, in our opinion, is well worth investigation by a Committee specially appointed for the purpose. Our enquiries have necessarily been limited in their scope, but they have convinced us that a considerable increase in the supplies of nitrogenous manures, both organic and inorganic, available in this country is possible. We consider it desirable that we should place on record the general impression on this point which we have gathered from the evidence tendered to us and from our own observations.

(i) Oil-cake meal.

236. As regards the first of these lines of development, the extension of the oil pressing industry is of much greater importance than the increased production of oil seeds, as the area under them in all India is already between 16 and 17 million acres. The exports of non-essential oil seeds from British India for the five pre-war years averaged 1,432,607 tons annually valued at nearly 24 crores of rupees and for the five years ending 1918-19 averaged 699,255 tons valued at nearly 12 crores. These figures are sufficient to show both the extent of the loss which India suffers by the export of a valuable by-product which should be returned to the land and the possibilities of an extension of the oil pressing industry which would enable the oil-cake to be retained in this country. As we have already indicated, there is an expanding demand for oil-cake meal as a fertiliser even at the high prices ruling at the present time ; and for the reasons given above we consider that, if it can be produced at a price of about Rs. 2-14-0 per maund, there is an assured market for a very large quantity of it in connection with the sugar industry alone. We understand that the main obstacle to the establishment of the industry at the centres of oil seed production is the difficulty in regard to the transport of the oil, and we would suggest that this question should be investigated by the Provincial Departments of Industries.

(ii) By-product sulphate of ammonia.

237. As regards the second line of development, that of processes for the by-product recovery of sulphate of ammonia from coal, we have been informed that there has already been an extension of the manufacture of coke with sulphate of ammonia as a by-product on some of the most important coalfields and that further development is likely. According to a trustworthy estimate which has been given us, the production of sulphate of ammonia on the Indian coalfields will be approximately 8,000 tons in 1921 and in five years' time will be about 20,000 tons per annum. It is, in our opinion, very desirable that a market should be found for this in India rather than in Java or Japan. The use of sulphate of ammonia in combination with oil-cake meal, and possibly in certain cases with phosphates, would be a factor of the utmost value in the increased production of sugar in this country.

(iii) Nitrogen fixation.

238. As regards the third line of development, nitrogen fixation, we have already mentioned the expansion of the synthetic industry which has resulted from the war. We consider that, from the point of view of development of the sugar industry alone, the successful introduction of synthetic processes in India is

a matter of the first importance. The cyanamide process is now thoroughly well established on a large scale in many countries and has proved a sound commercial proposition. The power requirements of this process are not high and its product 'Nitrolim' is one of the cheapest forms of nitrogenous fertiliser. It has the great advantage of producing a fertiliser in a directly marketable form which the presence of free and uncombined lime makes specially suitable for many classes of Indian soils. It has been estimated that, where electrical power is available at Rs. 60 per kilowatt-year, and coal and lime can be delivered at the factory at Rs. 8 and Rs. 7½ per metric ton respectively, this process, installed on an adequate scale, should produce combined nitrogen at a cost of Rs. 284 per metric ton. Even when a large allowance is made for increased cost of coal and lime, of freight and of marketing, there should be a wide margin between the cost of production of combined nitrogen in the form of cyanamide and the price of Rs. 1,540 per metric ton of combined nitrogen which we have estimated could be paid when the price of sugar is Rs. 15 per maund. In our Chapters on the United Provinces and the Punjab we have mentioned important hydro-electric schemes which are under investigation. We recommend that the possibilities of utilising these and similar schemes for nitrogen fixation should be thoroughly examined and that, if it is found that electric energy can be obtained at a rate approximating to Rs. 60 per kilowatt-year, a unit plant of sufficient size to afford trustworthy information should be installed. The exact site of such a factory would be determined by the extent to which raw material was available and by other considerations into which we are not competent to enter. We do not suggest that investigations into the question of nitrogen fixation should be confined to the cyanamide process, and would draw attention to the possibilities of the Haber process for obtaining synthetic sulphate of ammonia. We consider, however, that it is desirable that the cyanamide process should first be investigated, as this produces a fertiliser which, in our opinion, will be found very suitable for sugarcane.

239. Closely connected with the use of manures is the question of deep ploughing. We have emphasised throughout our Report that the introduction of improved varieties of cane is useless unless it is accompanied by the introduction of improved methods of cultivation, of which, as our description of agricultural practice in Java and on the farms at Shahjahanpur and Manjri will have shown, deeper ploughing is the first and most important element. The developments in this direction possible on the holdings of the ordinary cultivator and on large estates have to be considered separately.

Deep ploughing.

240. It is axiomatic that the greatest obstacle to the introduction of any improvements into the general agricultural practice of India is the excessive subdivision of holdings. The suggestions we make in Chapter XIX with a view to reducing this difficulty in the immediate neighbourhood of the factory can for an indefinite time to come only affect a small proportion of the area under cane in India and, in any case, merely touch the fringe of the problem, as it does not fall within our province to deal with it except from the point of view of cane cultivation. Given the present small holdings, it has to be determined whether any advance in the direction of deeper ploughing is possible. The plough now used by the cultivator is, in reality, only a harrow point and has no mould board. Its construction is such that deep ploughing with it is out of the question, and, though the cultivator has an idea that he can secure this by increasing the number of ploughings, he merely works the top soil to a tilth and does not obtain

(*a*) *on ryots' holdings.*

the depth essential for the proper cultivation of improved varieties of cane. The inadequacy of the Indian plough is the first thing about Indian agriculture which strikes the visitor to this country who is acquainted with agricultural conditions in other countries, and the result is that the number of improved ploughs which have been designed for introduction into India is legion. But the idea that the Indian plough is merely the result of ignorance of what a good plough should be is entirely unwarranted. The cultivator has found by long experience that nothing better is possible with his present bullocks. Failure to realise the fact that improvement in the bullocks must in most parts of India be a preliminary to an improvement in the plough has resulted in the country being flooded with ploughs which no pair of country bullocks of the ordinary type can draw. Many of these, otherwise excellent, require such large and expensive bullocks to draw them, that there is very limited scope for their adoption outside tracts, such as parts of the Punjab, Madras and Bombay, where a large type of plough bullock is employed. That is the position today, and the true line of advance in other areas lies in reducing the amount of work done by the bullocks off the land, such as cane crushing, the threshing of the *rabi* crop and irrigating. We make suggestions in Chapter XVIII for the use of power plant for cane crushing and *rabi* threshing, whilst the use of such plant in conjunction with tube wells would reduce the demands on bullocks for irrigation. We would repeat that the present country plough represents the limit possible with bullocks of the ordinary type in their usual poor condition. If they can be relieved of the three operations mentioned above, they will then be in decent condition for ploughing, and the introduction of improved ploughs of greater draught will be possible. This will result in improved yields and better fed bullocks and an improvement in the whole chain of farming practice. Coupled with a definite policy of cattle-breeding on the part of the Agricultural Department, it will give the country a bullock which the land can feed and which will be equal to the deep cultivation necessary to enable the land to maintain it. The policy must be one of gradual improvement ; and any attempts to introduce a bigger bullock until the land can feed it or to introduce a new plough until the bullocks can draw it are simply waste of time and money.

241. On large estates the question of deep ploughing assumes a different aspect. The perfection of cultivation on the cane plantations in Java on which we have commented in Chapter II has been obtained solely by hand labour. The tendency throughout the world is to increase the use of machinery and to lessen that of hand labour and the rapid rise in labour costs is hastening the transition. Labour difficulties are being increasingly felt in Java which has hitherto had the advantage of a plentiful, cheap and easily managed labour supply ; and it is evident that, sooner or later, Java will have to come into line with the rest of the world in this matter and to reduce the amount of labour employed in order to maintain a reasonable margin of profit. Large estates in India, especially in Provinces like Assam and Burma where the prospects of the factory system are especially favourable, are therefore in a position to profit by the experience of other countries. If development in these tracts is to be rapid, dependence upon a large labour force for essential cultivation is obviously out of the question. The solution of the labour problem here is, therefore, to be looked for in the use of steam tackle and motor tractors. We attach to our Report two illustrations showing steam tackle at work on a cane field in South India and the same field when ready for planting. It has been proved in at least one instance in Java that yields of cane as good as those from hand labour can be obtained when cultivation is carried out by steam tackle, and

(*b*) *on large estates.*
(*i*) *Steam tackle.*

the use of such tackle has the additional advantage that the entire field is worked thoroughly instead of a portion only, as happens when the trenches are made by hand labour. The facilities the tackle gives for handling cane cultivation over large areas are obvious. Combined with its superiority in working and its capacity for breaking up jungle grass land and carrying out drainage works in new areas, they make it an essential for all large concerns commencing operations in tracts where labour is scarce and expensive.

Valuable light has been thrown on the question of costs by the work which has been done at Pusa. Eight acres of cane were grown in the year 1919-20; and the total cost per acre of cane cultivated amounted to Rs. 136-6-8. The details are given in the table below :—

AREA 8 ACRES.

I.—Steam tackle operations.

			Rs. A. P.		Rs. A. P.
26th November 1918	...	Disc Harrowing	at 2 7 6 per acre	...	19 12 0
28th " "	...	Rolling	" 1 14 10 "	...	15 6 8
3rd and 4th February 1919	...	Ploughing	" 5 8 9 "	...	44 6 0
4th and 6th February 1919	...	Grubbing	" 1 15 3 "	...	15 10 0
6th February 1919	...	Rolling	" 1 14 10 "	...	15 6 8
7th February 1919	...	Disc Harrowing	" 2 7 6 "	...	19 12 0
			Total	...	130 5 4

II.—Other operations.

	Rs. A. P.
Cultivation	... 11 5 0
Manure, 13½ maunds per acre, and labour for applying it ...	... 283 5 5
Planting	... 79 5 4
Seed (Maunds 413-11-6 for 8 acres at 11 annas per maund) ...	... 284 2 0
Inter-cultivation	... 126 11 4
Harvesting and Carting	... 56 2 4
Total	... 840 15 11
Total of all agricultural costs	... 971 5 3

III.—Rent.

	Rs. A. P.
At Rs. 5 per acre per crop over 3 crops (*i.e.* August 1918 to February 1920)	120 0 0
Grand Total	... 1,091 5 3
Rate per acre	... 136 6 8

The steam tackle operations cost Rs. 16-4-8 per acre in all, but this is an outside figure which should be appreciably reduced when the tackle is used on an estate scale. Thus, the figure includes not only an allowance of Rs. 7-5-2 per day for replacements but also 5 per cent. interest charges and 5 per cent. depreciation charges on the cost of the tackle, the latter as well as the former calculated over the whole year, although the tackle was in fact employed only for 145.4 days of 10 hours each. On a large estate it would, of course, be employed practically throughout the year and for more than 10 hours per day. The inclusive cost per day of 10 hours works out at just under Rs. 40-8-0, a day's work at each of the operations of cane cultivation being placed at 7.3 acres for ploughing, 16.4 acres for disc harrowing, 20.7 acres for grubbing and 21 acres for rolling. The returns are less instructive when we come to correlate costs with results, for the obvious reason that the cane was grown for experimental and not for commercial purposes and of four acres of thick cane planted a large proportion failed, bringing the average yield for thick canes down to 324 maunds (11.9 tons) per acre. Even so, the thin and medium canes having yielded 604 maunds (22.2 tons) per acre, the crop throughout the area averaged 464 maunds (17.1 tons); and the whole cost of cultivation was thus 4.70 annas per maund against 5 to 6 annas per maund which we have in Chapter I estimated as the present day average cost to the cultivator of raising the thin, indigenous canes of Northern India by bullock power. It is evident, therefore, that, given areas large enough to keep it fully employed, steam tackle can effect material economies in the cost of cane cultivation.

(ii) Motor tractors.

242. On smaller estates, and even on large estates where it is not a question of breaking up large areas of new land, the motor tractor, whilst equally useful, would probably be found more economical than steam tackle, as its capital cost is much lower and it would not, therefore, involve such a heavy charge per acre as steam tackle does on any estate not large enough to keep it fully employed. Experiments to ascertain the most suitable type of tractor for different classes of soil are still in progress, and it is sufficient to say that, as it has been estimated, on the basis of the results obtained at Pusa, that a tractor will displace eight to ten pairs of bullocks, the scope for their use in India is enormous. But, whilst steam tackle and motor tractors can do so much to simplify the problem of deep cane cultivation, a word of warning must be added. It is useless from the point of view of labour saving to do preliminary cultivation by machinery, if the cane is so planted that all subsequent operations have to be carried out by hand labour. If labour saving devices are adopted for trenching and ploughing, it is essential that all subsequent operations up to harvesting should be done either by power or by bullocks. That bullocks can be used for this purpose has been successfully demonstrated at Manjri (*vide* Plate 20 at the end of the Report) and we consider that the results obtained there are so instructive that information regarding them should be distributed in bulletin form to all large landholders growing cane throughout India. We have said enough to show the importance of the application of power machinery to cane-cultivation and the desirability that this question should form one of the lines of work to be taken up by Sugar Research Institute.

Field experiments.

243. During our visits to the numerous Government farms on which cane experiments were in progress we observed that there was considerable diversity of method in carrying out varietal tests on a field scale, and we cannot but think that greater uniformity is both practicable and desirable. In the first place, there is often a tendency to conduct the tests on single plots of too diminutive a size for reliable conclusions to be drawn. Individual areas of $\frac{1}{20}$ or even $\frac{1}{30}$ of an acre for each variety have sometimes furnished the sole material from which comparative results have been ascertained and published. We are convinced that, whatever care is taken, the experimental error involved is of such a magnitude as to render results so obtained of no practical value. We would lay down $\frac{1}{10}$ of an acre as the minimum limit for each test plot, particularly as this area should yield a convenient quantity of cane to deal with for

the required tests. Wherever possible, also, the tests should be repeated over two or three such plots for each variety under experiment. The figures in the following table are supplied by our colleague, Mr. Clarke, and they illustrate actual results recently obtained at Shahjahanpur during the comparative trial of two varieties of cane sown on the flat in rows four feet apart. The test plots were taken at equal intervals in a field of 3½ acres and show the range of variation that may be expected :—

	Cane obtained from ⅒ acre mauṇds.	Juice per 100 cane.	Sucrose per 100 juice.	Glucose per 100 juice.
VARIETY A.				
Plot 1	91·6	65·4	15·4	0·81
Plot 2	87·4	64·9	15·0	0·97
Plot 3	90·6	66·1	16·3	0·50
Plot 4	88·1	66·4	16·0	0·74
VARIETY B.				
Plot 5	62·4	68·8	15·6	1·13
Plot 6	65·7	69·4	15·2	1·26
Plot 7	64·0	68·2	15·8	1·12
Plot 8	68·9	67·9	15·7	1·14

In the second place, all the tests relevant to a practical comparison between different varieties of cane are by no means always applied ; and on some farms nothing more than the weights of the cane grown on measured plots has been taken. This ignores the essential difference between cane and other crops, that weighment and ocular inspection do not afford even an approximate criterion of its commercial value, that that value depends mainly on the yield not of cane but of available sugar per acre ; and that only by careful and repeated chemical analyses can the sucrose content of each variety be determined. It is true that this involves the provision of special equipment for the crushing of the cane and the boiling and analysis of the juice on all farms at which these field experiments are in progress, but the experiments must remain inconclusive and are therefore useless unless this equipment is provided. We consider then, that, in addition to weighment of the cane, careful tests to ascertain the percentages of fibre and of sucrose in the cane, the percentage of sucrose in the juice and the purity of the juice are indispensable for the conduct of all varietal experiments with cane, and that on all farms which are unable to provide the equipment and expert supervision which these tests require varietal experiments should be abandoned without waiting for the constitution of the cane research stations advocated in our provincial Chapters to which the bulk of this work will, we hope, ultimately be transferred.

Agricultural demonstration.

244. We have emphasised throughout the provincial Chapters of our Report that a most important branch of work to which the Agricultural Department must devote its energies in increasing measure as its staff expands is the improvement of agricultural practice and the spread of better implements. The selection of superior varieties of cane, the distribution of sets of those varieties, the supply of concentrated fertilisers and even the extension of irrigation facilities will not yield the results which should reasonably be expected of them,

unless they are accompanied by a great advance in both these respects. It will, we think, be a very long time before demonstration of improved agricultural methods and of the use of better implements ceases to be an even more essential part of the work of the Agricultural Department on cane than the selection of new varieties and the organisation of supplies of sets. We fully recognise the excellence of the work which is being carried out on many research stations and demonstration farms ; but the methods there successfully worked out have hardly yet been introduced into general agricultural practice, and the comparative failure to extend them forms the weak link in the chain. It is for this reason that in Provinces such as the United Provinces, the Punjab and Bihar and Orissa, where the importance of the cane crop, in our opinion, justifies such a course, we have recommended the appointment, either immediately or in the near future, of a demonstration staff specially trained for and specially employed on sugarcane work. We have not suggested a special demonstration staff for work on cane in Bengal or Madras, and except in the special case of such concentrated cane areas as the Deccan canals tract, we do not consider that other Provinces will require a special staff for work on cane until the area under that crop expands to at least 100,000 acres. In all Provinces, however, in which such a staff is not appointed, we are of opinion that a demonstration staff on the lines we have suggested for cane work in the United Provinces is desirable for general propaganda work amongst cultivators. The organisation of such a staff in small units with a Provincial (Class II) Service officer in charge of a group of ten fieldmen is, in our opinion, a very suitable one. It would be an easy matter to provide for the special instruction of units of this size, the number of which could obviously be increased as the work expands. We would suggest that the officer in charge of such a unit and the fieldmen composing it should, when working entirely or mainly on cane, invariably be sent to the Sugar Research Institute or the nearest sub-station for short courses of instruction in the latest developments of cane cultivation, the management of small power crushing mills and the manufacture of gur.

In this connection we would point out that many simple improvements which would have a marked effect on the outturn of cane and gur can be introduced at once. The following are a few instances of such improvements, but the list is by no means exhaustive :—

(1) The replacement of mixtures of canes by pure lines of the indigenous varieties best suited to the tract.

(2) Better preliminary cultivation of the land and deeper ploughing, wherever possible, by the use of the turnwrest plough.

(3) Planting the sets of thin indigenous canes in rows two feet apart and of medium and thick canes at still greater intervals, and better cultivation between the rows.

(4) The correct use and the proper quantity of manure for indigenous canes.

(5) The introduction of the rotations recommended in preceding Chapters.

Whilst we realise the necessity for demonstration farms both as centres for the multiplication and distribution of sets and also for the promotion of improvements worked out at the cane research stations, we would again emphasise that demonstration work, if it is to be really fruitful in results, must

in the main be carried out on the fields of cultivators. Where this is done successful methods are adopted without hesitation. It has frequently been pointed out that small cultivators are apt to regard demonstration work on Government farms with suspicion, on the ground that it is carried out regardless of expense, and to question the suitability of the methods employed on the farms to their own conditions. Demonstration on the cultivators' own lands is free from such suspicion and merely forms an ordinary incident in the agriculture of the village. The important question of co-ordinating research and demonstration work on cane is one the consideration of which we must postpone to Chapter XXIII, since our views regarding it depend directly upon the research organisation we shall there propose.

Agricultural engineering.

245. In the preceding Chapters we have made recomendations for a considerable expansion of the Engineering sections of the Agricultural Department in some Provinces. It is, in our opinion, very necessary that the importance of agricultural engineering as a factor in agricultural development should be more definitely recognised than it has been hitherto. The evidence we have received on this point shows that it has, till now, been regarded as a distinctly secondary sphere of activity. As long as this attitude is maintained, it will become increasingly difficult to recruit or retain engineers of the requisite qualifications for the charge of the section. We are, therefore, strongly of opinion that Agricultural Engineers should not only be recruited on the same terms as members of the Indian Agricultural Service but should be included in the cadre of that service.

The extensive use of agricultural machinery for sugarcane cultivation on the lines we have foreshadowed will necessitate special arrangements for instruction in the proper use and care of oil engines, pumps, small power mills and improved tillage implements, a point in regard to which the Indian cultivator is markedly ignorant and careless. We, therefore, recommend that the Engineering section of the Agricultural Department in all Provinces where such a section has been established should have a special demonstration staff whose duty it would be to inspect the machinery given out or recommended by the Department, to give instruction in its use and to arrange for minor repairs and the supply of spare parts. Many instances of the necessity for such a staff came under our observation during our tours and we are convinced that, without it, any work done by the Agricultural Department in promoting the use of agricultural machinery or improved implements will lose nearly all its value. A statement in the Report on the working of Co-operative Societies in Bihar and Orissa in 1918-19 is of interest in this connection. The Supaul Central Bank indented for a type of cane crushing mill which had been found useful and hired them out to cane growers at Rs. 22 for the season, which was Rs. 10 less than the rate charged by the agents of another type of mill. Some of the mills went out of order ; but the Agricultural Department, which was requested to make arrangements for their repair, expressed its inability to help in the matter. It does not appear whether the mills had been recommended by the Agricultural Department. The loss of confidence in the recommendations of the Department and the set back to its work in other directions which must have resulted, if this was the case, are too obvious to require comment. The alternative lesson to be drawn from this incident is the desirability that, if Co-operative Societies desire the help of the Agricultural Department in regard to the care of any machinery obtained by them for the use of their members, such machinery should be of a type recommended by the Agricultural Engineer. Before leaving this subject, we would add that in Provinces, such as the United Provinces, where the word of the Engineering branch of

the Agricultural Department has already made marked progress it will probably be necessary to establish subsidiary centres where repairs and other minor work can be carried out.

Mycological aspect.

246. The thin indigenous canes of Upper India outside Bihar suffer less from disease than cane in any other part of the world. The two most common diseases are black smut (*Ustilago sacchari*) and red rot (*Colletotrichum falcatum*), but the damage caused by neither can be considered serious. Black smut is confined almost entirely to canes of the Saretha group and red rot to canes of the Pansahi group (including Uba) grown under unsatisfactory conditions of drainage. In Madras, Bombay and Bihar fungus diseases are more prevalent, the main damage to the crop being caused by diseases of the stem, notably by red rot which is found in Madras wherever cane is grown. We have already mentioned the measures taken by the Agricultural Department in that Province from 1902 onwards which have been markedly successful in controlling this disease. These measures have consisted in the introduction and spread of varieties resistant to disease, the planting of healthy sets and improvements in cultivation and drainage. The evidence we received showed that there is no factor so potent in inducing red rot as lack of drainage ; and this lends additional force to the recommendations in regard to drainage which we have made throughout. The important fungus diseases of cane are now fairly well understood as a result of the systematic work initiated by Dr. Butler, Imperial Mycologist, in 1902 and continued by him and his co-workers since then. There appears to be no cure for them ; but experience in Java, which is borne out by that in Madras, has shown that by the introduction of new varieties, the planting of healthy sets, careful cultivation and above all proper drainage, on all of which points we have made detailed recommendations, the damage done by them can be very greatly reduced, if not entirely eliminated. The mycological work on cane required in India in future will, therefore, be control measures, in the event of an epidemic appearing in new varieties, and the study of the relatively unimportant diseases of cane which have not so far been investigated.

In view of the far more urgent requirements of the Agricultural Department in other directions we do not consider that any additional staff is required specially for these purposes. A supernumerary Mycologist has recently been appointed to the staff of the Imperial Research Institute at Pusa, a Plant Pathologist has been added to the staff of the United Provinces Agricultural Department and the Central Provinces will shortly have a Mycologist. The two latter appointments will reduce the demands on Pusa. Several other local Governments and Administrations have decided to employ their own Mycologists for the investigation of fungus diseases, including those of cane, as soon as circumstances permit. We would, therefore, only recommend under this head that laboratory facilities for mycological work should be provided at the Sugar Research Institute the establishment of which we recommend in Chapter XXIII below ; and that, in the event of any problems arising which, in the opinion of the Director of the Institute, require local investigation, a Mycologist from the Pusa staff should be lent to the Institute for the purpose.

Entomological aspect

247. The most serious insect pests of cane in India are cane borers which cause very serious damage to the young cane crop in many parts, more especially in Bihar and the submontane tracts of the United Provinces. Other pests, such as grass hoppers, cane hoppers and *aleurodes* occur, but their attacks are usually sporadic and local. The damage done by such pests may, however,

be severe, as was shown at Kamrup in April and May, 1919, when three species of Rutcline beetles appeared in unusually large numbers and destroyed a large proportion of the crop. As regards cane borers, a large number of species are involved and these differ in habits, distribution and alternative food plants. Satisfactory methods of control in order to check the damage done cannot be initiated until the life histories of the various species have been worked out. So far little progress has been made in this preliminary work. We do not recommend that a whole time officer should be employed for work on cane borers ; but we consider that the loss caused by these pests is so serious that more attention should be paid to them than has hitherto been possible. In view of the fact that the problem of controlling them is not confined to a particular Province, we are of opinion that work on them can best be carried out under the control of the Imperial Entomologist at Pusa. We, therefore, recommend that the staff of the Pusa Institute should be strengthened by the appointment of an additional Entomologist whose principal duty would be the investigation of cane pests, but whose services would also be available for work on the numerous pests which affect other crops. We would suggest that laboratory facilities at the Sugar Research Institute should be given him similar to those we have recommended in regard to mycological investigations.

Import of cane.

248. Import of cane into India from other countries is permitted by the rules framed under the Destructive Insects and Pests Act, II of 1914, when the cane is accompanied by an official certificate that it is free from diseases or pests. The authorities whose certificates are accepted are specified in the schedule to the rules under the Act and are, with very few exceptions, the Directors of Agriculture of the countries from which the cane is obtained. The only officer in this country who is at present exempted from the operation of the rules is the Imperial Sugarcane Expert who may import cane intended for planting under his own supervision direct from any country without a certificate. The restrictions at present in force are, in our opinion, the minimum necessary to safeguard this country against the introduction of new pests and diseases of cane, and, except in the one respect indicated below, we do not suggest any modification of them. We consider that the Sugarcane Expert, Coimbatore, should continue to be permitted to import cane direct without an official certificate until the Sugar Research Institute our proposals for which are given in Chapter XXIII is established, when the privilege should be confined to the Director of the Institute who will control all research work on cane. Until the Institute is established we would also propose that the exemption now granted to the Imperial Sugarcane Expert should be extended to the officer in charge of the Research Station at Shahjahanpur, in view of the development which has taken place in research work on cane in Upper India since the rules were framed. The acclimatisation of cane imported direct to Upper India has proved very successful and possesses undoubted advantages over the introduction of such canes by way of Southern India. We understand that the Government of the United Provinces has on more than one occasion requested the Government of India to sanction our present proposal and that the request has been refused, mainly on the ground that the officer in charge of the Station at Shahjahanpur has not the necessary mycological and entomological assistance at hand which the Imperial Sugarcane Expert has at the Coimbatore Research Institute, but also on the subsidiary ground that the existing restriction involves no material delay in the delivery of the cane at its ultimate destination. Our enquiries show that the latter reason is not justified in fact, whilst, in regard to mycological advice, the objection no longer holds good in

view of the recent appointment of a Plant Pathologist to the Agricultural Department of the United Provinces. We consider that the Entomological Assistant attached to that Department is sufficiently competent to give the entomological advice necessary.

Water requirements of cane.

249. In the previous Chapters we have shown how greatly the possibilities not only of the extension of cane cultivation but also of improvement in outturn depend upon the provision of irrigation facilities and upon the best use being made of them. Broadly speaking, throughout the Peninsula and over the greater part of Upper India it is impossible to grow cane at all without irrigation. Even where it is possible to raise a crop of cane on the natural moisture, the lack of irrigation, except in Assam and parts of Burma and Bengal, presents a serious and often insuperable obstacle to the introduction of better varieties and the adoption of improved and intensive methods of cultivation. North Bihar possibly furnishes an exception to this statement owing to the remarkable powers of conservation of moisture possessed by its silted soils, but no scientific work has been done on the point. In view of the dependence of cane on irrigation throughout the greater part of India, the question of its water requirements assumes great importance, but it was one on which we received most conflicting evidence. There was, however, fairly general agreement that the cultivator habitually over-waters his crop, especially in areas irrigated by canals, to the detriment both of outturn and soil ; but it is obviously impossible to express a definite opinion as to the extent to which the crop is over-watered in the absence of definite information regarding the optimum amount of water required. We consider, therefore, that the water requirements not only of cane but also of other competing crops require careful investigation and recommend that this should be carried out on all the agricultural stations in whose programme of operations work on cane is included. The question is probably of greater importance in the Punjab than in any other part of India. We understand that the establishment of an irrigation research station specially for the study of the water requirements of various crops has been under consideration by the Punjab Government for some time past, but that no progress has yet been made in carrying out the scheme. We are strongly in favour of the establishment of such a station at an early date, and would suggest that it should be placed in charge of an officer with special qualifications, such as a Soil Physicist or a Physical Chemist, who should, if necessary, have the assistance of an agricultural officer for field work. The most suitable location for such a station would, in our opinion, be in one of the canal colonies.

Lining of canals.

250. It will be observed that in some of the provincial Chapters we have discussed the question of lining canals in order to prevent loss of water by percolation and consequent damage to cultivable land. All that we need say here on the general question is that nothing has yet been done in this country on a large enough scale to be of value, and that such experiments as have been made have not shown what saving of water would result or what the life of various forms of lining would be. The size and length of the canals and channels render the expenditure which would be involved a very serious matter. In the only instance in which actual figures were given us the cost of lining 128 miles of the main canal of a system the total length of which, including all Government channels, great and small, was 3,500 miles would have meant an addition of 40 per cent. to the total cost of the scheme and would have rendered it unprofitable. It is obvious that Government cannot afford to construct canals at a loss and that

the question cannot be regarded solely from the point of view of cane. We would, however, urge that, where in any new scheme concentrated areas of cane are to be served, the question whether, if a sufficient supply of water could thereby be guaranteed, the extra expense of lining the channels serving such areas could not be set off by an increase in the water rates, should be carefully considered.

Water rates.

251. Closely connected with the question of the water requirements of cane is that of the suitability of the water rates at present charged for that crop. The evidence we received on this point showed that, even in the Bombay Deccan, where the rates for cane are very much higher than they are anywhere else in British India, these are no bar to the extension of the area under cane and form only a minor part—usually a very minor part—of the costs of cultivation. In fact many witnesses assured us that the cultivators would be willing to pay a considerably higher rate, if they could be guaranteed a regular and abundant supply. This question and that of the distribution of water in the manner best suited to the needs of the cane crop are the only ones with which we are concerned. Into such general questions as whether water should be charged for not in proportion to the quantity consumed but in proportion to its utility to a particular crop, and whether water rates should be varied in different months of the year, we do not feel called upon to enter, though the interested reader will find these and other connected matters discussed in Section VIII of Mr. Padshah's Supplementary Note. Nor did we receive any evidence to show that the construction of any projects which would lead to an appreciable extension of the area under cane has been rendered impracticable owing to inability to charge water rates under the present system sufficiently high to make them productive. We have pointed out in previous Chapters that the concentration of cane cultivation would greatly facilitate satisfactory distribution of water. During the course of our enquiries we were greatly impressed with the advantages not only in regard to distribution but also in ensuring economy in the use of water which would be secured by the adoption of a system under which water would be sold by volume. After we had reached this conclusion the recommendations of the Indian Irrigation Commission of 1901-03 were brought to our notice. Our view that it would be a great advantage both to the Government and the cultivators, if the latter could be induced to take over their supplies at the outlets, to arrange all details of internal distribution between themselves and to relieve the canal administration of all further responsibility and of the great expense of recording the details of the irrigation and of making the final measurements and assessments is also the view of that Commission. Their general conclusion was, however, that the system of charging by volume could not, in spite of all its advantages, be safely introduced in India until a system of distribution by modules of the type which it might be proposed to use had been in force for a time sufficiently long to enable the people to understand what was proposed, and that, even then, the change in the system of assessment should not be forced but should be introduced gradually, as the people learned to appreciate its advantages. They added that it was an object to be aimed at and that irrigation officers should be encouraged to design and experiment on modules which would be suited to the conditions to be met with in practice, until the work of distribution could be carried out with all the regularity and certainty which were essential to the success of any scheme of charging by volume. Conditions have changed greatly since the Report of the Irrigation Commission was written and our enquiries showed that the advantages of a system of sale of water by volume

would be more greatly appreciated now than they would have been twenty years ago. The formation of Irrigators' Associations in the Bombay Deccan, where, it may be noted, the Irrigation Commission considered the possibility of establishing such a system specially encouraging, is, in our view, a hopeful sign that the co-operation between the cultivators and the Irrigation Department which are necessary to its working would be forthcoming. The system of sale of water by volume would obviously be a most suitable one for adoption by factories controlling their own cultivation. Unfortunately, an entirely successful module has yet to be evolved, but the strenuous efforts which have been made, especially in the Punjab, to perfect such a module render it at least probable that it will not be long before it is evolved.

Development schemes.

252. An interesting suggestion has been made to us that in Provinces such as Burma and Assam, where there are large areas of undeveloped lands still at the disposal of the State, such land might be developed by Government corporations formed for the purpose and working somewhat on the lines which have been so successfully followed by Improvement Trusts in Calcutta, Bombay and elsewhere. Such corporations would reclaim and drain the land, take such measures as proved feasible to remove the danger from diseases like malaria, provide communications and irrigation, where necessary, and carry out colonisation schemes. The land after development in this way would be offered to cane factories and to other enterprises of a similar character on suitable terms which would represent the full value to the enterprise of the work done by the corporation. Estate planning on a large scale and possibly also town planning would have to be undertaken, but this is work with which Improvement Trusts are already familiar. Schemes of this character cannot be looked upon from the point of view of cane cultivation alone, but are so bound up with general questions of development that we do not feel called upon to say more than that their possibilities appear to us to be well worth investigation. Mr. Padshah wishes the Agency Tracts of Madras specially mentioned as a promising field for such operations, as, in his opinion, the fact that these tracts are held under the Permanent Settlement and that tenants' rights have also to be considered should present no insuperable obstacle to development on the lines we have indicated, and he has little doubt that landholders and tenants would realise that development would result in great pecuniary benefit to both.

Standardisation of weights and measures.

253. Our enquiries have brought home to us the hampering effect upon industry and trade which results from the bewildering variety of weights and measures in use in India. In Section XIII of his Supplementary Note our colleague Mr. Padshah has put forward some interesting proposals for standardisation. Although the rest of us are in sympathy with the object Mr. Padshah has in view, we do not consider that it falls within our province to submit detailed recommendations on this head, especially as the subject has already been investigated by a Committee appointed for the purpose by the Government of India in 1913. We would therefore merely urge that early action upon the Report of that Committee is desirable. Whilst the benefit to India which would ensue from the adoption of a uniform system of weights and measures would be immense, and not least to future enquirers in such fields as that we have been called upon to explore, we are convinced that there is no one who stands to gain more from it than the cultivator; for we are in entire agreement with the view expressed by the Indian Cotton Committee, that the present lack of uniformity offers great opportunities for cheating him, of which many dealers and others are not slow to avail themselves.

Co-operation in relation to cane.

254. Numerous witnesses before us dwelt on the obstacles which are presented by the poverty and indebtedness so frequently found amongst the cultivating classes not only to the expansion of the area under cane in India but also to the adoption of improved varieties and the improved methods of cultivation without which they cannot be successfully grown. Whilst lack of capital sometimes prevents cane from being grown at all, it is far more often true that it prevents it from being grown as it should be grown. There is obviously no more effective method of placing the cane cultivator in a sound financial position than that of paying him a fair price for his cane ; and it is with that object in view that in Chapter XIX we propose that factories should pay for their supplies of cane on a sliding scale based on the price of the sugar obtained from them. But this scale is only applicable to tracts in which factories exist, and we would, therefore, here discuss how far the solution of the problem is to be found in the spread of co-operative activity. Outside the Deccan canals tract, with few and unimportant exceptions, the Co-operative Department has done little or nothing to cater specially for cultivators of cane. Many of the latter are, it is true, members of ordinary credit societies, but the fact does not appear to us to be adequately recognised that loans of larger amounts and for longer terms are required by the grower of cane than by the grower of other crops.

(a) History of the cane growers' credit societies on the Deccan canals.

255. The history and present position of the cane growers' credit societies in the Deccan canals tract are worthy of examination in some detail, as they reveal both the possibilities and the limitations of co-operative activity in relation to cane growing and the manufacture of gur. The 29 societies in the Nira canal tract date from 1911 and were formed among cane growers who had taken loans from Government under an elaborate loan scheme organised in 1907. When the societies were formed, the Bombay Central Co-operative Bank undertook the work of financing them. The loans outstanding, amounting to some Rs 3¼ lakhs, were repaid to Government and were treated as advances to the members of the societies. Eleven of the societies have been formed into three guaranteeing unions, whilst the remaining eighteen are under the direct control of a special officer of the Subordinate Civil Service stationed at Baramati. The Bombay Central Co-operative Bank advances no loans to societies from its branch at Baramati except with the previous sanction of the Union Committee in the case of Union Societies and of the special officer in other cases. The societies in the Godavari canals area, which are 14 in number and date from 1916, were formed on the same model as those in the Nira Valley. All the witnesses we examined on the point were agreed that the present position of the societies is far from satisfactory. Although on July 31st, 1919, after eight years of co-operative work, the working capital of the Nira societies amounted to about Rs. 10¼ lakhs, no less than Rs. 4 lakhs were in arrears. Most of these arrears were genuine arrears, that is, they were not covered by standing crops of cane, as, owing to the shortage of water consequent on the short rainfall of 1918, no fresh planting of cane was allowed during the early months of 1919. The demand payable to the societies on the Godavari canals between January 1st and July 31st 1919 amounted to Rs. 1,78,000. Of this only Rs. 81,000 were recovered, leaving arrears of Rs. 97,000. Numerous reasons were given for the comparative failure of the societies in both tracts. We were informed that the societies had been started in localities in which there was no demand for them and in which the people were insufficiently educated to understand or undertake the responsibility of joint liability. The most prosperous cultivators have sufficient capital to finance their own crops, and

are reluctant to undertake the obligations involved in unlimited liability. They, therefore, do not join the societies which are composed mainly, though not exclusively, of the men who had taken loans from Government under the old scheme and of the poorer cultivators. The managing Committees of the societies are often illiterate and indifferent, and shirk the unpopularity involved in strict supervision of the uses to which loans are put and in recovery of outstandings from slack members, who regard the societies not as their own co-operative property but as Government institutions which it is their business to cheat if they can. Loans are, consequently, frequently misused either from poverty or dishonesty, and there is a distinct lack of personnel capable of working honestly and co-operatively for the common good. Mistakes have been made in giving loans to persons who are not in a position to grow cane crops successfully, whether because they are not sufficiently expert or are too lazy, or because their land has deteriorated and is incapable of producing a paying crop, unless handled with great skill, or because their holdings are of an uneconomic size. Constant increases in the irrigation rates and fluctuations in the price of gur have added to the difficulties of the societies, which have been much accentuated by the shortage of irrigation supplies in 1918-19. The Godavari societies have special difficulties of their own. Until the advent of the canals the tract was liable to famine about once in every three years and these conditions have left a mark on it which will take long to eradicate. The people are still very poor, very illiterate and very unskilled in growing cane, and their methods of boiling gur are particularly defective.

(b) Co-operative gur depots on the Deccan canals.

256. The work of the Co-operative Department in the Deccan canals tract has by no means been confined to the provision of credit facilities. The Bombay Central Co-operative Bank has at its own risk opened three depots for selling gur, at Baramati and Nira in the Nira valley and at Kopergaon in the Godavari valley. Half the profits from the sales are credited to the societies. All sales are at present made by public auction, as the local merchants, who are almost the only bidders at the auctions, have threatened to boycott the depots, if outside sales are allowed. The depot at Baramati was actually boycotted for a month in 1919 because it made such sales, but the situation was saved by exporting several wagons of gur to big merchants in Bombay, Ahmadabad and Berar. All members financed by Co-operative societies are compelled under the byelaws of their societies to bring their gur for sale at the depots, though this is an obligation which is frequently evaded. Their debts are recovered from the sale proceeds, but small sums are paid to them on the spot to enable them to meet the expenses of further boilings and of cartage. The system has proved successful in so far as it has made for fair prices in the open market, honest weighment, moderate rates of brokerage and a purer product. The experience of the Deccan canals tract shows, however, that its utility is limited in small places by the constant risk of a combination amongst the local dealers. If they boycott it, the auction system fails, since outside buyers as a rule are few in number and of uncertain credit. The alternatives are either to open selling depots at the nearest large consuming centres, which, for example, would for the Deccan canals tract be such places as Bombay and Amraoti, or to enter into agreements with substantial and trustworthy merchants at such centres to buy gur or to retail it for the societies on commission. We were informed that the possibilities of all these methods are being explored in Bombay, and that, once an efficient outside selling agency has been established, it is hoped that the tyranny of the local dealers will be broken.

257. A branch of work undertaken by the depots of the Bombay Central Co-operative Bank in the Deccan canals tract which has unquestionably been successful is the supply of oil-cake manures. These manures have as a rule not only contained a higher percentage of nitrogen and been generally of better quality than those obtainable locally but have also been cheaper. The method of obtaining them from the factories for sale on commission has proved satisfactory and has been found a convenient way of eliminating the risk attendant on fluctuations in prices. This risk can also, as the late Registrar of Co-operative Societies in Bombay points out, be much reduced, if purchases are made by instalments spread over several months.

(c) Co-operative purchase of oil-cake manures on the Deccan canals.

258. Both on the credit and the trading side, the co-operative societies in the Deccan canals tract afford an object lesson of great value. Of the causes which have contributed to bring about the unsatisfactory condition of the credit societies some, such as deterioration of land and, to a less extent, lack of skill in cane cultivation and the manufacture of gur, are special to the tract in which the societies are located and will be largely remediable, if the recommendations we have made in our Chapter on Bombay are accepted. Poverty and illiteracy are unfortunately not the monopoly of any part of India, nor are defects in the management of co-operative societies confined to the Deccan canals tract. We look to the expansion of the work of the Co-operative Department and to the spread of education to remove them. We trust that, as the movement progresses, it will be found possible for societies to make advances to those of their members who are cane growers on a scale more in proportion to their needs. We would mention that the scale of advances which the Deccan canal societies are permitted to make to their members leaves nothing to be desired in this respect. It is as follows :—

(d) Prospects of development.

	Rs.
To cultivators who adopt the old method of planting ..	.. 400 per acre.
To those who adopt the Manjri method ..	.. 350 „
To those who grow ratoon crops ..	.. 250 „

Another feature of these societies which appears to us specially worthy of imitation is the procedure by which the societies pay to the Irrigation Department the water rates of all their members annually by a single cheque. This procedure is obviously calculated to facilitate the introduction of a system of sale of water by volume on the advantages of which we have laid stress in paragraph 251 above. We would add that we are convinced that factories which have not control of their own cane cultivation will find it greatly to their own benefit and to that of the cane cultivator, if they deal as far as possible with the latter through the medium of co-operative societies. Few of the factories we visited in the course of our tour were able to obtain cane except on a system of advances. The difficulties in dealing with a host of small cultivators would be very greatly reduced, if advances were made through the medium of co-operative societies, which are in a much better position than the factories to ensure that the advances are properly applied and that supplies of cane to ensure which they are given are actually forthcoming.

259. On the trading side some of the difficulties which are encountered in the co-operative supply of manure and the co-operative sale of gur have already been touched upon and partial remedies have been suggested. On this side

(e) Need of expert supervision for Co-operative trading societies.

the great need, in our opinion, is for a greater measure of expert assistance. The necessity for close touch between the Agricultural and Co-operative Departments is a point on which great stress is laid in the reports of both Departments ; but the small progress which, with a few honourable exceptions, has been made in developing agricultural co-operation for purposes other than credit shows, we think, how much remains to be done in this direction. If co-operative societies are to obtain the right kind of implements and the right manures for their members, and if power plant for crushing, improved furnaces for the manufacture of gur and tube wells are to be taken up by co-operative societies with any prospect of success, the help and guidance of the Agricultural Department are essential. But this, in our view, is not enough. Societies for purposes other than credit, especially those connected with cane growing, cannot be expected to prosper, unless they are treated as an entirely distinct branch of the co-operative movement. The ordinary staff of the Co-operative Department has hitherto had its hands too full with credit work to give them the attention they require ; and, though it is now some eight years since the law was altered to permit the Co-operative Department to take up this branch of work, the results achieved have been disappointingly small. They will remain so until agricultural trading societies have their own organisers and experts, who must be given a free hand and not bound by rigid rules and restrictions. For the present, at any rate, these officers must be provided by Government and their salaries, like those of the Registrar and his ordinary staff, must be borne by the State. Unless they are forthcoming, co-operation will, we fear, remain as at present almost a negligible factor in connection with cane growing in India except in regard to the provision of credit. We make our recommendations on this head with all the greater confidence, as in the Sugar Research Institute and the Sugar School we provide the means by which the training of the men competent to develop cane growing in its co-operative aspect can be secured.

Summary of Conclusions and Recommendations.

(1) The provision of a cheap supply of nitrogenous fertilisers is the most insistent problem of Indian agriculture.

(2) Before the war oil-cake meal was the cheapest and commonest form of nitrogenous manure used in India, but its use was mainly confined to the planting districts of Bihar, Assam and South India.

(3) Since the war oil-cake meal has cost more per unit of combined nitrogen than Indian sulphate of ammonia.

(4) If cane were intensively cultivated on a sufficient area to produce a million tons of factory sugar, cane alone would require 92,960 tons of sulphate of ammonia or 375,200 tons of oil-cake meal a year.

(5) The war has created new sources of supply through the perfection of synthetic processes for the production of combined nitrogen, and these threaten severe competition with the nitrate and by-product sulphate of ammonia industries.

(6) So long as sugar does not fall below Rs. 15 per maund the cane grower can profitably buy sulphate of ammonia at Rs. 315 per ton and oil-cake meal at Rs. 2-13-4 per maund to manure his crop.

(7) *The Departments of Industries should investigate the problems of transport of vegetable oils with a view to the promotion of oil pressing in India and so increasing local supplies of oil-cake.*

(8) *Five years hence the annual production of by-product sulphate of ammonia on the Indian coalfields should be 20,000 tons.*

(9) *The possibilities of utilising the power from hydro-electric schemes in India for nitrogen fixation by the cyanamide and other processes should be investigated.*

(10) *Deeper ploughing is the first essential of improved cane cultivation.*

(11) *The ordinary type of cultivator's plough is in present circumstances the best that his cattle can draw; and the first step necessary is to relieve the plough cattle of much of the other work they now do.*

(12) *The introduction of power plants for cane crushing, threshing and pumping would enable improved ploughs to be adopted.*

(13) *On large estates, and particularly where new lands are opened up, cultivation by mechanical means will be required.*

(14) *Experiments at Pusa indicate that cane cultivation with steam tackle is both effective and economical.*

(15) *Motor tractors are better suited to smaller estates, and there should be great scope for their use.*

(16) *If preliminary cultivation is done mechanically, the cane must be so planted as to admit of all subsequent operations being performed similarly or by bullocks.*

(17) *Field experiments with cane varieties should be conducted on test plots of not less than* $\frac{1}{4}$ *of an acre and should be repeated for each variety over two or three plots.*

(18) *Chemical tests in varietal experiments with cane are so important that such experiments should be abandoned on all farms which cannot furnish the equipment and scientific control necessary for conducting these tests.*

(19) *The most important work of the Agricultural Department is the demonstration of improved agricultural methods and the spread of better implements.*

(20) *Even outside areas for which the Committee have recommended special demonstration staffs for cane, staffs similarly organised for general propaganda should be created and given instruction at the cane research stations before undertaking cane work.*

(21) *Demonstrations must be carried out on cultivators' own fields.*

(22) *The importance of agricultural engineering should be recognised by the incorporation of Agricultural Engineers in the Indian Agricultural Service.*

(23) *This section of all provincial Agricultural Departments should have a special demonstration staff to inspect and repair all machinery issued or recommended by it.*

(24) *Subsidiary centres for the carrying out of minor repairs will be required as the work of the Engineering section develope.*

(25) *The indigenous canes of Upper India are remarkably free from disease.*

(26) *No cure has been found for the more important fungus diseases, and they are best dealt with by the exercise of control measures, such as the introduction of new varieties, careful set selection and cultivation and efficient drainage.*

(27) *The mycological needs of cane will be met, if laboratory facilities are provided at the Sugar Research Institute and, when necessity arises, a Mycologist from Pusa is lent to the Institute.*

(28) *Cane borers are the chief insect pests of cane and an additional Entomologist should be appointed to the Pusa staff principally for the investigation of cane pests throughout India.*

(29) *The power of the Imperial Sugarcane Expert to import cane from other countries without a certificate of freedom from disease should be transferred to the Director of the Sugar Research Institute when it is created.*

(30) *Till then the power should also be given to the officer in charge of the Research Station at Shahjahanpur.*

(31) *The water requirements of cane should be investigated on all agricultural stations working on cane.*

(32) *The establishment of the proposed research station in the Punjab for the investigation of the water requirements of all crops should be expedited and a Soil Physicist or Physical Chemist should be placed in charge.*

(33) *The possibility should be considered of meeting the cost of lining canals on which a concentrated cane area is to be served by increasing the water rates.*

(34) *The system of selling irrigation water by volume has great advantages and conditions are more favourable for its adoption than when the Irrigation Commission first expressed their preference for it when practicable.*

(35) *The possibilities should be investigated of reclaiming and developing Government waste lands by Government corporations for subsequent disposal to cane factories and similar enterprises.*

(36) *Early action on the recommendations of the Committee on Weights and Measures is required in the interests of the cultivator.*

(37) *Lack of capital is one of the main obstacles to the proper cultivation of cane, and outside factory areas co-operation must contribute to remove it.*

(38) *The co-operative credit societies and depots for the sale of gur and supply of oil-cake manures on the Deccan canals in Bombay furnish an object lesson both of the possibilities and of the difficulties.*

(39) *Co-operative advances to cane growers should be on a more liberal scale and for longer periods than to growers of other crops.*

(40) *Factories are advised to make advances to cane growers wherever possible through their co-operative societies.*

(41) *If co-operative trading societies are to succeed, much closer touch must be maintained between the Agricultural and Co-operative Departments, and such societies must be given their own expert organisers.*

CHAPTER XVI.

OTHER SOURCES OF SUGAR.

260. A matter which has not been specifically referred to us, but without some reference to which our Report would not be complete, is the possibility of meeting a more substantial part of India's demand for sugar from other sources than cane. As is well known, there are numerous other plants from which sugar is obtained in one part or another of the world, and several of them are already to be found in India. Even among these, however, there are only a few which appear to be worthy of consideration for development as a source of sugar on a commercial scale ; we do not propose to discuss alternatives of more or less theoretical interest, such as the Coconut palm (*Cocos nucifera*) or the Indian Sago palm (*Caryota urens*) which are already found in India, but are only tapped for sugar to a very small extent, or the Sugar Maple of Canada (*Acer saccharinum*) which is at present a stranger to this country. Nor is it necessary to make more than a passing reference to the Nipa palm (*Nipa fruticans*) which grows extensively in the tidal swamps of the Sundarbans of Bengal and of the Irrawaddy Delta and the Tenasserim coast in Burma, in which latter Province it is known as the *Dhani* palm. Its leaves are commonly used as a thatching material and its juice is tapped for the manufacture of country liquor; but, so far as we are aware, no attempts have yet been made in India to convert the juice into sugar. No information is, therefore, forthcoming regarding the probable yields of sugar per acre obtainable from this source, or the extent to which the rapid fermentation in the juice can be prevented, an important consideration with the Nipa palm, whose swampy habitat must always render rapid collection of the juice a problem of special difficulty. The fact that this palm occupies more or less submerged areas which cannot be utilised for other forms of cultivation is a point in its favour ; but the main reason why we reject it for the present as a likely source of sugar is that its future, if any, would appear to lie in Burma, where the prospects of developing sugarcane production on a large scale are especially favourable. For years to come, therefore, we think that the local Agricultural Department will be fully occupied with the problems of cane cultivation, and we have no hesitation in saying that their time will be better spent in promoting the cane sugar industry than in investigating possible alternative sources of supply. When the cane sugar industry has been well established in Burma and its agricultural needs are being successfully met, the possibilities of the production of sugar from the Nipa palm might repay examination. But that time is not yet.

Sources ruled out of practical consideration at present.

261. There are, however, two other species of palm in India from which large quantities of raw sugar have been produced for many years—the Palmyra, or *tari* (commonly known as "toddy") palm (*Borassus flabelliformis*) and the common Indian Date palm (*Phœnix sylvestris*). The Palmyra palm is widely

The Palmyra palm.

distributed throughout India and is in many localities used for the manufacture of a fermented liquor known as *tari* or toddy. The practice of converting the juice, which is obtained from the young inflorescence, into raw sugar is locally more restricted; its most important centres being the Tinnevelly district in South Madras, and the Pakokku, Lower Chindwin and Myingyan districts of Upper Burma.

262. In Tinnevelly the trees are grown on soil on which other crops cannot be successfully raised, usually on red or white sand. Even when they are deliberately planted in groves or topes, there is no apparent system adopted, and the distances between the trees are most irregular. Cultivation is seldom practised, the tapper of the trees not being as a rule their owner. Tapping cannot be started before the tree is some twenty years old, and as mature trees grow to a height of as much as fifty feet, the scaling of them twice a day during the tapping season, which extends from April to September, involves arduous labour and some bodily risk. The number of trees which a single tapper can deal with in a day is said to be from forty to fifty. In Southern India tapping is done solely by Shanars, a caste which is held in very low regard by the members of other castes who consequently evince no desire to adopt the same profession. The supply of tappers is thus strictly limited, and of late years it has shown distinct signs of shrinkage. This tendency is generally attributed to missionary activities, both religious and educational, among the Shanars, the sins of the Palmyra as a source of intoxicants being presumably visited upon it as a source of sugar ; but other contributory causes suggested to us in evidence were the emigration of a number of tappers to Ceylon after three consecutive years of drought in 1908-10, and the diversion of other tappers to work on irrigation projects in Travancore, and their subsequent assumption of the rôle of agriculturists. A large proportion of the Palmyra gur of Southern India is used for refining into white sugar and some for distillation into foreign spirit.

(a) in Madras.

263. The districts in which the Palmyra gur industry of Burma is centred occupy the central tract known generally as the "dry zone," over most of which the average annual rainfall varies roughly between 20 and 30 inches, and where there are large areas of upland country with shallow soils too poor to produce agricultural crops, but frequently covered with a stunted scrub jungle. As in Madras, the Palmyra topes are scattered and very irregularly planted, and the trees are usually the property of a comparatively well-to-do minority of landholders and not of the tappers themselves. The profession of tapping is not here a matter of caste, for there is no caste system in Burma ; but the highly specialised skill and the long training it requires almost inevitably render it a hereditary profession. In Burma, however, the main factor, not only limiting expansion, but actually threatening the decline of the industry is the great shortage of fuel in the dry zone districts, for which the industry itself is largely responsible.

(b) in Burma.

264. No attempt, so far as we are aware, has yet been made to estimate the weight of fuel used per unit of gur produced from the Palmyra palm ; we can, therefore, only refer to the estimates worked out regarding Date palm gur by Mr. Annett, which we give in a following paragraph, and which may be assumed to be broadly applicable here. There is a similar absence of

(c) Prospects of development.—
(i) of the existing industry.

information regarding the average number of trees planted per acre in Palmyra topes; and, though the average yield of gur per tree has been roughly calculated both for Upper Burma and South Madras, the wide difference between the two estimates—36¼ lbs. in the former case, and nearly 75 lbs. in the latter—renders it difficult to accept either without further investigation. Nor is anything known at present as to whether, and if so to what extent and by what means, the output of gur per tree can be increased. Although, therefore, chemical tests indicate that the "cane" sugar content of Palmyra juice is 14 to 16 grammes per 100 cubic centimetres, against only 10 to 12 grammes in the case of Date palm juice, the actual and possible yields of gur per acre are wholly uncertain; and special enquiries would have to be instituted to ascertain the economic future of the industry before any recommendations could be made for its improvement. But in present circumstances we doubt whether we should be justified in proposing the initiation of such enquiries. The decline of the existing industry is evident and has only temporarily been arrested by the high prices of raw and refined sugar. The labour supply cannot be increased, and the prospects of reducing the demand for it by the supply of mechanical means of scaling trees, such as portable telescopic ladders, or by the lacing of trees together, seem remote. Our recommendations in Chapter XVIII for the improvement of the existing methods of gur manufacture, particularly in respect of improved furnaces, will, we trust, prove of equal benefit to the manufacturer of palm gur, but, with this exception, we are unable to suggest any means of developing the Palmyra sugar industry on its present lines.

265. The alternative is the establishment of a centralised factory industry; but the obstacles in the way of this appear to us to be even more numerous and formidable. To the labour and fuel difficulties must be added the difficulty of transporting the juice in sufficient quantities to feed a factory of economic size. Attempts to solve this difficulty by means of pipe lines have proved a failure owing to the impracticability of entirely clearing the pipes of juice after a consignment has been transmitted and the fermentation of the residue left in the pipes. It has been suggested to us that this defect might be remedied by the substitution of wrought iron galvanised tubes, specially screwed and socketed, for the cast-iron pipes hitherto used; but in the absence of any practical tests we cannot say what value is to be attached to this suggestion. Moreover, a factory would always have to contend with the disadvantage that Palmyra juice is collected only in the early morning, and that its supplies for each day would all be delivered during a few hours out of the 24. Unless serious loss were to be incurred by the storage of juice, therefore, the factory would have to be equipped with a far larger evaporative capacity, and consequently a far higher boiler power, than a cane sugar factory dealing with the same volume of juice per day. To some extent these obstacles might perhaps be removed, if a factory grew its own Palmyra palms, properly concentrated and with scientific selection and cultivation, and also solved the problem of the collection of day juice as well as night juice. But the whole project is highly speculative, and as at least twenty years must elapse from its inception before any return on the capital outlay can be obtained, it is obviously not a commercial proposition, nor can we see that it is likely to be converted into such a proposition by the combination of Date palms with Palmyra palms as a source of the factory's supplies of raw material, even assuming such a combination to be possible. The overhead charges would be reduced, it is true, but the difficulties of labour, of fuel, of transport and of regulating an even supply of juice would remain as great as ever.

(ii) of a factory industry.

266. The Indian Date palm (*Phoenix sylvestris*) is also frequently met with in many parts of India, including parts of Madras and Bombay, and the Native States of Hyderabad and Mysore in Southern India, the Native States of the Central India Agency, and Eastern Bengal in Northern India. In several of these areas a local Date palm sugar industry exists; but by far its most important centre is the Jessore district of Bengal, where after a special enquiry the number of Date palm trees actually in use for the production of sugar in 1912 was estimated at just over five millions, producing some 50,000 tons of gur annually. The importance of the industry in Bengal has been recognised by the deputation of Mr. H. E. Annett, Agricultural Chemist to the Government of Bengal, to investigate its chemistry and agriculture. Mr. Annett's enquiries were confined to Jessore and mainly to the two manufacturing seasons 1911-12 and 1915-16. Though they are still incomplete, much valuable information has been obtained, which we propose to utilise only in so far as is necessary for our present purpose. Readers who are further interested may be referred to the two published Memoirs in which the results of Mr. Annett's work are recorded.*

The Indian Date palm.

267. The Date palm differs from the Palmyra palm in that its juice is obtained from the stem of the tree just below the crown of the leaves and not from the inflorescence. Another striking difference is the fact that the Date palm can be tapped within six years after planting, when its stem is only some eighteen inches high, and that it seldom grows to a greater height than thirty feet, being commonly much shorter than this. It is consequently less difficult to climb and a single tapper can deal with as many as sixty trees a day. The sap-bearing life of the tree has not been definitely ascertained, and is known to vary greatly, but on the average it may be taken as not less than 25 years. It is popularly believed to yield more juice and of better quality when grown on heavy soils, such as clay loams, than it does when grown on sandy soils. The seeds are sown in a nursery during the rains, and the young plants are planted out the following April or May after the first showers of the season have moistened the ground. Not much attention seems to be paid to the arrangement or spacing of the trees, which are set at anything from 9 to 17 feet apart, Mr. Annett estimating the average number of trees grown per acre at 240. In his opinion, the best spacing to adopt is at intervals of 11 feet, which would allow 360 trees to be planted to the acre. A pulse or oil-seed crop is usually sown between the trees, which benefit from the incidental loosening of the earth and removal of weeds. The quality of the cultivation, however, varies greatly on different plantations. The normal tapping season extends from about the second week in November to the first week in March and is thus over before the tapping of the Palmyra palm begins; this explains the suggestion we have already referred to that a factory should be established to manufacture sugar from both palms in order to obtain the benefit of a protracted season. The tapping or cutting of the Date tree is done in the afternoon, the earthenware pot which collects the juice being hung up about 3 or 4 P.M. and being removed between 6 and 8 o'clock the following morning before the sun has had time to get on it. As soon as it is emptied, the interior of the pot is well smoked for a few minutes over a heap of fired rubbish and is then kept mouth downwards on the ground until it is hung up again in the afternoon. It undergoes no other cleaning or neutralising process. The juice which exudes from the tree during the day is not collected, and after three nights' consecutive tapping the tree is rested

(a) in East Bengal.—
(i) Cultivation and tapping.

*Memoirs of the Department of Agriculture in India, Chemical Series, Volume II, No. 6 and Volume V, No. 3.

altogether for two nights. The number of collections taken from each tree in a season is about 45. Mr. Annett calculates the yield of juice per season from the average tree to be 170 lbs. in weight, though the very best plantations might yield as much as 300 lbs. per tree. A series of analyses made through the season 1911-12 showed that the sucrose content of the juice varied from 7.15 to 12.22 per cent. and the reducing sugars from 3.22 to 0.37 per cent., the best results being obtained in December, and the general tendency thereafter being for the ratio of sucrose to fall and that of reducing sugar to rise. The juice as it exudes from the freshly cut tree, however, contains only sucrose, and the inversion occurs during the hours in which the juice is accumulating in the pots. Mr. Annett's experiments have demonstrated that this inversion can be very largely counteracted, if the collecting pots are heavily limed, and that this process enables the day juice to be also manufactured into a good crystalline gur, with an increase of probably as much as 20 per cent. to the gur outturn per tree.

(ii) Gur manufacture.

268. It is unnecessary to describe in detail the existing methods by which the Date palm juice is turned into gur. They closely resemble the methods adopted in the manufacture of gur from cane which we describe in Chapter XVIII, and are equally inefficient. The gur obtained varies from one-seventh to one-ninth the weight of the juice employed in its manufacture, the average annual yield of gur per tree being thus about 21¼ lbs. The gur is of a dark colour owing to the presence of alkaline constituents in the juice, but Mr. Annett finds that this defect is easily remedied and a perfectly light-coloured gur obtained, if the alkalinity is neutralised by carefully gauged additions of mineral acid or extract of tamarind fruits to the juice before boiling. The addition of alum has he same practical effect. There is one respect, however, in which the defective methods employed by the manufacturer of Date palm gur affect him far more seriously than the manufacturer of cane gur. Cane provides its own fuel throughout the season in the shape of megasse and this should suffice for the season's needs. The Date palm also furnishes its own fuel, it is true, in the shape of the leaves stripped off at the time of preparation for tapping and these have a high fuel value ; but they do not last beyond the middle or end of December. Thereafter until the end of the season wood is used, or occasionally the dried stalks of *arhar* (*Cajanus indicus*). The number of units in weight of wood consumed per unit of gur turned out varies with the number of boiling pans heated by a single furnace and, according to Mr. Annett's experiments with the ordinary country furnace, averages 9.8 with a single pan, 8.6 with two pans and 6.4 with four pans. The exact cost of his wood fuel to the gur manufacturer is more difficult to gauge, as it is bought before it is either dried (with a consequent shrinkage) or split, while, on the other hand, it is said to be frequently obtained some time before the tapping season commences when the price of wood is low, and the splitting is done by the tapper's own family and thus costs nothing in actual cash. Whereas Mr. Annett's enquiries, therefore, indicated that the cost of wood, undried and unsplit, at Kotechandpur, the centre of the Jessore Date palm industry, averaged in 1915-16 rather over three annas per maund, the tappers themselves put the cost at not more than two annas. Even so, this means that the expenditure on fuel alone during the last 2½ months of the season varies from 13 annas to Rs. 1-4-0 per maund of gur turned out, according to the number of pans attached to each furnace, a very serious matter when

it is remembered that before the war Date palm gur was selling at Rs. 3 to Rs. 3½ only per maund, against prices for cane gur in the same district of Rs. 5 to Rs. 6. Improvement in the furnaces is thus of even greater importance for the future of Date palm gur than it is for the future of cane gur ; and it is fortunate that, as will be seen in Chapter XVIII below, very considerable improvements are, in our opinion, not only possible but practicable.

(iii) Prospects of development.

269. The salient facts of the position of the Date palm industry may now be briefly examined. There can be no doubt that, if the production of Date palm sugar (whether direct from the juice or, as it is now made in East Bengal, by refining the gur) is to be developed as an important source of India's supplies, the greatest prospect of success lies in the Jessore district, where the industry is still a large one and of long standing, and where the most efficient tappers in India are to be found. The present average production of gur per acre is not high, being only 2.23 tons, or 0.89 of a ton of refined sugar, taking the present average of about 40 per cent. sugar obtained from gur in the local refineries. But the more scientific planting of the trees alone might enhance these yields by 50 per cent. to 3.35 tons of gur and 1.34 tons of refined sugar. Also the juice yield of the best Date palms is nearly double that taken as the average in the above calculations, and it seems probable that much might be done to improve the yield by careful selection of seed combined with thorough cultivation. Appreciable further increases could be obtained by improvements in the methods of collecting and treating the juice and in the process of gur manufacture, and we have already indicated that the simple process of liming the tapper's pots would add 20 per cent. to the gur outturn by enabling the day juice to be collected in a fit state for manufacture. Finally the low percentage of sugar to gur obtained by the local refineries should be capable of material enhancement, for their methods are crude and wasteful, being very similar to those employed in the United Provinces for the manufacture of *khand* from *rab*, a description of which we give in our next Chapter (paragraph 278). There is a possibility, therefore, of very considerable yields per acre, the costs of cultivation are very small and the juice, if carefully collected, possesses a high degree of purity. No milling is required to obtain it and seasonal vicissitudes have only a very limited effect upon it. A manufacturing season of practically four months' duration is also assured. These are all substantial advantages which the Date palm possesses over cane as a source of sugar. When set off against the no less substantial disadvantages—that six years are required to establish a Date palm plantation, that the collection and transport of its juice are matters of special difficulty, that it requires the provision of fuel from outside sources and that the risk of entire destruction from the cyclones which periodically visit Eastern Bengal, if small, involves far more serious results than it does with cane—we consider that they fully warrant the prosecution of Mr. Annett's uncompleted enquiries to a definite conclusion. Those enquiries were interrupted by his deputation to undertake a special investigation of the morphine content of Indian opium, but we trust that, on his return to Bengal, he will be allowed to resume them. Much still requires to be done, particularly on the agricultural side of the problem, before it can be decided how far development is possible, and whether the most hopeful line of advance is in the direction of improving present methods of gur manufacture and refining or of establishing a factory industry for the manufacture of white sugar direct from the Date palm juice. In the latter event much will depend on the willingness of individual

tappers to sell their juice to a factory. Mr. Annett found them in 1915-16 unexpectedly reluctant to do so ; but, if a scale of prices based upon a reasonable proportion of the sugar value of the juice were devised on the lines we recommend in Chapter XIX for the purchase of cane, different result might be obtained.

(b) outside Bengal.

270. We have confined our attention to the prospects of Date sugar in Eastern Bengal because the lack of skilled tappers and of an organised industry elsewhere renders the possibilities of development more remote. The Agricultural Department in Bombay has recently investigated the possibilities in the Thana district of the Konkan ; but the number of trees available is estimated at hardly more than a tenth of those in the Jessore district of Bengal, while the local tappers are very inefficient and are said to be incapable of getting more than a third the quantity of juice per tree that a Bengal tapper can get. In Hyderabad the Date palm is not tapped excepting for liquor ; while in Mysore, where from the agricultural point of view we are disposed to think that there is a greater chance of establishing an industry than anywhere else outside Bengal, the Darbar holds the monopoly of the right to tap Date palms and the Excise policy of the State is opposed to the manufacture of Date sugar. Again, large as is the number of wild Date palms found in parts of Central India, there is no local practice of tapping, and the first problem would be the training of local tappers, which seems to us likely to prove no easy matter. At any rate it is clear that all these areas offer greater obstacles to the organisation of a prosperous Date sugar industry than does Eastern Bengal, and we are unable in their case to recommend any definite measures to that end before success or failure has been established in Jessore.

The sugar beet.
(a) in the Punjab.

271. The only other alternative source of sugar we propose to consider is the sugar beet. Attempts have been made to introduce it into North Gujarat in Bombay, but the return per acre (11 tons) was not found sufficient to attract the ryot in this highly cultivated tract, and, in considering the possibility of a future for beet in India as a source of sugar, we may practically limit ourselves to the Punjab and the North-West Frontier Province. In the Punjab sugar-beet was grown on small experimental plots at Lyallpur for three seasons between 1912 and 1915 from seed imported from France and Germany, when yields up to 10½ tons per acre were obtained with sucrose and glucose contents of 12.49 and 0.21 per cent. respectively. It was also grown in 1918-19 at Gurdaspur, where the sucrose and glucose contents varied from 10.4 to 13.8 and from 1.00 to 0.31 per cent. respectively. These returns are not particularly encouraging. The chief drawbacks are, however, that the hot weather comes on too soon to allow the plant to seed locally, and that it requires some eight to ten irrigations, or more than twice as much water as wheat, during the *rabi* season when the demand for water is greatest. We doubt, therefore, whether there is any future for the sugar beet in the Punjab, though it must be admitted that the experiments so far made have not gone far enough nor been on a sufficiently large scale to justify any final conclusions being based on their results. There might, therefore, be a case for prosecuting further investigations in the Punjab, should the crop establish itself successfully in the North-West Frontier Province, an eventuality the prospects of which it remains to consider.

(b) in the North-West Frontier Province.

272. Sugar beets have been grown experimentally at the Tarnab agricultural station in the Peshawar valley for the past six years, during which period the yield per acre has never been less than 16 tons and has usually exceeded 20 tons, the inclusive costs of cultivation being only Rs. 5 per ton. A series of analyses carried out between the 5th March and the 15th May, 1914 showed that the roots averaged 14.55 per cent. sucrose, and, as the quality improves from April to June, we were informed that beets in the latter part of the season should average as much as 16 per cent. sucrose. The sowing season extends from September to November and the roots can be harvested from April to June, the crop requiring not more than six or seven irrigations. It has also been established that the plant will produce fertile seed in the Peshawar valley. Further tests, particularly on the chemical side, are necessary before these strikingly favourable results can be accepted as typical, and it must not be overlooked that no factory tests have as yet been made and that the geographical situation of the Province renders the fuel problem of special importance. But, when full allowance is made for these considerations, we are of opinion that a strong *prima facie* case has been made out for the view that sugar beets can be successfully and economically grown in the North-West Frontier Province. The diffusion process, however, by which sugar is extracted from the beet, does not lend itself for adoption in a cottage industry, as does the milling of cane, and the establishment of sugar beet among the crops of the Province presupposes the existence of a sugar factory capable of dealing with the roots when they are grown. In other words, the factory must precede its raw material, a proposition which no concern would seriously consider, unless it had some alternative means of working remuneratively pending the development of its beet supplies. It follows that the future of sugar-beet in this Province depends upon the prior establishment of a cane sugar factory in the Peshawar valley, the possibility of which we have foreshadowed in Chapter VI. Such a factory might then have an unique opportunity of extending its working season by taking up a lease of land for the purpose of beet cultivation, and by passing on to the manufacture of beet sugar in April after the last of the windrowed cane has been crushed. We are not aware that a combined cane and beet factory has hitherto been successfully established in any part of the world, though an experiment on these lines is said to have been recently started in the Arizona State of the United States of America. The obstacles to such a combination have, however, been climatic rather than mechanical, conditions suitable for the cultivation of cane usually being unsuitable for the cultivation of beet and *vice versa*. The Peshawar valley has yielded practical results which appear to constitute it an exception to this rule. It is because no authoritative explanation has yet been given of the conditions, whether of temperature or humidity, responsible for this apparent peculiarity of the Peshawar valley climate, that we hesitate to describe it as more than apparent and regard it as of great importance that the beet experiments should be continued under more diversified agricultural conditions and with more continuous and detailed chemical supervision. In particular the effect of unusually cold weather on the roots should be tested and the possibility of progressive deterioration in crops grown from local seed should be investigated. We consider that the local Agricultural Department should find time to continue this work, which is of unusual interest and which, if its results are successful, offers great promise for the future of sugar in the North-West Frontier Province.

Summary of Conclusions and Recommendations.

(1) *With the possible exception of the Nipa palm, which may in the future repay investigation in Burma, the only alternative sources of sugar in India of practical interest are the Palmyra palm, the Indian Date palm and the sugar beet.*

(2) *Of the two main centres of Palmyra gur manufacture, South Madras suffers from shortage of tappers and Upper Burma from shortage of fuel.*

(3) *In the absence of scientific investigation, the extent to which the existing industry can be improved is unknown; but it is unlikely that its decline could be arrested in any event.*

(4) *Difficulties of tapping, fuel, and transport of the juice, and the impracticability of concentrated and scientific cultivation owing to the prolonged unproductive period of the tree preclude the organisation of a central factory industry for the manufacture of Palmyra sugar.*

(5) *Eastern Bengal is by far the most important centre of Date palm gur and sugar manufacture.*

(6) *Much light has been thrown on the industry by Mr. Annett's investigations which indicate that, while here also the fuel problem is acute, there are great possibilities of improving both the yield and quality of gur turned out.*

(7) *These possibilities, combined with the short unproductive period of the Date palm, the inexpensiveness of its cultivation, its comparative immunity to seasonal vicissitudes and its bearing season of four months, justify great hopes either of an improved gur and sugar refining industry or of a central factory industry for the direct manufacture of Date palm sugar.*

(8) *Further investigations are still required, particularly on the agricultural side, and these should now be prosecuted to a conclusion.*

(9) *Other Date palm areas offer definitely less prospect of development than Eastern Bengal, and investigation of their possibilities should be deferred until the improvement of the industry in Eastern Bengal has been attempted.*

(10) *The future of the sugar beet in India lies, if anywhere, in the North-West Frontier Province and the Punjab.*

(11) *In the Punjab results are so far discouraging but inconclusive, and further experiment should await the results obtained in the North-West Frontier Province.*

(12) *Very favourable yields both of roots and sucrose per acre have been obtained on the Tarnab farm, and fertile seed has been produced.*

(13) *The cultivation of the crop, however, presupposes a central factory to deal with the outturn.*

(14) *An unique opportunity appears to be afforded of a combined cane and beet sugar factory in the Peshawar Valley.*

(15) *The beet experiments should, therefore, be continued under more*

Part II—Manufacture.

CHAPTER XVII.

THE PROBLEMS.

Introductory.

273. Before we proceed to consider the steps necessary for the development of the sugar industry in India on its manufacturing side, it is essential to realise the present condition of this branch of the industry and the extent to which it calls for improvement. That a serious wastage of the sugar actually present in the cane occurs in the existing processes of extraction and conversion into both sugar and gur is already well-known. The Industrial Commission in paragraph 89 of their Report estimated roughly that of the sugar grown in India one-third was wasted owing to inefficient and primitive methods of extraction. They have not published the calculations on which their estimate was based, but we venture to think that the brief comparison we give below between the results of up-to-date methods of cane sugar manufacture employed in other countries and the results of the methods now prevalent in India will prove that the proportion of loss in manufacture estimated by the Industrial Commission is no exaggeration.

The processes followed in a modern cane sugar factory represent the result of long and laborious scientific research work, to which many eminent engineers and chemists in various countries have contributed. As a result of their labours, machinery has progressed stage by stage until, by the processes in use in all advanced countries, the extraction of sugar from cane has almost, if not quite, reached its commercial limit. A thoroughly up-to-date milling plant can to-day be counted upon to extract in the form of juice as much as 96 per cent. of the sugar actually present in the cane, and by competent control in the boiling house 90 per cent. of the sucrose in the juice can be recovered as manufactured sugar. In other words, by really efficient methods as much as 86.4 per cent. of the original sucrose in cane can be placed upon the market in the form of sugar; though it must be admitted that it has yet to be proved whether the same results can be obtained by an equally efficient factory from the cane at present grown in Upper India. It will be observed that in paragraph 336 of our Chapter on the manufacture of sugar we assume an extraction of only about 80 per cent. (9.5 out of an actual 12) of the total sugar contained in the cane, in order to be on the safe side. In India two articles of commerce are made from cane, *viz.*, gur and sugar. Gur may be briefly defined as cane juice in its natural state concentrated to solidifying point without having undergone any material

or other clarifying ingredient and the removal of the scum. When cleanly made it is a perfectly wholesome food and there can be no objection to its consumption on hygienic grounds. Of the total weight of sugar manufactured from the cane in India practically 99 per cent. is made in the form of gur (whether for consumption as such or for subsequent refinement into white sugar) against 1 per cent. made directly in the form of factory sugar. With gur here we include *rab* which only differs from gur in being of a thinner consistency, and which is mainly used for the manufacture of a crude sugar known as *khand*. The process is more or less confined to the Rohilkhand division of the United Provinces and the production of sugar from the *rab* is accompanied by even more waste than that involved in gur-making. Gur, therefore, almost completely dominates the present position of the industry in India, and is consequently responsible for the great bulk of the loss of sucrose involved in present methods of manufacture.

Loss of sucrose involved in present methods of gur manufacture.

274. For many reasons, but mainly owing to the small and scattered plots on which cane is grown in India, gur is always made in small quantities and its manufacture is a cottage industry. The canes are either carted or carried on the head from the field to the mill and must be crushed as soon as possible after cutting, if the best keeping quality of gur is to be turned out. Many kinds of mills, some of them of the most primitive description, are in use, but the 3 roller iron mill is gradually replacing the less efficient types in the ryot's equipment. These small mills, which are still worked by cattle power, when properly made and adjusted are remarkably efficient, but for two main reasons their extraction is in practice poor. In the majority of the cane growing tracts the strength of the cattle is inadequate to turn a properly adjusted mill, and in consequence the rollers are deliberately slackened off to bring them within the working capacity of the ryot's cattle. In the second place, little care is bestowed on the mills by the ryot, who allows them gradually to deteriorate into mere squeezing machines. Milling results are thus very unsatisfactory, and for the whole crop throughout India, we doubt whether the extraction exceeds on the average more than 55 per cent. of juice, corresponding to about 65½ per cent. of the total sucrose in cane with 84 per cent. of juice and 16 per cent. of fibre. The juice is boiled in open pans by direct fire to a thick consistency and on cooling solidifies. It is the mass thus obtained which is called gur, and it contains from 60 to 80 per cent. of actual sucrose according to the quality of the cane and to the care expended in its manufacture. The experiments carried out by Dr. Barnes and Mr. Clarke in the Punjab and the United Provinces respectively justify us in concluding that not less than one fifth of the sucrose in the juice is lost or inverted by the indigenous method of making gur. We therefore get an extraction of 52.4 per cent. of sucrose from the cane when gur is made in comparison with 86.4 obtainable in a modern sugar factory. The extent of this loss can be approximately calculated from the official statistics. In the nine years 1911-1920 the average area under cane in India (including Native States) was 2,717,750 acres annually with an average outturn of gur estimated over the same period at 1.046 tons per acre, or 2,843,033 tons altogether, had all

NOTE.—These calculations require explanation in one or two particulars. An area of 26,410 acres has been included for Hyderabad according to statistics separately furnished to us which are not at present embodied in the official returns. The average embraces a period of less than nine years for a few unimportant areas. Most of these unimportant areas, moreover, return no estimates of yield, and it has been assumed that their yield per acre is the same as the average yield of the rest of India.

the cane grown been turned into gur. The outturn in cane is not estimated in the official returns; but, taking 9 per cent. as a fair proportion of gur to cane for all India (and we do not think it is more), the above figures give us a total weight of cane per year of just 31.6 million tons. Of this very little more than 300,000 tons are directly manufactured into sugar and unknown quantities are used for sets and chewing. Here we are on speculative ground; but we hazard the following as a reasonable approximation to the facts. Yields being returned in terms of gur and not of cane, no allowance is required for sets wherever tops only are used, a practice which greatly predominates in the United Provinces, Bengal, Assam and Burma, and is probably followed on considerable areas in all Provinces. Taking 40 per cent. as the proportion of the total cane area on which whole canes are planted and 5 per cent. of the cane grown on this area as a standard allowance for sets, this for practical purposes is equivalent to saying that some 2 per cent. of all the cane grown in India is required to propagate the next year's crop; or in round figures 600,000 tons. Again, the area of Paunda canes in the United Provinces, the bulk of which is grown for chewing, is 75,000 acres, and may be taken to yield 20 tons to the acre or 1,500,000 tons in all. Not all of these canes will be used for chewing, but against this must be set off the quantity of canes other than Paunda that will be so used. Assuming that these two items balance one another, and that the weight of cane grown for chewing in the rest of India is not more than double the weight of such cane in the United Provinces (a liberal allowance considering the fact that the total weight of cane grown in all other Provinces and Native States only exceeds that grown in the United Provinces by less than 30 per cent.), we arrive at 4,500,000 tons as the amount of cane devoted to chewing annually. Thus of the 31.6 million tons grown 5.4 millions are used for other purposes and the balance of 26.2 millions is the quantity actually manufactured into gur, furnishing at 9 per cent. gur on cane 2,358,000 tons of gur. This cane may be credited with an average sucrose content of 12 per cent., and will thus comprise a total available weight of sucrose of 3,144,000 tons, of which only 52.4 per cent., or 1,647,456 tons, are extracted by present methods in the form of gur, against a possible extraction by thoroughly efficient methods in the form of sugar of 2,716,416 tons, involving a total loss including inversion of 1,068,960 tons of sucrose.

Loss of sucrose involved in present methods of sugar manufacture.

275. The second article derived from cane in India is sugar made by the vacuum pan process. Several grades are manufactured but all go into direct consumption in India. There are 18 factories which actually made sugar direct from the cane by the vacuum pan process during the season 1919-20 (*vide* appendix IV), but none of them crushes more than 400 tons of cane per day, of 24 hours. The whole of them together, therefore, do not turn out as much sugar as many a single factory in Java, Cuba and Hawaii. The equipment of these factories is on the whole fairly complete, but much of the machinery is of old design from which the best results cannot be obtained. As far as we can judge from the records we have been permitted to see and the data supplied to us, the manufacturing losses are considerable and probably avoidable with better control. It is unnecessary to describe here the different processes employed by the various factories, but, taking them together and basing our calculations on the returns given us by the various factories for the season 1919-20, which we consider may be regarded as an average season for India as a whole, the average extraction of the mills is only about 60 per cent. of normal juice, which is equivalent to an extraction of 71.43 per cent. of the sucrose in the cane. A yield of about 80 per cent. of commercial sugar is obtained from the sucrose in the juice. The Indian factories thus recover on the average 57.14 per cent.

of the original sucrose in cane and therefore fall far short of the 86.4 per cent. attained by thoroughly efficient factories in other countries. If we assume here also a sucrose content of 12 per cent. in the cane, we arrive at the following results :—

Cane crushed annually	300,000 tons.
Sucrose content	36,000 ,,
57.14 per cent. of the above recovered as sugar	20,570 ,,

If the same amount of cane had been crushed in a factory recovering 86.4 per cent. of the original sucrose, 31,104 tons of sugar would have been obtained, and 10,534 tons added to India's supply.

Difficulty of estimating money value of total sucrose lost.

276. We should have liked, if possible, to illustrate the magnitude of these losses in terms of money ; as money values, the measure of which can be gauged by the ordinary man, make a far more forcible and general appeal to the imagination than can any statement of a particular commodity expressed in mere quantitative terms. But it must, in the first place, be frankly recognised that the calculations made in the two preceding paragraphs themselves represent nothing more than the maximum gain theoretically possible with the existing area and methods of cane cultivation in India, and that in practice this gain cannot even approximately be achieved. A large proportion of the cane which is now grown, and will continue to be grown, in the various Provinces is so situated that its conversion into sugar in a modern factory is out of the question. The indigenous and wide-spread demand for gur also is one that must obviously continue to be met so long as it exists, and it would be idle to contemplate any very rapid supplanting of the taste for gur among the poorer members of the population by the taste for sugar. For a long time to come, therefore, a large quantity of the cane grown in India will continue to be manufactured into gur. Still, subject to these obvious limitations, the figures of loss in sucrose we have there given are an approximate representation of concrete facts, and do serve to indicate the absolute margin within which, on the existing supplies of raw material, savings are possible to a greater or less degree according to the pitch of efficiency to which the manufacturing industry, both of sugar and gur, is raised. When, however, we try to convert these figures of loss into terms of money, much more serious complications arise. What price, for instance, should be taken for the purposes of this valuation ? Present prices both of sugar and gur are admittedly abnormal ; but it is impossible to foretell what the normal prices of even the comparatively near future will be. Again, if the money values are to be applied to the maximum quantities of sucrose lost, as calculated above, then we are assuming a position in which more than a million additional tons of Indian sugar are suddenly thrown on the market, an assumption which could not be ignored in fixing the price at which it should be valued. If, on the other hand, any other method of valuation is adopted, not only do the two representations of loss—in quantity and value—cease to bear any relation to one another ; but we are at once involved in a maze of surmise as to the precise lines on which the Indian industry will in fact develop (*e.g.*, by the spread of small power gur plants, by the manufacture of gur in large factories or by the rapid supplanting of gur by factory made sugar) ; the degree of development probable on each line of advance and the extent of the saving in present losses which each will secure. When all these assumptions have been made, we think that the resultant calculation will have ceased to command either interest or value. But the most serious objection to any money presentation

existing losses is the fact that it would represent a gross valuation only, d would take no account of the extra capital, working expenses and labour volved in the more efficient methods necessary to recover this value. It is viously out of the question to attempt an assessment of these for the whole India ; and, since without them a gross valuation of present losses would meaningless, we have reluctantly come to the conclusion that we must be ntent with the quantitative estimates already given. Properly appreciated, ese estimates, theoretical as they are, should enable the general reader to alise the great scope there is for improvement in the manufacturing industry India quite apart from the improvements on the agricultural side dealt th in Part I of this Report. A calculation by Mr. Padshah of what is, in s opinion the money value of these losses will be found in Section II of his pplementary Note.

Possible methods of reducing present losses.

277. In the preceding paragraphs of this Chapter we have endeavoured to give an idea of the losses of sucrose which occur in the Indian sugar industry it is at present carried on. The problem before us on the manufacturing le is to suggest ways in which they can be reduced. There are no less an eight alternative methods of dealing with cane and its products to be nsidered. These are :—

(1) The introduction of less costly and more efficient methods of manufacturing gur on a small scale.

(2) An extension of the manufacture of sugar direct from cane in large factories, combined with improvements in the processes followed.

(3) An improvement and extension of the manufacture of white sugar from *rab*.

(4) The manufacture of white sugar direct from cane in small factories crushing only one or two tons of cane an hour and boiling in open pans.

(5) An extension of the manufacture of sugar from gur in large factories combined with improvements in the processes followed.

(6) The manufacture of gur in large factories.

(7) The manufacture of muscovado sugar or some other intermediate product direct from cane in small factories.

(8) The introduction of the manufacture of white sugar from muscovado sugar or other intermediate product in large factories.

is our considered view that the first two of these represent the main lines development of the sugar industry in India. For reasons which we give low, we are of opinion that the third, fourth and fifth must be ruled out. ıe possibilities of the sixth, seventh and eighth appear to us very limited, t we make recommendations in the following Chapter with a view to curing that they should be tested.

thods rejected as uneconomic.

a) The manufacture of white sugar from rab.

278. A brief description of the *bel* process of making *rab*, or massecuite and separating white sugar from it will furnish the justification for our view that it is in the best interests of the Indian sugar industry that there should no extension of this wasteful system. It should be mentioned that it is

mainly found in the Rohilkhand division of the United Provinces and that it is estimated to produce some 250,000 tons of sugar annually. The first stage in the process is the boiling down of the juice. This is done in a series of five pans which are placed in the form of a cascade over a furnace constructed to burn megasse and trash. The pans are hemispherical in shape, those of a typical *bel* in Rohilkhand having the following dimensions :—

Top Pan No. 1—Diameter 8 feet, depth 2 feet 4 inches.
Pan No. 2—Diameter 6½ feet, depth 2 feet.
Pan No. 3—Diameter 5 feet, depth 1 foot 6 inches.
Pan No. 4—Diameter 5 feet, depth 1 foot 6 inches.
Finishing Pan No. 5—Diameter 3 feet, depth 9 inches.

An installation of this kind works about 10 hours in the 24 and deals on an average with 90 maunds of juice a day, though, when weather conditions are favourable for evaporation and combustion, this may go up to 100 maunds. We have assumed that the extraction obtained by the ordinary iron mill used by the cultivator is 55 parts of juice per 100 of cane. On this basis 164 maunds of cane would be required daily to keep an installation dealing with 90 maunds of juice in full working and 182 maunds if the installation deals with 100 maunds of juice. One bullock mill can crush about 2 maunds of cane an hour. A *bel* of the size described above, therefore, requires 8 or 9 bullock mills to keep it supplied with juice. It is, however, usual to find some 12 mills clustered round a *bel* in Rohilkhand.

The juice is boiled down to a massecuite of approximately 85° Brix as compared with 95° Brix obtained in a modern factory with vacuum evaporation. The juice is merely heated in the first pan. In the second and third pans it is also clarified, sodium carbonate and the juice of the vegetable known as *bhindi* (*Hibiscus esculentus*) being used as clarifying agents. It is concentrated to syrup in the third and fourth pans and is boiled down to the final product, *rab*, in the finishing pan. The scum is removed by perforated iron ladles and is strained through muslin, the syrup so obtained being returned to the pans. The following analyses give the composition of typical *rab* or massecuite made in Rohilkhand :—

Juice.		Rab or massecuite.				
Sucrose per cent.	Glucose per cent.	Sucrose per cent.	Glucose per cent.	Ash per cent.	Brix.	Purity.
15·86	0·39	72·65	6·81	1·22	84·8	85·67
15·88	0·99	72·70	7·42	1·66	86·6	84·05
13·26	2·13	64·44	12·65	2·54	87·0	74·06
12·55	2·43	64·24	14·47	2·56	87·4	73·50

The hot massecuite is run into a series of small earthenware coolers in which it is kept in violent motion until crystallisation commences. It is then poured into spherical earthenware vessels known as *ghurras* which hold approximately 120 lbs. of *rab*. These are stored for two or three months and are then taken to the nearest market where they are sold to the numerous small local refineries which, it need hardly be said, are quite distinct from the large refineries which manufacture sugar from gur. In the refineries the pots containing the massecuite are broken and their contents are transferred to bags. These are stacked in piles of twelve and are pressed down by the

feet. The molasses exudes through the bags and runs off in small drains. This process lasts about eight hours, after which the resulting product is removed from the bags to another room in the refinery where it is stacked to a depth of three or four feet on bamboos covered with reeds or cotton stalks. There it is covered with a layer of water weed known as *siwar*, which is renewed on alternate days. After a month's treatment in this way, the upper layer which has become bleached is scraped off. Further scrapings take place on alternate days, the renewals of water weed continuing during the process. Each scraping is darker in colour than its predecessor. The sugar made by this process is known as *khand*. Local dealers estimate the average yield of *rab*, or massecuite, as one-fifth the weight of juice. On the basis of the extraction we have mentioned above this is equivalent to 11 maunds of *rab* to 100 maunds of cane. The wastefulness and inefficiency of the process are sufficiently demonstrated by its net result, which is 4 per cent. of sugar only as against 9.5 per cent. which we estimate as possible in a thoroughly efficient factory. In these circumstances it is obvious that the industry would be unable to withstand the competition of factory sugar, were it not that its product commands a special market and sentimental reasons bring in a considerably higher price for it than rules for factory sugar. It is equally obvious that, in spite of that higher price, the cultivator cannot receive what we consider a fair price for his cane ; and in practice it is mainly his indebtedness to the manufacturer (*khandsari*) which secures the latter his supplies of raw material. If this diminishes either as a result of the extension of co-operative activities or of the ability of the cultivator to sell his cane elsewhere, and if the prejudice against factory sugar disappears, as there is every reason to believe it will, the *bel* process appears to us to be doomed to extinction. It has, in our opinion, no future before it and we have, therefore, no recommendation to make regarding it.

(b) Direct manufacture of white sugar in small factories with open pan boiling.

279. Our reasons for disapproving the establishment of small factories crushing only one or two tons of cane an hour and boiling in open pans for the manufacture of white sugar may be very briefly stated. We are convinced that such factories are doomed to failure, as low outturn and consequent high costs of production would not allow them to compete against large modern factories turning out the same product. The loss of crystalline sugar which would occur in the boiling process would be very heavy and the high proportion of molasses which would be produced and which is inevitable in any system of open pan boiling would be wastefully disposed of. In the manufacture of gur there is no separation of sugar from molasses. They are sold and consumed together, and the above waste is avoided. We are fortified in this conclusion by the results obtained at the small Government factory erected at Nawabganj, near Bareilly, in the United Provinces which we have had an opportunity of visiting and the history of which we have studied. Since much was at one time expected of this experiment and the question of its disposal is, we understand, now under the consideration of the Local Government, we make no apology for going into the matter in some little detail.

(i) Origin and objects of the Nawabganj factory.

280. The factory owes its origin to the alarm which was aroused about the beginning of 1911 by the growing importations into India of cheap foreign sugars. The threat to the indigenous sugar industry was regarded so seriously that a resolution was introduced into the Imperial Legislative Council

in March, 1911 by one of the Indian non-official members proposing the enhancement of the duty on imported sugars to the extent necessary to enable the indigenous industry to survive. The resolution was opposed by the Government on the ground that they were already doing their utmost to improve methods both of cane cultivation and of sugar manufacture throughout the country; and they particularised the small power plant then being demonstrated at the Allahabad exhibition by Mr. W. Hulme on behalf of the exhibitors, Messrs. Blair, Campbell and McLean. This was a plant designed to turn out 1½ tons of sugar per day of 24 hours, with a five roller mill and a sugar house equipment differing little from that of a large factory except in the omission of an intermediate vacuum evaporator. In pursuance of the assurance given in the Imperial Council the whole question of the improvement of the indigenous industry was referred to the Board of Agriculture of 1911, which unanimously recommended amongst other measures the appointment of a Sugar Engineer. The Government of India obtained the Secretary of State's sanction to the creation of this post under the control of the United Provinces Government for three manufacturing seasons and to the appointment of Mr. Hulme to fill it. It was explained that the object in view was to fulfil the pledges given in Council the previous March and that Mr. Hulme would be required to improve indigenous methods with small plant. This aim was also put before the Local Government when Mr. Hulme's services were placed at its disposal and an allotment from Imperial revenues was made to it to meet the entire cost of the scheme. The original term of the appointment has been extended from time to time and Mr. Hulme's engagement did not actually terminate till April, 1919. His activities were, therefore, directed to the designing of a plant of the smallest dimensions workable on a commercial basis and employing the simplest processes and machinery possible with a view to obviating the necessity for highly skilled management and technical supervision; and during the season 1914-15 he erected a small factory adjoining the Government Agricultural Station at Nawabganj for the manufacture of crystal sugar or gur alternatively, as circumstances might dictate.

(ii) Description of the Nawabganj plant.

281. Modifications in and additions to the original plant have been made from time to time; but the following is a description of its main features. The mill is a compact arrangement of eleven rollers and is capable of crushing one ton (27.2 maunds) of cane per hour. There are no intermediate megasse carriers such as are usually found with multiple mills. The megasse passes from roller to roller by gravitation and is finally delivered on to the firing platform in front of the steam boiler from whence it passes into a specially constructed megasse furnace attached to the boiler. The juice from the mill is pumped to the top of a wooden chamber and is there treated with $S.O_2$. The sulphured juice is limed to neutrality and heated by means of steam coils in clarifiers. The clear juice is decanted off, passed through bag filters and taken to the evaporator. The evaporation is carried out in a film evaporator of the Wetzel pattern provided with a revolving cylinder of copper pipes and heated by exhaust steam from the engine that drives the cane mill supplemented by a small quantity of steam direct from the boilers. The juice when sugar is made is concentrated to a density of 40 degrees Beaumé and put into crystallisers to grain out. After graining the sugar is separated from the molasses in a centrifugal machine and dried. The crystallisers, defecators and centrifugals are of standard pattern, and the most striking and novel feature of the plant is the mill, which is capable of giving a very high extraction. In 1917-18 as much as 83.11 per cent. of the sugar in the cane was reported to have been extracted on the average throughout the season.

It is, in fact, the efficiency of the mill which has emphasised the chief defect of the plant as a whole, namely that the evaporating capacity has not been equal to the crushing power. This defect apart, however, both the machinery and the design were pronounced by our technical members to be excellent and the best of their kind.

(iii) Its results.

282. Nawabganj appears to have been selected as a site for the factory, because a nucleus of the cane supply could be counted upon from the farm and little difficulty was anticipated in effecting purchases from the neighbouring cane growers. This anticipation has not been fulfilled, as the indebtedness of the cane growers to the local *khandsaries* has enabled the latter to maintain a firm hold upon them and largely to prevent the delivery of their cane to the factory. Only in one year has the factory secured a full supply of cane, and this has naturally operated to render its financial results more unfavourable than they need otherwise have been. And since shortage of raw material affords no valid basis for condemning the plant, we propose to confine our examination of its financial aspect to the year in which it did not labour under this extraneous disadvantage. This was 1917-18 when the working season extended over 103 days. We reproduce below the Profit and Loss Statement issued by the factory for that year.

Expenditure.		Receipts.	
Particulars.	Amount.	Particulars.	Amount.
	Rs. A. P.		Rs. A. P.
1. Establishment	2,337 12 4	1. Price of 1,919·44 maunds sugar credited into Treasury.	27,196 14 6
2. Wages, Stores, Renewals, etc. ...	3,851 10 6	2. Price of 1,430·55 maunds Molasses credited into Treasury.	2,948 3 6
3. Cost of 36718 maunds sugarcane ...	13,572 9 6	3. Miscellaneous receipts	508 9 9
4. Cost of fuel	4,261 9 9	4. Valuation of 90·65 maunds of sugar in stock at Rs. 13.	1,178 7 0
5. Other working expenses ...	1,739 10 0	5. Valuation of 65·55 maunds sugar spent as seed Jam making and lost in transit, etc., at Rs. 15.	983 6 3
6. Profit	7,949 4 11	6. Valuation of 175 empty kerosene oil tins.	100 0 0
Total ...	33,715 9 0	Total ...	33,715 9 0

The statement, it will be observed, is incomplete and makes no allowance for either interest on capital charges or depreciation. The establishment charges, also, include nothing on account of Mr. Hulme's salary, although he was in-charge of the factory throughout, or of the salary of the Chemist who assisted him. The total cost of the plant up to that year had been Rs. 67,840 again excluding the cost of Mr. Hulme's own services in supervising its erection. Depreciation on this at 5 per cent. (Rs. 3,392) reduces the profit returned to Rs. 4,557, which works out at a return of only 6.7 per cent. on capital outlay. As an optimum result this is only moderately encouraging; but, as we have pointed out, it is based on what are really incomplete accounts both of capital cost and of working expenses; while no provision has been made for working capital. When these defects have been remedied, it is obvious that the percentage of profit returned must be materially reduced. Moreover the inclusive

cost of the cane was only 5.91 annas a maund, whereas we estimate the present day cost to the cultivator of raising the thin, indigenous canes of Upper India as being between 5 and 6 annas a maund and, as will be seen from Chapter XIX, regard 6 annas a maund as the absolute minimum which any factory should give for its cane, that is, even when the price of sugar is well below the Rs. 14.56 per maund which the Nawabganj sugar fetched in that year. And once the cane cultivator is released from his financial entanglements, he has always the alternative of converting his own cane into gur which at that period was selling at Rs. 5 to Rs. 6 per maund, giving an equivalent gur value to the cane of 7.2 to 8.7 annas. Such a price as this for its cane would of course have nearly if not quite absorbed the factory's profit.

283. In investigating the reasons why so small and precarious a profit was obtained even in the best year we shall still confine our attention to the returns of actual work done in that year not merely because it exhibits the factory at its best but because in other years gur also was manufactured and the mistake was made of not keeping the records distinct for the two products. The returns for those years are in consequence largely unintelligible. According to the report for 1917-1918 the sucrose content per 100 cane was 12.27 and the sugar obtained per 100 cane 5.6. There is no record of the polarisation of the sugar obtained in this year, but taking the highest figure recorded in the report for 1916, *viz.*, 99.77, the process used in this factory recovers only ($5{\cdot}6 \times \frac{99.77}{12{\cdot}27}$ or) 45·53 parts of sucrose as crystalline sugar per 100 sucrose in the cane. We have already pointed out that the mill gives a high expression and, if the published figures in the report of 1917-18 may be accepted, of the total loss of 54.47 per cent. of sucrose incurred in manufacture, only 16.89 per cent. is attributable to the milling, leaving no less than 37.58 per cent. attributable to the boiling. In other words, the gain due to the superior efficiency of the factory's crushing plant as compared with those of other factories in India was far more than counter-balanced by the inefficiency of the process in the sugar house. And these losses are inevitable so long as evaporation is effected under atmospheric pressure ; so that there is little prospect of reducing the very high cost of manufacture which works out at Rs. 12.41 for every maund of sugar (with its proportionate residuum of molasses) produced. We point out in Chapter XIX and illustrate in Plate No. 25 that factories working with such a low efficiency cannot pay a price for cane on the sliding scale we propose which will enable them to compete with more efficient factories extracting from 7.5 to 9.5 parts of sugar per 100 cane. This alone, in our opinion, is sufficient to condemn the Nawabganj plant.

(iv) Causes of failure.

284. Our conclusion is, therefore, that the problem Mr. Hulme was set to solve is insoluble and that no advantage is to be gained by the continuance of the factory on its present lines. Had its activities been directed entirely to the manufacture of high-class eating gur, the experiments on which appear to have been only half-heartedly undertaken, the result might have been different ; but we do not recommend that this should now be done, since considerable further outlay would be required to restore the balance between the evaporative and the crushing capacities of the plant, and it would in any event be necessary to remove it to a more suitably located site for the supply of cane. We deprecate disposal of the factory as it stands ; because this would encourage continuance of white sugar manufacture by a method which we regard as commercially unsound. Nor would we advocate the transfer of the

(v) Disposal of the Nawabganj factory.

plant to the Sugar School the constitution of which we shall propose in Chapter XXV. Some time may elapse before the School comes into being, and when it does it will require for demonstration purposes entirely new and up-to-date machinery. All things considered, we are of opinion that the United Provinces Government should find means of using the excellent milling plant profitably on or in connection with one or other of its sugar research stations, and that so much of the rest of the machinery as is of standard design should be sold to existing sugar factories.

285. We next pass to a discussion of the possibilities of the gur refining industry. We would state at the outset that we do not consider that an extension of the production of sugar from gur would in the long run prove of advantage to the Indian sugar industry. Our enquiries in India and Java and the experience which some of us have of other great sugar producing countries have convinced us that the best results are obtained when cane is converted into a marketable product for direct consumption, whether in the form of gur or sugar, at the place where it is grown. It is undoubtedly true that the position of factories which refine sugar from gur has improved greatly in recent years, and that they have shared in the general prosperity resulting from the high prices which have ruled for sugar. But it cannot be overlooked that they are compelled to work with raw material of poor quality from which they obtain a relatively small proportion of sugar, and that, should there be a heavy fall in prices, they would find it increasingly difficult to withstand the competition of factories manufacturing sugar direct from cane. The refining industry has to face the losses incurred in two processes, the manufacture of gur and the manufacture of sugar. Our enquiries showed that the Indian refineries obtain on an average not more than 45 per cent. of sugar from gur. On the assumption we have adopted throughout, that 9 tons of gur are on an average obtained from 100 tons of cane, this means that refineries recover 4.05 tons of sugar from every 100 tons of cane against the 9.5 tons which we consider should be obtained in an up-to-date Central Factory working directly on cane. An industry which obtains as little as this cannot, except in abnormal conditions such as have prevailed since 1915, afford to pay a price for gur which, when worked out in terms of cane, will encourage the cultivator to grow cane, still less to extend the area under it and increase the yield per acre by investing capital in improved methods of agriculture. If the sliding scale for the purchase of cane which we propose in Chapter XIX is adopted, the price paid by a factory obtaining 4.05 per cent. of sugar from cane would be the price of 2.025 maunds of sugar for 100 maunds of cane. With sugar at Rs. 12 per maund, this works out at 3.89 annas per maund of cane and with sugar at Rs. 20, at 6.48 annas. The first of these prices for cane is very much below and the latter is only slightly above the figure at which we place the cost of production of cane in Upper India at the present time. The gur refining industry also suffers from the handicap imposed by the heavy freight on its raw material which is often brought from great distances. So far as we can see, the only advantage it possesses is that, by collecting that raw material from scattered areas, it overcomes, though in a very expensive manner, the greatest difficulty which confronts the factory in India, that of obtaining adequate supplies. The proposals which we make in a subsequent Chapter with the object of securing concentrated areas in the neighbourhood of the factory will we trust, obviate this difficulty in a more effective manner. We are, therefore, unable to take a hopeful view of the future of the gur refining industry in India or to support any suggestions for its extension.

(c) Manufacture of sugar from gur in large factories.

Summary of Conclusions and Recommendations.

(1) *Of the total quantity of cane sugar produced in India 99 per cent. is turned out primarily as gur or* rab *against only 1 per cent. produced direct from the cane as factory sugar.*

(2) *In gur manufacture 34 per cent. of the sucrose in the cane is lost or inverted compared with the results obtainable by an up-to-date sugar factory.*

(3) *The Committee calculate that this means for all India a loss of 1,068,960 tons of sucrose.*

(4) *Sugar factories in India, mainly owing to inefficient milling, lose on an average about 29 per cent. of the sucrose in the cane as compared with the results obtainable by an up-to-date factory.*

(5) *The Committee calculate that this means for all India a loss of 10,534 tons of sucrose.*

(6) *These figures represent the theoretical limit of possible improvement; but this cannot in practice be even approximately attained.*

(7) *The manufacturing problem is to decide by what lines of improvement these losses can be most materially reduced.*

(8) *The manufacture of white sugar from* rab *is most wasteful and cannot survive, if the prejudice against factory sugar disappears and the cane-grower is enabled to sell his cane elsewhere.*

(9) *The direct manufacture of white sugar in small factories with open pan boiling must also be condemned on the grounds of high cost of production, heavy losses of crystalline sugar and an unduly high proportion of molasses.*

(10) *This conclusion is supported by the results obtained at the small Government factory at Nawabganj, United Provinces, which has proved a commercial failure despite the excellence of its design and equipment.*

(11) *The Nawabganj factory should now be closed, use should be found locally for its highly efficiency milling plant and such parts of the rest of the plant as are of standard pattern should be sold*

(12) *Gur refining in large factories has also no future before it; as the low quality of its raw material and the heavy losses inevitable with the combination of processes by which the sugar is manufactured render the industry incapable of withstanding efficient competition in normal times.*

CHAPTER XVIII.

THE MANUFACTURE OF GUR.

286. In the preceding Chapter we have given a very brief description of the processes of manufacturing gur, known as gul in the Bombay Presidency and jaggery throughout the rest of Southern India and Burma. This was necessary in order to illustrate the main thesis of that Chapter, which is the extent of the losses which occur in the manufacturing process adopted in India. As we now proceed to make detailed recommendations for improving these processes in the case of gur, some amplification of that description is necessary. In order to avoid overloading this part of our Report with detail, we shall give only a general sketch of the industry, and it must be understood that there are somewhat wide variations in the local practice.

Present methods of manufacture.

287. We shall commence with the first stage in the process, the crushing. The pestle and mortar mill was in general use for this purpose in India up to the middle of the last century, and this very primitive form of mill is described by Sleeman, Mrs. Parkes and other writers who had an intimate knowledge of the rural India of that period. It has completely disappeared, and the wooden roller bullock mill which supplanted it is only occasionally found in the most backward parts of the country. Iron mills are now in universal use all over the great gur-producing tracts of India. The most common form of these is the three roller mill, though the less efficient two roller mill is still fairly common in some parts. The use of the latter is, however, dying out, the efforts of the Agricultural Department having done much to hasten its extinction. Experiments carried out on Government farms have shown that a high extraction of juice can be obtained by the best type of three-roller mill when it is working properly. Indeed it is doubtful whether any type of mill could be evolved which would give a higher extraction of juice from a single crushing. But it is obvious that the better the extraction from a mill worked by bullock power, the heavier the strain on the bullocks. All the witnesses before us who had practical experience of the crushing of the cane crop by bullock mills laid great stress on this point and were agreed that the deterioration of the cattle in consequence of the heavy demands on them during the crushing season presented a serious obstacle to the introduction of better methods of cultivation. There can be no doubt that, if this deterioration could be expressed in terms of money, the figure would be a very high one.

(a) *Crushing.*

To show what can be done under the best conditions, that is, when a three-roller mill in proper order is worked by cattle of good quality, we give the

following results which were obtained in the United Provinces from the medium indigenous cane known as *Dikchan* :—

Type of mill.	Maunds of cane crushed per hour.	Maunds of juice expressed per 100 maunds of cane.	Maunds of juice expressed per 100 maunds of juice in cane.
Three roller iron bullock mill with 8 inch rollers.	2·53	66·8	80·5
Three roller iron bullock mill with 6 inch rollers.	1·83	59·7	74·7

Such high efficiency as this cannot, however, be obtained for any length of time by cultivators with their light and often under-fed cattle. Our examination of the megasse from numerous village mills made only too evident the loss of efficiency which results from the loosening of the mill in order to reduce the strain on the cattle and so to enable them to get through the crop. Whilst the enquiries we made on the spot showed that the extraction obtained by the cultivators' mills varied between wide limits, they also showed that for the same type of mill and cane it did not reach the figures given above. Differences in canes and in mills were responsible for the variations to a far less extent than the lack of the power necessary to work the mills at their full efficiency. The canes of Upper India contain a high percentage of fibre, 16 to 18 per cent. being usual. The thick canes of Southern India contain much less than this, and it follows that the lowest extraction is obtained in Northern India and the highest in the Peninsula. As has been already stated, we estimate that, over India as a whole, the cultivator obtains on an average not more than 55 parts of juice per 100 of cane.

288. The mill is always near the boiling house and the juice is usually taken from the mill to the pan in kerosene oil tins, though the earthen jar, or *ghurra,* is still sometimes used for the purpose. The boiling house is a mud hut with a thatched roof. The most common furnace is merely a circular hole in a raised earthen platform at the end of the hut. The pit of the furnace is level with the floor of the hut and the furnace is fed through a large aperture in the front of the earthen platform. Occasionally, as for example, in parts of the Bombay Presidency, the top of the furnace is level with the floor in which a large semi-circular hole is made to feed it. This type of furnace is usually lined with brick. Whatever the type of furnace, unless it be one of the improved types introduced by the Agricultural Department, the feeding hole is usually the only passage for the entrance and exit of air and for the removal of ashes. The result is that, owing to the want of a regular supply of air, neither the fire nor the heat produced by it is steady. The fuel is never completely burned and charred material collects at the bottom of the furnace. It is seldom that furnaces of this type are able to work only on the megasse produced by the mills, and this has to be supplemented by wood or by the stalks of *arhar* (*Cajanus indicus*) or of cotton. As a general rule one boiling pan only is used. This is a shallow pan about 4½ to 5 feet in diameter and one foot in depth. In this the juice is concentrated to a semi-solid mass which contains approximately 10 per cent. of water. The scum is removed as boiling proceeds, and during the boiling a dilute solution of sodium carbonate and the juice of the *bhindi* (*Hibiscus esculentus*) are used as clarifying agents. As the contents of the pan begin to assume a semi-solid consistency they are violently stirred. When the charge is

(b) Boiling.

considered ready, the fire is drawn and the pan removed from the furnace. As a rule the gur is either moulded into small blocks or run into earthenware vessels which hold approximately half a maund.

289. Gur when cleanly made is an appetising article of diet. It is the form of sugar most extensively consumed in India and appears as an article of commerce in even the smallest bazaars. Its quality, however, depends largely on the purity of the juice from which it is made and varies greatly in different parts of India. In Upper India the gur made from Dhaul and Saretha in Meerut and the adjacent districts of the United Provinces is highly prized. It is largely exported to the bazaars of the Punjab where it fetches a high price. The gur made in the Deccan from the pure juice of the Paunda canes and in the Godavari delta from that of Mauritius varieties is of equal if not greater value. On the other hand, the gur made in the east of the United Provinces and in Bihar from such canes as Hemja is of inferior quality and commands a lower price. It is this gur which is mainly used by the refineries in Upper India.

Qualities of gur manufactured.

We give below a table showing the analyses of some gurs of Upper India and the Peninsula.

Cane.	Sucrose.	Glucose.	Ash.	Moisture.	Remarks.
Katha (Punjab) 1915 ...	70·41	9·11	...	...	Percentage of ash and moisture not determined.
Merthi (Punjab) 1915 ...	71·10	11·07	...	...	Ditto.
Dhaulu (Punjab) 1915 ...	62·57	18·36	...	...	Ditto.
Reora (United Provinces) 1908.	77·87	8·57	...	...	Ditto.
Kuswar (United Provinces) 1908.	65·34	19·03	...	...	Ditto.
Hemja (United Provinces) 1908.	72·39	12·85	...	...	Ditto.
Lalri (Punjab) 1908 ...	66·31	13·07	4·35	...	Cultivator's gur. Percentage of moisture not determined.
Paunda (Belgaum district, Bombay) 1918.	87·38	4·73	1·54	3·36	Solid. Hard, dark sample.
Paunda (Belgaum district, Bombay) 1918.	77·90	7·53	1·08	4·88	Solid. Light yellow sample.

290. This description has, we trust sufficiently shown the crudeness and wastefulness of the present methods of manufacturing gur. To the waste of juice in the crushing has to be added waste of fuel and waste of sucrose in the boiling. The waste of fuel is partly due to the actual loss of heat by conduction and cooling during the frequent removal of the pans and partly to the imperfect combustion already mentioned. The late Dr. Barnes placed the combined loss of sucrose which occurred during the milling and boiling processes in the Punjab at from 34 to 57 per cent. He estimated that from 16 to 23 per cent. of this loss occurred during milling and from 3 to 14 per cent. during boiling, the remainder being lost in handling the juice and gur. In an earlier series of experiments carried out at Partabgarh in the United Provinces in 1908 Mr. Clarke found that one-fifth of the sucrose in the juice was destroyed or inverted during boiling.

Wastage involved in present methods.

In considering these figures it has to be remembered that not all the inverted sucrose is lost as food. Some of the non-crystalline sugar produced by inversion remains in the gur and has nearly the same food value as sucrose. The experiments carried out by Dr. Barnes and Mr. Clarke are merely a statement in figures of the fact of which there is abundant evidence that the losses which occur at all stages in the manufacture of gur are considerable.

291. It has, we think, been made clear in the preceding paragraphs that the development of the gur industry must proceed on two main lines. The first is the introduction of power crushing on a relatively small scale by mills of better design than the present three roller mill. Such mils would be driven either by oil or steam, and we consider that the most convenient unit would be a mill crushing one or two tons of cane an hour. The second is the introduction of an improved furnace which will so economise the use of fuel by securing more complete combustion and absorption of heat that the juice extracted by the power mill can be converted into gur by means of megasse alone.

Lines of improvement.

292. There is, in our view, no agricultural operation to which power driven machinery can be more effectively applied than for crushing cane. If increased outturns are to be secured, it is above all essential that improved methods of cultivation should be adopted. They can only be adopted to the extent that the number of cattle available and their condition permit. A special feature of Indian agriculture is the rapidity with which tillage operations have to be carried out when the right conditions occur. Here again, if work is to be done at the precise moment when it will yield the best results, everything depends upon the cattle supply. One of the most pressing problems in Indian agriculture would be in a fair way towards solution if the bullocks could be relieved of two of the agricultural operations which make the heaviest demands on their strength, the crushing of cane and the threshing of the *rabi* crop. These are both operations which can be carried out by power driven machinery ; and, in our opinion, the successful introduction of such machinery presents fewer difficulties than do most changes in agricultural practice in India. The question of its introduction for threshing the *rabi* crop lies outside the scope of our enquiry ; but the immense saving of cattle power which could result from it would mean so much all over Upper India, if it were utilised on the preparation of land for cane, that we have no hesitation in drawing the attention of the provincial Agricultural Departments to the possibilities in this direction.

Improved mills.

(a) Power-crushing.

Whilst we regard the introduction of the small power plant as indispensable to the development of the gur industry, we do not overlook the difficulties which will be encountered and the importance of the economic factors involved. A brief examination of the attempts which have been made to introduce such a plant and the results obtained will give a clearer conception of what these are. It is in the United Provinces, Madras and Mysore that the problem has been attacked with the greatest energy.

293. For some years prior to 1912 the work of the Agricultural Department in the United Provinces on this problem consisted of attempts to manufacture white sugar by a system of open pan boiling over a free fire combined with power crushing by a three roller mill and the separation of sugar from the molasses by means of a hand driven centrifugal machine. Special tests carried out in 1909 gave the following results from juice obtained from the thin canes of

(a) Previous experiments with power-crushers.

(i) in the United Provinces.

the Allahabad district with a sucrose content of 15.12 per cent. and purity of juice of 81.7—

1st sugar (polarisation 95.16) 6.3 parts per 100 parts of juice.
2nd sugar (polarisation 86.89) 2.7 ditto.
Molasses (polarisation 35.92) 8.2 ditto.

The extraction obtained by the mill was not determined by a direct test, but was estimated at 65 parts of juice per 100 parts of cane. The results of later work have shown that this figure was considerably higher than could actually have been obtained by the type of mill used, and that the extraction should have been placed at not more than 60 per cent. Calculated on this basis, the results work out at—

1st sugar 3.78 parts per 100 parts of cane.
2nd sugar 1.62 parts per 100 parts of cane.
Molasses 4.92 parts per 100 parts of cane.

It should be mentioned that the second sugar, as its polarisation shows, was of very poor quality and was only separated from the molasses with great difficulty.

Efforts to extend this process were abandoned in 1912 for reasons into which it is unnecessary for us to enter. The reasons which have led us to condemn the Nawabganj experiment apply with greater force to factories of the type we have described ; and it is easy to see why the work of the Agricultural Department on this plant ended in complete failure and financial loss. The principle of using power crushing to work up the cane crop was a perfectly sound one. The fundamental error lay in the attempt to manufacture white sugar by a wasteful and inefficient method instead of making gur for direct consumption. The experience gained in the United Provinces strengthens our conviction that small factories for the manufacture of white sugar are unsound from every point of view.

294. The experiments with small power plant and improved furnaces in Southern India have been conducted on different lines. Here power crushing in conjunction with improved furnaces has been utilised for what we regard as its proper purpose, the manufacture of gur. It is true that the operations have so far not proved a financial success and that they cannot, therefore, be said to have done much to solve the problem; but the results obtained, especially those at Pallapalaiyam near Coimbatore in the Madras Presidency from 1915 to 1917, have at any rate thrown valuable light on the difficulties which will be encountered, if the combination of small power plant and improved furnace is to come into general use, and on the conditions which must be fulfilled to ensure its success.

(ii) in Madras.

The installation at Pallapalaiyam was established in 1912 at Singanallur, but owing to difficulties in obtaining supplies of cane was removed to its present site some two or three miles nearer Coimbatore in 1914. A similar installation was established at Chitwadigi in the Hospet taluk of the Bellary district in 1914, but did not long survive. In both cases the price fixed by the factory for manufacture was Rs. 3 per *pothi* (260 lbs.) of gur, which is equivalent to 15.2 annas per maund of gur, or, with the quality of cane used in Madras, to about 1.8 annas per maund of cane. This price was based on estimates which had been obtained of the cost of making gur in different districts of Madras varying

between Rs. 2-8-0 and Rs. 6 per *pothi* of gur. It was soon found that the estimate for the Hospet taluk, Rs. 5 per *pothi*, had been pitched far too high and should have been halved. In these circumstances the installation had no prospect of success and was soon closed. As the following figures show, the installation at Pallapalaiyam has worked at a loss—

—	1916-17.	1917-18.	1918-19.
Days worked	142	143	161
Hours worked per day	11·8	11·2	Details not available.
Running charges per *pothi*	Rs. 1-8-5	Rs. 1-11-4	
Fixed charges per *pothi*, including interest, depreciation, repairs and renewals.	Rs. 1-12-4	Rs. 1-13-0	
Total charges per *pothi*	Rs. 3-4-9	Rs. 3-8-4	Rs. 3-8-0

It will be seen that the total running and fixed charges per *pothi* of gur have always been higher than the charge made to the cultivator, which experience has shown is the highest charge at which supplies of cane are forthcoming. The figures we have given were for seasons when the plant was working continuously; and it may, therefore, be assumed that no reduction in cost is possible with this plant and these conditions.

The combined plant at Pallapalaiyam has many obvious defects. The most prominent of these are the necessity for passing the cane twice through the mill, which halves its capacity, and the use of three and sometimes four furnaces to deal with the juice from a mill crushing 22 maunds of cane an hour. Conditions such as these result in heavy fixed and running charges and mean that the plant, even when working continuously throughout the season, cannot make gur at a cost below that which is incurred by the cultivator.

295. Little need be said about the experiments which have been carried out in Mysore. We were informed that ten installations had been put up by the Department of Industries and Commerce of which five were worked departmentally and five were put up for private individuals. Only one of the former is now in existence and that has recently been transferred to another locality. Only two of the private installations are still working. We were supplied with no figures of their working; but the fact that only three out of the ten installations survive is sufficient evidence that they have not been a success. The failure of the departmental factories was attributed partly to their inability to secure regular supplies of cane, which led to a great increase in fixed and running charges and detrimentally affected the quality of the gur turned out, partly to the absence of carting facilities and partly to prejudice. We cannot but think that the results obtained might have been different, had this been regarded as an agricultural rather than an industrial matter, and had there been a preliminary investigation by the Agricultural Department of the possibilities of the tracts in which the installations were located.

(*iii*) *in Mysore.*

296. The work done everywhere in India has clearly shown that the problem is to determine the size of power plant which will give at least as much gur as is at present obtained by the bullock mill and the country furnace at a cost, including interest, depreciation, renewals, and necessary expert supervision, which shall not be greater than that incurred by the cultivator's methods. No plant, in our

(*c*) *Low costs of manufacture the first essential for power crushing installations.*

opinion, has any chance of success, unless it is of sufficient size and capacity to bring the total fixed and running charges within this limit, and unless it is so placed that a full supply of cane is assured throughout the season, as intermittent working immediately increases costs. The first essential, therefore, in considering the possibilities of a power plant in any particular tract is that trustworthy data regarding the actual cost incurred by the cultivator in crushing cane and making gur should be obtained. Experience in Mysore has already shown that the lack of accurate information on this point may lead to installations being put in localities in which they have no chance of operating successfully. We have seen that the cultivator in Madras will not bring his cane to a power installation, if he is charged a higher rate than 1.8 annas per maund of cane for its conversion into gur. The rate which will induce him to do so in Upper India is much more difficult to arrive at. As we point out in Chapter XIX, although much time and trouble are expended on gur making, the work does not involve much actual outlay in money beyond the hire of the mill and pan. The cultivator is as a rule not impressed by representations of theoretical benefits which cannot be immediately translated into terms of money. It is at any rate certain that the cost of crushing cane by power plant in Upper India is greater than in the Peninsula owing to the higher fibre content of the cane. Whilst in Madras it is necessary to crush about 8½ maunds of cane to obtain a maund of gur, in Upper India with the canes at present grown it is seldom that less than 11 maunds of cane are required for one maund of gur. The estimates of the cost of making gur given us by different witnesses ranged from 1.87 to 2.50 annas per maund of cane.

Our conclusion after careful examination of all the data on the subject is that it would not be a sound proposal to instal a small power plant in Upper India which could not crush cane and manufacture gur at a cost, including all charges such as interest, depreciation, renewals and a certain amount of expert supervision, of 2 annas or under per maund of cane, which is equivalent to at least Rs. 1-6-0 per maund of gur with the thin canes of Upper India. It need hardly be pointed out that, if any subsidiary operation, such as the threshing of the *rabi* crop, can be combined with power crushing, this will materially reduce the fixed charges.

297. There is no reason why the organisation of small power plants should follow the same system everywhere. In Madras, and to some extent in Mysore, the installations have been established and worked by Government Departments with a view to the benefit of the small cultivator. This is one line of development. Another is the working of such installations by co-operative societies, though the need for expert supervision here is a matter to which we have drawn special attention in paragraph 259 of Chapter XV. More promising, perhaps, than either of these are the prospects on large estates, especially in Upper India. Taluqdars in Oudh and large landholders in other parts of the United Provinces and the Punjab realise the profits which can be derived from cane growing and gur manufacture; and it is probable that before long there will be many estates in both Provinces which will have from 150 to 200 acres under cane on their home farms. It was specially brought to our notice that the extension of cane cultivation on the home farms is at present limited by the existing means of working up the crop, and that their owners were in a position to purchase a suitable installation for this purpose, if one were available.

(*d*) *Scope for the introduction of power crushers.*

298. We proceed to discuss the technical improvements possible in the mill of small power installations. The present type of three roller mill on the market does not give any better extraction than that obtained by a well kept and well

(*e*) *Technical improvements in the mill.*

adjusted bullock mill. In Madras, as we have already stated, it has been found necessary to pass the cane twice through the mill to bring the extraction up to a point which will satisfy the cultivator. Experiments on Government farms in Upper India have given the following results :—

Cane.	Type.	Parts of juice per 100 parts of cane.
Dikchan	Three roller iron mill worked by bullocks with 8 inch rollers.	66·8
	Smaller type of iron mill worked by bullocks with 6 inch rollers.	59·7
	Three roller power driven mill with 8 inch rollers	56·2

Our enquiries on this point have convinced us that the claims which have been put forward that the existing type of three roller power driven mill gives an extraction which is much higher than that obtained from a good bullock mill are not borne out by the facts, of which we consider that the table above gives an accurate representation. It will be seen that the power mill is inferior to the bullock mill when the latter is working under the best conditions, and that it only gives slightly better results than the bullock mill as worked by the cultivator, which we have estimated to give an extraction of 55 parts of juice per 100 parts of cane. There is thus considerable room for improvement in the existing types of small power mills. A most desirable improvement, in our opinion, would be the addition of an extra pair of splitting roll crushers to the mill, which, by adding two extra rollers at a comparatively small additional cost, would virtually convert it into a five roller mill and enable it to give a higher extraction. We would, therefore, direct the special attention of the Engineering Section of the Agricultural Departments in all Provinces to the question of designing a small power mill on these lines. We would suggest that a standard design for mills of the following capacities should be worked out.

Type No. 1—Capacity one ton of cane per hour.

Type No. 2—Capacity two tons of cane per hour.

It can only be decided by actual experiment which of these capacities will prove economically sound in the conditions in which it is proposed to use the plant.

Improved furnaces.

299. We cannot too strongly emphasise that it is useless introducing more rapid and less costly methods of crushing cane, unless provision is made at the same time for more expeditious disposal of the juice. Much time and thought have been devoted to the solution of the problem of enabling boiling to keep pace with crushing, and a number of improved types of furnace have been evolved. We would mention the Poona and Manjri furnaces in Bombay, (a photograph of one of the latter in operation will be found in Plate 23) the furnace designed by Sir Alfred Chatterton more especially for conditions in Madras and Mysore, and the furnace designed by Mr. McGlashan which is in use on the Government farms in the Central Provinces. We do not propose to describe these in detail. Whilst all of them, (more especially the last three) represent a marked improvement on any furnace previously in existence, it cannot be said that any of them has proved entirely satisfactory in practice. It is seldom, if ever, that one furnace suffices to deal with the juice produced by a small power mill. This defect, which adds materially to the cost of manufacturing gur, is largely due to the design of the furnaces which are so constructed that the gasses are not completely burned and that the efficient absorption of heat is impossible owing to the arrangement of the pans. We attach to our Report a plan of a furnace which has been designed by our colleague, Mr. Craib, with a view to the removal of defects which have been found in all existing furnaces. The dimensions given in the design can, of course, be altered to suit the requirements of the two sizes of power mill which we have suggested. We estimate the cost of the furnace at Rs. 4,000 to 5,000 which, added to the cost of the power mill, which we place at Rs. 8,000 to 10,000, makes the total cost of the installation we propose Rs. 12,000 to 15,000. We strongly recommend that this furnace with the modifications, if any, which practical experience may suggest should be given a thorough trial on the cane research stations in the various Provinces. We would add that an alternative to the single furnace which might also be tried is a separate furnace under each finishing pan. This would do away with the side flues.

Government assistance to the gur making industry.

300. In paragraphs 301 and 302 of their Report the Industrial Commission made various recommendations regarding the grant of Government assistance by way of loans to small or cottage industries and to co-operative societies. They suggested that this class of loans should be made by the Department of Industries to persons or bodies whose financial position and character were found on enquiry to be suitable. Other forms of security than landed property might be accepted, but in such cases a stipulation should be usually made that applicants should find a fair percentage of the total outlay from their own resources. It should be a condition of the loan that it should be spent on approved types of plant, and the Department itself might, when desired by the applicant, purchase the plant. The Commission considered that there were numerous types of plant suitable for the purpose of agriculture or of small industries which could be made available by Government on the hire purchase system. They were of opinion that some maximum limit must be placed on the amount of individual loans advanced and on the value of plant supplied under this system, but that it would be for the Local Government to determine the figure to which the powers of the Director of Industries should extend. It was added that for advances of this kind, whether in cash or by way of hire purchase, special provision would be necessary for the recovery of outstandings. In the absence of such provision, the difficulty of recovery would tend unduly to restrict the giving of advances. The Land Improvements Loans Act and the Agriculturists' Loans Act do not cover the granting of loans for purposes unconnected with agriculture, nor do they permit the loan taking the form of plant made over to the recipient on a hire purchase system. For these reasons, the Commission concluded that fresh legislation embodied in a special Act would be required.

Except in one important respect, we consider that these recommendations apply in their entirety to the gur making industry and would give them our cordial support. Whilst the gur making industry has invariably been held to be an " agricultural object " for which the grant of loans under the Agriculturists' Loans Act is permitted, the Act does not, as the Industrial Commission point out, allow the loan to take the form of plant made over to the recipient on the hire purchase system. If power plant of the type we have suggested, the initial cost of which is undoubtedly high, could be made available on such a system, the stimulus to the development of the gur industry on sound lines would undoubtedly be very great, and we strongly endorse the recommendation of the Industrial Commission on this point. We differ from the Commission, however, in regard to the Department which should be entrusted with the task of assisting the industry. We are emphatically of opinion that the manufacture of gur must be regarded as the concern of the Agricultural Department and not of the

Department of Industries. We have emphasised that, if power plant for crushing is to be introduced with any prospect of success in a particular tract, it is essential that trustworthy data regarding the actual cost incurred by the cultivator in crushing cane and making gur should first be obtained and carefully studied, and have pointed out that the failure of the installations in Mysore was largely due to the absence of such data, which can only be satisfactorily obtained by the Agricultural Department. We have suggested that designs for improved power plant should be worked out by the Engineering section of the Agricultural Department, and that the improved furnaces of which we attach a plan should be given a thorough trial on the cane research stations. It will be evident, therefore, that the gur making industry can only be developed by a Department which is in the closest touch with the grower of cane and has the expert knowledge at its disposal necessary to keep him on the right lines. It must, therefore, be left as at present to the care of the Agricultural Department.

Manufacture of gur in large factories.

301. In the preceding Chapter we have included in possible methods of dealing with cane the manufacture of gur in large factories. Under this process the syrup leaving the triple effet would run direct to the finishing fire-heated battery. In this battery the remaining water would be driven off until a boiled sugar mass was obtained which, on being run into coolers and kept in motion, would turn into a dried sugar powder varying in colour from light yellow to brown, and could be made into balls or cakes of gur acording to requirements. The whole of the glucose as well as the sucrose would be contained in this product. The points in favour of this method of dealing with cane are the increased outturn of gur which would be obtained by the substitution of the high extraction and efficient boiling of the factory for the crude and wasteful methods of the cultivators and the greater cleanliness of the product which would be made in the factory. On the other hand, it is doubtful whether modern factories with plant for turning out white sugar would find the manufacture of gur a sound commercial proposition. There is also the possibility that the high extraction in the factory would result in the gur containing impurities which are now absent from it and whose absence gives it its special appeal to the palate of the consumer. Mr. Craib considers that this would undoubtedly happen and that, for this reason, there is no future for factory gur. The majority of us would like the question further investigated, and consider it one which might be taken up by the Government factory in conjunction with the Sugar Research Institute.

Manufacture of muscovado sugar or other intermediate product in small factories.

302. The possibilities of manufacturing muscovado sugar or some other intermediate product direct from cane in small factories and of working this up into white sugar in large factories, which we have also mentioned in the preceding Chapter, may be briefly dealt with. The use of steam driven plant capable of dealing with a larger amount of cane than the small gur plants we have described appears to us to be worth trial on an experimental scale in tracts where there is some concentration of cane areas, though not sufficient to meet the needs of a central factory. Plant of this character might be designed to deal with the cane produced by 300 to 500 acres, *i.e.*, in Upper India about 3,600 to 6,000 tons of cane per annum, and to make various products according to the local requirements. Such plant would be able to employ more powerful milling and better defecation than is possible with the small gur plant ; and the evaporation and concentration of the juice by means of steam in Aspinall pans would mean a higher percentage of recovery of sucrose than can be obtained by the small gur plant. The product turned out could be either gur for direct consumption or

an intermediate product such as a massecuite which could be transported short distances to a central factory for refining after the cane crushing season is over. Muscovado sugar might also be made in districts where the juice is of sufficient purity, though we regard it as doubtful whether the purity of the juice in Bihar and, in fact, over the greater part of Northern India is sufficiently high to make this feasible. The possibilities of such plant would, in our opinion, require very careful investigation ; and we would, therefore, suggest this as another line of enquiry to be taken up by the Research Institute as opportunity permits. It is, in our opinion, specially desirable that it should be definitely ascertained whether eating gur of good quality can be made by the higher extraction and better defecation which will be possible when working on this scale. If this proves feasible, the plant will represent an advance on the small gur factories which, in present conditions, we consider the best and indeed the only practicable line of development for the gur industry. If not, their usefulness will be limited to cases in which factories desire a subsidiary source of supply. The intermediate product turned out by plant of this character would give a raw material for refining superior to the gur made by the ordinary methods of open pan boiling, though it is necessary to point out that it would require special means of transport and storage and could only be transported over short distances.

Summary of Conclusions and Recommendations.

(1) *Properly adjusted and worked, there is probably no more efficient single crushing mill than the three roller iron bullock mill, but the strain on the bullocks renders proper adjustment and working impossible.*

(2) *The rollers are, therefore, deliberately slackened, and on the average not more than 55 parts of juice are extracted per 100 of cane.*

(3) *The chief defect of the country gur furnace is the irregularity of air supply and the consequent waste of heat and fuel.*

(4) *The first essential for improvement is the introduction of power crushing with small plant.*

(5) *The attempts to do this in the United Provinces were nullified by their attachment to a scheme for the manufacture of white sugar with open pan boiling.*

(6) *The correct line of advance is power crushing for the manufacture of gur and this been attempted in Madras and Mysore.*

(7) *In Madras the plant has proved defective, the cane having to be passed twice through the mill and too many furnaces being required to deal with the juice, and it has consequently worked at a loss.*

(8) *Only three out of ten installations in Mysore survive ; and failure seems to have been due mainly to the choice of unsuitable localities for them.*

(9) *The experience thus obtained indicates that, if power crushing is to succeed, the plant must be capable of turning out as much gur and as cheaply as the cultivator's plant.*

(10) *This means that the plant must be able to turn out gur at not more than 1.8 annas in Madras and 2 annas in Upper India per maund of cane crushed.*

(11) *There should be a special opening for such installations on large estates in Upper India.*

(12) *To ensure efficient extraction the small power crusher should have a pair of splitting roll crushers in front of the three roller mill.*

(13) *The Agricultural Engineering Department of each Province should evolve a standard design for small power mills to crush one and two tons of cane per hour.*

(14) *The improved furnaces so far designed are all defective in the arrangement of the pans and the incomplete combustion of the gases.*

(15) *A plan of a new furnace designed to eliminate these defects is attached to the Report.*

(16) *The Industrial Commission's recommendations for the grant of loans for small or cottage industries are well suited to encourage the gur making industry, except that the disposal of these loans should be entrusted to the Agricultural Department and not to the Department of Industries.*

(17) *It is doubtful whether gur manufacture in large factories is a commercial proposition; but the problem should be investigated in the Government sugar factory.*

(18) *The practicability of manufacturing muscovado sugar or some other intermediate product direct from the cane in small factories is also doubtful; but should be investigated.*

CHAPTER XIX.

THE SUGAR FACTORY AND ITS RAW MATERIAL.

The existing industry in India.

303. In Chapter XVII we dwelt on the great scope there is for the sugar industry of India on the manufacturing side and in the succeeding Chapter we have made recommendations the object of which is to secure a reduction in the great waste which at present occurs in the manufacture of gur. We have next to consider recommendations for the extension of the sugar factory industry. As a prelude to them, it is necessary briefly to review the present conditions of that industry. Of the 22 factories in India which work either entirely or mainly on cane ten are located in Bihar, five in the United Provinces, three in Madras, one in the Punjab, one in Assam, one in Mysore and one in Baroda. Of the Bihar factories one has not commenced work at the time of writing, but was to do so in December, 1920. One of the factories in the United Provinces only worked experimentally in 1919-20, but is expected to have a full working season henceforward. The Punjab factory has been idle for two years owing to difficulties in regard to the purchase of cane. The Mysore factory has recently recommenced work after closing down for some years. The factory in Assam had a very short season this year as it was in process of remodelling and enlargement. The Company which manages the factory in Baroda is at present in liquidation but is under reconstruction ; and it is expected that the factory will shortly reopen. Of the 10 refineries working on gur by factory methods five are in the United Provinces, three in Madras, one in Bihar and Orissa and one in the Punjab. The Cossipore Sugar Works near Calcutta constitute the only refinery in the sense in which that term is generally understood in other countries, as it operates on Java raw sugar

It may be noticed that the total number of factories, including refineries, in India according to our figures is 33, whereas the Department of Statistics, which recently undertook a census of the sugar production of India, sent out schedules to 90 " factories " and actually received returns from 40. The reason for this difference is that we have used the term "sugar factories" in the sense in which it is used in other sugar producing countries to include only manufacturing plants which employ the vacuum pan process, and have therefore excluded the numerous small concerns which have been regarded by the Department of Statistics as factories, though they do not employ that process. A list of the 33 sugar producing concerns which we regard as coming under our definition of " sugar factories " will be found in Appendix IV. We would here express our thanks to the factories in India for the readiness with which they replied to the questions we sent them. Unfortunately, owing mainly to the lack of expert staff on which we comment below, the replies in many cases were not as complete as we could have wished, and the limitations imposed on us

by the character of the information we received will be evident in what follows. So far as our information goes, the production from cane alone in 1919-20 of all the 18 factories which actually worked on cane in that year was only 23,100 tons of sugar, or little more than half that of the largest factory in Java in its best year and approximately equal to the production of three average factories in that island. To obtain this sugar over 337,000 tons of cane were crushed, the percentage of sugar to cane being thus only 6.85. The output of the different factories varied very greatly. It ranged from about 250 to about 3,350 tons, the average being about 1,280 tons. The area of cane which supplies the 186 factories in Java is less than that in the Punjab which has one factory only, and even that is not working.

Shortage of cane supplies the chief defect.

304. The only conclusion which can be drawn from the figures we have given here and in Chapter XVII is that the Indian factories speaking generally are both small and inefficient. If there is one cause more than another to which both the smallness and the inefficiency can be attributed, it is the difficulty they experience in obtaining an adequate supply of cane. In our Chapter on Java we have pointed out that the strong position now occupied by the sugar industry in that island is very largely due to the possession by the factories of complete control over the lands which supply them with cane, and have described in detail the system of leases by which that control is secured. With one striking exception, that of the East India Distilleries and Factories Company at Nellikuppam, the area of land owned or leased by factories in India is negligible. Time and again in the course of our enquiries we were assured that, unless some method of securing an adequate supply of cane to a factory could be devised, there was no future before the Indian sugar industry, as capital would not be attracted to it. New factories are, however, being established, if in small numbers, which shows that there is some exaggeration in this statement. On the other hand, the figures we have obtained of the working of existing factories furnish substantial justification for it. 50 per cent. of the factories only crush half the cane with which their mills are capable of dealing, 30 per cent. crush from two-thirds to three-quarters and the remaining 20 per cent. about four-fifths. No factory in India, therefore, works up to its full capacity, the main reason being its inability to secure sufficient cane to enable it to do so. We are agreed that no great extension of the factory system is possible so long as these unsatisfactory conditions continue ; and we proceed to discuss ways in which they may be remedied, if not entirely obviated. At the risk of dwelling on the obvious, we would point out that a factory producing sugar from cane must be situated in the midst of the tract which supplies it with raw material. Cotton mills and steel works are in the fortunate position of being able to draw on all parts of the world for their supplies of raw materials ; but a cane sugar factory is dependent on its immediate neighbourhood, not only because cane cannot be transported for long distances without rapid deterioration, but because its value is so small in comparison with its bulk that the cost of carriage rapidly becomes prohibitive. It follows from this last consideration that the more compact the area on which a factory depends for its cane the greater the economy in working. It is also of the greatest importance to the efficiency of a factory that, even when an adequate supply of cane is available, it should be available at the right time. In present conditions the factory frequently has to defer to the convenience of the cultivator who refuses to harvest his cane except when his other agricultural operations leave him free to do so. The result is that much of the cane which is brought in is either unripe or occasionally overripe.

Possibilities of a factory obtaining cane-land by purchase or grant.

305. There is, it need hardly be said, no more satisfactory method by which the difficulties in which factories find themselves owing to their inability to secure an adequate supply of cane could be overcome than by the purchase by factories of their own land. The possibilities in this direction are, however, very limited and it may be said at once that in no part of India does there appear any likelihood of factories being able to purchase any large areas of land by direct negotiations with the existing holders. The extreme fragmentation of holdings generally throughout India, the multiplicity of interests in them, the frequent encumbrances on them and the consequent difficulty in obtaining a valid title, but above all the reluctance of holders to part with their land all present an almost insuperable obstacle to such purchase. Compact blocks of land large enough for the purpose of a factory cannot, therefore, be obtained in absolute ownership without the assistance of Government, which may be given in two ways, either by the grant of Crown waste lands or by compulsory acquisition of occupied lands under the Land Acquisition Act, (I of 1894). The recommendations we have made in Part I of our Report will have shown that we are whole-heartedly in favour of the former course. But it is only in undeveloped Provinces such as Burma or Assam, and possibly to a small extent in tracts under new canals in the Punjab and the United Provinces, that waste lands suitable for cane are available. The extent to which such lands are available has yet to be investigated and even in the most favourable circumstances, the development of the cane industry in such tracts must take time. The question which arises, therefore, is whether immediate action should not be taken to secure for factories the possession of sufficient suitable land to make them less dependent on other sources of supply by putting the provisions of the Land Acquisition Act in force on their behalf, either in the great cane growing areas of the United Provinces, the Punjab or Bihar, or in the Peninsula where climatic conditions are specially favourable to the successful cultivation of cane, though a variety of causes has prevented its extension on the same scale as in sub-tropical India.

Compulsory acquisition of cane-land for a factory.

(*a*) *arguments for.*

306. We regret that we have been unable to come to a unanimous conclusion as to the desirability of the compulsory acquisition of land by Government on behalf of factories desirous of growing their own cane. We all realise that this course would provide the surest and speediest solution of the difficulties which hamper the Indian sugar industry, and none of us has any desires to minimise the weight of the arguments which can be adduced in favour of it. The importance of developing the Indian sugar industry in the interests both of this country and of the Empire need no emphasis from us. We do not deny that, if land were acquired for a factory, it would be put to better use than if left to the small cultivator of cane, or that a factory would be in an immeasurably stronger position than the small cultivator to adopt better varieties of cane, suitable rotations and improved methods of cultivation. It would be in a position to carry out drainage schemes or to establish pumping installations which are entirely beyond the capacity of the ryot, and would use its water supplies to the best advantage and so prevent the water-logging which bids fair, if unchecked, to become the curse of the Deccan canals tract. Another argument in favour of land acquisition which has been placed before us is that it is useless for the community to spend time, thought and money on the creation of such organisations as the Sugar Board or Sugar Research Institute which we shall shortly propose, if, owing to conservatism, self interest or poverty, large or small cultivators and mortgage lawyers or money lenders are

to be allowed to interfere to prevent such organisations yielding their full results. Tracts under new canals furnish the additional argument that, when Government provides a supply of water, it is justified in taking steps to secure that that supply is put to the best use, in order that it may yield the highest possible returns to the community which has provided the funds to enable water to be given. This would appear to have been one of the main reasons which led to the acquisition by the Bombay Government of land on the Pravara canal in the Deccan and its subsequent grant on lease to the Belapur Sugar Syndicate for the cultivation of cane. We would here mention that, so far as we are aware, the Government of Bombay is the only provincial Government which has adopted the view that the acquisition of agricultural land for a sugar factory satisfies the provisions of Section 40 of the Land Acquisition Act that the acquisition must be needed for the construction of some work, and that such work must be likely to prove useful to the public.

(b) arguments against.

307. In spite of the weighty arguments in favour of compulsory acquisition of land for sugar factories, the majority of us are opposed to such acquisition, even when subject to the safeguards subsequently mentioned, except in the special cases we deal with in paragraphs 311-313 and to the limited extent we have suggested in our Chapter on Bombay, that is, where it is absolutely essential either to prevent further land going out of cultivation owing to water-logging or to enable land which has already gone out of cultivation to be reclaimed. In coming to this decision we have not overlooked the recommendation of the Indian Industrial Commission that Local Governments should acquire land compulsorily on behalf of an industrial concern, if they are satisfied—

(1) that the industry itself will, on reaching a certain stage of development, be in the interest of the general public,

(2) that there are no reasonable prospects of the industry reaching such a stage of development without the acquisition proposed and

(3) that the proposed acquisition entails as little inconvenience to private rights as is possible, consistently with the meeting of the needs of the industry.

It is the view of the majority of us that the first of these conditions only is satisfied by the sugar industry. We agree that a development of that industry is most desirable in the general public interest ; but we do not agree either that there are no reasonable prospects that it will develop without compulsory acquisition or that acquisition can be carried out without undue interference with private rights. We are, of course, agreed that sugar factories should be placed in the same position as other industrial enterprises in regard to land required for buildings or for means of transport such as tram lines or light railways ; and, as will be seen below, we would go even further than this in advocating a special privilege in respect of land required for demonstration and the propagation of sets, and for the construction of wells and pumping plant. The acquisition of land merely to ensure an adequate supply of raw material stands on quite a different footing. Our colleague Mr. Padshah, whilst in favour of compulsory acquisition, is of opinion that it should be used only in the last resort when all other means of inducing the cultivator to grow cane have

failed. The majority of us are strongly opposed to any attempt to force the cultivator to grow cane, however distant the threat that he will be dispossessed of his land if he refuses to do so. We see no justification for placing cane in a different category from any other crop in this respect. The argument that it is in the real interest of the cultivator that he should be compelled to grow a crop which is so profitable as cane and to cultivate it in the way which secures the highest return and that such compulsion is also desirable in the best interests of the community is, in our opinion, one which can be carried to very dangerous lengths. It would undoubtedly be to the advantage of the cultivators of India and of the Empire as a whole, if more long staple cotton were grown in this country. Again, the question of the supply of more nitrogenous manures is one the solution of which is likely to become of vital importance to Indian agriculture. Every argument which has been adduced in favour of the compulsory cultivation of cane or the compulsory acquisition of land to enable a factory to grow its own supplies may in a few years apply with greater force to the cultivation of oil seeds. In short, the logical conclusion of those arguments is that the agricultural production of India would be immeasurably increased to the benefit of the country and of the world at large, if all land were handed over to be exploited by capitalist enterprise. The truth of this proposition is as undeniable as the impossibility of putting it into practical application. The majority of us remain convinced that no drastic interference with the ordinary laws of supply and demand is called for. We hold the view that, given the increased yields of better varieties of cane which should result, if the recommendations we have made in Part I are adopted, and the increased efficiency in the factory to secure which we shall make proposals below, the payment of a fair price for cane, in combination with such measures as the grant of waste lands, where they are available, and an extension of the system of leasing land, will ensure that sufficient cane will be forthcoming greatly to reduce, if not entirely to obviate, the dependence of India on foreign sources for the bulk of her supplies of sugar.

(c) Mr. Padshah's scheme for compulsory acquisition in the last resort.

308. It will be gathered from what has been said above that Mr. Padshah dissents from our conclusions on this head. In addition to the arguments in favour of land acquisition which have already been set forth he urges that the total area under cane in British India, some 2¾ million acres, is little more than 1 per cent. of the net area cropped and that it is improbable that more than five per cent. of the existing cane area would, if the principle of compulsory land acquisition were accepted, ever come under its operation. He does not propose that land should be acquired until every other expedient has been tried and failed ; and suggests that any concern which invokes the assistance of Government to obtain land should be compelled to adduce evidence that it has first tried all other means of obtaining a satisfactory supply of cane, such as the offer of the highest price consistent with economic working in consideration of a long lease, or a measure of control over cultivation, or the offer of shares in the factory or of participation in its profits. He also recommends that, when land is acquired, it should not be handed over to the concern in full ownership, but should be granted to it on a long lease on certain conditions, one of which would be that the factory should enter into a permanent agreement to give the existing cultivators the contract for the supply of cane on a scale such as we suggest below, and that the cultivators would not be ejected, unless they wilfully failed to fulfil their obligations. He holds that under this proposal the only compulsion would be to make the agriculturist see his own best interests, and that one interest alone cannot be allowed to prevent

the full production of a crop, especially when it is of such importance as cane, since in a poor country the consequences of shortage of production are not limited to a producer negligent of his own real good but constitute a crime against an impoverished community. He further strongly supports the recommendation of the Industrial Commission that it should be a *sine qua non* that, whenever land is acquired compulsorily, arrangements should be made to offer dispossessed cultivators who are not willing to continue as tenants of the factory suitable land in exchange.

(d) Criticisms of Mr. Padshah's scheme.

309. We cannot help thinking that the safeguards with which Mr. Padshah has been at such pains to surround his main proposal will either prove illusory or defeat the very object he has in view. That object is to attract capital to the organisation of a central sugar factory system in India. It is Mr. Padshah's view, to quote his own words, that the capitalist "might be deterred from the sugar adventure merely by the thought of the appalling task awaiting him" (*i.e.,* in the negotiation of large numbers of agreements with cane growers), and that "unless factories be secure of a regular cane supply, factories would be foolish to start business." It follows that, if Mr. Padshah's safeguards of the local cultivator's interests are to operate at all, they must come into operation before the factory has been built. Now the education of the ryot in the benefits of establishing a common interest between himself and a capitalist enterprise with all the consequences involved of new agricultural methods, increased outlay and a complex system of payments for his produce must be a gradual and difficult process even when supplemented by practical demonstration. How much more difficult and tedious a process must it be, then, for a concern whose medium of practical demonstration, the factory, is not yet in existence, and which has nothing to depend on but verbal exposition and persuasion. If the condition that every effort to secure a system of voluntary agreements must have been used before compulsory acquisition can be allowed is conscientiously enforced, we doubt whether capital will regard the scheme as contributing anything material to the solution of the problem of cane supply. If, on the other hand, it is not conscientiously enforced, the possibility of an ultimate resort to compulsory acquisition would tend to result in other expedients being tried in half hearted fashion and there would be grave danger, with compulsory acquisition looming in the distance, of the cultivator being induced to agree to almost any terms proposed by the factory in order to ensure continued possession of his land. Further, experience has shown that the expedient of providing dispossessed cultivators with suitable land is very difficult to apply in practice, partly because suitable land at a reasonable distance from the holdings from which they have been ousted is seldom easy to find, and partly because of their unwillingness to move to such land even when it is available. We understand that it was originally intended to provide the cultivators who were dispossessed at Belapur with other land, but that this was not found practicable. We cannot contemplate with equanimity the establishment of factories in the midst of an aggrieved and sullen peasantry, which we are convinced would be the inevitable outcome, if land were acquired by Government on any large scale in order to promote the development of the sugar industry.

Mr. Craib prefers to express no opinion on the subject of land acquisition on the ground that he has been appointed to the Committee as an expert on sugar production and that his acquaintance with the conditions under which land is held in India is insufficient to justify him in pronouncing upon the desirability or otherwise of compulsory land acquisition.

(e) The legal position.

310. Before we conclude our discussion of the general question of compulsorily acquiring cane lands for sugar factories we should, perhaps, make a brief reference to the present law on the subject, more especially because Mr. Padshah has cited it to impute reactionary ideas to us. We are aware of the ruling in what is known as the Ezra judgment that section 40 of Act I of 1894 constitutes the Government, as the custodians of the Public interest, the sole judges of the two facts mentioned therein, namely whether the land is required for the construction of some work, and whether that work is likely to prove useful to the public. A declaration of a Local Government under section 6 that any particular land is needed for a public purpose is therefore final and cannot be challenged on the ground that the purpose is not in fact a public one. Yet notwithstanding that *legally* a Local Government is empowered to declare any purpose a public purpose within the meaning of the Act, it is surely permissible to consider whether a particular declaration thereunder appears *equitably* to fulfil the provisions of the Act. The exercise of a giant's strength, in short, is not automatically justified by the possession of it. We agree, as we have already said, that it is in the public interest that an extensive sugar industry should be built up in India. But we are not convinced that the compulsory acquisition of agricultural land is "needed" within the meaning of the Act, if that interest is to be served. Still less are we satisfied that the first provision of section 40 which we have already cited is fulfilled, namely that the "acquisition is needed for the construction of some work." Speaking, we admit, purely as laymen, we consider that the raising of a crop of cane for delivery to a factory cannot without undue straining of terms be described as the construction of a work; nor, if in the alternative the factory itself be regarded as the work, can the acquisition of cane land to feed it be reasonably declared necessary for its construction, when it is clearly needed only for its exploitation.

(f) Compulsory acquisition to the extent necessary for set supply and demonstration approved.

311. Whilst the majority of us are strongly opposed to any attempt to compel the cultivator to grow cane for a factory, however disguised the form the compulsion may take, we are of opinion that there is one direction in which a very limited measure of compulsory land acquisition is desirable in order to assist the development of the sugar industry. The aim which underlies all our proposals is to secure the co-ordination of the interests of the cane grower and of the factory; and we are agreed that, short of any pressure on the cultivator, Government should render all the assistance it can in bringing this about. As we have already stated, we hold the view that, if our recommendations are accepted, the sugar industry in India should be able to secure adequate supplies of its raw material. But we realise that the difficulty of initiating and spreading the improvements in the various directions we suggest is very great, and that it will not be completely overcome by the machinery of the Sugar Board or the expansion of the Agricultural Department which we propose, unless the assistance of private enterprise is enlisted. We are, therefore, of opinion that, when factories are willing to help in carrying on an active propaganda in favour of the introduction of better varieties of cane and of improved methods of cultivation, they should be given every encouragement to do so. It will, however, be obvious that they will be able to do very little, unless they have some land under their own control which can serve in the first instance as a source of the supply of sets and in the second for the demonstration of improved methods of cultivation. We would, therefore, recommend that, where

factories are unable to obtain land for this purpose, small areas should be acquired by Government and leased to them on suitable conditions. The area required would vary with the size of the factory, but it should be large enough to enable the factory to distribute annually to the cultivators in the neighbourhood a supply of sets sufficient to plant a large proportion of the cane it requires. We have emphasised in several of our provincial Chapters that a periodic change of varieties is essential, if a high standard of production of cane is to be maintained. Government has neither the staff nor the resources to enable it to carry out the effective substitution of new varieties of cane for old ones over large tracts ; and it becomes, therefore, a matter of vital importance that factories should assist in this work. They can only do so, if they possess sufficient land under their own control to enable them to supplement the work of the Sugar Research Institute and its sub-stations by propagating on a large scale new varieties of cane, as they are evolved, and by distributing them on a commercial basis.

A factory producing 10,000 tons of sugar annually will require, even in the most favourable conditions which may be expected in Northern India, an area of at least 6,000 acres of cane on which to draw for its supplies. To be in a position to provide sets for planting half this area it would need 200 acres. As cane would not be grown on the same land more frequently than one year in three, this means that a total area of 600 acres would be necessary. We do not consider it essential that this should be in a compact block. In fact, the purpose we have in view would be more suitably achieved by several small blocks. There should be no great difficulty in acquiring 600 acres of land in the large area from which a factory on the 10,000 ton scale would draw its supplies, if such land were acquired in small blocks of 100 acres each. This is a suitable unit for irrigation from a tube well, and we are not in favour of larger blocks than this, because suitable distribution of the blocks throughout the factory area will facilitate the issue of sets at sowing time and eliminate the risk of damage and deterioration involved in transit over long distances. It will also enable them better to serve their other purpose, that of demonstrating the advantages of adopting improved methods of cultivation.

312. We do not recommend that the land acquired by Government under this scheme should be handed over to the factories in outright possession. In order to ensure that the scheme is worked to the greatest advantage of the area in which the factory is situated, some measure of control by Government over the uses to which the land is put is desirable, and this can best be secured by the grant of a lease, which should be for a short term of years only in the first instance. We would not make any discrimination between existing factories and those which may be established in future, except that the former should be called upon to show that they do not already possess the means of carrying on the work we have described above, as well as that they are unable to obtain on their own initiative new land for the purpose. The facility of obtaining small blocks of land on lease from Government in the way suggested would be especially valuable in the case of new factories, as it would enable them to test the possibilities of the area in which they proposed to operate and to lay the foundations of a supply of better varieties of cane before the factory commenced working. It would also afford a means of gaining the confidence of the cultivators from the outset. We have no wish to lay down hard and fast rules as to the terms on which leases should be granted. Apart from the fact that these must vary according to local conditions, we do not consider it desirable that the discretion of the Local Governments should be fettered

(g) Terms on which such land should be allotted to factories.

in any way. We would, however, suggest that the following conditions would prove suitable in most cases.

(*i*) The factory should undertake to plant annually at least one quarter of the area leased to it with improved varieties of cane in a manner approved by the Sugar Research Institute.

(*ii*) It should undertake to sell sets of such improved varieties to local cultivators who are willing to take them at a rate not higher than that at which it purchases cane.

(*iii*) In tracts in which canal irrigation does not exist it should undertake to instal masonry or tube wells and pumping plant of sufficient capacity not only to irrigate the area leased to it but also to provide water for an equal area of cultivators' cane, such water to be sold at a rate not higher than a maximum rate approved by Government.

For new factories the further condition would be necesary that the factory should be erected within a specified period. In such a case condition (*ii*) would also need modification, and would merely be that the sets would be sold at a rate not above the prevailing rate for sets.

We have recommended that the lease should be granted for a short term of years only in the first instance. If at the end of that period it was found that the land had been put to the uses for which it was intended, the lease would of course be renewed for another period and would continue to be renewed at suitable intervals, so long as it continued to fulfil its purpose.

313. We consider that there is another direction in which every effort should be made to enlist the assistance of factories, and that is in regard to the improvement of the water supply in the tracts in which they operate, as the capital necessary for the installation of tube wells and pumping plant is seldom to be found in the villages. If a factory is willing to help in this matter, it should, in our opinion, be encouraged to do so, even though it may not be desirous of embarking on the experiment of leasing land for the purpose of propagating better varieties of cane and demonstrating improved methods of cultivation. We therefore recommend that, if any factory is willing to instal wells and pumping plant in the area from which it draws its supplies but is unable to obtain land for the purpose, such areas, each of which would not exceed one or two acres in extent, should be acquired and leased to it. Whenever wells and plants are installed on land leased from Government, the plant should be of a capacity approved by the Agricultural Department, and the factory should undertake to sell water to cultivators at a rate per acre of watering not exceeding a maximum rate approved by Government. As the water supply would be obtained from land which was the property of Government though leased to a factory, and the maximum rate charged for it would also be fixed by Government, the factory should have the same rights in regards the distribution and recovery of charges as are at present possessed by Government in regard to water supplied from a Government irrigation source.

(h) Compulsory acquisition for a factory willing to instal wells and pumping plant also approved.

314. We feel convinced that the scheme we have outlined above would bring factories and cane growers into much closer relations than exist at present to the mutual advantage of both. Whether even it satisfies the provisions of the existing law to which we have drawn attention in pargaraph 310 is a matter for

(i) Justification of the Committee's scheme.

lawyers to decide; but the direct public interest which each branch of the scheme is designed to serve and the need of acquisition therefor are, we think obvious ; and it is not unreasonable to describe the constitution of set and demonstration farms and of tube-well plants as constructions of works in the sense of section 40 of the Land Acquisition Act. Ours is differentiated from Mr. Padshah's scheme not only by the fact that the extent to which the principle of compulsory acquisition may be applied is definitely and narrowly restricted but also in the main object which it is designed to serve. That object is to confer direct and immediate benefit specially on the local cultivators of cane by the provision of centres for the distribution of improved sets and irrigation water and the dissemination of improved agricultural methods. We consider ourselves justified in requiring them to contribute a fraction of their land in pursuance of that object. Under Mr. Padshah's scheme, on the other hand, the small section of the local community on whom such a special contribution is levied would be required to make it without the guarantee of any compensatory benefit other than to share equally with the rest of the community (on whom no levy has been made) in a possible reduction of Indian sugar prices which the construction or extension of the factory may be presumed to promote.

Possibilities of a system of leases.

315. The possibilities of grants of waste land to factories being limited and compulsory acquisition, except to the limited extent recognised in the foregoing paragraphs, having been ruled out of consideration by the majority of us, we have to discuss the practicability of other methods of securing adequate supplies of cane to the factories. An expedient which has so far been singularly neglected in India is that of leasing large blocks of land. It is by leases alone that the factories in Java obtain the control of their supplies, as none of them is owned by natives of the island and no one who is not a native of Java can acquire land in absolute ownership. We are aware that many difficulties would be met in introducing a system of leases in India which are not encountered in Java, where the system is in reality a survival from the days when compulsory cultivation of cane was enforced and has, therefore, a long tradition behind it which has made it a comparatively easy matter for the factories to obtain all the land they require on lease. The communal spirit which exists in the villages in Java to a far greater extent than it does in most parts of India has also been of the greatest assistance to the factories in this respect. But in spite of the superior advantages which are possessed by the Java factories, we recommend a trial of the system in India, and do so with all the greater confidence in that it has already been adopted with signal success in one instance, that of the East India Distilleries and Factories Company at Nellikuppam. We see no reason why it should not be worked with equal success elsewhere. The argument that the smallness of holdings and the number of leases into which a factory would have to enter would prove an insuperable obstacle does not impress us. The factory at Nellikuppam leases land from about 700 holders and is proposing greatly to increase the number. Holdings are no larger and interests in land no less complex in the neighbourhood of Nellikuppam than they are in most other parts of India. Even in Oudh, where there are very few tenants with occupancy rights, we do not consider that it should be impossible to make satisfactory arrangements with both landlords and tenants without derogating from such rights as are possessed by the latter. We strongly recommend that, whenever a factory wishes to embark on the experiment of leasing land and desires Government help in the matter, the services of a Government officer not lower in rank than a Deputy Collector should be placed at its disposal to assist it in making the necessary arrangements. It would, of course, have to be made clear that the employment of such an officer in no way involved any measure of compulsion

and that his services were being utilised as much in the interests of the cultivator as of the factory and with the object of ensuring that the terms offered were fully understood by the cultivators. In order to prevent any suspicion of compulsion we are inclined to think that it would be better if the officer were paid by Government and not by the factory. The expenditure involved would be small in comparison with the advantages to the community which would result from the development on the right lines of such an important industry. Whether the factory should lease the land *quasi*-permanently, *i.e.*, whether it should retain continuous possession for the period of the lease, is a matter of detail ; but we are of opinion that it would probably be advantageous if the land were handed back to the cultivators for the period for which it is not required for cane, *i.e.*, for two years out of three or three out of four according to the rotation adopted. The improved methods of cultivation and the higher manuring which would be given by the factory should have a marked effect in increasing the yields of the crops rotated with cane. This effect should greatly impress not only the cultivator who leased the land but also other cultivators in the neighbourhood and should lead to a speedy extension of the system by ocular demonstration of its advantages.

Allotment of shares and distribution of profits to cane growers.

316. Another method of securing an adequate supply of cane which has yet to be tried in India is that of giving the cultivator a direct interest in the results obtained by the factory either by the grant of shares or by participation in the profits. We are glad to see that the possibilities in this direction are being recognised in the prospectus of a factory which is in process of establishment in the Deccan canal area. We understand that a block of 5,000 shares of Rs. 100 each in the company, the capital of which is Rs. 30 lakhs, was reserved for the growers of cane in the tract on which the factory will draw for its supplies and that these have been taken up. According to the published prospectus, when the company earns profits which enable it to pay more than 10 per cent. dividend, the amount of such profits set aside for dividend shall, after 10 per cent. has been paid, be divided into four equal parts of which one shall be divided amongst the cane-growing shareholders in the proportion of the cane supplied by them to the total tonnage of cane supplied to the company including any cane which may be grown by the company itself. The remaining three parts and the balance, if any, of the fourth part are divided amongst all shareholders including the cane-growers who hold shares. The realisation of the common interest of the factory and the cane grower involved in this arrangement marks, in our opinion, a step in advance. It will, however, be evident that the principle of reserving shares in a factory for the growers who supply it with cane is only applicable to new factories and even then only where cane is grown by comparatively large holders who have capital to invest. It is specially suited to the Deccan canal tracts, where cane is grown in larger blocks than it is elsewhere in Bombay, to parts of Bihar and the United Provinces, where there are large holders who can put fairly extensive areas under cane, and possibly also to Burma, where the cultivator is more versed in the ways of business than he is in India proper. Failing the adoption of the scale for the purchase of cane we suggest below, we should like to see a great extension of the system of participation in profits, and would recommend that a definite proportion of these profits should be set aside for distribution not only to cane growing shareholders but to all cane growers supplying the factory in proportion to the quantity of cane supplied and with reference also to its quality.

317. We have now by successive stages arrived at the crucial problem of the factory industry, which is to discover some way by which, when it is not possible to secure adequate supplies of cane by grants of waste land or by leases, the ryot may be induced to dispose of his cane to the factory. Hitherto matters have worked in a vicious circle. Put briefly, the position is that, the more efficient the factory, the higher the price it can afford to pay for its cane. The majority of Indian factories have in the past been regrettably inefficient and have not, therefore, been able to pay a price for cane high enough to induce the grower to part with it in preference to turning it into gur. Our object has been to devise a scale which shall prove equally satisfactory both to the factory and the grower ; and in deciding on such a scale we have been greatly influenced by the system in force in Cuba and Louisiana where a large proportion of the cane grown is purchased by the factories from planters and independent cultivators. The system of payment in both countries is based on two factors, the prevailing price for sugar and the amount of sugar obtained by the factory from the cane. In Louisiana the basis of the sliding scale on which payment is made to the cultivator is the average price of yellow, clarified sugar on the Louisiana Sugar Exchange for the week of delivery. A rate per ton of cane is agreed on by the factory and the grower which varies from 80 cents to one dollar per ton and is apparently fixed on the basis of the quality of the cane which has been found by experience to be produced by the grower or throughout his district and of the results which the factory has obtained from such cane in previous years. To give a concrete example : if the rate agreed upon were 90 cents per short ton (of 2,000 pounds) of cane, and the price of fine yellow sugar on the Louisiana Sugar Exchange were quoted in a given week at four cents per pound, the grower would receive 90 x 4 cents, or 3.60 dollars, per ton for his cane delivered in that week. Rates of 80, 85, 90 and 95 cents and one dollar per ton of cane are given, but in recent years 90 cents appears to have been the most usual rate. In this case, therefore, the grower receives for every ton (of 2,000 pounds) of cane the current market price of 90 lbs. of fine yellow sugar. In 1913 the average production of sugar in Louisiana factories was 143.26 lbs. of sugar from one ton of cane, the highest recovery being 182.93 lbs. and the lowest 114.46 lbs. It will thus be seen that in Louisiana the price paid for cane is somewhat in excess of half the price of the sugar obtained from it.

Payment for cane on a sliding scale.
(a) The Louisiana and Cuba systems.

In Cuba the method of payment universally adopted is to give the grower either a percentage of the sugar obtained from the cane he supplies or its equivalent in money. From 4½ to 7½ tons of sugar or its monetary equivalent is paid for every 100 tons of cane delivered, the amount varying according to the local conditions. Cultivators who grow cane on land belonging to the factory or who have received advances from it are naturally paid at a lower rate than those who grow cane on their own land and bear all the risks involved in doing so. Payment is made twice monthly, the price adopted for sugar being that at Habana or other port for the preceding fortnight. The average price paid for cane by factories in Cuba may be taken as the monetary equivalent of 6 tons of sugar for every 100 tons of cane. As the extraction obtained by Cuban factories is 12 tons of sugar for every 100 tons of cane, it follows that in Cuba the price paid for cane is one half the price of the sugar obtained from it.

318. We have given considerable thought to this most important question, and see no reason why a system which has worked so well in Cuba and Louisiana should not work equally well in India. A sliding scale of payment has, in our opinion, very much to commend it. It enables the grower and manufacturer to share alike in the increased profits which may

(b) System recommended for adoption by Indian factories.

result from a rise in the price of sugar and it ensures that both parties are equally affected by a fall. It tends directly to promote efficient factory working, as without efficiency the factory will be unable to pay the price which will secure it adequate supplies of cane, and the more efficient the factory the less per unit of finished product will be the cost of its raw material. On the whole, we consider that a sliding scale based on a price per ton of cane equal to one half that of each ton of sugar produced from it is suitable for Indian conditions, though, as we suggest below, if any modification is called for, it should be in the direction of greater liberality. We now proceed to discuss the manner in which it would work in India ; and, to make this part of our argument clearer, we attach a chart (Plate No. 25) showing the price per maund of cane which would be paid on the scale we propose in the following three cases :—

(1) that of an inefficient factory which only recovers 5 tons of sugar from 100 tons of cane,

(2) that of a factory working with moderate efficiency and recovering 7.5 tons of sugar from 100 tons of cane. This is somewhat above the average returned by existing factories in India,

(3) that of a really efficient factory which recovers 9.5 tons of sugar from 100 tons of cane.

As the competition of gur is such an important factor in considering the question of payment for cane, we have also shown in the chart the gross gur value of cane per maund and the corresponding prices of gur. By " gross gur value of cane per maund " we mean the price the cultivator would get for his cane, if he converted it into gur and obtained 9 maunds of gur from every 100 maunds of cane, which is the ratio of gur to cane we have adopted throughout.

319. In discussing the applicability of this sliding scale to India we have first to see how it would work if adopted by existing factories or in existing cane tracts. Nearly all the present factories are located in Upper India, and if the scale is found suitable for adoption by them, it should obviously prove still more suitable for factories which may be established in any part of India in the future, as these would be in a position to profit by the mistakes of their predecessors. It has always to be remembered that in this country two markets exist for the produce of cane, the gur market and the sugar market. In the gur market, which is confined entirely to India, prices are determined mainly by the seasonal variations in the cane crop, but partly by the quality of the gur. Except for the sugar manufactured by *khandsaries*, which has a small artificial market of its own in which prices are determined almost entirely by the strength of caste prejudice or sentimental considerations, the sugar market is a world market in which the prices are ruled by the outturn and cost of production in competing countries. The most important of such countries for India is Java. No examination of the sliding scale we suggest would be of any value if it neglected the consideration that the factory is not the only outlet the cultivator has for the disposal of his cane. He can always work it up into gur, if he is not satisfied with the price which is offered him by the factory. In the discussion which follows we have throughout adopted pre-war conditions as the only satisfactory basis for dealing with questions of costs and prices, since their constant fluctuation during the period of the war and after

(c) How the system would work in practice.

render any comparisons based on figures subsequent to 1913 of extremely doubtful value.

(i) in tracts where high-class eating gur is manufactured.

320. In the great cane-growing tracts of Upper India two qualities of gur are produced. That manufactured in the Meerut Division of Agra, in parts of Oudh and in the North-West Frontier Province is of specially good quality and is used entirely for eating. That manufactured throughout the rest of Upper India is, generally speaking, of inferior quality and in Gorakhpur and Bihar is largely sold to refineries. Factories in Upper India, therefore, will fall into two quite different categories in regard to the purchase of cane according to the class of gur manufactured in the locality from which they draw their supplies. In 1913, the last complete pre-war year, in the main tract in which high class eating gur is the staple product, namely, the Meerut tract, the price of gur was Rs. 5.05 per maund. If we assume, as we have done throughout, that the outturn of gur is 9 per cent. on cane, this is equivalent to a price of 7.27 annas per maund of cane, in other words, the cultivator who converted his cane into gur and sold it to the local merchant was getting 7.27 annas per maund for that cane. The price of factory sugar in this tract for the same year is not directly ascertainable, as it comprises no factories of its own and the officially recorded statistics we have felt bound to discard for reasons which we shall elaborate in Chapter XXII (paragraph 366). The price may, however, be fairly assumed to correspond closely with the actual price at which sugar was sold f.o.r. from the Bihar factories enhanced by the actual railway freight from the factory area to the Meerut tract. This is justified by the fact that the price realised by the Bihar factories is itself regulated by the price of foreign sugar landed at Calcutta, so that the Meerut price calculated in the manner we have adopted corresponds not only with the Bihar price *ex*-factory but with the Calcutta price of imported sugar. The average price realised for their sugar by a group of Bihar factories throughout the year 1913 was Rs. 8.40. The railway freight from Muzaffarpur to Meerut was 10 annas 4 pies per maund, so that the Meerut price may be taken as Rs. 9.05. The question which has to be decided is what rate the factory obtaining this price for sugar could afford to pay for its cane. With an extraction of 7.5 parts of sugar per 100 of cane, which, as we have pointed out, is rather above that of the average Indian factory, it would pay 5.43 annas per maund of cane, if payment were made on our sliding scale. A really efficient factory obtaining 9.5 parts of sugar per 100 of cane would, under the same scale, have been able to pay 6.88 annas per maund for its cane. Factories of both standards, therefore, would have been paying less than the gur value of the cane in that year, the less efficient 1.84 annas less and the more efficient 0.39 of an anna less, and would, in our opinion, stand no chance of obtaining more than an insignificant supply of cane. We were frequently informed that the cultivator is anxious to be rid of the trouble of converting his cane into gur and would be quite willing to dispose of it to a factory, if he could be certain of getting the same price for it. As we have just shown, that assurance cannot in fact be given under all conditions ; but, even if it could, we are somewhat doubtful whether the statement is true of the tract under discussion. The limited experience available seems to indicate that the cultivator will not sell his cane to the factory for the equivalent of the price he obtains for it in the shape of gur. The tract is relatively well provided with bullock power, and the fact that it costs him labour and trouble to make gur of his crop does not appeal to him strongly, as no actual outlay of money appears to him to be involved. It is not easy to estimate the addition which must be made to the gur price to induce him to sell his cane. Our colleague, Mr. Clarke,

who has great experience of the United Provinces, places it at from 2 to 3 annas a maund. In other words, the factory would have to depend for its profits on the price of sugar being maintained at a level which cannot with confidence be anticipated. Our conclusion, therefore, is that no factory depending for its supplies on the purchase of cane in the open market could establish itself with any prospect of success in a tract in which high class gur is manufactured, so long as the pre-war ratio between the price of such gur and of factory sugar is maintained.

(ii) in tracts where gur of inferior quality is manufactured.

321. The position is quite different in those parts of Upper India where much of the gur turned out is of inferior quality and commands a much lower price. In the Gorakhpur division of the United Provinces and in North Bihar, which are the only tracts where the factory industry is established on a scale which merits consideration, the price of gur is low not only on account of its inferior quality, but also on account of the distance from large markets. The production is in excess of local demands and much of it is sold to refineries. The price of refining gur ruling in these tracts in 1913 as given us by a group of factories, (for we must again reject the official returns) was Rs. 2.59 per maund, which is equivalent to a gur value for cane of 3.73 annas per maund. It must be borne in mind that in this tract during two-thirds of the season the gur produced is of this low quality. If we assume as before an extraction of 7.5 per cent of sugar on cane, the price of cane on the sliding scale we propose would have been 5.04 annas per maund, even though the price of sugar was as low as Rs. 8.4 per maund, as we have already said it was in this tract in 1913. Had the efficiency of the factories been such that they were able to obtain 9.5 per cent. of sugar on cane, they would have been able to pay 6.38 annas per maund for cane. We are compelled to the conclusion that the difficulties in regard to supplies of cane of which we heard so much during our tour in Bihar have been almost entirely due to the fact that an inadequate price has been offered for it, and that the factories have looked for their profits rather to maintaining a low price for cane than to increasing their own efficiency and securing the co-operation of the cultivator. We are glad to be able to state that this bids fair to be rectified. Two of the most important factories in Bihar are now purchasing cane on a sliding scale much on the lines we suggest ; but at present the operation of the scale is confined to the cane grown on estates, and the factories do not deal directly with individual cultivators. The introduction of the system has already had a marked effect on the development of the cultivation of cane in the neighbourhood of the factories, and an extension of it is under contemplation by other factories under the same managing agency.

To sum up this part of the discussion : in the great cane-growing tracts of Upper India the scale we suggest, *viz.*, a price for cane which is equal to half the price of the sugar manufactured from it, should, even if prices returned to pre-war levels, prove amply sufficient to secure an adequate supply of cane except in tracts where high class gur is manufactured. In the south the competition of other crops such as paddy is a more important factor than it is in the north ; but, as far as the competition of gur is concerned, there is nothing to prevent the successful establishment of really efficient factories.

(d) Need of a minimum price.

322. We have stated above that we consider the suggested scale a suitable one, even if the price of sugar falls to its pre-war level. The further question arises whether it would still be applicable, if prices fell below that level. In Chapter I we have pointed out that the average cost to the cultivator of growing the

competition of high class eating gur had not to be faced were paying less for the cane required to make a maund of sugar than the factories in Louisiana, Porto Rico and Hawaii ; and that the cost of manufacture of sugar in India was greater than in any other cane sugar producing country in the world. The chart also shows the extent to which in the pre-war period the cost of sugar produced in India exceeded that of Java sugar landed in India. Notwithstanding this difference, factories in India were not only able to exist but also to make a profit, the reason being partly that the price of Java sugar when sold in India was not determined by the cost of production in Java *plus* freight and duty, but by the price of sugar in other sugar producing countries, and partly that railway freights afforded a considerable measure of protection to sugar of local manufacture in up country markets. Since 1913 the doubling of the duty and the great increase in ocean and railway freights have, in spite of the enhanced railway freight on cane, greatly strengthened the position of Indian factories relative to those of Java. The great lesson which is to be drawn from the chart is that, if Indian factories are to hold their own against foreign competition, they can only do so by reducing the cost of manufacture.

Methods by which factories could profitably assist local cane-growers.

327. We are convinced that payment for cane on the sliding scale we have proposed will do more than anything else to remove the difficulties experienced by factories in India in securing an adequate supply of raw material. For a season or two its working might be beyond the understanding of the cultivator ; but the greatly enhanced price for his cane he would receive under it would quickly convince him of its superiority to any other method of payment. There are various ways in which factories can supplement it to great advantage. The relation between the factory and the cane grower is at present almost entirely one of buyer and seller only, and the system of advances adopted by most factories hardly tends to obscure this fact. Our aim throughout has been to secure that community of interest between the factory and the cane-grower which has hitherto been so conspicuously lacking in the Indian sugar industry. It is for this reason that we have recommended that factories should be placed in a position to acquire land on lease for propagating sets, for demonstration of improved methods of cultivation and for installing tube wells and pumping plant. If factories adopt this scheme, they will require agricultural officers to carry it out, and we trust that the Sugar School the establishment of which we propose will provide them. It will be obvious that, if the leased land is to serve its purpose, the work of the agricultural officers cannot be confined to it, and that their advice and assistance should be freely placed at the disposal of all cane-growers who supply the factory with cane. We think that factories would do well to allow their agricultural officers as far as possible to assist all cane growers in the locality, not merely those who already sell their cane to the factory, as every cane-grower would be a potential seller to the factory. In fact we would go so far as to say that, even where factories have no land of their own, they would find the employment of an agricultural officer to advise and assist cane-growers in the tract from which they draw their supplies a profitable investment. Such an officer would be of great assistance in regulating the supply of cane to the factory according to ripeness, a matter which at present is in many cases dealt with in very haphazard fashion.

Another way in which the factory can assist the cultivator is in securing a supply of concentrated manures. Factories are in a very much better position than the cultivator to obtain these at cheap rates, and they would lose nothing by disposing of them at cost price. They could also render assistance of the same character in obtaining improved agricultural implements.

Railways as a means of supplementing cane supplies.

(a) Possibilities of new projects.

328. Although we are whole-heartedly in favour of sugar factories making it their constant aim to concentrate their cane areas as much as possible, we cannot but admit that this is an ideal which cannot always or immediately be realised, and that the speedier means of transport which railways afford may contribute materially to the solution of the factory's problem of supply. Statistics furnished us showed that the incidence per maund per mile of the freight rates on cane in the main factory area of North Bihar, which is served by a metre gauge system, the Bengal and North-Western Railway, was equivalent to less than one-ninth of the corresponding rate of cart hire ; so that, when full allowance has been made for the extra cost of loading and unloading as well as of bringing the cane to the railway line, there is clearly much scope for the economic use of rail transport, provided expeditious despatch is secured. While, therefore, we recognise that cane traffic, which is seasonal and somewhat difficult to handle and the carriage of which is over comparatively short leads, can hardly by itself justify the construction of a public railway line, we would strongly endorse the representations which were made to us by several witnesses that a great impetus would be given to cane cultivation and the factory industry in certain localities, if railway communications were opened up. We have drawn attention in Chapter IV to the possibilities created in North Bihar by the presence of a large number of European planters in a position to undertake intensive cultivation of remunerative crops whose interest in cane as a promising substitute for indigo has already been awakened. A considerable traffic both in cane and other produce is, therefore, to be anticipated, if projects which, we understand, have already been put before the Railway authorities are carried out for a loop line across the southern part of the Darbhanga district from Laheria Serai to Hasanpur Road, and a branch line in the Champaran district from Chakia on the Muzaffarpur-Narkatiaganj railway through Rajpur to Kurnoul. Schemes for the linking up of the same railway, whether from Chakia or Sagauli junction, with the branch line from Chupra to Mashrak are said to be held up by the difficulty and expense of bridging the intervening Gandak river ; but another line which would be free from this objection and which would tap several large estates is a branch from Motihari or Jiudhara, several miles north-west of Chakia, to Chatia Barharwa ; and we trust that its possibilities will be investigated.

Outside Bihar perhaps the most promising area for development from this point of view is the Gorakhpur district of the United Provinces, the cane area of which has in recent years varied between 120,000 and 145,000 acres. Project reports and estimates were received in 1916 by the Bengal and North-Western Railway for a line north from Captainganj through Maharajganj to the Nepal frontier at Thunthibari (41 miles), for a line from Maharajganj to Pharenda on the Gorakhpur-Gonda loop railway and thence north to Nautanwa (25 miles) and for a line connecting Captainganj with Tahsil Deoria on the Gorakhpur-Saran railway (32 miles). All three lines would traverse important cane tracts and we trust that their consideration, which was deferred during the war, will now be undertaken. Even more important than any of these, however, for the increased production of sugar is a line running from the western end of the Gorakhpur-Saran railway down to the Gogra and connecting up with the small branch line from Bhatni Junctio at Barhaj Bazar, its present rail-head and an important centre of the indigenous refining industry. Another important project the survey of which has already been sanctioned is that for a loop line

from Nalbari or Tihu on the Parbatipur-Gauhati branch of the Eastern Bengal Railway to Tangla on the Rangia Tangla extension. The line would traverse a part of the Kamrup district of Assam in which large concessions have been taken up for the cultivation of sugarcane, jute and other crops by three well-known Calcutta firms. All the above lines would be of the metre gauge. Besides these there are two narrow gauge projects the execution of which would be of benefit to the sugar industry. That for a 2½ feet gauge line from Berhampur on the Bengal Nagpur Railway to Russelkonda in the Ganjam district of Madras has been under consideration for some time, and its construction by the District Board is now contemplated. The line would pass close to the Aska sugar factory and would help to open up a district with great agricultural possibilities. The scheme for an extension of the Dhond-Baramati Railway for some eight miles through Malegaon to Pandara in the Poona district of Bombay, a survey of which has just been sanctioned, would serve an area commanded by the Nira canals in which proposals are already on foot for the erection of a sugar factory. Needless to say, therefore, we should be glad to see both projects carried out in the near future.

(b) *Improvements on existing lines.*

329. We need hardly point out that with a commodity like cane, the deterioration of which sets in early and proceeds rapidly, promptitude in delivery is a fundamental necessity. Pick up stations should, therefore, be provided at as many convenient points as possible and every effort should be made to comply punctually with requisitions for trucks. It is equally important that the trucks provided should be properly adapted for the carrying of cane. We understand that, no doubt owing to the exigencies of the war, covered steel wagons have frequently been used to carry cane in recent years. Not only are such wagons inconvenient for the loading and unloading of cane but the high temperatures which are generated in them, particularly as the cane harvesting season advances, directly hasten the fermentation of the juice. Open trucks with low sides are best suited for employment on this traffic.

(c) *Light railways and tramways.*

330. An alternative to the public railways as a means of transport which is largely resorted to in Java, Cuba and other sugar producing countries is the system of light railways or tramways privately owned by the central factory. It is natural that this system should find its greatest scope where sugar is grown on large estates which alike secure the concentration essential to economic working and reduce or eliminate the necessity for acquiring rights of property or of way over the lands of others. In the undeveloped tracts of India where large grants for sugar cultivation and manufacture are still obtainable it is obvious that a net work of light-track railways will equally be required ; but even outside these special areas we think that there already exists, and will as the industry develops exist to an increasing degree, an opening for the use of light railways and tramways to convey cane from the field to the factory. Much will depend on the success which attends the various measures we have proposed with a view to the concentration of the areas of supply ; but the provision of means of transport which will relieve the cane grower of the trouble of carting his crop to the factory will itself tend to promote concentration. Whether it will be practicable to combine with the quasi-permanent main tracks temporary and easily movable feeder lines right up to the cane fields along which the trucks would, as in Java, be man-handled or drawn by bullocks to the main system is a question which only detailed experience of each locality can decide. Outside private estates, however, there is no doubt

that the main tracks for such systems will usually have to be laid along the berms of the public roads, and we trust that the provincial and district authorities will so far recognise their obligations to co-operate in promoting the local production of sugar as to accord a sympathetic hearing to such proposals. We would include also the railway authorities in this appeal. An instance was brought to our notice in Southern India in which the efforts of a sugar factory to develop a light railway system were impeded by the refusal of a public railway to allow a level crossing to be laid across its own line ; and while we realise that the safety of the travelling public must remain the paramount consideration, we cannot but feel that efficient safeguards might have been devised which would have enabled the factory's scheme to be carried through without essential security being jeopardised, more particularly as railways are already familiar with the measures necessary for the control of road traffic in similar circumstances.

Licensing of factories.

331. Another point on which we regret that we have been unable to come to a unanimous conclusion is that of the desirability of licensing factories. In Java no new sugar factory can be erected without a license from Government. This condition, it is important to note, has not, however, been imposed in the interests of the factory, but in order to prevent an undue extension of cane cultivation at the expense of food crops. The arguments in favour of a system of licensing factories in India are of an entirely different order. It has been represented to us that, no matter how great the extent to which the position of factories in regard to supplies of cane is strengthened, capital for the development of the sugar industry will still not be attracted to those parts of the country in which cane is grown on an extensive scale, but in which waste lands are not available, or in which it is not possible to lease land. It is in these parts that an extension of the cane industry is specially desirable ; but new factories will not be established in them, it is argued, as in present conditions there will be no certainty that they may not have to face the competition of more powerful concerns and be squeezed out of existence. Two of our members also, for reasons which they have given in separate notes, advocate a system of licensing factories. The majority of us, whilst admitting that there is much force in their arguments, are not in favour of such a drastic interference with the freedom of the industry as a system of licensing would involve. We are of opinion that an efficient factory paying for cane on the scale we propose and entering into the close relationship with the cultivators which would be possible under the scheme we have recommended for the acquisition of small blocks of land for propagation of sets, demonstration purposes or improvement of water supply would have no reason to fear that another factory would establish itself in the same locality. We would remark in passing that the facilities for obtaining land on lease from Government which we have proposed would naturally not be given to a factory proposing to establish itself in an area in which a factory was already working successfully and paying an adequate price for cane ; but we do not consider it desirable that the fear of competition should be entirely removed. The essential factor in the sliding scale we propose is that, the higher the extraction, the higher the price the cultivator gets for his cane. It is suggested that this advantage could be secured to the cultivator even under a system of licenses by means of a stipulation that the factory's percentage of sugar on cane must not fall below a minimum figure ; but we foresee serious difficulties in giving effect to this suggestion. The percentage of sugar extracted depends on a number of factors besides the efficiency of its manufacture. The fibre content of each variety of cane received, the purity of its juice, the degree of ripeness, the means

and length of transport and the vicissitudes of the season all have their direct influence on the results obtainable, as the statistical records of the Java industry bear ample testimony ; and when a reasonable margin has been provided for all these circumstances the minimum limit of extraction would be worthless as a protection to the cane grower. Increased efficiency in the factory and closer relations with the cultivator are, in our opinion, far better weapons against intruders than a system of licenses. We would again repeat that India with a cane area of 2¾ million acres has only 22 factories working entirely or mainly on cane against 186 in Java with a cane area of about 400,000 acres. Even with the limitations imposed by the existence of the gur market, these figures show that it is stating the position very mildly to say that the number of factories could be greatly increased before any necessity arose for them to encroach upon each other's supplies.

Effect of shortage of cane supplies on length of factory season.

332. We have dealt at considerable length with the obstacles to the efficient working of Indian factories which are presented by the inadequacy of their supplies of cane, and have suggested various ways in which these can be overcome. We have given figures which show how far the supplies of cane fall short of the capacity of the factories. It only remains to add on this head that this shortage is reflected in the length of the working season. In Java a sugar factory works on an average for 126 days. In India the period varies in length from 60 to 115 days, but is seldom more than 100 days. It need hardly be pointed out that, the shorter the working season, the heavier the overhead charges and the greater the difficulty of securing economic working. Even those factories which work for more than 100 days have often to stop owing to irregular supplies, with a consequent increase both in expenses and in sugar losses.

Summary of Conclusions and Recommendations.

(1) The smallness and inefficiency of Indian factories are mainly attributable to their difficulties in obtaining adequate supplies of cane.

(2) No factory works up to its full capacity, and half of them crush only half the cane their mills could deal with.

(3) The problem is to concentrate the area on which the factory draws for its cane and to ensure supplies at the right time.

(4) There is little likelihood of factories solving this problem by purchase of compact blocks from existing landholders.

(5) The grant by Government of Crown waste lands to factories is strongly recommended ; but the opportunities for development on these lines are restricted to the undeveloped Provinces and occasional waste areas coming under the command of new canals.

(6) Compulsory acquisition by Government of cane lands for factories would afford the speediest solution of the problem and weighty arguments can be urged in support of it.

(7) Except in certain special and restricted cases, however, the majority of the Committee are opposed to such compulsory acquisition as being dangerous in principle and unnecessary in practice.

(8) Their objection to Mr. Padshah's scheme for compulsory acquisition in the last resort and subject to certain safeguards is that the safeguards would either nullify the scheme or themselves prove illusory.

(9) It is at least doubtful whether compulsory acquisition for such a purpose is contemplated by the existing law.

(10) In so far as this is necessary, however, in order to enlist the co-operation of factories in effecting improvements in cane cultivation, compulsory acquisition of small blocks is recommended for use as centres of demonstration and improved set supply.

(11) The limit of area might be so much as is required to provide sets for half the cane the factory can crush, or, allowing for rotations, 600 acres in all, preferably in several blocks of not more than 100 acres each, for a factory producing 10,000 tons of sugar a year.

(12) These blocks should be leased to the factory by Government for short terms subject to specific conditions of local public service.

(13) Plots of one or two acres each should also be acquired, when necessary, and leased to a factory which undertakes to instal tube wells and pumping plant of an approved capacity for the supply of irrigation water to cane growers.

(14) Greater efforts should be made by factories to obtain cane lands on lease ; and Government should be prepared to assist factories by lending the services of one of its officers to explain the terms offered.

(15) The Java system of handing the land back to the lessor in intermediate years between two crops of cane is recommended for trial.

(16) Cane supplies might be increased by the grant to cane growers of shares or of a participation in the profits of the factory.

(17) The great need is, however, an adequate scale of payment for cane.

(18) A sliding scale based on a price for cane equal to one half the price of the sugar produced from it is recommended.

(19) In considering how this scale would work in practice it must always be remembered that the cane-cultivator has in gur an alternative outlet for his produce.

(20) In the tracts where the best eating gur is made the price under this scale could not always be counted on to be as high as the corresponding gur value of the cane ; and these are not promising areas for sugar factories so long as the pre-war ratio between the prices of such gur and factory sugar is maintained.

(21) In tracts where most of the gur made is of inferior quality the price paid under the sliding scale should always be well above the gur value of the cane.

(22) The scale should be subject to a minimum price for cane of 6 annas per maund.

(23) An alternative system worth trying is an initial payment on a somewhat more moderate scale combined with a bonus at the end of the season equivalent to not less than the difference between the initial payment and the amount due under the half sugar value scale.

(24) *To enable monthly settlements to be made under the scale proposed, the Director of Statistics should issue monthly a statement of the average wholesale price in the principal markets of white sugar manufactured in India.*

(25) *Factories should also allow their books to be examined to enable an independent assurance to be given that their payments for cane have been duly based on the sliding scale.*

(26) *Payment should be made on a more liberal scale for canes of low fibre content.*

(27) *A comparison of the costs of producing sugar in India with the costs in other countries shows that it is in respect of cost of manufacture rather than cost of cane that Indian factories have to fear foreign competition.*

(28) *A factory should also assist local cane cultivators with the advice of its agricultural officer and, even if it has no cane land of its own, should employ such an officer for this purpose.*

(29) *In view of the difficulties of concentrating the factory's area of supply, railways can contribute materially to solve the supply problem.*

(30) *There are several projects for new lines in North Bihar the execution of which would be of great benefit to the fatory industry there.*

(31) *Other schemes that should be proceeded with are for branch lines or extensions in Gorakhpur (United Provinces), Kamrup (Assam), Ganjam (Madras) and Poona (Bombay).*

(32) *On existing lines the chief need is a prompt service of open trucks with low sides.*

(33) *With the development of the industry there will be a growing need for privately owned light railways to convey cane to the factory; and the authorities controlling existing roads and railways should as far as possible afford the necessary facilities.*

(34) *The licensing of factories by Government is not recommended, as no efficient factory paying full value for cane and entering into close relations with its cultivators need fear competition; while the possibility of competition is a valuable stimulus to efficiency.*

CHAPTER XX.

THE MANUFACTURE OF SUGAR.

The handling of the cane.

333. There is no respect in which Indian sugar factories compare more unfavourably with those in other countries than in their methods of handling cane as it comes in. In all the other great cane producing countries of the world mechanical means of dealing with cane are almost universally adopted. Not only do these save labour but they ensure that constant and even supply of cane to the mills which is essential, if a high figure of extraction is to be maintained. In India, on the other hand, the most prominent features of the factory yard are the number of hands employed and the confusion, especially in the neighbourhood of the cane carrier, which is caused by the movement of full and empty carts. Except in the few factories in which cane is brought on railway trucks into the factory yard and alongside the carrier, to which the cane is invariably removed by hand labour, the usual procedure is for the bullock cart after weighment to discharge its load at the spot which is considered most convenient and then to return to the scale in order that its tare may be ascertained. As carts almost always come in very irregularly, cane has to be stored in order to keep the mills supplied. In consequence it often deteriorates before it can be crushed, and the deterioration affects all the subsequent operations in the factory. We would mention that one factory we inspected has a system of "cutting orders" with the object of eliminating this difficulty. The successful working of this system requires much closer co-operation between the cultivators and the factory than usually obtains. We have made recommendations which will, we trust, bring about a great improvement in this respect, and have suggested that, if factories had an agricultural officer of their own, it should be possible to make arrangements that cane would only be brought in as it can be used. In every factory so far established in India the mills are fed by hand labour, a duty which such labour can never be depended upon to perform satisfactorily. Even the best milling plant will not give good results, if it is only fed intermittently. In Cuba, where the milling capacity of the factories is especially large, the cane trucks, the capacity of which is twenty tons, are fitted with hinged sides. The trucks are run on to a tipping platform alongside a hopper or a specially constructed conveyor, and are then tilted by means of a hydraulic ram until they are emptied. In this way three men can discharge 60 tons of cane in an hour, whilst in an Indian factory 24 men cannot unload more than 15 tons of cane on to the carrier in the same time. In Java, where the cane trucks are smaller than those in Cuba and hold from six to eight tons of cane only, they are run alongside the carrier, the contents are hoisted bodily from them by means of an electric crane and deposited on a sloping platform and from this the canes are fed to the carrier by a rake which is worked mechanically. This method requires more labour than that adopted in Cuba, but is equally efficient in securing a regular supply

of cane to the mill. As the bulk of the cane in India must continue to be brought in to the factories on bullock carts, the contents of which it should be possible for a crane to hoist on to the carrier without difficulty, and as the capacity of the mills is comparatively small, the Java system of dealing with cane is in every way more suited to Indian conditions than that in use in Cuba; and we consider that a marked increase in efficiency would result, if it were adopted in this country.

The milling.

334. As a general rule, the mills in use in Indian factories are of old design. In no factory that we visited did the milling plant consist of more than eleven rollers in all, and one factory had only a crusher and one three-roller mill. The milling plant in most factories consisted of a crusher and two three-roller mills. Frequently each mill is operated by a separate engine, which makes it almost impossible to maintain the uniform peripheral speed which is essential to high extraction. Another disadvantage which arises, if each mill is worked by its own engine, is that steam is used uneconomically and that the costs of working are correspondingly high. The juice pans in the majority of Indian factories are shallow, and several men or boys are, therefore, employed to keep the juice flowing and are compelled to work in difficult and awkward positions in order to do so. Hand labour is invariably employed to prevent the strainers through which the juice passes on leaving the pans from clogging by removing dirt and fine megasse from them. This operation is thus far less cleanly than it would be, if mechanical strainers were used.

Though the principle that multiple crushing is necessary to secure a high extraction of the juice in cane is beyond dispute, opinions differ greatly as to the number of mills necessary and the way in which they should be arranged to give the best results. It is, however, now generally recognised that the thorough breaking up of the cane before it reaches the first mill is of great importance; as it not only ensures the most effective use of maceration from the outset but also allows the number of mills to be reduced, thereby effecting a great saving in capital cost and the use of power. In Hawaii the cane is broken up by means of a shredder, whilst in Cuba double crushers are used for the purpose. We consider that in India, where the bulk of the cane produced has a percentage of fibre which is as high as 16 to 18, the most efficient plant would probably consist of two crushers in front of a train of three three-roller mills, or 13 rollers in all. Under this arrangement there would be two macerations, the juice from the third mill being used for maceration after the first mill and water being used after the second mill. Another arrangement which would probably be found equally satisfactory would be a crusher in front of a train of four three-roller mills, or 14 rollers in all. Under this arrangement there would be three macerations, water being applied after the third mill, the juice from the fourth mill being used after the second mill and the juice from the third mill after the first mill. Whichever method is adopted, the juice pans should have sloping sides so as to make them self-cleansing, and mechanical juice strainers should be used both to save labour and to ensure cleanliness.

Fuel consumption.

335. Before passing on to consider the question of improvements in the sugar house, we should mention the great variations in the amount of fuel used. In a well organised factory the megasse should be sufficient to raise the steam required to carry out all the factory operations, but only one of the factories in India from which we received returns has found this possible. All other factories had to supplement the supply of megasse by the purchase of fuel. One factory purchased a weight of fuel amounting only to 0.67 per cent. of the cane crushed, whilst another only used 2.3 per cent. and a third 3.3 per cent. Excluding three factories whose high fuel consumption was due to abnormal causes and a fourth which employed the diffusion process and is, therefore, not comparable, the rest used from 4 to 6.2 per cent. The average for all factories except the four already excluded was 4.31 per cent. on cane crushed and 63 per cent. on sugar produced. Of the total weight of fuel consumed 48 per cent. was wood and 52 per cent. coal. The cost of the fuel required constituted, therefore, a serious item in the total manufacturing charges and a great handicap to Indian factories as compared with factories in other parts of the world which are able to work on their supply of megasse alone. The most important factor in this question is undoubtedly a regular supply of cane. Where this is secured, and the megasse is still unable to furnish all the fuel required, a careful examination of the causes of the shortage should be carried out at once.

The sugar house.

336. As a rule, the factories in India are well equipped with machinery for making sugar, but the arrangement is frequently faulty. In many plants the machinery is not well balanced. One part of it has a greater capacity than another, which results in low efficiency and diminished output. The processes of juice clarification are the same as are in use in other countries. These are :— ordinary defecation solely by the use of lime, sulphitation, when both sulphur and lime are employed, and carbonatation. The cost of production by these three processes increases in the order in which they have been stated and the quality of sugar produced improves in the same order. In other words, the carbonatation process is the most expensive both to instal and to work, but gives the best quality of sugar. The yield of sugar, given equally efficient scientific control, is approximately the same by all three processes. It is a matter of individual choice which of them should be adopted and a decision in the matter would be influenced by several considerations into which it is unnecessary to enter; but whenever the object is the manufacture of white sugar, we consider on the whole that the sulphitation process is the more suitable for India on the grounds of economy in installing and working and the small difference in the quality of sugar produced as compared with the more expensive carbonatation process. The defects of the sugar houses in India do not lie so much in the machinery as in the control which is exercised over it. As we have already remarked, the lack of this control was obviously revealed by the returns sent us, the incompleteness of which made it difficult for us to come to definite conclusions as to the results which Indian factories were obtaining in comparison with those of other countries. We have assumed that cane in India contains on an average 12 per cent. of sugar. If it were dealt with in a thoroughly efficient factory, it would be possible to obtain 9.5 per cent. of marketable sugar from it. From cane with the same sugar content factories in Java recover 9.75 per cent. of marketable sugar against an average of 6.85 per cent. in Indian factories, the best of which obtain less than 8 per cent. There is thus a difference of almost 3 per cent. between the results obtained by factories in India and in Java. We should have liked to make a detailed investigation into the causes of this great difference in the interests of individual factories; but this has been impossible, partly because the time at our disposal has not permitted, but mainly because none of the factories keep complete chemical or analytical records. We should perhaps mention that the members of our Committee who have technical experience were able in several cases to make suggestions for improvement in the course of their inspection of factories, some of which have already been acted upon. In the sugar house the

main losses of sucrose occur in the filter mud and in the molasses, though there are also large losses from pilfering. The boiling capacity of the pans and the cooling space in the crystallisers are sometimes insufficient, and the yields of sugar are consequently further reduced. If workers are careless and supervision is not strict, there are also some losses from fermentation and some from entrainment, that is, from the boiling over of the pans into the water used for condensation. As regards losses in the filter mud, we observed that in many cases this was thrown away, although it contained a percentage of sugar which justified further treatment. As regards losses in molasses, it need hardly be pointed out that the sugar in molasses is not really lost ; but that, if the percentage of molasses to sugar is high, this means that a larger proportion of an inferior product is being turned out than is necessary. An efficient factory should produce not more than 2.5 to 3 per cent. of molasses from cane as compared with 9.5 per cent. of sugar. Most Indian factories turn out a much higher percentage of molasses than this. According to the returns we have received, only one produced less than 3 parts of molasses per 100 parts of cane ; five produced between 3 and 4 parts, six between 4 and 5 parts and six more than 5 parts. We saw evidence of excessive acidity and fermentation in some of the factories we visited, resulting in undue inversion.

The first essential more efficient chemical control.

337. Whilst a very great improvement in the efficiency of factories in India can undoubtedly be secured by the introduction of mechanical appliances for dealing with cane and juice, by the replacement of old mills by modern crushing plant and by improvements in the balance and arrangement of machinery, the principal need of almost all existing factories is for better supervision and above all for more chemical control. In Java, Cuba, Hawaii and other important sugar producing countries the management of a factory can immediately discover the cause of bad work by an examination of the daily record; but this is not possible in India where, as long as most factories have either no chemist at all or chemists with insufficient training and experience, they will continue to work largely in the dark. Though it is desirable that the manager of a factory should have some knowledge of chemistry and engineering, this is not absolutely essential, provided he has administrative ability. What is essential is that every factory should, in addition to the manager and a fully qualified engineer, have a highly trained chemist with practical as well as analytical experience who should see that proper records and analyses are kept of the cane which enters the factory, the megasse, the juices, the massecuites, the filter mud, the various molasses, etc. The analyses must be complete, as, if only partial analyses are kept, losses cannot be traced. A proper balance of sucrose and glucose should also be kept. These items and their weight should be ascertained both for the cane entering the factory and also for the sugar and molasses going out of it, as well as for the megasse and filter mud. The difference, if any, between the sucrose and glucose in the cane, and that in the sugar, molasses, megasse and filter mud will represent losses 'unaccounted for.' If chemical control is efficient, these should be small. If they are large, immediate investigation to discover the cause is called for. A serious increase in glucose will point to the fact that undue inversion and fermentation are taking place. We find that the glucose in the molasses from some factories is only ten times that in the juice ; whereas in others working by the same process it is 22 or 23 times. These big variations reveal an unsatis-
state of affairs which would be avoided, if proper chemical control were
d.

give in Appendix V in tabular form the records which we consider it
e for a factory to maintain. They are based on returns which are

actually made by factories in Cuba, and they represent, in our opinion, the essentials for intelligent factory supervision.

The second essential greater economy in labour.

338. Although as a result of the absence of mechanical appliances for dealing with cane and juice the disparity between the number of hands employed in Indian factories and in other parts of the world is especially marked in the milling department, it is also very noticeable in other branches of the factory operations. The returns we have examined on this point show that only one factory employs on an average less than one hand for each 100 tons of cane dealt with during the season. The majority employ from one to three hands to each 100 tons of cane, though in a few cases the proportion is much higher than this. The modern factory in St. Kitts in the West Indies employs less than one hand to every 200 tons of cane worked up during the season. It employs only a little more than 400 hands to deal with 1,000 tons of cane a day ; whilst some Indian factories employ as many hands or more to crush no more than from one-fourth to one-half of that amount. Even allowing for the comparative inefficiency and also the cheapness of Indian labour, it will, therefore, be seen that there is considerable scope for reduction of labour costs in India by the introduction of labour saving appliances and also by more systematic control.

Java results which should be emulated.

339. We would add that in 1915, 1916 and 1919 the canes worked on by the factories in Java had a sugar content which approximated very closely to that of Indian canes. For the three years mentioned it was 11.63, 12.32 and 12.38 respectively, an average of 12.11 per cent. against the average of 12 per cent. we have assumed for India. The purity of the raw juice in the same years averaged only 83.4 per cent. and of the clarified juice 85 per cent. The yield of sugar on cane was nevertheless 9.85 per cent. and of molasses 3.08 per cent. It should be the aim of Indian factories to get as near these results as possible from cane with similar sugar content and purity; and it is with the object of enabling them to secure the adequate chemical and engineering control which more than anything else will help them to do so, that we make the recommendations in regard to sugar schools which will be found in Chapter XXV below.

The Indian gur refineries.

340. We have so far dealt only with factories which work entirely or mainly on cane. It will, of course, be understood that our recommendations in regard to factory control and the maintenance of chemical and analytical records apply with equal force to refineries, especially to those which manufacture sugar from gur. We have already mentioned that there are only ten refineries in India working on gur alone which can be regarded as " factories " as we have understood the term. Most of them are very small and the largest is only able to handle about 30 tons of gur a day. Their raw material is as a rule gur which cannot be sold for consumption as such; and it is not, therefore, surprising that the sugar they manufacture is of low quality. It is usually of a pale yellow colour with a polarisation of 97 to 98¼. The hands employed are few in number compared with a cane factory, and vary between 125 and 250. The results obtained by the refineries in North India are specially poor. The average recovery of the seven largest of them is only 42¼ parts of pale yellow sugar and 41½ parts of molasses from 100 parts of gur. The losses, which consist of water and impurities removed from the gur, are thus 16½ per cent. The refineries in Southern India, which mainly handle gur made from Palmyra juice, do considerably better than this. Their recoveries average about 52½ per cent. of sugar and 36 per cent. of molasses, and their losses are thus 11½ per cent. It will be obvious from these figures that the very high percentage of molasses obtained

and the heavy losses incurred place refineries in a very disadvantageous position as compared with factories working directly on cane. Some improvement in that position would undoubtedly result, if they could obtain a better raw material, such as muscovado sugar or even a higher quality of gur. But, as we have already indicated, the results obtained by a refinery must always, owing to the character of its raw material, compare so unfavourably with those obtained by an efficient factory which can command adequate supplies of cane, that no proposals for the development of the gur refining industry would be justified.

Prospects of developing a factory industry particularly in Upper India.

~~341.~~ We realise that many of our conclusions are to some extent speculative and controversial. This was inevitable in view of the nature of the problem which confronted us. Had that problem been merely that of increasing the quantity and improving the quality of the supply of material to an already flourishing industry, it would have been a comparatively simple one in the solution of which we should have had the benefit of a large body of expert evidence. But we have been entrusted with the task of examining the possibilities of establishing the industry itself; for India cannot be said to possess an organised sugar industry. In such an enquiry there is obvious room for divergence of opinion. We have endeavoured to devise a scale of payment for cane which will prove fair both to the cultivator and the factory. We are convinced that, unless some such scale as we have proposed is adopted, it is unlikely that adequate supplies of cane will be forthcoming. We admit, however, that experience alone can decide whether in the conditions of Upper India where, as we have pointed out in Chapter I, the high average yields of Hawaii and Java cannot become the general rule, such supplies will be forthcoming from areas sufficiently concentrated to make a factory crushing 1,000 tons of cane daily a commercial proposition. Our expert members consider this the lowest economic limit in present day conditions when the capital required to start a new factory is several times that required before the war. Experience alone can decide also whether, if there is a heavy fall in the price of sugar, the scale we propose might not prove too heavy a burden on the factory in Upper India. In Part I of our Report we have shown that, even in the tropical parts of India in which climatic conditions are specially favourable for cane growing, there is little hope of a factory industry on an appreciable scale outside the Deccan canals tract, Assam and Burma. Expansion in the Deccan canals tract depends on the rate at which additional irrigation facilities are provided, whilst in Assam and Burma it depends on the solution of the labour problem and the rate at which the general development of those Provinces proceeds. In any case, it does not appear probable that the addition to the sugar supplies of India from these three sources in the near future will be appreciable in comparison with the imports. If, therefore, the problem before us, which is that of rendering India self-supporting in the matter of sugar supplies, is to be solved, it is obvious that that part of the country in which two-thirds of the cane is grown on three-fourths of the total cane area and most of the sugar at present manufactured is produced must contribute to its solution. We cannot too often repeat that the crux of the factory problem is to secure an adequate supply of cane in concentrated areas. There are two ways in which this can be done. The first is by a greater outturn of cane from the present acreage, and the second is by a greater area of cane in the immediate neighbourhood of the factory. We have made recommendations in Part I of our Report the object of which is to secure the former; but we realise that the dissemination of the agricultural improvements we have suggested must be a slow process. In regard to the latter we have been unable to recommend such measures as compulsory land acquisition, immediate or ultimate, but

have proposed various expedients for bringing about such relations between the factories and the cultivators as should, in our opinion, secure the former the supplies of cane they require. Should these expedients prove successful, as we trust they will, we consider that the prospects of the establishment of a flourishing factory industry in Upper India are distinctly hopeful. The best evidence in support of our views is to be found in the existence of factories in Upper India which were making profits notwithstanding the low efficiency on which we have commented and the low price of sugar which prevailed before the war. Factories in India, more especially in Upper India, may have to be content with a smaller margin of profit than in Java or Cuba ; but we see no reason why that margin should not be more than ample to attract capital to the industry, even allowing for the handicap under which new factories will start, owing to the greatly increased capital required per ton of sugar produced. It is, however, desirable, if not essential, that capital should be shown the way. If this is not done, it is very probable that it will not be prepared to make the undoubted effort that will be required in applying our recommendations to the great cane growing tracts of India, the fringe of which only, namely the extreme east of the United Provinces and the adjacent part of North Bihar, has so far been exploited, and will follow the line of least resistance in seeking openings in Burma and Assam.

A Government pioneer factory recommended for Upper India.

342. For these reasons we recommend that a factory should be established by Government in a part of Upper India in which cane is extensively grown, but which is at present untouched by the factory industry. The exact location of such a factory is a matter which would require careful investigation; but we would suggest that a suitable site for it might be found in the Karnal or Rohtak district of the Punjab. Although the methods adopted by the factory both in relation to the cultivation of cane and the manufacture of sugar would serve as a model to all factories in India and Burma, its more immediate object would be to demonstrate the possibilities of the factory industry in the cane growing tracts of Upper India. It would, therefore, obviously be advantageous, if the factory were established almost on the boundary line between the two greatest cane growing Provinces of India, as it would be, if it were in either the Karnal or the Rohtak district. The two districts together have an area of about 80,000 acres under cane, most of which is under the Western Jumna Canal; and though, as we have stated in Chapter V, we consider that the cane area directly under that canal has, in all probability, reached its limit, there are possibilities of extension under tube wells, especially if the project for the provision of electric power from the falls in the Sutlej river eventuates. Additional reasons for suggesting this tract as a suitable one for a Government factory are that there is as yet no factory worthy of the name in the Punjab and that, as would appear from the Reports of the Punjab Agricultural Department, the possibilities of establishing a Government central factory in the Rohtak District have been under consideration for some time past. Samalkha and Sonepat in this tract have been mentioned as possible sites for such a factory, in view of the facts that there are some 30,000 acres under cane in the Sonepat and Panipat tahsils and that the soil is good and canal water and means of transport are available.

(a) Estimate of cost and return on capital outlay.

343. We submit an estimate of the cost of a factory crushing 1,000 tons of cane daily over a season of 100 days. This, for reasons we have already given, we consider should be the minimum size of the factory. We also submit an estimate of the probable return with sugar at Rs. 20 and Rs. 12 per maund; whereas the price at the time of writing (the end of October, 1920) is Rs. 31 per maund for 'ready' sugar in Calcutta.

Capital cost.	Rs.
Cost of factory *f.o.b.*	35,00,000
40 per cent. additional for freight, erection, etc.	14,00,000
Cost of tramways, offices, houses for staff, etc.	7,00,000
Total	56,00,000
Add working capital	3,00,000
Grand total	59,00,000

Balance sheet with sugar at Rs. 20 per maund.

Expenditure.	Rs.	Receipts.	Rs.
100,000 tons (or 2,720,000 maunds) of cane at half the value of the sugar produced from it with 8·5 per cent. extraction.	23,12,000	8,500 tons (or 231,200 maunds) of sugar at Rs. 20 per maund.	46,24,000
Manufacturing charges on 231,200 maunds of sugar at Rs. 3 per maund.	6,93,600	3,000 tons at 3 per cent. on cane (or 81,600 maunds) of molasses at Rs. 3 per maund.	2,44,800
Depreciation at 5 per cent. on a capital cost of Rs. 56 lakhs.	2,80,000		
Total ...	32,85,600	Total ...	48,68,800

Leaving a net profit of Rs. 15,83,200 or 26.83 per cent. on a total capital cost of Rs. 59 lakhs.

Balance sheet with sugar at Rs. 12 per maund.

Expenditure.	Rs.	Receipts.	Rs.
100,000 tons of cane at half the value of the sugar produced from it.	13,87,200	8,500 tons of sugar at Rs. 12 per maund.	27,74,400
Manufacturing charges ...	6,93,600	3,000 tons of molasses at Rs. 1·12 per maund.	1,42,800
Depreciation at 5 per cent. on a capital cost of Rs. 56 lakhs.	2,80,000		
Total ...	23,60,800	Total ...	29,17,200

Leaving a net profit of Rs. 5,56,400, or 9.43 per cent. on a total capital cost of Rs. 59 lakhs.

It need hardly be said that this balance sheet, though based on the best information we have available, can only be regarded as a tentative one. In the most favourable circumstances about two years must elapse before the factory can be erected. Conditions are changing so rapidly that an estimate framed in the light of those which exist today may then require material modification. Our estimate of the capital cost of the factory is based on a quotation for £350,000 drawn up in September and received in October, 1920 within a few days of the completion of our Report. The price quoted in January last for a factory of the same size was £220,000 only. Had the price of the factory remained at this figure, the returns on the capital cost would have been 38.68 and 14.8 per cent. respectively, the allowance for freight, etc., being placed at 50 per cent. of the cost of the factory plant instead of 40. The very great increase in the *f.o.b.* cost of the factory, amounting to nearly 60 per cent., may be the result of the uncertainly consequent on the prevalent industrial unrest. We need hardly

point out that, if the prices of machinery remain at their present level, they must impose a serious handicap on the development of the sugar industry in India. We cannot but regard them as abnormal, and are, therefore, of opinion that the prospects of such a development are more hopeful than our balance sheet would indicate. We have thought it our duty to frame as cautious an estimate as possible ; and it is for this reason that we have based our balance sheet on prices of sugar of Rs. 20 and 12 per maund, below which we hardly think they are likely to fall in the near and more distant future respectively. It will be observed that we have based the capital cost on the official rate of exchange, one rupee equal to two shillings, which does not apply at the present moment and may not apply when the factory is erected. It is the opinion of Mr. Craib that the provision for cost of tramways, etc., has been placed at too low a figure, owing to the fact that the factory will, at the outset, have to draw its supplies from a larger area than should subsequently be necessary, if it proves able to concentrate on the lines we have recommended. We have estimated the extraction at 8.5 per cent., that is, 8½ tons of sugar for every 100 tons of cane, though we have throughout indicated our belief that a factory working with the most modern methods should be able to improve considerably on this, and that 9.5 per cent. at least should be a perfectly practicable standard even with the thin canes at present grown in Upper India. Again we have taken the manufacturing charges at Rs. 3 per maund of sugar produced, a figure which differs little from that for some of the present factories in India which are on a much smaller scale and work with lower efficiency than the factory we propose would do. Provided the factory can secure full supplies of cane, we consider that these charges should work out at an appreciably smaller figure.

344. We should prefer that the cost of the factory should be met by Government, the profits derived from its working being devoted towards the cost of the Sugar Research Institute and the Sugar School, the establishment of which we propose in Chapters XXIII and XXV. We are, however, strongly of opinion that, if the factory is to serve the purpose for which it is intended and is to be a true pioneer factory, it must be run on ordinary commercial lines. This must involve a very considerable departure from the usual procedure followed even in regard to those branches of Government activity which are classified as quasi-commercial. We would, therefore, suggest that the managing body of the factory should consist of five directors, of whom one should be Managing Director. The Director of the Sugar Research Institute should be an *ex-officio* Director of the factory and the Government should nominate one other official as Director. The remaining Directors should be non-officials nominated by the Sugar Board. It would obviously be advantageous if all four Directors, other than the Managing Director, were members of the Sugar Board, but we do not regard this as absolutely essential. The non-official Directors should receive the usual fees, and we consider that these might also be given to the official Directors, in view of the extra work and responsibility which would devolve on them as the result of their presence on the Board. It is in regard to the remuneration of the Managing Director and the staff of the factory that we recommend the most material departure from existing practice. In order to secure that these have the expert qualifications which will be required and that they have a real interest in the success of the factory, we are of opinion that they should be recruited on special agreements, and that, in addition to receiving adequate salaries, they should be allowed to participate in the profits of the factory by the grant of a bonus on the system which prevails in Java. Freedom of action by the Board of Directors is essential; and in order to secure this it would be necessary for the Government of India to sanction a lump sum grant to cover the estimated expenditure

(b) Systme of management.

of each year in regard to the administration of which the Board would be allowed complete discretion. We would add that, with a view to preserve the purely commercial character of the factory, its accounts should be audited by a firm of chartered accountants.

(c) *Method of raising the capital for the factory.*

345. We realise that, in consequence of the many heavy claims on them in other directions, Government may be unwilling to provide the funds required for the factory in the ordinary way. In that event, we would suggest that the capital required might be raised by a loan issued specifically for this purpose in the form of debentures, on which Government would guarantee 7 per cent. interest free of income-tax, and the holders of which would also share equally with Government in any profits above 7 per cent. up to 13 per cent. The debenture holders would thus receive a definite guarantee of 7 per cent. interest on their holdings, and would also have the possibility of obtaining an additional 3 per cent. A block of debentures should be reserved for the cultivators of cane in the area on which the factory would draw for its supplies. If this scheme were adopted, the Board of Directors might consist, in addition to the Managing Director, of the Director of the Sugar Research Institute, one Director nominated by the Sugar Board, and two directors nominated by the debenture holders. Under this scheme the factory would virtually be worked by a Joint Stock Company. Whichever alternative is adopted, we consider that it should be provided in the Articles of Association or otherwise that the factory should carry out any general experiments which may be regarded by the Sugar Board as of obvious benefit to the sugar industry as a whole. The presence of the Director of the Sugar Research Institute, and probably also of other members of the Sugar Board, on its Directorate would ensure harmony between its policy and that of the Sugar Board and the Research Institute.

We would emphasise that the factory should be given no privileges which Government are not prepared to give to a private factory; for the fact that it is a Government factory should not place it in a special position. There would thus be no question of compulsory land acquisition beyond that of the land required for buildings and means of transport, as well as for seed and demonstration farms and tube wells to the extent advocated in paragraphs 311-313 of the preceding Chapter. The land in the latter cases would be leased to the factory on the same terms as would apply to an ordinary factory. The factory would pay for its cane by one or other of the alternative methods we have recommended, and would endeavour to obtain control of part or the whole of its own cultivation by a system of leases. For that purpose it would be accorded no more favourable treatment than a private factory, merely being given the services of a Government officer to assist it in making the necessary arrangements.

Government financing of private factories not recommended.

346. We would add that we have carefully considered the possibility of establishing such a factory as we have proposed by private enterprise assisted by a Government loan or subsidy, but have rejected it, as we are convinced that, if the factory is to serve the purpose for which it is intended, such an alternative would involve a measure of dual control which would greatly impede, if not entirely prevent, its successful working.

We have also considered the question whether Government should not actively assist the establishment of large factories by the grant of a loan, such as has been given in two cases in the United Provinces, or by a guarantee of

dividends. Whilst we have no desire to fetter the discretion of Local Governments in this matter, we feel bound to say that we see no necessity for such a course. Recent experience has shown that capital in India is readily forthcoming for financing sound industrial undertakings. There is here no question of introducing an entirely new industry, or of supplying an existing deficiency in the interests of national safety. In these circumstances we are emphatically of opinion that Government funds can be far more usefully devoted to the assistance of the sugar industry as a whole than to that of private enterprises, discrimination between which would be exceedingly difficult. It is for this reason that we recommend the establishment of a Sugar Board, a Sugar Research Institute, a Sugar School and a Government factory. The Sugar Board will watch over the interests of the industry as a whole, the Sugar Research Institute will furnish it with expert advice and assistance in all its branches, whether in field or factory, whilst the Sugar School will supply the qualified men of which it stands so greatly in need. The Government factory, in addition to demonstrating the possibilities of the great cane growing tracts of Upper India, will serve as a model to all factories in India, as a vehicle for carrying out experimental work of value and, in conjunction with the Sugar School, as a training ground for the men who look to the industry for a career.

Distilling as a subsidiary industry to sugar manufacture.

347. Though it is not strictly germane to the question of sugar manufacture, we cannot close this Chapter without a brief reference to the subsidiary industry which is attached to several of the Indian sugar factories, namely, that of distilling. Our direct interest in these distilleries is confined to the outlet they provide for the profitable disposal of the molasses obtained in the factory ; and though we have been asked among our terms of reference to examine the present conditions governing the manufacture of rum under license from Government and the question of distributing such Government contracts, general questions of excise policy and administration, regarding which numerous representations were made to us, fall outside our purview as a Committee, nor could we pronounce with any authority on them if we would. The continuous still is the system generally in use and this should, if maintained in good order and efficiently supervised, recover most of the alcohol contained in the wash. As, however, we were not supplied with data of the degrees of attenuation resulting from fermentation,we cannot express an opinion regarding the actual efficiency attained. With one or two commendable exceptions, however, the distilleries we visited were housed in low-roofed, unventilated buildings under conditions which must militate against rapid and complete fermentation. We have already indicated that Indian sugar factories should in future reduce the proportion of molasses they turn out to the cane they crush; but there is no doubt that, if our hopes of development are realised, the actual quantity of molasses produced in India will largely increase; and there have before now been times when the economical disposal of its by-products has made all the difference between profit and loss to the sugar industry. But it will be some years at least before India can meet her own requirements of molasses even at the present rate of demand. In the five pre-war years 1909-14 the country's annual net imports of molasses averaged 93,354 tons valued at Rs. 41.53 lakhs and there was a steady upward tendency throughout the period. In the five succeeding years 1914-19 the net imports fluctuated between such divergent limits as 125,000 and 19,000 tons, the latter mainly owing to shipping difficulties but also in some degree to rising prices. The average for the quinquennium was 80,794 tons valued at Rs. 41.40 lakhs. In 1919-20 the net imports were 71,980 tons valued at no less than Rs. 89.39 lakhs. The total production of molasses in India in that year cannot

be exactly determined, as the returns furnished us by the Indian refineries are not quite complete. They are, however, complete enough to enable us to fix the figure for both factories and refineries (including Cossipore) at approximately 30,000 tons. Thus, even ignoring the considerable imports of foreign and country spirits from other countries, particularly Java rum, which might well have been distilled locally, the normal present demand in India for molasses is about four times the amount actually produced; and we consider it reasonably certain that with a return to normal prices that demand will steadily expand. Molasses is required not only for distilleries but for the curing of tobacco and as a cattle food; and it is for this last purpose that we expect the demand most materially to develop. The time is remote, therefore, when the sugar manufacturer in India need anticipate any difficulty in disposing of his molasses or can legitimately regard the excise policy of Government as prejudicial to the prosperity of the industry.

The Government policy regarding distillery contracts.

(a) Term and notice.

348. To turn now to the particular aspect of the question which has been referred to us, the object of the contract supply system is to avoid the dangers of unregulated competition among the distillers for the custom of retailers by substituting a regulated competition in the form of tenders for the privilege of supply at a fixed price per gallon within specified areas for stated periods. Perhaps the most frequent complaints we received were directed against the term of these contracts, which have hitherto been in most Provinces for three or five years, and the unduly long period fixed between the date for the submission of tenders and the date from which the contract begins to run, which in one Province was as much as 15 months. There is no doubt that the former of these complaints has arisen mainly out of the abnormal fluctuations in the prices distillers have had to pay during the last few years for their basic material. In fact opinion amongst the distillers themselves was by no means unanimously in favour of shortening the contract period; while in several Provinces the grievance has already been met by the offer of new contracts for shorter terms or for the old term at the option of the tenderer. We venture to doubt whether the critics of the longer contract term are likely to maintain this attitude when the period of abnormal fluctuation has passed, more particularly as we observe that the reason for which the Excise Committee of 1905-06 advocated three or five year contracts was in order to make them long enough to eliminate the usual trading risks. The same authority can be cited for the practice of calling for tenders some time in advance, the object being to give Government ample time to make arrangements in case any combination between possible tenderers should arise. When due allowance has been made for this, we think that it should be possible to safeguard the interests of Government without issuing such long notice as may seriously embarrass the distillers; and since six months' notice is all that is required in some Provinces, we do not see why it should not be found adequate in all.

(b) The contract rate.

349. When all has been said, however, there is considerable force in the representation which was made to us that under the contract system the distiller is not a free agent and that the Government which interferes for reasons of public policy with his operations should do all that is possible to eliminate the speculative element in them. Nor have we here only the interests of the distiller in view. The great rise in the cost of molasses and mahua has compelled tenderers for new contracts to pitch their tenders at rates which, if there is any approach to normal conditions again in the near future, will leave them very large profits. The desideratum, if attainable, is certainly a moderate but steady

margin of profit; and it appears to us that it is worth considering whether this is not attainable by the adoption as the contract rate of a sliding scale based on the market price of the distiller's basic material. Whether it would conflict with the Government's Excise policy that the rates of retail sale should fluctuate correspondingly it is not for us to say; but we may point out that these fluctuations could be greatly reduced by setting the distiller's sliding scale in operation at fairly long intervals only; and that it is within the power of Government to eliminate the fluctuations altogether, if they wish to do so, by means of counteracting modifications in the rate of still-head duty.

(c) Distribution of contracts.

350. Regarding the present system of distributing distillery contracts we have little to say and very few representations were made to us. The complaint of one witness from the United Provinces that small distillers had been ruined by the grant of the contract for several districts to a single contractor and that of another that differentiation in rates had been made between European and Indian contractors are really criticisms from opposite points of view of the *via media* pursued by Government on the advice of the Excise Committee. That Committee on the one hand took exception to the then system in the United Provinces of encouraging small, local distillers all over the Provinces on the grounds that it rendered improvement in processes and in storage extremely difficult, that the cost of production was unquestionably higher than when manufacture was concentrated under competent direction and above all that effective control of the distiller's operations was practically impossible. On the other hand they realised that there was a liability of the contract system engendering a monopoly of supply, and in view of the evils to which such a monopoly might give rise they considered it justifiable to grant to the smaller distillers a slightly higher contract rate, not as additional profit, but to cover the absolute expenses of manufacture. The action objected to is thus, in both instances, the result of deliberate policy the reconsideration of which would not be warranted without the formulation of much more fundamental criticisms than we received,

Summary of Conclusions and Recommendations.

(1) *The present methods of handling the cane in Indian factories are particularly defective and injuriously affect the milling results.*

(2) *Great improvements could be effected if steps were taken to regulate deliveries and the Java system of lifting cane loads on to the carrier by mechanical means were adopted.*

(3) *The commonest defects in the mills are inadequate preliminary crushing, the driving of each mill from a separate engine and the faulty designing of the juice pans and strainers.*

(4) For the high fibred Indian canes two crushers in front of a train of three *three-roller mills with two macerations is probably the most efficient plant.*

(5) The juice pans should be self-cleansing and mechanical juice strainers *should be used.*

(6) *The high proportion of fuel consumed in addition to megasse is a direct consequence of the irregularity of the cane supply and constitutes a serious item in the costs of manufacture.*

(7) *In the sugar house the arrangement and balance of the machinery are frequently faulty.*

(8) *For white sugar manufacture the sulphitation process is best suited to India, being more economical than the carbonatation process.*

(9) *What is mainly responsible for losses in the sugar house is not the machinery but the control that is exercised over it, and the incompleteness of the chemical and analytical records maintained.*

(10) *Losses chiefly occur from sugar lost in the filter mud and left in the molasses and from pilfering.*

(11) *The first essential for improvement is better supervision and above all more efficient chemical control.*

(12) *The chemical and analytical records which a sugar factory should maintain are exhibited in Appendix V.*

(13) *There is considerable room for economy in labour by the use of labour saving appliances and the exercise of systematic control.*

(14) *The Indian gur refineries are small and turn out sugar of low quality.*

(15) *The percentage of recovery in the North India refineries is specially low.*

(16) *Owing to the poor quality of the raw material worked, there is little prospect of material improvement in the refining industry.*

(17) *Several of the Committee's conclusions regarding the prospects of sugar production in Upper India are inevitably speculative; yet this all important cane tract must contribute, if India is to become self-supporting.*

(18) *Unless initiative is forthcoming, capital is likely to concentrate only on new and undeveloped areas such as Burma and Assam.*

(19) *Government should, therefore, erect a pioneer factory in Upper India outside the present factory zone, possibly in the Karnal or Rohtak district of the Punjab.*

(20) *It should be run on purely commercial lines by a directorate of five—a managing director, the Director of the Sugar Research Institute* (ex-officio), *another official nominated by Government and two non-officials nominated by the Sugar Board.*

(21) *The managing director and factory staff should be recruited on special agreements and participate in profits.*

(22) *Should Government be unable to provide the funds, a loan should be raised in the form of debentures carrying a guaranteed interest of 7 per cent. free of income-tax and a half share in all profits above 7 per cent. up to 13 per cent.*

(23) *The factory should be required to carry out general experiments for the benefit of the sugar industry, and should receive no privileges which would not be given to a private factory.*

(24) *The grant of Government loans or guarantee of dividends for the promotion of private factories is not necessary.*

(25) *Most of the distillery buildings attached to sugar factories are too low-roofed and unventilated for rapid and complete fermentation.*

(26) *India's present normal annual consumption of molasses is about four times the 30,000 tons she produces; and the demand, specially for use as a cattle food, should steadily expand.*

(27) *Government's Excise policy is not, therefore, likely to handicap the sugar industry for a long time to come.*

(28) *The objections to the length of the term of distillery contracts are based on temporary causes and have in several Provinces already been met.*

(29) *The period of notice for the submission of tenders should not exceed six months.*

(30) *The possibility should be considered of adopting as the contract rate a sliding scale based on the market price of the distiller's basic material.*

(31) *Such criticisms of the system of disributing distillery contracts as the Committee received were opposed to the deliberate policy of Government and did not justify its reconsideration.*

Part III—The Industry and its Organisation.

CHAPTER XXI.

THE TARIFF QUESTION.

351. Amongst the questions which have been referred to us is the examination of the effects of controlling the imports of refined and raw sugar and molasses into India by a duty and, where necessary, of grading this duty so as to give preference to sugar grown in British dependencies. As will be seen below, we do not suggest any alteration in the existing rate of duty. It is not, therefore, necessary for us to deal with the previous history of this question at any great length. Until the Mutiny the general rate of import duty levied in India was five per cent ; but, owing to the financial stringency consequent on the Mutiny, it became necesary to increase it to 10 per cent. In 1864 the rate was lowered to 7½ per cent. with an implied understanding that it would be further reduced to 5 per cent. when the state of the Government's finances permitted. This time did not arrive until 1875 when a general revision of the tariff took place. The Tariff Act, XVI of 1875, was accordingly passed which adopted 5 per cent. as the general rate on all imports. All import duties were abolished by the Indian Tariff Act, XI of 1882. In 1894 it became necessary to reimpose a tariff on imported goods. The tariff valuation for sugar adopted for the purposes of that Act is of interest as compared with that now in force. It was as follows :—

History of the Tariff—
(a) in the 19th century,

Description of sugar.	Tariff valuation.	Duty.
	Rs.	
China candy per cwt.	20·0	5 per cent.
Loaf per cwt.	23·0	„
Crystallised beet per cwt.	14·0	„
All other sorts, including saccharine produce of all kinds and confectionery per cwt.	*ad valorem*	„

Soon after the Act of 1894 was passed the question of bounty-fed sugar began to assume great importance. 1890-91 was the first year in which the imports of sugar from Austria and Germany were on an appreciable scale, and in that year they amounted to 35,450 tons. The figures then fell off for a few years, but in 1897-98 they increased to over 100,000 tons. The main reason for this great increase was that in 1897 the United States had passed an Act imposing countervailing duties on bounty-fel sugar and, in consequence, it was driven to find its market in India. In order to meet this state of affairs the Indian Tariff Amendment Act of 1899 was passed. This gave the Government of India power to impose an additional duty on sugar imported into India equal to the net amount of bounty or grant paid or bestowed directly or indirectly by the country, dependency or colony exporting such sugar, however the bounty might be paid or bestowed.

352. The history of the Brussels Convention is given in various standard works on sugar and need here be only briefly touched on so far as it affected India. The main provision of the Convention was that the countries agreeing to it pledged themselves to abolish all direct or indirect bounties on the production or exportation of sugar from the date of issue, and not to grant new ones during the term of the Convention. The maximum surtax, or difference between import duty and excise, was to amount to 6 francs per 100 kilogrammes of refined sugar and 5.50 francs per 100 kilogrammes of raw sugar. All sugar coming from countries where bounties were granted on the production or exportation of sugar was to be specially taxed, the extra duty to be not less than the amount of the bounty. The countries joining the Convention agreed to allow each other's colonial sugar to enter at the lowest import duty when premiums were not granted. The Convention was to come into force on September 1st, 1903, and to remain in force for five years in the first instance. The Government of India considered that, even if India decided to adhere to the Convention, until it came into force this country had no protection under the existing law against the indirect assistance which was being given to Austrian and German sugar by the working of the cartel system, as the result of which, owing to the very high import duty on sugar entering those countries, the sugar manufacturers were able to sell their sugar for local consumption at prices which enabled them to export sugar at a very low rate ; in other words, to dump it in foreign countries and especially in India. In these circumstances the Tariff Amendment Act, VIII of 1902, was passed, the relevant clause of which is :—

(b) from 1902 to 1915.

> "Where the rate of duty or other taxation imposed in any country, dependency or colony upon sugar not produced therein exceeds the rate of duty or other taxation imposed on sugar produced therein by more than the equivalent of six francs per one hundred kilogrammes in the case of refined sugar or five francs and fifty centimes per one hundred kilogrammes in the case of other sugar, then the Governor-General in Council may impose, in addition to any other duty or taxation imposed by this Act or by any other Act for the time being in force, a special duty not exceeding one moiety of such excess."

This Act was to remain in force until August 31st, 1903, *i.e.*, until the Brussels Sugar Convention came into force. In the end, however, the Government of India decided that, in order to retain full freedom of action, this country should not adhere to the Brussels Convention. With the object of retaining power to levy duties on sugar imported from countries which had not joined the Convention or which, having joined it, failed to conform strictly to its provision regarding the limitation of the surtax to six francs per 100 kilogrammes, Act XI of 1904 was passed reviving the provisions of the Tariff Amendment Act of 1902. The only countries against which the provisions of Act XI of 1904 were ever utilised were the Argentine Republic and Chile. The countervailing duties against these two countries were, however, abolished in 1909 and 1912, mainly on the ground that no sugar was imported from them into India. It is worthy of mention that Sir Edward Baker in his financial statement for 1906-07 discussed at some length the results of the imposition of countervailing duties on bounty-fed sugar, and showed by facts and figures that, so far as any direct effect on Indian cultivation, imports or prices was concerned, the measures of 1899 and 1902 had been without any material result. The Acts of 1899 and 1904 are still on the Statute Book.

353. In 1916 a general revision of the Indian Tariff was undertaken. The duty on sugar of all sorts except confectionery was raised from five to ten per cent., as against a general all-round duty of 7½ per cent. The enhanced tariff on all commodities, sugar no less than others, was imposed solely for the purpose of meeting a deficiency in revenue which it was no longer practicable with the continuance of the war to cover by temporary loans. The reasons given for the specially high rate on sugar were that the imports were exceptionally large and India's facilities for internal supply exceptionally good. Protection for the indigenous industry, therefore, did not even furnish a subsidiary motive for the imposition. The tariff valuation for imported sugar is at the time of writing (October, 1920) as follows :—

(c) since 1915.

Description of sugar.	Valuation per cwt.	Duty.
	Rs. A. P.	
(i) Sugar of all sorts, including molasses and saccharine produce of all sorts, but excluding confectionery :—		
Sugar, crystallised and soft, from Java 23 Dutch Standard and above ...	18 8 0	10 per cent *ad valorem.*
Sugar from Java 16-22 Dutch Standard	16 8 0	Ditto.
Sugar from Java 15 Dutch Standard and under	16 0 0	Ditto.
Sugar from Japan or Formosa	20 8 0	Ditto.
Sugar refined in China	20 8 0	Ditto.
Sugar from Egypt	19 8 0	Ditto.
Sugar from Mauritius	17 0 0	Ditto.
Sugar crystallised beet	18 8 0	Ditto.
Molasses from Java	6 6 0	Ditto.
Molasses from other countries	6 6 0	Ditto.
Sugar all other sorts including saccharine produce of all kinds	*ad valorem*	Ditto.
(ii) Confectionery	Ditto	7½ per cent. *ad valorem.*

The system on which this scale of valuations has been drawn up is that the actual average value for the previous calendar year of "23 Dutch Standard and above" is taken throughout the succeeding calendar year as the basic standard of valuation, all other sugars being then automatically valued at fixed amounts more or less than the standard valuation according to the scale below :—

Description of sugar.	Differentiation.
	Rs. A. P.
Beet crystals	To be valued at the same rate as Java 23 Dutch Standard and above.
Sugar, crystallised and soft, from Mauritius	1 8 0 lower.
Java 16 to 22 Dutch Standard	2 0 0 lower.
Java 15 Dutch Standard and under	2 8 0 lower.
Japanese and Formosan crystals	2 0 0 higher.
China crystals	2 0 0 higher.
Egyptian crystals	1 0 0 higher.

This system of valuations was only brought into force from January 1st, 1920. The system previously adopted was to fix the valuation for each different kind of sugar on the basis of the average price of its own kind for the previous year. This gave rise to difficulties and anomalies which need

not be specified here. The following figures show the great disparity between the valuation at present in force and present prices :—

Description of sugar.	Imported during the month of August 1920.		Imported during 1920.*	
	Quantity.	Average net value per cwt.	Quantity.	Average net value per cwt.
	Cwt.	Rs. A. P.	Cwt.	Rs. A. P.
Java 23 Dutch Standard and above ...	364,092	45 12 0	4,853,229	33 8 0

*Figures for the whole year incorporated while the Report was in the Press.

It is, we think, a fair conclusion from the history of Indian tariffs on imported sugar that the measures taken against bounty-fed sugar in 1899, 1902 and 1904, which have had little or no practical effect, were the only measures ever designed to serve protective purposes ; and that the sole object with which the tariff has been imposed or enhanced from time to time has been the raising of additional revenue.

354. We labour under two great disadvantages in discussing the tariff on sugar imported into India. In the first place, every indication points to the likelihood that the whole question whether the Indian tariff system should be revised in order to afford protection to Indian industries will come under discussion in the very near future. Sugar is only one and not the most important item in Indian imports ; and the question whether the Indian sugar industry needs a more substantial measure of protection than is afforded by the present import duty, will, if our anticipations prove correct, be determined by considerations which do not affect that industry alone. In the second place, the witnesses we examined on this point were unable to support their opinions regarding it by detailed facts or figures. They merely expressed the view based on general impressions that the enhancement of the duty from 5 to 10 per cent. had proved beneficial in developing the industry. Some of them advocated a further large increase in the duty ; but the majority, which included those witnesses to whose opinions we attach most weight, considered it sufficiently high in present conditions. Neither the statistics of imports nor those of the amount of sugar produced in India since the duty was enhanced assist in any way in coming to a conclusion on this point, owing to the utter subversion of normal conditions which has resulted from the war. After careful consideration of such evidence as is before us, we are agreed that no alteration in the present scale of duty is called for as a protective measure.† During the discussion of the Tariff Amendment Bill of 1902 Lord Curzon warned Indian producers and refiners that the future of their industry must depend on extended cultivation and the substitution of modern methods for the crude and old fashioned processes so generally adopted in India. This statement is as true and the warning as necessary to-day as it was in 1902. Our recommendations throughout have been aimed at securing the extension of cane cultivation and, what is far more important, the adoption of improved methods both of cultivation and manufacture. The present duty affords a very substantial measure of protection to the Indian sugar industry. It cannot be overlooked that, in addition to the direct protection it receives, which, it is important to note, will in all probability in 1921, when the tariff valuation will be based on

Retention of the existing scale of duty recommended.

†Since the Committee dispersed the duty on various commodities, has been enhanced including that on sugar from 10 to 15 per cent. *ad valorem.* As in 1916, the sole object of the enhancement is the raising of additional revenue.

the average prices of 1920, fall little short of that received by sugar manufactured in Germany in the palmiest days of the bounty system, the sugar industry in India is indirectly protected to a large extent, especially in present conditions, by ocean and railway freights. We consider that the combined effect of the direct and indirect protection enjoyed by the industry is such as to furnish it with an unique opportunity of setting its house in order pending the more severe competition which may be expected when prices fall to a level more nearly approaching that which prevailed before the war. We fear that any increase in the duty might result in bolstering up an inefficient industry to the detriment of the consumer; and that, secure behind a high protective wall factories in India might make no effort to reach the standard of those in other sugar producing countries, notably in Java, where the industry has been able to dispense with any protection, subsidy or assistance from Government. On this head, therefore, we would only suggest that, if our anticipation that the whole question of the Indian tariff will shortly come under review is not realised, the position in regard to the sugar industry might be reconsidered when more normal conditions are restored and the protective effect of a ten per cent. duty on imported sugar becomes far less than it is at present. As we have already stated, Act XI of 1904 is still in force, and its provisions can be utilised, should there be any revival of attempts to dump bounty-fed or cartel sugar in India in consequence of the recent abrogation of the Brussels Convention.

355. In this connection we have considered the advisability of substituting a quantitative duty on sugar, adjusted on the basis of polarisation, for the *ad valorem* duty at present in force. A quantitative duty has two great advantages. With such a duty the industry knows exactly where it stands and can enter into forward arrangements with the greater confidence because one very important disturbing factor has been eliminated. In the second place, the imposition of an *ad valorem* duty means that such measure of protection as is afforded by an import duty is given in the greatest degree when it is least required, that is, when prices are at their highest. The hardship this entails on the consumer is obvious and is removed by the substitution of a quantitative duty. On the other hand, there is obviously no advantage in imposing a quantitative duty unless that duty is to remain in force for a considerable period of years. If such a duty were fixed on the scale of prices at present prevailing, it might result in a greater measure of protection to the industry than is called for and in its turn work to the disadvantage of the consumer. If, however, the duty were fixed on a lower scale than is justified by present prices and those prices continue, the result would be a serious and unnecessary loss of revenue to Government. On the whole, therefore, whilst we think a quantitative duty preferable to an *ad valorem* duty in normal conditions, we would not suggest an immediate alteration in the present system, but would, here again, suggest that the position should be reconsidered as soon as circumstances permit.

Question of substituting a quantitative for an ad valorem *duty considered.*

356. The question of a preferential tariff on sugar imported into India from other parts of the Empire is one on which we hesitate to express an opinion, even though it has been specifically referred to us. We feel that the position in regard to it is in every way similar to that in regard to the general question of the revision of the tariff on sugar, and that it must be decided by far wider considerations than those which fall within our purview. In the last pre-war year, 1913-14, the imports of sugar into India from other

Imperial preference.

parts of the Empire were 145,000 tons valued at Rs. 262 lakhs,* of which 139,500 tons valued at Rs. 250 lakhs came from Mauritius. From foreign countries the imports were 658,000 tons valued at Rs. 1,167 lakhs. Of this 583,000 tons valued at Rs. 1,027 lakhs came from Java and 74,000 tons valued at Rs. 137½ lakhs from Austria Hungary. In 1918-19 the imports of sugar from other parts of the Empire were 143,000 tons valued at Rs. 468 lakhs, of which 77,000 tons valued at Rs. 255½ lakhs came from Mauritius and 62,000 tons valued at Rs. 188 lakhs from the Straits Settlements. The great increase in the imports from the Straits Settlements does not, however, represent a real increase in the imports of Empire grown sugar; but was largely Java sugar diverted owing to the difficulty of shipment direct from that country. The direct imports from foreign countries were 363,500 tons valued at Rs. 1,069 lakhs, of which 363,000 tons valued at Rs. 1,065 lakhs came from Java. As regards molasses, the imports in 1913-14 from the Empire were 2,850 tons valued at Rs. 1.35 lakhs, practically all of which came from Mauritius. In 1918-19, they were 388 tons valued at Rs. .37 of a lakh. The imports from foreign countries in 1913-14 were 87,000 tons valued at Rs. 37½ lakhs and in 1918-19 18,600 tons valued at Rs. 18.45 lakhs; practically the whole of this in both years came from Java. In 1913-14 the imports of confectionery from the Empire amounted to 3,600 tons valued at Rs. 25½ lakhs and in 1918-19 to 58 tons valued at about Rs. 1.05 lakhs. Almost all of this was from the United Kingdom. The imports of confectionery from foreign countries both in 1913-14 and in 1918-19 were negligible. These figures show conclusively that the only part of the Empire which would receive any benefit from the introduction of a preferential tariff on sugar imported into India is Mauritius, and that sugar can, therefore, only play a very minor part in any general scheme of Imperial preference. We have given our reasons for considering 10 per cent. a sufficiently high duty on imported sugar. It follows that we are not in favour of an increase in the duty on sugar imported from foreign countries in order to permit a preference to be given to Empire grown sugar. We are of opinon that, if a scheme of Imperial preference is introduced, the general duty on sugar and its by products should remain at its present level, and that sugar imported from other parts of the Empire should receive the same proportional preference as is granted under the general scheme.

Summary of Conclusions and Recommendations.

(1) *Apart from the more or less abortive measures taken against bounty-fed sugar in 1899, 1902 and 1904, the tariff on sugar imported into India has hitherto been purely for revenue and not for protective purposes.*

(2) *In view of the impending investigation of the general policy of revising the Indian tariff to protect Indian industries, it is difficult to discuss this question for sugar separately; nor does the conflicting evidence received or the abnormal state of the indigenous industry and the import trade afford any reliable guidance.*

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* For the purpose of these valuations we have throughout adopted the old conversion rate of Rs. 15 = £1 in accordance with the system followed in the last issue of the Annual Statement of the Sea Borne Trade of British India with the British Empire and Foreign Countries from which our figures have been taken.

(3) *The present tariff combined with ocean and railway freights should provide ample protection to the Indian sugar industry; but, if the question of general policy is not meanwhile investigated, the particular case of sugar should be reconsidered when normal conditions are restored.*

(4) *A quantitative duty is preferable to an* ad valorem *duty; but the present time is not opportune for the change.*

(5) *The only part of the Empire which would benefit from an Imperial preferential rate on sugar imported into India is Mauritius.*

(6) *If Imperial preference is adopted generally, it should be adopted in favour of Empire sugar by means of a proportional reduction on the present tariff.*

CHAPTER XXII.

STATISTICAL.

Prefatory remarks.

357. Although the question of improving the statistical information at present published by Government in regard to cane and sugar was not specifically referred to us, we have considered it desirable to deal with it in our Report, as we have found ourselves greatly hampered throughout our enquiries by the absence of trustworthy statistical information on various points. We consider that much could be done not only to improve the accuracy of the sugarcane forecast but also to enhance the value of the information regarding sugar contained in such publications as "Agricultural Statistics of India", "Commmercial Statistics of India," "Estimates of Area and Yield of principal Crops in India," "Prices and Wages in India" and the "Annual Statement of the Sea Borne Trade of India."

Forecasts of area and yield.
(a) The area estimate.

358. The possibility of improving forecasts and final statistics of area and yield of crops in India was carefully considered at a meeting of the Board of Agriculture held at Pusa in December, 1919. We are in general agreement with the recommendations of the Board on the subject and it is only necessary for us to discuss their application to the special case of cane. In order to make this discussion intelligible, a brief description of the methods adopted in India in framing an estimate of the outturn of a crop appears unavoidable. The three essential factors are the area, the standard normal outturn per acre, and a fraction representing the relation of the crop reported on to the normal outturn per acre. As regards the first of these, we accept the view that the figures of the area under cane are on the whole fairly accurate except in the tracts which have a permanent settlement, and that it is difficult to suggest any method by which they can be improved in the latter except by an improvement in the detailed maintenance of land records. The area under cane in Bihar and Orissa and Bengal, which stand third and fourth respectively amongst the cane growing Provinces of India, is sufficiently large to make this a matter of some importance. We would, however, draw attention to the not infrequent discrepancies between the area under cane in each Province as given in the Agricultural Statistics volume and the same area as given in the Area and Yield volume. We are aware that certain reasons for discrepancy are furnished in the Introductory Note to the latter volume and in the footnotes to its table No. 6; and these explanations fully account for the differences noticeable in the areas for Bombay and in earlier years for Bengal and the Punjab. But there are other differences which cannot be so explained, and their occurrence is so arbitrary that it is difficult to see how they can be justified. Taking the latest issues of the two publications available, the 34th issue of the Agricultural Statistics volume and the 21st issue of the Area and Yield volume, whereas the two sets of figures agree throughout for Madras and from 1912-13

onwards for the Punjab, for all other Provinces (except, as we have indicated, Bombay) they alternate between agreement and disagreement. Thus, for the United Provinces the four years 1909-12 and 1915-16 are years of agreement and the five years 1912-15 and 1916-18 are years of disagreement ; and this is typical. The differences are as a rule small ; but the following are instances in which they may be regarded as being not altogether negligible in proportion to the cane area of the Province :—

Province.	Year.	Area in acres according to "Agricultural Statistics."	Area in acres according to "Area and Yield."	Difference in acres.
United Provinces	1913-14	1,389,300 (a)	1,379,900	9,400
Bengal	1916-17	220,000 (a)	204,000	16,000
Assam	1913-14	57,900 (a)	46,500	8,600
Central Provinces and Berar ...	1914-15	17,000 (a)	19,000	2,000

(a) rounded according to the system of rounding adopted for the same year in the Area and Yield volume.

It seems to us that these discrepancies and the arbitrary variation they exhibit between agreement and disagreement from year to year create unnecessary confusion, and that it should be possible to eliminate all differences which are not either self-explanatory or explained specifically by adopting whichever is held to be the more accurate estimate in the appropriate tables of both publications.

359. As regards the second factor, the standard normal outturn, this is briefly defined in the "Manual on the Preparation of Crop Forecasts" as the average yield on average soil in a year of average character. It does not correspond with the average figure for a series of years, which is an arithmetical abstraction and may possibly never occur. The Agricultural Department in each Province maintains a statement for the different districts of the normal or average yield per acre of the principal crops on irrigated and unirrigated land of average quality. In order to test the accuracy of this statement and to enable it to be revised, if necessary, a system of crop cutting experiments is in force in all Provinces. Under this system plots of land of average quality are selected and the crops grown on them are cut and weighed in the presence of responsible officers of the district staff or of the provincial Agricultural Department. The results of these experiments, which are made yearly, are reported to the Director of Agriculture who may, after scrutinising them, revise the standards previously adopted for any particular district or for the Province as a whole. This revision is ordinarily made once in five years. The normal outturn of the cane crop is given in terms of gur per acre and not in weight of cane. A few figures taken from the Statements in Appendix A to the Agricultural Statistics of India will show how unsatisfactory the present figures are and what little reliance can be placed on them. The standard outturn adopted for every district in Madras, from the Nilgiris with three acres under cane to Vizagapatam with 30,000, is 5,040 lbs. of gur per acre. In Bombay the standard outturn for the Deccan canals tract, 7,000 lbs., is the same as for Southern Gujarat. The evidence we received was by no means such as to justify the yields for these two tracts being placed at the same figure. On the other hand the standard outturns in

(b) The estimate of standard normal outturn.

(i) Present defects.

the Central Provinces for irrigated cane alone vary from 1,500 to 3,500 lbs., though there is no reason to believe that the disparity in local outturns in the Central Provinces is greater than it is in Madras and Bombay. The figures of crop experiments, the results of which have not yet been used for the revision of the provincial standard outturn, are even more illustrative. On the basis of the crop experiments for the quinquennium ending 1916-17, the average yield of gur per acre in Bengal is returned at 803 lbs. in Bakarganj and 8,613 lbs. in Midnapur. In Bihar and Orissa the range is from 851 lbs. in Bhagalpur to 4,043 in the Santal Parganas. The provincial standards of average yield adopted in this Appendix are apparently intended to correspond with the provincial standard or normal yields per acre of those crops for which forecasts are prepared which will be found in Table 3 of the Area and Yield volume. There are, however, two small discrepancies which require explanation, the gur yield for Bihar and Orissa being returned alternatively at 2,460 and 2,464 lbs. and that for the North-West Frontier Province at 2,660 and 2,685 lbs.

360. Sufficient has been said to show how far a forecast based on the present standard normal outturn may be from accordance with the facts. At its last meeting the Board of Agriculture recommended that an attempt should be made to ascertain the total actual yield of the crops in regard to which forecasts are issued by the collection and detailed study of the statistics of movement by rail or sea, of manufacture or of any process such as baling and of estimates of local consumption and carry over. The forecast for any particular year would then be based on the "average yield" per acre, the "average yield" being the average of the actual yields of the ten preceding years for which figures were available. The use of the term "normal" would entirely disappear, and the results obtained by the methods described would merely be called the "average yield." The Board of Agriculture realised the difficulties in the way of ascertaining the actual yield in this way, but did not consider that these should prove insuperable, except, perhaps, in the case of sugarcane. In our opinion, methods which may be possible for ascertaining the yield of other crops are quite unsuitable for cane. The proportion of the cane crop which is moved by rail is almost infinitesimal, whilst by far the greater part of the gur manufactured is consumed locally or moved by road. Statistics of movement by rail or sea are therefore of no assistance, nor do those of the manufacture of white sugar help in any appreciable degree. Matters are further complicated by the large amount of cane which is used for chewing. We can see no way in which satisfactory estimates of local consumption and carry over, if any, could be framed. In these circumstances we are of opinion that, so far as sugarcane is concerned, the standard normal outturn must continue to be based on crop cutting experiments, and that these experiments must be conducted in a more regular and systematic way than they have been hitherto. We endorse the view, which is generally accepted and is being acted on as far as possible, that they should be carried out by the Agricultural Department, as it is most desirable that they should be conducted by men who have practical training in Agriculture. As in the case of cane the normal outturn will continue to be determined by crop cutting experiments, and these experiments will not merely be used as a means of checking figures obtained in other ways, it is necessary that they should be numerous. We would place the number required at not less than 150 in the United Provinces and 100 in Bihar and Orissa and the Punjab. The number in other Provinces would vary in proportion to the area under cane. We consider that the results of these experiments should be reported in terms of weight of cane and not of gur, and that it is important that they should be carried out

(ii) Suggested improvements.

on an area of not less than one-fifth of an acre in each case. It is not, in our opinion, necessary that the weight of gur obtained from the plots should be ascertained in every case ; but it is essential that the conversion factor for the season, *i.e.*, the weight of gur produced from every 100 tons of cane, should be discovered, as this varies considerably from year to year. For this purpose it would be sufficient, if two or three boilings of gur were undertaken in each representative tract by the most representative process in that tract. The number necessary in each Province should not be more than 10. The variety or varieties of cane most largely grown in the tract would be selected for the experiment. It is of the greatest importance that the experiment should be carefully supervised. There would of course, be no interference with the actual process ; but the supervising officer would see that all weighments were accurately made. Crop cutting and gur boiling experiments should, unless there is a very marked diversity of local conditions, be carried out during the same period. In Upper India, for example, the most suitable time for them would be the first fortnight of January, the object being to select a mean period which would most nearly represent the average yield of gur throughout the season. The weight of cane having been ascertained by the crop cutting experiments, the total yield for the year would be worked out in the office of the Director of Agriculture. As soon as figures on which sufficient reliance can be placed are available for a series of years, the method proposed by the Board of Agriculture would be followed. The " average yield " on which the forecast for a particular year would be based would be the average for the ten years preceding. In this connection we would point out that, as the varieties of can grown on Government farms are not as a rule those grown by the ordinary cultivator, the results obtained on Government farms are of no statistical value whatever as regards cane even for the purposes of comparison between the outturn of one season and another.

361. We now come to the third factor in framing an estimate of outturn, the fraction representing the relation of the crop reported on to the normal outturn per acre. This seasonal factor, or condition figure, is commonly known as the " anna estimate." Practically all over India the outturn is estimated in annas, a certain number of annas being taken to represent the normal outturn, and the outturn of the year under report being estimated at so many annas higher or lower than the normal. The number of annas taken to represent a normal crop is not, however, the same everywhere, but varies between 12 and 16 annas. This difficulty is met, though only partially, by not using the anna notation in the published forecast, where it is replaced by the American notation, 100 being taken to represent a normal crop, and the estimated outturn being stated as a percentage of that crop, the conversion of the anna estimate into the percentage estimate being made by the district officer or the provincial authority. The original anna estimate is in most cases framed by the *patwari* (village accountant) or an official of similar standing. Opinion is unanimous in regard to the unreliability of the estimates so framed, and there is little doubt that the outturn of all crops in India is persistently under-estimated. It has frequently been pointed out that the main reason for this is the ingrained pessimism of the Indian cultivator and village official, as a result of which it is very rarely that a normal crop is reported. Efforts have been made from time time to improve matters, but it cannot be said that they have met with any measure of success. We agree with the view expressed by the Board of Agriculture that the primary reporting authority must be left to its traditional practice, and that the only method of arriving at the seasonal factor

(c) The seasonal factor or anna estimate.

or condition figure is to interpret the estimates of the primary reporting authority in terms of past experience of them, and to translate them into intelligible language before publishing them. The formula adopted by the Board of Agriculture for working out forecasts was :—

$$\text{Tal yield} = \text{Area} \times \text{average of } \frac{\text{Actual yield}}{\text{Area}} \times \frac{\text{Seasonal factor}}{\text{Average seasonal factor}}.$$

The average of $\frac{\text{Actual yield}}{\text{Area}}$ would, as explained in the preceding paragraph, be the average for the ten preceding years. The average seasonal factor would also be the average of the ten preceding years. The possibility of adopting an average extending over as long a period as possible was considered, but was rejected owing to the liability of error as the result of improvements and extensions of cultivation, and the introduction of improved varieties. We agree with this view, for we trust that the cumulative effect of all these factors will become very considerable as time goes on. The seasonal factor for each Province, as pointed out by the Board of Agriculture, can only be worked out by an officer with experience of the mentality of the local reporting agency. The final result would be given in some such form as the following :—

> " The condition figure for the cane crop is estimated at 75 per cent. as against a ten years average of 80.4 per cent. This means that the condition of this year's crop is equal to 93.3 per cent. of the ten years' average."

Of the three essentials for a correct forecast, area, standard normal outturn per acre and anna estimate, the figures of area must continue to be supplied by the Land Revenue Department. We have already proposed that the figures of standard normal outturn should be supplied by the Agricultural Department. The anna estimate must continue to be supplied mainly by the Revenue Department ; but we trust that, as the Agricultural Department expands, it will be possible for that Department to take this work over. We agree with the view expressed by the Indian Cotton Committee that in all Provinces which have a Director of Agriculture, the work of submitting crop forecasts to the Department of Statistics should be undertaken by him.

362. As regards the remaining proposals of the Board of Agriculture concerning forecasts, we agree that all forecasts of cane should be subjected to a careful detailed examination in the light of the actuals as soon as these become available, and that the results of this examination should be published for general information. For the reasons we have given above, the actuals in the case of cane would be calculated from the results obtained from the crop experiments. We also agree that the figures in each forecast should be compared with those given in the previous forecast of the same year and with the final forecast of the previous year and that they should be accompanied by final area figures, final estimates and actual outturns in terms of cane for the previous five years so as to show at a glance the relative accuracy of the estimates. The reason why we consider that the actual outturn should be given in terms of cane only is, that it is not in accordance with the facts, as the present returns imply, that all cane grown is converted into gur ; and there is no present means of ascertaining how much of it is diverted to other purposes. The conversion factor of cane into gur for the previous five years would, however, be stated ; and we also recommend that a statement should be added as soon as this becomes practicable showing the cane crushed in factories, and the sugar and molasses produced by them. It is doubtful whether non-official agencies are in a position to render as great a measure

(d) Comparison with actuals and local expert supervision required.

of assistance in the compilation of the cane forecast as of that of other commercial crops, but efforts should be made to enlist the assistance of factories and large and small landholders in the work of crop reporting. We strongly support the proposal that there should be a careful check of the returns in the office of the Director of Agriculture and that an officer of at least the standing of an Assistant Director of Agriculture, with training in statistical theory and practice as well as in agriculture, should be attached to all provincial Agricultural Departments for statistical work, which should include that on forecasts and costs of cultivation. Our enquiries have impressed on us the necessity for such an appointment. We had hoped to be able to obtain useful assistance in coming to a conclusion regarding the relative profits of cane and other crops in each Province by a study of the costs of cultivation ; but we regret to state that, though we obtained a mass of information on this point from the provincial Agricultural Departments, the discrepancies in it are so obvious that we have been unable to regard it as of any real value.

(e) Dates of publication of cane crop forecasts.

363. The only question which remains for consideration is the dates of the forecasts. The prescribed dates at present are as follows :—

—	Provincial.	All India.
First forecast	August 15th ...	August 20th.
Second forecast	October 15th ...	October 20th.
Third forecast	...	...
United Provinces and North-West Frontier Province ...	February 16th ...	February 16th.
All other Provinces	January 31st ...	

The first and second forecasts merely give the acreage figures and an expression of opinion regarding the condition of the crop, such as that it is reported to be good. The third forecast gives figures both of area and outturn in terms of gur. The only suggestions which we received in regard to the dates of publication were that the third forecast should be issued earlier than it is at present and not later than the end of January. At present it is not published until the harvest in the most important cane growing tracts of India has been in progress for several weeks. We support this proposal by which only two Provinces, the United Provinces and the North-West Frontier Province, would be materially affected. It was also suggested to us that the second forecast should contain a condition figure. We also support this proposal, especially as we observe that such a figure is already given for the most important cane growing Provinces. We have already recommended in preceding paragraphs that the outturn figures in both the second and third forecasts should be in terms of weight of cane. These should be given in tons.

The "Agricultural Statistics of India."

364. The recommendations we have made above should greatly improve the character of the information regarding cane and gur contained in the "Agricultural Statistics of India" and the "Estimates of Area and Yield." The arrangement of the former volume leaves much to be desired and detracts greatly from its usefulness. The Provinces are not systematically arranged and the table of contents has, therefore, invariably to be consulted when information in regard to a particular Province is desired. We consider that the Provinces should

be given in alphabetical order. We can see no advantage in treating Agra and Oudh, Bombay and Sind, Upper Burma and Lower Burma, the Central Provinces and Berar as separate units ; but, if it is considered desirable that separate statistics should be available in each case, we would suggest that a combined total should be struck for the whole Province. We would also suggest that, in Provinces in which there are Commissioners' divisions, the division in which each district is included should be shown in the provincial tables.

The "Commercial Statistics of India."

365. The only information regarding sugar factories in the "Commercial Statistics of India" is contained in the tables which give the number of factories owned and worked by companies or individuals and the number of persons employed in them. The value of this information can be gauged from the fact that 31 of the small factories manufacturing raw sugar from date juice in the Jessore district of Bengal were included in the returns of 1916, though they find no place in them in any other year. If our recommendations in regard to the establishment of a Sugar Research Institute are accepted, it will be possible greatly to expand the information regarding sugar contained in this volume by, for example, including, as well as in the forecasts, figures of the total weight of cane crushed by the different factories and of the outturn of sugar and molasses.

"Prices and Wages in India."

(a) The Tables of up-country wholesale prices examined.

366. A considerable amount of miscellaneous information in regard to prices of sugar and gur is given in the volume known as "Prices and Wages in India." In order to facilitate the working of the sliding scale for the payment of cane we have suggested, we have recommended in Chapter XIX that the Director of Statistics should issue, immediately after the close of each month, a statement showing the average wholesale price of white sugar manufactured in India prevailing in the principal markets during the preceding month. These statements should of course be incorporated in the annual issue of the volume under consideration. As regards the information at present contained in this Volume, Tables 2(17) and (18) record the average annual wholesale prices of gur and refined sugar respectively per ten maunds for various districts. The value of the latter table is very largely discounted by the fact that it embraces returns for the United Provinces only, apparently because no other Local Government suggested the inclusion of refined sugar in these Tables when their revision was undertaken in 1896. The reason is not quite convincing, and though the main centre of the gur refining industry is in the United Provinces, the main centre of sugar manufacture direct from the cane is not ; and in any event the indigenous production of refined sugar bears far too small a proportion to the imports to justify this policy of splendid isolation. We trust, therefore, that the Table will in future be enlarged to include returns from all the major Provinces in which refined sugar is consumed to an appreciable extent. But the most serious defect in these two Tables, as it seems to us, is the unreliability of the statistics which they do record. We have already expressed in paragraphs 320 and 321 of Chapter XIX our inability to accept their testimony regarding the sugar and gur prices of 1913 in the Meerut tract and North Bihar respectively. A brief explanation of this decision will serve to illustrate the defectiveness of the Tables as a whole. Although Meerut itself is one of the three reporting districts in western Agra included in Table 2(18), it has furnished no quotation of sugar prices since 1909. The unreliability of the prices it returned before that year may be gauged from a comparison of those for 1907 and 1908 which are recorded as Rs. 46.25 and Rs. 138.12, an increase of just 200 per cent. The difference between the wholesale prices of imported sugar in the same two

years as recorded in the much more reliable Table No. 5 is less than 10 per cent at Calcutta and 8 per cent. at Bombay. Yet if, in the absence of direct figures for Meerut in 1913, we take those of the nearest reporting district—Aligarh—, we find that according to the official returns refined sugar sold there for Rs. 13-6-0 per maund, although it would have paid the Bihar factories to sell their product in this locality for a little more than Rs. 9 per maund. There was no shortage of railway wagons in 1913 to prevent this. The inference is clear. Either the official figures are wrong or they refer to a different product than the factory sugar with which that of the Bihar manufacturers competes. In other words, the Aligarh figure may be for an Indian hand made sugar commanding a fancy price in a restricted market of its own on account of racial or religious prejudice. To turn now to the price of gur in North Bihar in 1913. The price recorded in Table 2(17) for that year in the Muzaffarpur district, which is the most central of all the reporting districts for this purpose, is Rs. 39.82 per ten maunds ; whereas the refineries actually bought their gur in this tract for prices averaging only Rs. 2.59 per maund over the whole season. Here the difference is probably explained by the fact that the official figure is for the higher quality of gur manufactured for direct consumption, although the bulk of the gur produced in this tract is of the lower quality used for refining.

(b) Their main defects and suggestions for improvement.

367. It would be easy, but it is unnecessary, to multiply such illustrations. They point to two radical defects in the present system of collecting these statistics of up-country wholesale prices. Sufficient care is not taken either to see that the figures returned accord with even approximate accuracy to the facts or to ascertain the exact nature of the products to which the reported facts relate. Consequently no rational principle is followed in their selection and the Tables are little more than lists of figures between which no valid comparison can be made. The first essential for improvement, therefore, is a more precise and detailed classification of the commodities reported on. Sugar in India is distinguished not only according to colour and quality but also according to its source and process of manufacture, and these distinctions are reflected in the prices. So too with gur, the value of which varies not only according as it is sold for direct human consumption or for refining or as a cattle food but also within these main classes according to colour, consistency, keeping properties and flavour, qualities dependent on the varieties of cane used as well as on the skill employed in manufacture. Over-elaboration would, of course, tend to defeat its own object ; but we would suggest the adoption of the following main classes at least :—

A. for gur :—(1) high class eating gur (2) ordinary eating gur (3) refining gur (4) gur for cattle ; the further information being given in respect of the first two classes whether the gur is of local manufacture or imported and, if imported, the tract in which it was produced.

B. for refined sugar :—(1) foreign white sugar (2) Indian factory white sugar (3) *khandsari* or other special Indian hand-made sugar.

The class of gur or sugar quoted would be entered against each reporting district or station. It might then be found advisable to group the reporting centres according to the kind of gur or sugar quoted. The great advantage of a more exact classification, however, will be that it will then be possible to devise a more rational reporting system ; and to fix with regard to the comparisons required, and not merely with regard to the individual circumstances of a

particular market, the kind or kinds of gur and sugar of which the prices should be furnished in each case. When such a system has been devised, it will then be worth while, and in fact necessary, to effect improvements in the method of collecting these statistics. At present, we believe, their collection is entrusted to the subordinate district authorities whose preoccupation with what are to them far more important matters naturally tends to the perfunctory discharge of a duty the object of which they perhaps hardly appreciate. It is true that provision is made at various stages for the scrutiny of these returns in the course of their transmission to the Director of Statistics ; but scrutiny can only detect the existence of the more obvious mistakes : it cannot with any certainty correct them. Reliability in the primary reporting agency is all-important, and it is difficult to see how this is likely to be secured so long as the Statistical Department is practically confined to a centralised office discharging the sole function of critical compilation. It is not so much a new reporting agency that is required as efficient supervision and direction of the existing agency ; and with a view to supplying this here we recommend that in the collection of price statistics the subordinate district authorities should work under the control of the Statistical Assistant Director of Agriculture whose appointment we have supported in paragraph 362 : and that it should be one of his duties to check by local enquiry the statistics they return and to instruct them in the objects and methods of their collection.

(c) Other Tables.

368. The remaining Tables in this publication with which we are concerned may be briefly dealt with. In Table No. 5, " Prices of staple articles of Import in 1873 and from 1893 to 1918 ", the only kinds of sugar for which prices are given are refined Austrian beet sugar for Calcutta, with consequently no quotations later than 1914, and Mauritius No. 1 for Bombay, although since 1906-07 the imports of Java sugar into India have very greatly exceeded those of either. In Table No. 7, " Prices of staple articles of export in 1873 and from 1893 to 1918 " figures are given for Calcutta of " date, gurpatta " and " dulloah." The latter, we understand, is the local name for the first sugar obtained by the Indian refiners in Bengal from Date palm gur ; but some authoritative explanation of both terms seems required. Table 3 in Appendix G gives the monthly wholesale prices in Calcutta per standard maund of sugar of the following kinds, Java T. M. O. white, Mauritius, Cossipore 1st class white, Cossipore grey No. 2 and Valley gur. We consider this a very useful table the value of which, from our point of view, would have been greatly enhanced if it had included a series of pre-war years. We would suggest, however, that the price quoted for Java sugar in it should be that of Java 23 Dutch Standard and above, as that is the basis of the tariff valuation at present in force ; and also that some explanation should be given of the term Valley gur as well as the reason for including it. In Table 4 in Appendix G, which gives monthly retail prices in Calcutta since the outbreak of the war, the quotations for sugar are for Cossipore 1st class and Java 2nd and 3rd class. Here again we would suggest that the quotations of Java sugar should be in terms of the Dutch Standard ; nor is it clear to us why the same kinds of sugar are not quoted as in the preceding table, which would permit of an instructive comparison between wholesale and retail prices. Table 5 in the same Appendix gives the maritime freights of the chief exports from Calcutta to London, Liverpool, Dundee and Mauritius at the end of each month from the outbreak of the war. We would suggest that a similar table should be given for inward freights and should include the freight on sugar from Java. Authoritative information, on this point in a Government publication would have been of material assistance to us, and we have had to seek it from other sources. The inclusion of tables for other ports

similar to those given for Calcutta would, in our opinion, be advantageous. The Wages Tables should, we consider, include a statement of the wages paid in a sugar factory. Our examination of the information regarding sugar in this volume seems to us to show that the compilation of the main tables published in it has become rather a matter of routine, and that sufficient attention has not been paid to the necessity of revising them from time to time in the light of alterations in trade conditions.

The Annual Statement of Sea Borne Trade.

369. We presume that the various headings under which the imports and exports of sugar are entered in the Annual Statement of the Sea Borne Trade of British India will be altered in future issues in order to bring them into accordance with those now adopted for the tariff valuation. The only suggestion we have to make in regard to this volume is that both imports and exports of sugar should be given in tons instead of in hundredweights.

Summary of Conclusions and Recommendations.

(1) Of the three essential factors for an accurate estimate of the cane crop of India, the area estimate is fairly accurate outside the permanently settled tracts, where a revision of the land records system is required to improve it.

(2) There are, however, certain unexplained discrepancies in the area as recorded in (1) *the "Agricultural Statistics of India" and* (2) *the Estimates of Area and Yield of principal crops in India", which should be reconciled.*

(3) Little reliance can be placed upon the figures at present adopted for the second factor, the standard normal outturn of gur per acre.

(4) The Board of Agriculture's recent proposals for arriving at an average yield are unsuitable for cane, and its standard normal outturn must continue to be ascertained directly from crop-cutting experiments.

(5) These should be more numerous, more systematic and carried out by the Agricultural Department in each Province, and the results should be reported in terms of weight of cane.

(6) The average proportion of gur to cane should be ascertained by a few carefully selected and supervised boiling tests in representative tracts.

(7) When reliable figures for a sufficient number of years are available, the average yield of the ten preceding years should be adopted in place of the standard normal outturn.

(8) Yields obtained on Government farms should be rejected for statistical purposes.

(9) The third or seasonal factor as operated under the present system tends to persistent under-estimation of yield, and should be corrected by reference to the condition figure reports of the previous ten years.

(10) As the Agricultural Department expands it should take over from the Revenue Department the duty of supplying the condition figure.

(11) The Board of Agriculture's recommendations are supported for comparing previous and present forecasts with actuals and for the appointment of an Agricultural officer with statistical training to each provincial Agricultural Department for statistical work, which should include forecasts and costs of cultivation.

(12) The second cane forecast should include a condition figure and the final forecast should be published not later than the end of January.

(13) A certain amount of rearrangement would considerably improve the "Agricultural Statistics of India."

(14) The "Commercial Statistics of India" should include statistics of cane crushed and sugar and molasses turned out by sugar factories.

(15) The monthly sugar price returns recommended in Chapter XIX should be reproduced in "Prices and Wages in India."

(16) The Table of up-country wholesale sugar prices should include quotations from other Provinces besides the United Provinces.

(17) The chief defects of this Table and the Table of up-country wholesale gur prices are the unreliability of the statistics and the inadequate classification of the commodities quoted.

(18) A more detailed classification will enable a more rational reporting system to be adopted with regard to the comparisons between reporting centres required.

(19) The necessary supervision and direction of the primary reporting agency should be provided by placing it under the control of the special statistical officer of the Agricultural Department recommended in item (11) *above.*

(20) Detailed improvements are suggested in other Tables of "Prices and Wages in India."

(21) Imports and exports of sugar should be recorded in tons in the "Annual Statement of Seaborne Trade."

CHAPTER XXIII.

FORMATION OF AN INDIAN SUGAR BOARD.

370. As will be evident from Chapter II, we were very greatly impressed by the manner in which the development of the sugar industry in Java has been assisted by the completeness of its organisation. Two powerful associations, independent of each other but working in the closest conjunction and entirely without assistance from Government, look after the interests of the industry one on the commercial side and one on the agricultural and manufacturing side. India has no organisation of this character. In making this statement we have not overlooked the existence of the Indian Sugar Producers' Association. That this body, which was founded in 1911, has not so far proved as useful to the industry as might have been expected was shown by the fact that several witnesses who appeared before us were unaware that the concerns they represented were members of it, though their names were included in the list supplied to us by the Association. In any case, the objects of the Association are entirely commercial, and it does not contemplate any work of the kind carried out by the Research Station Association in Java. We are emphatically of opinion that, if any progress is to be made in India, an organisation on the Java model must be evolved, though that model will require extensive modification to adapt it to Indian conditions. We realise that in the present backward state of the industry Government assistance will be essential both financially and in other ways to the success of such an organisation for some time to come, and that, therefore, its character must at the outset be largely official. But we consider it of great importance that the scheme for its constitution should be so framed as to enable it eventually to be handed over almost entirely to non-official agency; and in the proposals we submit below we have kept this aim steadily in view. We regret that here also we have been unable to carry our colleague Mr. Padshah with us; and we must refer to section XII of his Supplementary Note for the form of organisation which he considers necessary for the industry.

Need for organisation of the Indian sugar industry.

371. We recommend that a strong permanent Board, which might be known as the Indian Sugar Board, should be immediately established. In view of the functions which we propose should be assigned to the Board, we consider that its numbers should be kept as low as possible and that it should consist of the following official and non-official members—

Formation of an Indian Sugar Board proposed.

The Agricultural Adviser to the Government of India

The Director General of Commercial Intelligence.

The Director of the Imperial Sugar Research Institute the establishment of which we recommend below.

Two agricultural experts from the cane growing Provinces.

Two growers of cane.

Two manufacturers.

Two representatives of general business interests.

The three first of these would be *ex-officio members*. The two agricultural experts would be members of the Indian Agricultural Service. It may be thought that we have provided insufficient representation for the Agricultural Department on the Board in view of the importance of the cane crop in many Provinces; but, as will be seen below, we propose that all research work on cane should be taken over by an Imperial Sugar Research Institute. Further, it will always be possible to co-opt an agriculturist from any Province to the Board when the problems of that Province come under discussion. The Board will thus consist of five official and six non-official members. Our reason for proposing a non-official majority will be gathered from what has been said above. We look forward to the time when the Board will be almost entirely a non-official body; and, notwithstanding that, at the outset, the funds to enable the Board to carry out the functions assigned to it must be mainly provided by Government, we consider that its constitution should be such as to emphasise that this is the ultimate aim. There are some of us who consider that, as the administration of large Government funds will be in the hands of the Board, and as it is doubtful whether it will be possible to find a non-official Chairman who would be willing to devote the time and energy which will be required, if the Board is to be a live institution, the Agricultural Adviser to the Government of India should, for the present, be *ex-officio* Chairman of the Board. The majority of us, however, recommend that the election of the Chairman should be left to the Board itself, but should be subject to the approval of Government; as they are of opinion that the industry should realise from the commencement that its future must lie in its own hands and that Government can only assist it up to a point. They would have no objection to the election of an official, such as the Agricultural Adviser, as Chairman; and are of opinion that, if a non-official Chairman is elected, the post should be an honorary one. We are agreed that the members of the Board other than the three *ex-officio* members should be nominated by Government in the first instance; but we consider that one of the first duties of this Board should be to evolve a scheme for securing the representation on it of the various branches of the industry by some method other than Government nomination. In doing so they will no doubt give full consideration to the organisation of the General Syndicate of Sugar Manufacturers in the Netherlands Indies, which we have described in Chapter II. Whatever scheme may eventually be adopted, provision should be made for obtaining the considered opinion of the industry itself not only in regard to the direct representatives of its own interests but in regard to the two agricultural experts who will hold seats on the Board. The members of the Board should, as soon as proper representation is secured, hold office for three years. Membership would be honorary, but members would receive the usual travelling and other allowances for attending meetings.

372. The most important function of the Sugar Board would be the general control of the policy of the Sugar Research Institute which we consider, equally with the Board itself, to be essential to the development of the Indian sugar industry. It cannot be too strongly emphasised that India with some 2¾ million acres under cane has only one whole time expert working on that crop, whereas Java with its

Imperial Sugar Research Institute proposed.

400,000 acres has more than 25. The agricultural officers in the Provinces whose other duties have permitted them to pay any attention to cane are few and scattered and are frequently not in touch with what is being done outside their own Provinces. There is no central authority of any kind to which the industry can turn for assistance on the chemical and engineering sides. We, therefore, propose that a Sugar Research Institute on the most modern lines should be established, the work of which would, as in Java, be carried on in three departments—or divisions, as we should prefer to call them in India, so as to avoid possible confusion with existing nomenclature,—agricultural, chemical and engineering. As regards the relationship of these divisions to each other, we consider that the model of the Agricultural Research Institute at Pusa is one which might suitably be followed. The heads of the three divisions would be entirely independent of each other, but would, as at Pusa, in administrative matters be under the control of the Director of the Institute. We are of opinion that a Director for the whole Institute is necessary for several reasons. In the first place, the Chairman of the Sugar Board, whether an official or a non-official, will not be a wholetime officer as is the President of the Board of the Research Station Association in Java, to which the heads of the scientific departments at Semarang and Pasoeroean are responsible. In the second place, we consider that the Director should be largely a touring officer and should stand in much the same relationship to the sugar work of the Provinces as the Agricultural Adviser does to general agricultural development. In the third place, the Institute will take over the work of the present Sugar Bureau. One of its functions will, therefore, be the collection and dissemination of information of a general character falling outside the scope of a particular division. The publication of the sugarcane forecast, which we consider might eventually be taken over by the Institute, and the collection of information regarding the cane and beet crops of other countries furnish examples of what is meant. Whilst each of the divisions would be responsible for its own publications, the Director would be in general charge of the publication work of the Institute, as the Agricultural Adviser is of that at Pusa. The Institute should publish an annual review of the general sugar position with special reference to the Indian crop. In this matter, and in regard to such matters as programmes of work, possible overlapping of the work of the three divisions and similar subjects, the Director and the Heads of the three divisions would form a Council of which the Director would be Chairman and in which he would have the casting vote. In order to ensure relief from routine work, the Director should have the assistance of a Secretary who would also be Secretary of the Sugar Board and of the Council of the Institute.

Functions of the Institute and recruitment of its officers.

373. We do not consider it necessary to specify in detail the work which would be carried on by the Sugar Research Institute. The references to it which we have made in preceding Chapters and, above all, the full description in Chapter II of the work which is being done at Pasoeroean and Semarang are sufficient, in our opinion, to show the character of the main problems which it will attempt to solve. We would, therefore, merely add that it will be called upon to deal with other questions which are peculiar to India as compared with other cane growing countries. An important range of such questions would be a consideration of the needs on the crushing and manufacturing side of the cultivator who does not grow cane for a factory, such as improved bullock mills, small power crushing plant and the manufacture of gur. Again, we think that the Institute should investigate the possibilities of beet sugar in India, a question which, as we have shown in Chapter XVI above, has hardly been touched. It should also render what assistance it can to the palm sugar industry.

It will be obvious that, to ensure the successful establishment of such an Institute, men of very high qualifications will be required and that it will be necessary to offer liberal terms to attract such men. We, therefore, consider that the first Director and heads of the three divisions should be recruited on special terms according to their qualifications. The Assistants in the various divisions, the Secretary and the officer in charge of the sub-stations in each Province, the establishment of which in several Provinces we have recommended in the previous Chapters of our Report, should be recruited as members of the Indian Agricultural Service. The post of Director of the Institute or head of a division should, in ordinary circumstances, when vacated by the first holders, be filled by selection from the staff of the Institute, as, unless the latter have definite prospects of promotion before them, it will be difficult to obtain suitable men. The post of Director of the Institute might then carry not less than the same pay and status as that of the Director of a provincial Agricultural Department, whilst the post of a head of a division might carry the same pay as a post in the selection grade of the Indian Agricultural Service.

Relationship of the Institute to the provincial Agricultural Departments.

374. The exact relationship of the Institute to the local Agricultural Departments is a matter to which we have devoted much thought. In the preceding Chapters of the Report we have recommended the establishment in various Provinces of a number of sub-stations, the work on which would be carried on directly under the Research Institute. The cane breeding station at Coimbatore would also become a sub-station under the Institute. The work on these stations would be purely research work. Conducted under the control of the Sugar Research Institute that work, except at Coimbatore and its subsidiary station, if any, where cane breeding would continue to be carried on, would be briefly to test both local and imported varieties as well as canes evolved at Coimbatore in order to discover the most suitable cane for the local conditions, to work out the best methods of cultivation for such cane, to secure as far as possible the control and elimination of disease by the adoption of proper methods of cultivation, and to discover the most satisfactory way in which to manufacture gur in tracts in which it is of importance. Once the right varieties of cane are discovered, the work of propagating and distributing them will be taken over by the provincial Agricultural Department. We wish to make it clear that we are not proposing that all work on cane should be taken over by an Imperial Department. We realise that centralisation of this character is both impossible and undesirable. What we propose is that the research work for which, in our opinion, a central Institute with sub-stations staffed by fully qualified officers and properly equipped is essential, should be undertaken by an Imperial Department. An authority will thus be provided to which both the provincial Agricultural Departments and factories will be able to turn for advice and assistance. We believe that the inclusion in our scheme of sub-stations in the principal cane areas of India working under the Central Institute will remove the main objection hitherto raised to the centralisation of research work, which is that it is not possible for the staff of a Central Institute to keep in touch with local conditions. As will be understood from what has been said above, we consider that the distribution of new and improved varieties, demonstration of improved methods of agriculture and propaganda should remain under the direct control of the local Agricultural Department. Deputy Directors of Agriculture must continue to be the medium by which the results of the investigations of the research officers are introduced into the local agricultural practice. As a general rule, therefore, no canes should be given out by the Institute or the sub-stations except through the local Agricultural Departments; but we would make

an exception in favour of factories growing their own cane, who should be allowed to communicate directly with the agricultural division of the Institute. In all cases, however, in which canes are given out to such factories the Institute should immediately inform the provincial Agricultural Department concerned. Factories would, of course, communicate directly with the engineering and chemical divisions of the Institute.

375. Before we leave this subject we propose to discuss frankly a difficulty regarding which we are aware that some whose opinions are entitled to respect entertain considerable misgiving. Stated briefly, it is is that the separation of research and demonstration which our scheme involves, and is indeed designed to secure, may occasion heart-burnings which would in practice tend to nullify the benefits of what is otherwise admitted to be a distinct administrative improvement. There are two aspects of this separation of functions, we understand, which are regarded as likely to contribute to the difficulty. In the first place, there is the distribution of the work between an Imperial and a provincial organisation on the score of which the Imperial Agricultural Research Institute at Pusa has not altogether escaped criticism in the past. The validity of that criticism it is not for us to examine; but, assuming its validity for the moment, we would point out that the Imperial Sugar Research organisation we propose is differentiated from Pusa by the facts not only that it will work through local branches or sub-stations in close touch with the provincial Agricultural Departments but that the status and pay of its officers will be on precisely the same footing as those of the provincial officers with whom they will co-operate. Even, therefore, if the old sense of inequality between officers of the Imperial and provincial departments, which of course is no monopoly of the Agricultural Service, should contrary to our anticipation survive the new order of things inaugurated by the Reforms Scheme, there is nothing in our proposals which from the administrative point of view could give rise to dissatisfaction on the ground of an unfair distribution either of authority or of privilege.

The difficulties involved.

(a) in the separation of administrative functions.

376. There remains, however, the scientific aspect of the question which is, to our mind, the more important of the two. It would be idle to deny the existence in some quarters of the Agricultural Service at least of an impression that demonstration work is of a definitely inferior order to research work. If the effects of that impression have not as yet been conspicuous, this is due to the smallness of the Department in most Provinces in comparison with the vastness of the task before it. Every officer of the Department, the Deputy Director as well as the Agricultural Chemist and Botanist and Entomologist, has hitherto had to shoulder his share of the burden of research to the inevitable detriment of demonstration which will always suffer so long as it has a claim on only a part of the attention of the officers to whom it is entrusted. A material expansion of the Department in practically all Provinces, however, has now been sanctioned; and as it is carried into effect the Indian public will naturally and rightly look for a great acceleration in the process of spreading agricultural improvements for which the Department was called into being. And we are profoundly convinced that that object will not be realised as fully as it ought to be realised so long as demonstration is not given the recognition and the esteem it deserves. Demonstration is not the handmaid of research, but its full and equal partner. It is hardly an exaggeration to say that research without demonstration is

(b) in the separation of scientific functions.

as useless to Indian agriculture as demonstration without research. It is not, perhaps, surprising that the agricultural officer, fresh from his studies, in whatever branch of scientific agriculture, should sometimes betray a predisposition to see in the laboratory and the research station, in the publication of treatises and the commendation of fellow scientists the whole future and aim of his life's work in India. It is a defect of his training for which his subsequent experience must provide the remedy, for experience will show him that with the achievement of the most definite results on the Government farm the problem of improving Indian agriculture has only begun. The task of disseminating those results calls for a concentration undistracted by other labours and for attainments and qualities of the highest order. Demonstration requires its full share of the best men in the Department; and it has work to give them in every way worthy of their abilities. It offers constant opportunity both for the use and the enlargement of their scientific knowledge in the observation of existing agricultural conditions and practice and in detecting local variations of behaviour and result upon the conclusions established at the research stations. For the enthusiasm and patience which always imbue the true scientist they will find no less scope in touch with the realities of Indian rural life than they found in pure research; while human sympathy and understanding will be required of them in greater measure than before. There is thus no valid ground for holding that, if the functions of research and demonstration are separated in the interests of efficiency, any invidious distinction will be involved. Each is in the same degree essential to the solution of the great problem of promoting the ryot's prosperity: each is in the same degree dependent on the other for assistance to that end. And it is because we are persuaded that progress will be hampered until this separation of functions is effected that we advocate it most strongly in the interests of improved cane cultivation. The organisation we propose provides for co-operation between its two constituent branches on an equal footing in all respects; and it is with a view to ensure harmonious relations that we have recommended that the Director of the Sugar Research Institute should be a touring officer in close personal touch with the work on cane which is being done in the Provinces and that the Agricultural Adviser should be a fellow-member with him of the Sugar Board. The position of factories in relation to the Institute will be somewhat different. We trust that, as a result of the recommendations we have made in regard to leases and grants of land, factories will be in a position to control the cultivation of their supplies of cane to a large extent. If this anticipation is realised, it is probable that a group of factories may desire to have an adviser of their own on the agricultural side and may be willing themselves to meet the cost of such an appointment. Such an attitude is to be encouraged; but we consider that the officer should be provided by the Institute and should work under its control. The gradual expansion of this system would facilitate progress towards handing over the Institute to the industry itself subject to the reservation we make below.

377. As stated at the commencement of this Chapter, our aim has been to provide the sugar industry in India with an organisation which can eventually be handed over almost entirely to non-official control. We realise that the time for this may be distant; but, as will have been observed, the organisation of the Sugar Board we have proposed involves the exercise of a large share of non-official control over the general policy of the Institute from the outset. While, therefore, we realise that the industry as a whole is at present neither extensive nor prosperous enough immediately to provide any large proportion of the funds necessary for the formation and maintenance of the Institute, we feel strongly

Maintenance of the Institute.

(a) in the immediate future.

not only that Government should expect it to contribute within the limit of its means but that the industry itself will recognise self-interest in doing so as well as obligation. For it is inevitable that it will, through its representatives on the Board, speak with the greater influence and authority according as it speaks with the voice of a partner rather than a beneficiary. At the same time we think Government would be well advised to entrust the task of evolving a practical system of contribution to the first representative Board. As soon, therefore, as the scheme of representation contemplated in paragraph 371 above has been set in operation, it should be the object of the new Board to evolve such a system as will command both the full co-operation of the industry and the approval of Government. We have no desire to fetter the discretion of the Board in its task; but since the whole object we have in view is that its non-official element should, as the industry expands, progressively assume a more preponderating share both of the cost and control of the Research Institute, we should perhaps indicate what is, in our view, the ultimate goal to be aimed at and the lines along which, as it seems to us, it is most likely to be attained.

(b) ultimately.

378. As we have mentioned in Chapter II, the funds for research work on cane in Java, amounting in 1919 to about Rs. 12 lakhs, are provided entirely by the industry itself by means of a voluntary levy which is equivalent to about Rs. 3 on every acre of land cultivated by each constituent factory or plantation, subject to a maximum contribution of Rs. 8,750. While we have already said that the Indian industry should be asked similarly to contribute towards the cost of cane research work in its own interests, we would point out that, even though there should be a great extension of the system of factories cultivating land which they own themselves or have leased, numerous cases will remain in which this arrangement will either not be possible at all or only partially so, and in which factories will have to depend, as at present, on cane purchased from cultivators or on gur or on both. A levy on each ton of sugar manufactured seems thus more suited to Indian conditions than one based on acreage. The main obstacle in the way of a voluntary levy is the large acreage of cane which, however greatly the factory system extends, will still be grown for conversion into gur or for chewing purposes. The area of cane not cultivated by factories in Java is negligible. It will, as far as can be foreseen, never be so in India. The Institute the establishment of which we have recommended is not intended for the benefit of factories alone. Its object is to assist all growers of cane alike, no matter how small the area they grow, and to bring about an improvement in the methods of gur manufacture equally with those of sugar. Government cannot relieve themselves of their responsibility for the interests of the small cultivator. Even if the Research Institute were handed over entirely to non-official agency, they would, of course, continue to look after those interests as they do at present, through the provincial Agricultural Departments ; but it is essential that the latter should still be able to avail themselves of the work of the Research Institute. If funds for the Research Institute were provided by a levy on factories and the control of the Institute were handed over entirely to a non-official body, it would be only natural for the Institute to be regarded as working in the interests of factories alone, and that the interests of the small cane grower would be considered as outside its scope. A voluntary levy on all cane lands in India is obviously impracticable; and, even if such a levy were confined to holdings above a certain size, the difficulties of collection would prove insuperable. A compulsory levy is equally out of the question, apart from the fact that the Government of India have recently declared themselves opposed to the policy of imposing a general cess which shall be earmarked for the improvement of a particular crop. It is true that a recent Ordinance

of the Government of British Guiana prescribes a levy not exceeding one dollar per acre upon all lands under cane cultivation, provided that no assessment is made when less than twenty-five acres of cane are grown by one person. The fund so collected is administered by a Committee which consists of six persons elected by the British Guiana Planters' Association, and of which the Director of Science and Agriculture is *ex-officio* Chairman. Such a high minimum area is, however, obviously unsuited to India and experience in a small colony affords no criterion of what can be done in a large empire. A compulsory levy not being practicable in India and a voluntary levy being only partially so, that is, in the case of factories but not of cane lands, we conclude that the only solution is to be found in a voluntary levy combined with a Government subsidy. Even when the industry is in a position to take over the whole Institute, we would, therefore, suggest that, in order to ensure the necessary assistance to the cultivator who does not grow cane for a factory, the Government should grant the Indian Sugar Board a subsidy, and in right of such subsidy should continue to appoint one official member to the Board who might be the Agricultural Adviser to the Government of India. It might also be of advantage to the Board if the Director General, Commercial Intelligence, continued to be a member of it ; but we would leave this to the Board itself to decide. The amount of such a subsidy would, of course, depend on the position of the industry when the Institute was taken over by it. As regards the position of the staff of the Institute including its sub-stations when the Government connection with it ceases except to the extent just proposed, we consider that all officers willing to serve under the reorganised Sugar Board should continue to be regarded as Government servants for the period of their engagement or until retirement and should be seconded for that period. If any officers are unwilling so to serve, efforts should be made to provide suitable posts for them elsewhere, *e.g.*, by absorption into the ordinary ranks of the Agricultural or Industrial Department and, if this proves impossible, they should be permitted to retire on proportionate pensions.

Functions of the Sugar Board.

379. As we have stated above, the most important function of the Sugar Board would be the general control of the policy of the Research Institute. Whilst the Director would be left a wide discretion in administrative matters and there would be no interference by the Board in technical details, the Board would be responsible to Government for the proper administration of the funds allotted to the Institute and for ensuring that the work of the latter was carried on in the manner best calculated to promote the development of the Indian sugar industry. The Board would also advise both the Government of India and Local Governments in regard to any question of policy relating to the sugar industry, and would be consulted by Government in regard to any legislation on matters connected with sugar or rules framed under such legislation. It would keep in close touch with economic and other conditions in the cane growing tracts, and would suggest any measures it considered desirable to meet the changes in these conditions which may occur. For the reasons we give in paragraph 381 below, it would scrutinise the forms of returns sent out by the Research Institute, and no proceedings for failure to submit returns would be undertaken except on its complaint. We need hardly add that our recommendations do not preclude Government from consulting any other bodies connected with the sugar industry existing at present or which may be formed in the future. We look forward to the time when the manufacturing industry in India will have a strong body to represent it on the commercial side, corresponding to the General Syndicate of Sugar Manufacturers in Java and working either in close conjunction or complete fusion with the proposed Sugar Board.

380. It is obviously impossible to give more than the roughest estimate of the cost of the proposals under this head. As the Secretary of the Sugar Board will also be Secretary of the Research Institute, and as membership of the Board will be honorary, the cost of the Sugar Board itself will be small, being merely that involved in the travelling and halting allowances of its members. We have endeavoured to frame an approximate estimate of the cost of the Research Institute and its sub-stations and consider that the lowest figure at which the initial charges can be put is some 35½ lakhs. The figures on which this estimate is based are given in Appendix VI, and it will be seen that we have included also the cost of the cane breeding stations and of the Sugar School dealt with in our next two Chapters. The recurring charges are still more difficult to estimate, since these depend not only on the salaries on which the first Director and heads of divisions are recruited but on the extent of the subordinate staff found necessary as well as on other indeterminable factors such as methods of cultivation employed. In similar circumstances the Indian Cotton Committee based their calculation of recurring cost on the number of additional posts in the Indian Agricultural Service involved in their proposals and took Rs. 50,000 per post as a fair average cost per annum of a Director, Deputy Director or other scientific officer, and his subordinate establishment, etc. This figure agrees fairly well with the Rs. 44,000 a year which the cane breeding expert and his station at Coimbatore have cost, allowing for certain savings which his use of accommodation in the Agricultural College, Coimbatore, has effected. Rates of pay, however, in all branches of the Agricultural Department have just been substantially enhanced and incidental expenditure is likely to increase also. If provision is made for this and for the additional cost involved in the attachment of a Sugar School to the Central Reseach Institute, we think Rs. 70,000 must be taken as a more representative figure. In addition to the ten posts in the Imperial (or Class I) Service which our proposals for the Central Research Institute involve and the post of cane breeding expert, the permanent retention of which we shall recommend in Chapter XXIV, we have advocated in our provincial Chapters the creation of whole-time posts of cane research officers for the United Provinces, Bihar and Orissa, the Punjab, Assam, Burma, Madras and Bombay, or seven in all. Only on the Bihar and Orissa cadre does a sanctioned post exist to fill the appointment recommended. The existing post of cane breeding expert is only on a temporary basis and no account can fairly be taken of it. In all, therefore, we recommend the creation of 17 new appointments, immediately or eventually to be incorporated in the Indian Agricultural Service, the recurring cost of which, with their subordinate establishments and incidental expenditure, will thus be Rs. 11,90,000 or in round numbers Rs. 12 lakhs per annum. This estimate, we are aware, makes no provision beyond establishment charges for the upkeep and cultivation of the various research stations. We would point out that, judging from experience at Shahjahanpur, the sub-stations should not only pay their own way but yield a margin of profit, even when the cost of supervision is included. In justification of this statement we attach, as Appendix VII, a typical budget of the Shahjahanpur farm. The net recurring cost of our proposals should accordingly be very much less than the figure indicated, and be practically confined to charges on account of the Sugar Research Institute itself and the Sugar School which will be associated with it. Whilst the budget of the Institute would be submitted to Government and approved by them, we consider that the Sugar Board should have full powers to vary details within the limit of the budget allotment. We are also of opinion that the ordinary account rules should be relaxed so as to permit any margin derived from the successful working of the research stations to be devoted to the expansion of the activities of the Institute.

Cost of our proposals.

381. The proposals we have submitted in this Chapter will involve legislation on one point, namely, in regard to the submission by factories of returns to the Research Institute. We are of opinion that, in return for the very liberal measure of assistance the sugar manufacturing industry will receive, if our proposals are accepted, it is only reasonable that factories on their part should furnish the Research Institute with any information it requires. As stated in Chapter II, we were greatly impressed by the completeness of the information supplied by the factories in Java to the scientific departments of the Research Station Association at Pasoeroean and Semarang, and by the absence of any objection to the publication of these results, as it is realised that such publication is in the best interests of all factories. We have noticed with regret that there is in India, generally speaking, great reluctance to allow any information in regard to the working of a factory to be known outside the factory itself. If the Research Institute is to be of real service to the sugar industry, it must be in possession of as complete data as can be obtained. We have little doubt that the majority of factory owners will realise this and will be ready to co-operate, but it is obviously desirable that the practice in this respect should be uniform ; and, in order to ensure this, we recommend that the submission of any returns required by the Research Institute should be made compulsory, by legislation. The principle of compulsory submission of returns by factories has already been accepted in sections 18 (2) and 15 (1) (*i*) of the Indian Factories Act (XV of 1881) ; and we consider that these provisions should be extended to cover the submission of returns to the Sugar Board. We are aware that, in the present backward condition of the Indian industry some time must elapse before most factories will be in a position to submit as full returns as those which are submitted in Java ; and it is for this reason that we would allot to the Sugar Board as one of its functions the scrutiny of the forms of return prescribed by the Institute with the object of seeing that its requests for information are reasonable. No proceedings for failure to submit a return should be undertaken except on the complaint of the Board. The question whether any returns should be treated as confidential would be a matter for the discretion of the Board.

Legislation involved.

382. As in the case of the Government factory, the exact location of the Sugar Research Institute is a matter which will require careful investigation. It would obviously be advantageous, if the Government factory and the Research Institute could be established in the same place ; but this, we consider, is precluded by the difference in the objects they are intended to serve. The Government factory will be a pioneer factory, and must therefore, be located in a tract which is at present untouched by the factory industry. The Research Institute must, on the other hand, be placed where it can not only render as great measure of assistance as possible to the existing industry but also deal with the problems of the cane growing tracts where factories have yet to come into being. The majority of the factories in India are in the east of the United Provinces and North Bihar. Whilst, therefore, the Research Institute should be in fairly close proximity to this tract, it must be established in a district the climatic conditions of which do not differ too greatly from those which prevail further west and north, in other words, where they are, as far as possible, representative of the whole of the great cane growing tract of India which extends from central Punjab through the United Provinces to the east of Bihar. After careful consideration, we are of opinion that a site in the Basti or Kheri district of the United Provinces would most nearly fulfil the requirements we have postulated. Whilst climatic conditions in Basti, where frost seldom occurs, approximate

Site of the Research Institute and headquarters of the Sugar Board.

nearly both to those of the adjacent district of Gorakhpur, (the area under cane in which is larger than in any other district of the United Provinces except Meerut and exceeds the whole cane area in Madras or Bombay), and to those of North Bihar, there is yet a sufficiently marked difference to render it possible for the Institute, if located in this district, to attack the problems of Rohilkhand, Meerut and the Punjab. Kheri, the area under cane in which is much the same as in Basti, *viz.*, about 50,000 acres, is, it is true, farther away from the factory area, but its climatic conditions are perhaps more representative of North India as a whole. It is, moreover, a district, a large part of which will come under irrigation from the Sarda Canal system, under which we anticipate a considerable extension of cane growing ; and the Research Institute, if located there, would be in a better position than in Basti to work out the problems arising on the three classes of cane land, land irrigated from canals, land irrigated from wells and land dependent on rainfall. One point of great importance in connection with the location of the Research Institute is accessibility. From this point of view it is unfortunate that neither of the districts we have suggested as suitable can be reached by a broad gauge line of railway ; though Basti is traversed by the main line of the Bengal North-Western Railway and Kheri by that of the Rohilkhand-Kumaon Railway, both metre gauge systems. This is a difficulty which cannot be overcome, if the Institute is to be placed where it will be most useful ; but we would insist that it should be near a railway station, as we cannot but think that the situation of Pusa several miles from a station on a branch line has been a serious handicap on its utility as an all India Institution.

Whatever the site ultimately selected for the Sugar Research Institute, its close association with the Sugar Board in the organisation we have proposed necessitates, in our opinion, the adoption of the same place as the headquarters of the Board. The maintenance of a close and intimate knowledge of the work of the Institute is essential to every member of the Board, if he is adequately to discharge his functions of control ; and the Board's meetings should furnish a valuable opportunity of acquiring that knowledge. While, therefore, we would allow the Chairman to convene meetings at any other more central place, when necessary, as for example on an occasion of emergency, we hold strongly that ordinary meetings of the Board should be held, as far as possible, at the Research Institute even at the cost of some personal inconvenience to members.

Continuance of the Sugar Bureau pending its absorption in the Institute.

383. We have proposed in paragraph 372 above that the Research Institute should take over the work of the present Sugar Bureau which was established in April, 1919 as the outcome of a Resolution passed by the Board of Agriculture in its meeting at Poona in December, 1917 that no time should be lost in starting an office for the collection and dissemination of information on all aspects of the sugar industry in India. The number of enquiries received and answered by the Bureau is in itself sufficient testimony to its usefulness, and there was a general consensus of opinion amongst the witnesses we examined that it had already amply justified its existence. The nucleus of a valuable library has been formed and considerable progress has been made in the collection and indexing of all the literature on sugar published in India, though work in this direction has been hampered by the heavy demands for information which have been made on the small staff of the Bureau. We have no hesitation in recommending that the Bureau should continue on its present lines until it is absorbed in the Research Institute.

Position of Native States.

384. In concluding this Chapter a word should be said about the position of Native States in regard to the proposals. Native States of India, with the exceptions of Hyderabad and Mysore, are not at present important cane growing tracts ; and, though we have discussed in Chapters XIII and XIV above the possibility of development in Hyderabad and Mysore, the average area under cane in those States during the last five years has only been about 30,000 and 37,500 acres respectively. In these circumstances there is not sufficient justification for proposing that Native States should be requested to contribute to the maintenance of the Institute. At the same time, we do not consider that the benefits of the Institute should be confined to British India alone, and would recommend that Native States should be encouraged to call upon its officers for advice and assistance. We would further suggest that, if any Native State wishes to open a sub-station under the Research Institute on the same lines as we have proposed for such stations in British Provinces, and is willing to meet the cost, if any, involved in the maintenance of such a station, the proposal should be welcomed.

Summary of Conclusions and Recommendations.

(1) Organisation of the Indian sugar industry on the Java model is essential to progress.

(2) At the outset this organisation must be largely official ; but the object should be eventually to hand it over almost entirely to non-official control.

(3) It should take the form of an Indian Sugar Board with five official and six non-official members.

(4) In the first instance all members will have to be nominated by Government ; but the first duty of the Board should be to evolve a scheme to secure representative appointments.

(5) Members should then hold office for three years and their tenure should be honorary.

(6) An Imperial Sugar Research Institute should be established with three divisions, agricultural, chemical and engineering, each with its own independent head ; and it should control the work on the various research stations already proposed for the Provinces.

(7) A Director is required for the administrative control of the whole Institute and to keep in touch with the sugar work of the Provinces.

(8) In addition to the more obvious lines of work the Institute should consider the needs of the small gur manufacturer, investigate the possibilities of beet sugar production and assist the palm sugar industry.

(9) The first Director and heads of divisions should be recruited on special terms, and other officers of the research organisation as members of the Indian Agricultural Service.

(10) Subsequent Directors and heads of divisions should be appointed by promotion and given the status and pay of provincial Directors of Agriculture and officers in the selection grade of the Indian Agricultural Service respectively.

(11) It is only research work on cane that would be taken over by the Institute and its sub-stations; and the local Agricultural Departments would remain responsible for distribution of improved varieties, demonstration and propaganda.

(12) As an exceptional case, the Institute might, with the knowledge of the local Department, issue canes direct to factories controlling their own cultivation.

(13) The objection that the Committee's scheme would be difficult to work because it involves a separation of functions (a) *between Imperial and provincial and* (b) *between research and demonstration is met* (a) *by the provision for local research stations and equality of pay and status in the two branches and* (b) *by the facts that in Indian agriculture demonstration is as important as research and requires equally high attainments, so that no invidious distinctions are involved, and that separation is now essential to progress in agricultural improvement.*

(14) Factories should be encouraged to maintain their own agricultural advisers provided and controlled by the Sugar Research Institute.

(15) The sugar industry should be expected to contribute towards the cost of the Institute from the outset; and the first representative Board should evolve a practical system of contribution.

(16) Peculiar conditions in India, especially the importance of the gur industry, preclude the complete elimination of Government interest in the Institute; and when the industry is in a position to take over the main control, its funds should be provided by a voluntary levy on factories supplemented by a Government subsidy to ensure consideration of the interests of the small grower.

(17) The functions of the Sugar Board would be to control the politcy of the Research Institute and the administration of its funds, to advise Government on matters affecting the sugar industry, and to supervise the issue and receipt of returns by the Institute.

(18) The cost of the Sugar Board would be negligible: that of the Research Institute, the Sugar School and the sub-stations is estimated at 35½ lakhs non-recurring and 12 lakhs recurring, but the latter should be largely reduced by the earnings of the sub-stations.

(19) Profits on the research stations should be devoted to the expansion of the activities of the Institute.

(20) The submission by factories to the Institute of returns approved by the Board should be made compulsory by legislation; but proceedings for default should only be taken on the complaint of the Board.

(21) The Research Institute should be located where it can serve not only the existing factory industry of Upper India but also the great cane tract further west and north; and a site in the Basti or Kheri district of the United Provinces would fulfil these requirements.

(22) The same place should be adopted as the head-quarters of the Board, though the Chairman should have power in case of necessity to convene meetings elsewhere.

(23) The Sugar Bureau should be continued pending its absorption in the Research Institute.

(24) Native States should not be asked to contribute to the maintenance of the Research Institute, but should be encouraged to seek the help of its officers and to open research stations under it.

CHAPTER XXIV.

COIMBATORE.

History of the cane-breeding station.

385. The proposal for the establishment of an acclimatisation and cane-breeding station in Madras emanated from the Board of Agriculture in India at its seventh meeting in November, 1911, when the general question of the improvement of the Indian sugar industry was discussed. Such a station was regarded as essential for the botanical improvement of canes in India; and of the three main sources of improved varieties, namely (1) bud variations, or sports, consisting of mutations rising spontaneously in the fields, (2) selections, including the acclimatisation of exotic varieties and (3) the cross-breeding of seedlings, it was pointed out that the last postulated the ability of the canes to arrow and to produce fertile pollen. So far as had been then ascertained, this only occurred in Madras and that Presidency was consequently selected for the location of the proposed station. The recommendation of the Board was accepted by the Government of India, who, with the concurrence of the Government of Madras, in June, 1912 obtained the Secretary of State's sanction to the opening of the station at Coimbatore, the headquarters of agricultural research in Madras near the southern slopes of the Nilgiris, and the appointment to its control of Dr. C. A. Barber, Economic Botanist to the Government of Madras, for a period of five years. It was then contemplated that, on the retirement of Dr. Barber, the management of the station might be entrusted to his successor as Madras Economic Botanist in addition to the regular duties of the post. It was laid down that the officer appointed to the charge of the cane-breeding station would be expected to tour throughout India, and to use his appointment for the benefit of all Provinces alike; and the Imperial character of the station was marked by the allotment of Rs. 2½ lakhs from Imperial revenues to cover the estimated expenditure, both initial and recurring, throughout the five year period of sanction. In view, however, of the fact that Dr. Barber would be working in close communication with the officers of the Madras Agricultural College at Coimbatore, and that questions of a petty character regarding the limitations of his functions and rights were likely to arise, it was considered better to leave the control of his appointment with the provincial Government. Office and laboratory accommodation were provided in the Agricultural College, and Dr. Barber entered on his duties in October, 1912; though a special area for the cane-breeding experiments was not acquired till April, 1913, the first seedlings being grown in the Botanic Garden, Coimbatore. The soil of the experimental area was of the dry, garden type, irrigated from wells; as the main object of the station was to breed seedlings for the important cane tracts of Northern India, and the wet land on

which cane is ordinarily grown in Madras was not considered suitable for this purpose. The soil was somewhat saline and unfit for cane at the outset, but this was rectified by a dressing of tank silt followed by deep ploughing and a crop of irrigated *juar* (*Andropogon sorghum*). Field bean (*Dolichos lablab*) was then grown as a green manure and ploughed in ; after which the land was thoroughly drained and prepared, and cane sets were planted in trenches. As a result of this treatment, the growth of North Indian canes on the station is now excellent.

At its ninth meeting held in February, 1916, the Board of Agriculture in India, in view of the approaching expiry of the period for which the station had been sanctioned, recommended that it should be continued under general financial and administrative arrangements similar to those which had hitherto prevailed. Their recommendation was endorsed by the Madras Government, who pointed out that it was impossible for their Economic Botanist to assume charge of the station and that a whole-time officer would be required to succeed Dr. Barber, as he was shortly due to retire. The Government of India took the opportunity to raise the question whether the station should not be transferred to Imperial control under the direction of their Agricultural Adviser but, in view of the Local Government's obvious reluctance in according assent to this proposal, they dropped it and obtained the sanction of the Secretary of State to the continuance of the station for another five years and to the recruitment on special terms under a temporary agreement of a specially trained expert in cane breeding. An annual assignment of Rs. 44,000 a year was made from Imperial to provincial revenues to cover the estimated cost of the station. Dr. Barber continued to hold charge till he went on leave preparatory to retirement in April, 1919, since when the post, known officially but somewhat inaccurately as that of Government Sugarcane Expert, has been held on a temporary footing by Rao Sahib T. S. Venkataraman who was associated with Dr. Barber as his senior Botanical Assistant throughout. Efforts to obtain a thoroughly qualified expert for the post from Europe have so far been unsuccessful. The total area of the station is now 52 acres. Coimbatore, we should add, stands about 1,300 feet above sea level, and its average annual rainfall is only 22 inches.

Work done.

386. It being the main object of the cane-breeding station to replace inferior local canes all over India by others giving a higher sucrose yield per acre and at the same time capable of being grown under similar conditions of soil and climate, it was decided that the problem should be approached, in the first instance, by an attempt to raise seedlings. The following lines of work were, therefore, taken up :—

3. The testing of the permanence of their characters when seedlings are reproduced by cuttings, and ultimately when they are grown under field conditions in the locality for which they are intended.

The collection and acclimatisation of varieties was naturally a matter of time, and in the early stages the work was practically limited to the thick canes already found arrowing in the neighbourhood of Coimbatore, although the soil of the station was not really selected for nor suited to the growth of thick canes. A number of seedlings were raised from these canes, but it was recognised that the progeny of thick canes were likely to prove of very limited utility in Northern India and it was mainly to benefit this area that the cane-breeding operations were directed ; for Southern India with its tropical conditions already possessed several thick canes of good type, and was better able to profit by the introduction of high class exotics than the Provinces of subtropical India. Every effort was, therefore, made to push on the work on thin canes, over a hundred varieties of which had been collected at the station before the end of 1913. It was soon discovered that the time of planting had a marked effect on the arrowing of these canes, the ordinary planting season on garden land from February to April being unsuitable, and the last six weeks of the second season from August to November being favourable. As soon as this initial difficulty had been overcome, the policy of the station was directed to obtaining crosses between the thin, local, indigenous canes of Northern India and thick, imported, tropical varieties ; crosses of thin with thin varieties having been found to produce seedlings of almost invariably poorer quality than the parent canes. The method adopted was to select the best cane of each locality, to grow it and make it flower, to cross it with good, thick canes, and to select the best of the resultant seedlings for trial in the locality from which the thin parent cane was obtained. The range of parents has latterly been enlarged by the inclusion among them of the wild reed canes (*Saccharum spontaneum*) which exhibit the qualities of hardiness and immunity to disease in an exceptional degree, and are less strictly limited in their period of flowering than other varieties. They thus form a valuable link between the early flowering thick canes and the late flowering thin canes, whose different flowering periods render them extremely difficult to cross at all. This work of crossing has been greatly facilitated by the important discoveries that the occurrence of open anthers is an indication of the presence of fertile pollen in the male flowers—an hypothesis which has been corroborated by the Java test proving the presence of starch grains in the pollen—and that fertility in the female flower can be determined by the presence of starch grains in the stigma and style. It is not necessary to record in any detail the degree of success obtained in producing fertile seed from each variety of cane tested but, in general, it may be stated that the fullest development of arrows is found in various highly developed, thick canes of the

which cane is ordinarily grown in Madras was not considered suitable for this purpose. The soil was somewhat saline and unfit for cane at the outset, but this was rectified by a dressing of tank silt followed by deep ploughing and a crop of irrigated *juar* (*Andropogon sorghum*). Field bean (*Dolichos lablab*) was then grown as a green manure and ploughed in ; after which the land was thoroughly drained and prepared, and cane sets were planted in trenches. As a result of this treatment, the growth of North Indian canes on the station is now excellent.

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Work done.

1. The collection of as many varieties in the station as possible and their acclimatisation to the local conditions with the ulterior object of making them flower,

2. The evolution of seedlings suited to the varying conditions of soil and climate in India with a high percentage of sucrose in the juice, great vigour and good habit, and

3. The testing of the permanence of their characters when seedlings are reproduced by cuttings, and ultimately when they are grown under field conditions in the locality for which they are intended.

The collection and acclimatisation of varieties was naturally a matter of time, and in the early stages the work was practically limited to the thick canes already found arrowing in the neighbourhood of Coimbatore, although the soil of the station was not really selected for nor suited to the growth of thick canes. A number of seedlings were raised from these canes, but it was recognised that the progeny of thick canes were likely to prove of very limited utility in Northen India and it was mainly to benefit this area that the cane-breeding operations were directed ; for Southern India with its tropical conditions already possessed several thick canes of good type, and was better able to profit by the introduction of high class exotics than the Provinces of subtropical India. Every effort was, therefore, made to push on the work on thin canes, over a hundred varieties of which had been collected at the station before the end of 1913. It was soon discovered that the time of planting had a marked effect on the arrowing of these canes, the ordinary planting season on garden land from February to April being unsuitable, and the last six weeks of the second season from August to November being favourable. As soon as this initial difficulty had been overcome, the policy of the station was directed to obtaining crosses between the thin, local, indigenous canes of Northern India and thick, imported, tropical varieties ; crosses of thin with thin varieties having been found to produce seedlings of almost invariably poorer quality than the parent canes. The method adopted was to select the best cane of each locality, to grow it and make it flower, to cross it with good, thick canes, and to select the best of the resultant seedlings for trial in the locality from which the thin parent cane was obtained. The range of parents has latterly been enlarged by the inclusion among them of the wild reed canes (*Saccharum spontaneum*) which exhibit the qualities of hardiness and immunity to disease in an exceptional degree, and are less strictly limited in their period of flowering than other varieties. They thus form a valuable link between the early flowering thick canes and the late flowering thin canes, whose different flowering periods render them extremely difficult to cross at all. This work of crossing has been greatly facilitated by the important discoveries that the occurrence of open anthers is an indication of the presence of fertile pollen in the male flowers—an hypothesis which has been corroborated by the Java test proving the presence of starch grains in the pollen—and that fertility in the female flower can be determined by the presence of starch grains in the stigma and style. It is not necessary to record in any detail the degree of success obtained in producing fertile seed from each variety of cane tested but, in general, it may be stated that the fullest development of arrows is found in various highly developed, thick canes at the one extreme of cane evolution and in the most primitive class of Indian indigenous varieties commonly found in the Punjab at the other extreme. The great Saretha group is the most prolific among North Indian canes in producing masses of flowers from which any number of seedlings can be raised, but its members are liable to smut. The Sunnabile group, on the other hand, flowers sparsely and very few of its component varieties produce seedlings. The Pansahi group arrows profusely, but does not usually produce fertile pollen. In the Nargori and Mungo groups, the arrows are nearly always deformed and frequently fail to protrude from

their sheaths. The progress made in the raising and selection of seedlings, first at the Botanic Gardens, Coimbatore, and then at the cane-breeding station during the first seven years of its existence is indicated in tabular form in the statement we give below.

Statement of progress in the breeding work at the Coimbatore Cane-Breeding Station.

Year.	No. of varieties arrowed.		Seedlings raised.			Seedlings planted.		Seedlings selected for further trial.	
	Thick.	Thin.	Total.	Per cent. thick.	Per cent thin.	Thick.	Thin.	Thick.	Thin.
1911-12 ...	The cane-breeding station was not yet in existence, but a preliminary lot of 45 seedlings was planted out in the Botanic Garden, Coimbatore.								
1912-13 ...	3	3	10,600	94	6	1,650	417	168	51
1913-14 ...	*Nil*	*Nil*	22,000	91	9	2,200	200	266	3
1914-15 ...	5	4	20,000	55	45	2,060	1,340	107	115
1915-16 ...	35	36	30,000	38	62	2,000	2,100	56	148
1916-17 ...	62	34	99,000	41	59	1,400	3,400	20	136
1917-18 ...	83	52	75,000	17	83	700	4,000	*Nil*	160
1918-19 ...	19	15	10,800	3·5	96·5	*Nil*	8,200	*Nil*	128
1919-20 ...	116	86	62,000	19	81	270	7,780	...	...

NOTES.—(*a*) As in the previous year, the 19 2-13 seedlings were raised in the Botanic Gardens, Coimbatore.
(*b*) The failure of any varieties to arrow in 1913-14 was due to the fact that the land of the station was not acquired till April, 1913. The canes were consequently planted in May, the wrong time for arrowing,
(*c*) Dots indicate that the figures are not yet available.

The figures clearly indicate the steady rate at which thin seedlings have supplanted thick in the breeding work of the station, until the latter class had practically dropped out of the operations altogether prior to the last season (1919-20), when a fairly large number of thick seedlings were raised, all we understand, from new parents. The fall in the total number of seedlings raised in the last three years does not connote any reduction of activity at the station, but is due to the accumulated knowledge of earlier years facilitating the elimination of parents found undesirable for the purpose in view. The statement illustrates, of course, only the work done at Coimbatore itself ; and not the extent to which selected seedlings have been distributed for local trial in Northern India. It is only recently that the experiments have reached a stage that enabled this to be done ; the first batch of seedlings to be so distributed having been despatched in February, 1918 to 14 agricultural stations, mainly in Upper India. Up to the year 1920 this local distribution had covered a total of 33 seedling varieties ; some of which are reported to have shown considerable promise ; though further trials are necessary before they can be finally pronounced suitable to be given out to cane cultivators. Other lines of work at Coimbatore have been the classification of cane varieties, with the study of morphological and other differences inherent therein, and the acclimatisation of new varieties imported from foreign countries for direct distribution and not merely for crossing purposes. Out of some 75 varieties imported from Antigua, Barbados, Demarara, Hawaii, the Philippines, the United States of America, Mauritius, Java, New Guinea, Australia and Formosa, the varieties D 74, P. O. J. 33A and Fiji B are said to have proved most successful in this way.

Continuance of the station.

387. The Coimbatore cane-breeding station has so far been sanctioned for two short-term periods, each of five years only, the second of which expires in October, 1922. When these temporary arrangements were made, it was contemplated, not that the problem could be finally solved in the time specified, but that the work might reach a stage at which, (the main lines of progress having been determined) close and continuous supervision by a highly trained expert officer employed solely for this purpose would be unnecessary, and the detailed work could be carried out by an assistant under the general guidance of a member of the Indian Agricultural Service who would combine this with his other regular duties. Events have not fulfilled this anticipation ; and we are not surprised, for, in our opinion, it was never justified. It is true that we shall have recommendations to make below in two respects limiting and in a third respect expanding the present activities of the station as a cane-breeding centre. It is also true that the station should, we think, be called upon to add to its functions and to act in future as a cane research station for South Madras. Still, when due allowance has been made for the former modifications, and even if the latter development be ignored, we think it clear that a continuous supply of new and improved varieties of cane is as necessary in India as it is proving in other cane-growing countries and that the wide diversity of conditions of climate, of soil and of agricultural practice in the various parts of this country, combined with the exceptional scope for effecting improvements in cane cultivation, render the cane-breeding problems even more complex here than elsewhere. Detailed expert supervision by an officer thoroughly trained in the technique of cane breeding is, therefore, and must always be required for their solution ; and we have no hesitation in recommending, as the first of our proposals, the establishment on a permanent footing both of the cane-breeding station at Coimbatore and of the post of cane-breeding expert. This change will, we hope, be introduced without delay, and simultaneously should be effected the transfer of the station to Imperial control which the Government of India suggested in 1917. Whatever grounds there may have been for entrusting the work to provincial administration in its earlier stages and when the officer in charge was himself a member of the Madras Agricultural Department ; there can be none now when the work has reached a stage at which it must come into closer contact with cane research organisations and workers in other parts of India ; and when it is proposed to entrust the station to an officer recruited specially from Europe. That officer should now be recruited as a member of the sugar research organisation the creation of which we have advocated in the preceding Chapter, and he should be placed directly under the control of the head of the Agricultural division of the Sugar Research Institute. It will then be necessary for him to evacuate the laboratory and office accommodation occupied by his predecessors in the provincial Agricultural College, and complete equipment will have to be provided at the station itself together with the requisite chemical and botanical staff of assistants.

Future work of the station.

(a) Cane breeding for Northern India.

388. Except in so far as we have definite recommendations to make to the contrary, we consider that the main lines of work already started at the cane-breeding station, including that on the classification of cane varieties, should be followed up with such modifications as the practical experience of the Sugar Research Institute may render necessary form time to time. In certain respects, however, we are of opinion that the policy hitherto pursued calls for reconsideration. Our most material criticism concerns the ideal which the officers in charge of the station appear to have set more and more definitely before themselves of envolving a type or types of cane for

Upper India which will withstand the indifferent usage to which the ordinary cultivator at present subjects it and at the same time increase his yield of sucrose per acre. We realise that over a large proportion of the cane area of the Northern Provinces the spread of improved methods of cane cultivation will be slow and that the stages of improvement will be gradual ; and, in so far as the object is to obtain new varieties which will enhance the acre yield of sucrose without requiring a complete agricultural revolution, we regard it as entirely wise. But where the standard of cultivation is so low as it is in most of the cane tracts of Upper India, we are convinced that, in attempting to achieve lasting improvements by the substitution of new varieties for old without any complementary improvement in the treatment they will receive, the station is pursuing a Chimera. There are, it is true, very definite limits beyond which the thin canes of the North India type will not economically respond to scientific agricultural treatment ; and such treatment, if it is to reap its full value, requires improved varieties of cane to deal with. But it is only where the standard of cultivation is already comparatively high, that any permanent advantage is to be looked for from the spread of improved varieties without the simultaneous adoption of improved agricultural methods ; and it follows that, in our opinion, the cane tracts of Upper India offer very little scope for progress along this line of advance. Here varietal and cultural improvements must go hand in hand ; and the object of the cane-breeding station should be to evolve canes which will adapt themselves to local conditions of climate and soil, and will return profitable enhancements of yield to such improved methods of cultivation as the local agricultural authorities consider reasonably within the means of the ordinary cultivator to adopt in the near future.

389. Another respect in which the policy of the station appears to us to require modification is with regard to its system of distributing seedling found suitable for local trial. At present these seedlings are sent to any farm of the provincial Agricultural Departments on which cane is being grown ; and little regard appears to be paid to the comparative importance of the position occupied by cane in the activities of each farm or to the possibility of applying the necessary tests for the establishment of the success or failure of each variety. The insignificant number of farms on which cane has been given predominant attention, no doubt, furnished considerable excuse for this procedure in the past ; but, even so, we think that the policy was mistaken, and that it is a waste of time and money to issue seedlings to stations where cane is not an object of special study, and where the full equipment of laboratory, power mills and boiling plant necessary for a critical examination of the canes received does not exist. The average Circle farm has not the area nor the machinery ; and the average Deputy Director of Agriculture in charge of it has not the time for the extensive and detailed tests these seedlings require ; and their distribution should in future be confined to the existing stations, the constitution of which into specialised cane research stations we have proposed in our various provincial Chapters and to the new cane research stations the creation of which we have also recommended. Until the Sugar Research Institute is complete, we would suggest that the distribution of seedlings in British India should be limited to the following farms which are at present devoting considerable attention to cane problems :—

(b) System of distribution.

Shahjahanpur in the United Provinces.
Pusa in Bihar.
Gurdaspur in the Punjab.

Jorhat in Assam.
Samalkota in Madras.
Manjri in Bombay.
Tharsa in the Central Provinces.

390. The organisation of these local stations for research work on cane will facilitate a further change in the functions of the cane-breeding station which we wish to put forward. It seems to us that there is at present a tendency for the process of selection of seedlings for trial elsewhere to be carried rather further at Coimbatore than is wise, if the best practical results are to be obtained. It must be remembered that Coimbatore owes its existence as a cane-breeding station to the fact that canes can be made to produce fertile seed there, when they will not do so in Upper India. It was not chosen because it was in any way typical, either climatically or agriculturally, of the cane areas of the North. The opportunities, therefore, of deciding at Coimbatore what seedlings are and what seedlings are not likely to prove successful in the Punjab, the United Provinces or Bihar are strictly limited, and any attempt to exceed those limits may involve the rejection of seedings which would, on local trial, have proved suitable for introduction. The behaviour of a cane on the soil of the cane-breeding station is not an index of its behaviour elsewhere ; nor is it always possible, even granted the most intimate and scientific knowledge of the local conditions of another tract, to infer from results at Coimbatore the prospects of a particular cane proving successful in that tract. The breeding work of the station would, we are convinced, derive nothing but benefit from the restriction of the selection work to a purely general and preliminary survey with a view to the elimination of canes obviously unfit for any practical purpose and to the division of the rest of the seedlings raised into broad groups according as they possess certain main characteristics known to be suited to particular cane tracts. In making this selection the officer in charge of the cane-breeding station would be guided by the known requirements of each tract in respect of types, and by the periodical reports received from the cane research stations of each Province by the Agricultural division of the Sugar Research Institute. The critical and final tests necessary for a more detailed selection would then be made at the cane research stations, to the officers in charge of which much of the selection work now attempted at Coimbatore would thus be entrusted; and the cane-breeding station would be freed to devote more whole-hearted attention to the breeding side of the work.

(c) System of selection of seedlings.

391. Another line of work at present pursued which should, we think, be discontinued on the formation of the Sugar Research Institute is that of acclimatising canes imported from foreign countries for direct distribution to other parts of India. We do not overlook the fact that the station was originally constituted as an acclimatisation (as well as cane-breeding) station. From a careful perusal of the proceedings of the Board of Agriculture in India of 1911, which originated this proposal, we gather that the reasons which weighed with the Board in supporting this combination of activities were that acclimatisation of exotic canes had already been practised with success in Madras, that the cane industry was well developed there and that the cultivators could command the necessary capital. Our Chapter on Madras indicates that we are wholly unable to endorse at least one of these premisses ; but their accuracy or otherwise is of no moment : for none of them in any way supports the initiation of acclimatisation work at Coimbatore for other Provinces in India than Madras itself ; and even there the

(d) Discontinuance of acclimatisation work.

experience of Samalkota has shown that over-centralisation leads to frequent failure. The fact that up to the present the cane-breeding expert has been the only officer in India allowed by the rules framed under the Destructive Insects and Pests Act (II of 1914) to import canes direct from foreign countries without an official certificate from the country of origin that they are free from pests and diseases has, perhaps, furnished some justification for the practice ; but we have already advised in paragraph 248 of Chapter XV that this power should be transferred to the Director of the Sugar Research Institute as soon as it comes into being. We recommend, therefore, that all attempts to acclimatise exotic canes at the cane-breeding station for direct distribution elsewhere than to the southern districts of Madras should be abandoned as outside the scope of the station.

(e) Breeding of thick canes.

392. There is, on the other hand, one important respect in which we should be glad to see the breeding operations extended. We have already pointed out that until last season (1919-20), thick canes had almost totally disappeared from the list of seedlings obtained ; and have emphasised in our Chapters on Madras and Bombay the importance of evolving new thick varieties for those Provinces instead of depending solely on the acclimatisation of exotics. To these Provinces we would add not only the Peninsula generally but also Burma and Assam, where the prospects of developing a factory industry are exceptionally promising, and where the demand for a constant supply of new varieties of thick and medium canes may shortly be insistent. We were informed that of the total area of 52 acres on the station only 6 acres were really suitable for the cultivation of thick canes, and, if this is true, we would recommend that the latter area should be increased as soon as possible by 25 or 30 acres, and that the breeding of thick and medium canes for those Provinces to which they are specially adapted should be accorded an important place in all future programmes of work. This leaves some 46 acres for breeding experiments on thin canes; and, if our proposal is accepted that much of the selection work at present carried out at Coimbatore should be made over to the cane research stations, we doubt whether any extension here is necessary. This, however, is a matter which might well be held over for decision in the light of the opinions expressed by the cane-breeding expert and the officers of the Sugar Research Institute when appointed.

Coimbatore as a cane research station for South Madras.

393. We have already adumbrated our proposal that the cane-breeding station at Coimbatore should combine its present functions with those of a cane research station for the southern districts of Madras. We wish here, however, to make it clear that nothing could be further from our intention than to minimise in any way the paramount importance of the primary and essential object of the station as a centre for the breeding of canes for all India. Anything that would jeopardise or impede the fulfilment of that object must be discountenanced at once, and, should experience belie our view that the officer in charge at Coimbatore will be able to find time to deal with the more general research problems of cane growing in addition to the special problem of breeding, we should be the first to advocate the abandonment of the proposal which we base on it. For the present, however, we consider such a combination of functions practicable, particularly as the same reason which precludes us from suggesting a separate cane research station for South India—namely the comparative smallness of the cane area and the limited prospects of extension—precludes us from recommending that the area to be devoted to general research work on local cane problems should be on anything like the scale we have considered necessary in other cane tracts. Separate land will have to be acquired for this purpose, and this must always be kept entirely distinct from the cane-breeding area, but should be as nearly as possibl

ntiguous with it. Its extent will naturally depend on the time which the officer charge is able in practice to spare for the solution of the local problems of outh Madras, but, in the first instance, at any rate, 50 acres should suffice. ater on, it may be found advisable to take advantage of the two planting seasons this district by making this a centre for the rapid multiplication on a large ales of sets of approved varieties in the manner described in paragraph 22 of ir Chapter on Java, and, in that event, a good deal more land would have to be ken up ; but, except for this purpose, we do not think it will be advisable greatly extend the 50 acres we have suggested so long as the cane-breeding expert mains in charge of both branches of work. It is unnecessary to indicate in etail the lines of work that should be undertaken : they will broadly correspond ith those we have already laid down generally for Madras in Chapter X. Ve think, however, that a special series of experiments should be opened to certain the water requirements of cane, in view of the large number of irrigaons now given in the Coimbatore district ; and that the work on acclimatisation exotic canes for the southern districts of Madras, to which we have already said at we would now restrict the acclimatisation work of the station, should, of ourse, be transferred from the cane-breeding area to the area to be acquired for ocal research work.

Need for a second cane-breeding station.

394. This completes our recommendations for the station at Coimbatore ; but it does not exhaust the discussion of the problem of cane-breeding for all India. aluable as the work done at Coimbatore has been, it has throughout laboured nder the disability that by no means all of the North Indian or of exotic canes ill produce fertile seed there. The great Mungo group of indigenous canes has roved an almost complete failure in this respect and the Panhasi and Nargori groups have been hardly less disappointing. The possibilities of evolving successful seedlings for the cane tracts to which these canes belong would be greatly nhanced, if this serious limitation on the number of available parents could be emoved. Recent experience in Mysore has afforded reason to believe that canes which will not yield fertile seed in Coimbatore may be induced to do so in other ocalities. Whether the conditions governing this variation in habit depend n altitude, rainfall or some other cause has yet to be ascertained, but an effort hould certainly be made to discover a new area in which canes exhibiting steriity at Coimbatore can be made to produce seed and a site should there be selected or the establishment of a second breeding station. Other things being equal, t would, we think, be found administratively more convenient to select a site in a Province of British India, and we would instance the Madras districts on the astern border of Mysore, particularly the western taluks of Chittoor, as a tract worthy of investigation. Preliminary trials might well be started at once ; but we would deprecate any final selection of a site until the Sugar Research Institute has been created and a permanent incumbent of the post of cane-breeding expert has been appointed, and their advice obtained. Should the site ultimately decided on fall within the tract we have tentatively proposed, we consider that, like the station at Coimbatore, it should filll the dual rôle of breeding station and general research station for the central districts of the Rresidency. The respective areas would here also be kept quite distinct, and 50 acres should be fully adequate for each, or 100 acres in all.

Administration and staff.

395. The location of the cane-breeding work for all India in Madras, combined with our proposal to take advantage of the presence of the breeding stations to link them up with research work on local problems, necessitates a readjustment of the administrative machinery we have designed for other Provinces. Here it

will be impossible to centralise the provincial research work under a single cane specialist without an overlapping of activities and a collision of functions which it is eminently desirable to avoid. Madras will, therefore, have to be treated as two Provinces, the northern portion, consisting of the districts to be served by Samalkota and the research station we have proposed for Ganjam and Vizagapatam, to be under the control of the special officer recommended for those stations in paragraph 167 of Chapter X, together with the central districts east of Mysore, if a second breeding station is not eventually located there; and the southern portion, comprising all districts served by the breeding station or stations, as the case may be, to be under the control of the cane-breeding officer. Much the more important work, from the provincial point of view, lies in the former of these two zones; and, while we realise that the arrangement we have preferred is far from being ideal, we are convinced that it is the best practical arrangement for some time to come.

It remains to consider whether any additional staff is required for the efficient control of the cane-breeding stations, on the assumption that their activities will in future be directed along the lines we have laid down. So long as there is only one station, that at Coimbatore, it is, we think, obviously within the capacity of a single expert officer to control under the general direction of the head of the Agricultural division of the Sugar Research Institute. This of course postulates the appointment of a thoroughly competent staff of Assistants with chemical and botanical attainments of as high an order as is at present obtainable in India. For this purpose we need hardly point out that the existing scale of pay for these Assistants, (which is, we believe, only Rs. 50 per mensem rising by annual increments of Rs. 10 to Rs. 150) will need to be very materially raised. The main point for consideration is, however, whether a second breeding expert of equal qualifications with the first will be required to control the second breeding station, when it is opened. So much depends on future developments that we hesitate to dogmatise in the matter, but, on the whole, we are inclined to the view that, provided the two stations are not unduly far apart, the cane-breeding officer in charge of Coimbatore, which would, of course, remain his headquarters and the more important station, should be able to supervise the operations at the second station also, the detailed experiments being carried out under his orders by the senior of his Botanical Assistants, who would reside at the station and be granted a duty allowance in addition to his pay as Assistant in virtue of his enhanced responsibilities. A Chemical Assistant would also be required permanently on the station, but we would leave it to the officers of the Sugar Research Institute to advise whether a special allowance would be warranted in his case. We need hardly add that no scientific Assistant should be appointed to the new breeding station who has not received a thorough training in the technique of cane-breeding at Coimbatore; and that, in the earlier years of the new station at least, the additional charge of the research work on local problems will be too much for the Assistant in charge of the breeding experiments. A separate Assistant, preferably with good chemical qualifications, should be appointed to discharge the duties of this branch of the station's activities.

Dr. Barber's work

396. We cannot close this Chapter without an acknowledgment not only of the great benefit to India of the work done by Dr. Barber during the six years that he held charge of the cane-breeding station at Coimbatore but also of our own obligation to him. It is the soundness of his botanical researches at Coimbatore that has enabled us to recommend a forward policy of expansion

cane-breeding work; and the frequent occasions on which we have cited him our authority in our provincial Chapters themselves testify to the extent l value of his labours on the classification of Indian canes. We are further lebted to him for the compilation of special notes for our use, of which we glad to record that we have taken liberal advantage.

Summary of Conclusions and Recommendations.

(1) *The Coimbatore cane-breeding station and the post of cane-breeding pert should now be made permanent.*

(2) *The station should be transferred to Imperial contr*

(3) *The main lines of work now in progress should be continued, except that ie attempt to evolve improved varieties of cane for Upper India which will nithstand the indifferent usage of the ordinary cane grower should be abandond as impracticable.*

(4) *Seedlings should only be distributed for trial to farms on which cane is n object of special study.*

(5) *The selection work at Coimbatore should be confined to a purely general nd preliminary survey, detailed selection being transferred to the cane research stations in the various Provinces.*

(6) *The acclimatisation of imported canes at Coimbatore for direct distribution to other parts of India should be discontinued except for South Madras.*

(7) *More attention should be paid to the breeding of new varieties of thick canes for Peninsular India, Burma and Assam.*

(8) *The area of the station should, if necessary, be increased by some 25 or 30 acres for this purpose.*

(9) *Coimbatore should also become a cane research station for South Madras.*

(10) *Separate land will be required for this purpose, but 50 acres should suffice.*

(11) *In addition to undertaking the branches of work indicated in Chapter X, the research station should carry out special investigation into the water requirements of cane.*

(12) *A second cane-breeding station is required mainly for the raising of seedlings from parents that will not produce fertile seed at Coimbatore.*

(13) *A suitable site might be found in the Chittoor District of Madras, but its selection should await the creation of the Sugar Research Institute.*

(14) *If located in the Chittoor tract, the station should also serve as a cane research station for Central Madras.*

(15) *An area of 100 acres in all should suffice for both purposes.*

(16) The cane research officer recommended for Madras in Chapter X should control the cane work in the northern districts only; the cane work in the southern districts being controlled by the cane-breeding expert.

(17) The cane-breeding expert should control both breeding stations, making Coimbatore his headquarters.

(18) He should be provided with a thoroughly competent staff of Botanical and Chemical Assistants, the rates of pay for whom should be raised.

(19) His senior Botanical Assistant should hold charge of the second breeding station under his control, and should receive a special allowance.

(20) A Chemical Assistant is also required for the second breeding station; and the cane research work there should be entrusted to the charge of a separate Assistant.

CHAPTER XXV.

SUGAR SCHOOLS.

The demand for an indigenous supply of expert assistants.

397. The examination we have made in Chapter XX of factory conditions in India has demonstrated the regrettable inefficiency of sugar factories in this country as compared with those in other sugar producing countries. Our enquiries have shown that one of the most important reasons for this inefficiency is the difficulty of obtaining an expert staff of chemists and engineers. And this difficulty is in its turn undoubtedly attributable to the fact that the terms offered have not been sufficiently attractive to induce men from other countries to come to India combined with the fact that it has hitherto been impossible to secure men trained in India. The cane cultivation at present controlled by the factories themselves in India is almost negligible. We look forward, however, to a marked increase in it as a result of our recommendations; and we also trust that even where factories do not control cane cultivation they will in the future realise the desirability of taking a greater interest in the agricultural development of the area which supplies them with cane than has hitherto been apparent. Should our anticipations in these two respects be fulfilled, trained agriculturists with a thorough knowledge of cane cultivation will become as necessary to a factory as chemists and engineers.

The chemical control in Indian factories is of the most superficial description; and yet, when factory administrators wish to replace rule of thumb methods by efficient control and look for chemists with a training which fits them to undertake duties of a responsible character, they are unable to find them in India. All that can be done, therefore, is to engage men who have passed the Matriculation or School Final examination, or possibly the F. A., or F. Sc. examination, and to teach them certain purely mechanical processes such as the way in which to polarise sugar and megasse. These men have not a sufficient knowledge of chemistry, physics or mathematics to make good chemists, and in nine cases out of ten are nothing more than chemical mechanics. It will be evident that, when the chemical work of a factory is in the hands of men with such indifferent training as this, efficiency cannot be expected. The position is much the same in regard to engineers and agriculturists. Trained men are not at present produced in India, and the demand for them in all the sugar producing countries of the world has made it difficult, if not possible, to recruit them from outside this country. The result is that, with scarcely an exception, all the factories we visited in India are under-staffed on the expert side. The superior staff seldom numbers more than four or five; and few of these have had any special training in sugar.

Need for a centre of specialised training.

398. In order to secure the development of the sugar industry in India on right lines, it is, therefore, a matter of vital necessity that an educational organisation should now be provided which will offer men in this country an opportunity of securing the technical training which will qualify them to enter the

sugar industry as competent workers. Our enquiries convinced us that even in present conditions the industry offers excellent prospects to those who are prepared to fit themselves by a suitable training for employment in it. The necessity for an educational organisation being thus apparent, we proceed to discuss the form it should take.

The training required in sugar chemistry, engineering and agriculture is of a highly specialised character and is given in none of the science, technical or agricultural institutions at present in existence in this country. So far as we have been able to ascertain, the technical colleges in other countries which give courses of instruction in sugar technology and the special agriculture of the sugarcane are the Audubon Sugar School of the Louisiana State University, the College of Hawaii, the Royal Technical College, Glasgow, the Technical High School, Charlottenburg, Berlin, and the Fruhling and Schultz Sugar School, Brunswick. The last three of these give instruction in sugar engineering and chemistry only. The sugar schools in Louisiana and Hawaii, on the other hand, are situated in countries which produce cane, and therefore devote attention to both cultivation and manufacture. They work in conditions resembling those which exist in India, and we shall, therefore, examine briefly their organisation, objects and results in order to see how far the experience they have gained can be applied to the solution of the problem of training competent men for sugar factories in India.

The Audubon Sugar School.

(a) History of its development.

399. The Audubon Sugar School was established in 1891 by the Louisiana Sugar Planters' Association as a part of the Sugar Experiment Station which had been started some five years earlier for the study of agricultural and manufacturing problems. The material equipment of the Sugar Experiment Station and Sugar School is valued at 100,000 dollars (Rs. 3,12,500 at the pre-war rate of exchange). It consists of very complete laboratories both for chemical control and chemical and bacteriological research and a library devoted to the literature of sugar. A prominent feature is a small nine roller mill crushing just under one ton of cane per hour and a complete plant for turning out white sugar. On the Sugar Experiment Station are grown all the well established varieties of cane together with many yet in the experimental stage. It was anticipated at the outset that the school would appeal mainly to graduates of schools of engineering; and the course, which was of two years duration, was, therefore, mainly post graduate in character. It was, however, soon found that, under the conditions then existing in Louisiana, the demand for training came mainly from men of mature age, many of whom were already employed in the industry, and that the standard of education of most of the students was not such as to enable them to undertake with any prospect of success the advanced course which was all the institution offered. It is highly probable that the same difficulty will be encountered in India in the initial stages of technical training for the sugar industry; and we shall therefore discuss it later in this Chapter. The difficulty is one which is common in the early stages of development of all branches of technical education. It is stated to have somewhat hampered the work of the Audubon School at the commencement, but it appears to have been successfully overcome by individual attention to each case as it arose. In 1896 the Sugar School was incorporated in the Louisiana State University, and in 1908 its importance had become such that it was reorganised as a college of the University. By this time the standard of the candidates for admission had so improved that the University authorities were able to insist on a sound preliminary training in chemistry,

physics, mathematics and the biological sciences as given in the ordinary University courses before the special work on sugar technology and agriculture was taken up.

(b) History of the courses of training prescribed.

400. The course as prescribed in 1897 lasted for four years, the first two of which were devoted to preliminary training in science, and the last two to practical work. In 1899 the course was extended to five years, as it was considered that an additional year was necessary for a sound scientific training. Under this arrangement the first part of the course is confined to mathematics, organic or inorganic chemistry, analytical chemistry, mechanical engineering, electrical engineering and English. The teaching in all these subjects is of a standard similar to that of other American Universities. Until 1903 the last two years of the course were devoted to practical work on the plantation and in the small model factory on the Sugar Experiment Station and to special lectures and laboratory work on sugar chemistry and engineering, stress being laid on the speed and accuracy of analytical work. In 1903, however, as the result of the experience which had been gained with selected students, arrangements were made for all students to spend their last year in an ordinary factory under strictly commercial conditions, which means that the students receive the regular salary of Assistant Chemists or Engineers. This policy, which has now become the regular policy of the school, was only rendered possible by the co-operation of factory managers, who met the authorities of the school more than half way and have invariably given the students all the assistance in their power. The advantages of spending the final year in a factory instead of in undergoing a routine course at the school have been very marked. The students have been given self-confidence, an appreciation of working conditions and a sense of responsibility which could have been obtained in no other way.

In the early years of the school chemists and engineers with chemical training were in greater request than agriculturists, and the tendency was, therefore, for students to study chemistry or engineering at the expense of agriculture. Of late years the increased openings for scientific agriculturists in sugar countries has led to a greater demand for instruction in tropical and sub-tropical agriculture. In order to meet this demand a special course in agriculture was started in 1912, and the students now specialise throughout the course either in agriculture or chemistry and engineering, though both courses have much in common.

(c) Details of the practical training provided.

401. It will be gathered from what has been already stated that the courses during the last two years are essentially professional; and it, therefore, appears worth while to examine in somewhat more detail the methods which have been so successfully applied to initiate the student into the working details of his future employment. As a result of the preliminary training, the students enter their fourth year with a knowledge of sugar analysis, of the main principles of agricultural practice and of the general mechanics of sugar house machinery. Their practical work commences at the beginning of that year, when, before the season opens for cane crushing they are required to overhaul the machinery of the small experimental factory at the Audubon Experimental Station and to clean and repair it. After the crushing season has begun each student in turn is placed in charge of the different parts of the factory such as the cane mill, sulphitation apparatus, clarifiers, filter presses, double effet evaporators, vacuum pans and centrifugals. He is required to operate these himself. An elaborate system of chemical control, which is practically identical with that in use in the

large factories in Cuba and Porto Rico, has been instituted for the small experimental plant. Each student is given a definite amount of cane and is required to carry out a detailed and systematic chemical and mechanical control of the model factory. At the end of the season's work the students are thoroughly conversant with the technique of every part of the Sugar House, though of course they are not skilled artisans. The following season, as already stated, is spent on factories and plantations in the State. On these the students are treated as ordinary employees, receiving no special favours and expecting none. They are paid the same salaries as other men employed on the same work and retain their positions only if their work justifies it.

It only remains to add in regard to this school that there has always been a keen demand for the graduates, of whom ten to twenty-five pass out every year, and that the school has attracted students from every sugar producing country in the world.

Sugar School of the College of Hawaii.

402. The college of Hawaii was established in 1907 by an Act of the legislature of the Territory of Hawaii. The funds for its maintenance are provided partly by the local and partly by the Federal Government ; and the management is vested in a Board of Regents who are appointed by the Governor of the Territory and are five in number. The courses in Sugar Technology form part of the regular courses offered by the College and are designed primarily for students who intend to take up active work in some branch of the sugar industry. The college possesses no special cane station or model factory of its own ; and the practical training included in the courses is carried out on the experiment station of the Hawaiian Sugar Planters' Association and in the factory of the Kahuku Plantation.

(a) System of theoretical instruction.

403. There are two alternative courses in Sugar Technology both of which last for four years, an agricultural course which is intended for men who propose to devote themselves to cane cultivation and an engineering course which is intended for men who wish to specialise in factory work with a view to employment as chemists or engineers. Both these courses in the first two years are identical with the ordinary agricultural and engineering courses of the college, except that some special work on chemistry is included in the engineering course. In the last two years of the agricultural course advanced chemistry is studied in addition to purely agricultural subjects for the reason that sugar production is probably more dependent on chemistry than any other branch of agriculture. The students are, therefore, instructed in the principles of sugar analysis, in order that they may be able to carry out tests with different varieties of cane. Lectures on sugar manufacture are also given, as it is considered very necessary that an agriculturist should know what becomes of the cane he has grown. The last two years of the engineering course are devoted to work on sugar manufacture and sugar analysis, special attention being given to chemistry.

(b) System of practical training.

404. The practical training of the students of both courses is undertaken during two periods, one of eight weeks during the summer vacation at the end of the third year and one of eighteen weeks during the second term of the fourth year. During these periods the students taking the agricultural courses work as student assistants on the experimental station of the Hawaiian Sugar Planters' Association and those taking the engineering course as apprentices in the factory of the Kahuku Plantation, where they are subject to the regular discipline of the factory. Whilst they are working outside the college all students receive a

stipend of 45 dollars a month and travelling expenses which, in the case of the engineering students, are paid by the factory. The final examinations are held at the end of the second period of practical training. As at the Audubon School, students who pass these examinations receive the degree of B.Sc.

Lines on which a Sugar School for India should be established.

405. We have already expressed the opinion that a Sugar School which will provide a thorough training in agriculture, chemistry and engineering should now be established in India. We suggest below the principles which should be followed and the aims which should be kept in view in establishing this school, in order not only that it may meet the needs of the Indian sugar industry in present conditions but also that it may adapt itself to changing conditions, as the industry develops. We recognise, however, that further enquiry into the working of Sugar Schools in other countries is desirable before the details of the courses of instruction to be given at this school are finally determined. We consider that the school should form an integral part of the Sugar Research Institute, the establishment of which we have proposed in Chapter XXIII. There is an obvious objection to this ; which is that, if the officers of the Sugar Research Institute have to undertake teaching duties, their research work will be hampered. We admit the force of this objection ; but, on the other hand. it must be remembered that courses in agriculture with special reference to cane and in sugar technology have a very definite and practical object. For this reason it is desirable that intructions should be given by expert officers in close touch with the details of the industry. This can only be secured by combining the Sugar School with the Research Institute. The number of students at the proposed school is not likely to be large, and the proposal we make later in this Chapter for preliminary training at agricultural and engineering colleges will eliminate teaching of an elementary character. Even if the combination of the Research Institute and Sugar School had not the advantage of securing training of a thoroughly practical character, we should not feel justified in recommending a separate school on account of the heavy expenditure which would be involved.

Character of the training to be provided.

406. The aim of the Sugar School should be to give a full course in agriculture and technology of such a character as will not only enable students who pass through it to take up junior posts as chemists, engineers or field managers immediately on leaving the school but will also qualify them to work up in due course to the position of managers of concerns which both grow cane and manufacture sugar. The realisation of this aim must be gradual, as at first special provision for less advanced work will be required to meet the immediate needs of the industry. It is probable that at the outset the greater number of applications for admission will be from men who are already employed in the sugar industry and require a specific course of instruction in one branch of work only, such as improved methods of cultivation, methods of mill control or laboratory practice. The demand for special instruction should, however, disappear as the needs of men already employed are satisfied.

Preliminary courses at Agricultural or Engineering Colleges essential.

407. We regard it as essential, if the school is to fulfil its aim, that students admitted to it should have received a thorough grounding in elementary mathematics, chemistry and physics with some preliminary training in the general principles of agriculture or mechanical engineering. This training can best be provided by the first and second years' courses at the existing Agricultural and Engineering Colleges ; but these will require to be supplemented in some respects, as it is desirable that students should come to the Sugar School with a working

knowledge of the principles of sugar analysis, the estimation of reducing sugars and the construction and use of the polariscope. As we have already said, the number of students seeking admission to the Sugar School will not be large; and there should, in our opinion, be no difficulty in making arrangements under which such students would first be admitted to the ordinary courses of an Agricultural or Engineering College and be given some additional instruction in chemistry and physics. We attach special importance to this training preliminary to the full course of the Sugar School, and are of opinion that it should be rigidly insisted on in all cases.

Courses of theoretical training at the Sugar School.

408. We consider that the course at the Sugar School itself should be of 2½ years' duration. It should commence in October and the last term should end in April. This will enable instruction to be given during three crushing seasons and during two complete agricultural seasons from planting to harvest. The sugar industry consists of two well defined branches, the growing of cane and the manufacture of sugar. This division should be recognised in the organisation of the Sugar School, which should have two sections, an agricultural section for students who wish to specialise in cane cultivation and ultimately to become field managers, and a chemical and engineering section for students who wish to specialise with a view to becoming chemists and engineers in factories. The courses in both these sections will have some work in common. It is necessary that a field manager should have some knowledge of engineering, and it is very desirable that chemists and engineers should have some knowledge of cane cultivation. In both sections attention will be paid to chemical work, whilst in the chemical and engineering section special importance will be attached to instruction in methods of sugar analysis and in regard to the speed and accuracy of the analytical work required in factory control. We do not propose to enter into any great detail regarding the precise nature of the courses which should be given, since, as we have already stated, further enquiry on this point is desirable. Instruction would, of course, be given by means of lectures, laboratory work and workshop practice at the school; and we need not do more than emphasise that practical work on the farm which would be attached to the school and in the factory should form the most prominent feature of the course. The lectures and laboratory work would deal with such subjects as the following:

The principles of improved methods of cultivation and manuring and the selection of varieties of cane.

The use and benefits of drainage and methods of carrying it out.

A study of the use of irrigation water and methods of applying it.

The chemistry of sugar house products.

The analytical methods used in factory control.

The descriptive study of the machinery used in sugar factories.

Theories of heat as related to evaporation, cooling and condensing, with special reference to the design of evaporators and vacuum pans.

The design of sugar machinery.

We consider that, as many modern factories are substituting electric for steam power, the engineering course should include electrical engineering.

Provision of practical training.

409. In order to provide for the practical training, the importance of which we have emphasised so often in this Chapter, it will be necessary that, in addition to lecture rooms and laboratories, the school should have a farm for the practical instruction of the students in the agricultural section and a small model factory for that of the students in the chemical and engineering section. The farm should, in our opinion, be not less than 500 acres in extent, but this includes provision for the experimental area required for research in the Sugar Research Institute itself. The farm will provide cane for the small factory; and both farm and factory should, if properly managed, be almost, if not entirely, self-supporting. We have suggested the addition of a factory to the school, as we are strongly of opinion that a student can only gain a really thorough knowledge of all the mechanical operations connected with the manufacture of sugar by actually carrying them out himself. This he would be unable to do in a large factory ; nor would he in such a factory receive sufficiently detailed instruction in regard to the overhauling of machinery and the repair and care of the various parts. Before a student is sent to a large factory, therefore, we regard it as essential that he should have proved himself competent in the different branches of the work of the small factory we propose, which should be a complete model of its kind, suitable for purposes of instruction in all the major operations carried out at a white sugar factory of commercial size. A very strong reason for the inclusion of a small factory in the equipment of the school is that factories working under commercial conditions cannot afford to have their operations hampered by the presence of a number of inexperienced students. Admission of the students of the school to factories will obviously be much more easily secured, if they have already received an appreciable measure of practical training. We consider that students who have passed satisfactorily through the school should spend the last cane harvest during their course at a large factory. If our proposals in regard to the establishment of a Government factory are accepted, this will present no difficulty. If, however, a Government factory is not established, it will be necessary to make arrangements with private companies to receive the students from the school as assistants. In view of the value to the sugar industry of a supply of properly trained men, we have no doubt that such companies would be willing to co-operate in this matter, as they have done in Louisiana and Hawaii. As in Louisiana, the students when employed either in the Government factory or in a private factory should receive exactly the same pay and treatment as ordinary employees doing the same work.

The final examinations would be held at the end of the third crushing season, *i.e.*, at the end of the practical training in the factory. We recommend that a diploma should be granted to those students who pass the examination, but would suggest that the school should ultimately be affiliated to a University, and that successful students should then receive the B. Sc. degree.

Summary of Conclusions and Recommendations.

(1) One of the greatest needs of the Indian sugar industry is a properly trained staff of chemical, engineering and agricultural assistants.

(2) The specialised technical training which will qualify men to enter the sugar industry as competent workers should be provided in the country.

(3) Of the educational institutions in other countries which give courses of instruction in sugar technology the Audubon Sugar School of the Louisiana State University and the College of Hawaii furnish the most instructive precedents for India.

(4) The School for India should provide a thorough training in sugar agriculture, chemistry and engineering and should form an integral part of the Sugar Research Institute.

(5) The ultimate standard of training to be aimed at should be worked up to gradually with due regard to the immediate needs of the industry.

(6) Prior to admission students should have taken the first two years' course of an Agricultural or Engineering College with some additional instruction in chemistry and physics.

(7) The Sugar School course should extend over 2½ years and three crushing seasons; and should be conducted in two sections, an agricultural section and a chemical and engineering section, though a part of the training will be common to both.

(8) Practical field and factory work should form the most prominent feature of the course; and for this purpose the school should have its own farm and small model factory.

(9) The last cane harvesting season of the course should be spent either on the Government factory or on large private factories by arrangement with the companies.

(10) A diploma should be granted to students passing the final examination until the school is affiliated to a University, when the B. Sc. degree should be awarded.

CHAPTER XXVI.

CONCLUSION.

410. We have now completed our examination of the main problem that has been set before us and of its subsidiary issues. We have shown, we trust, the great possibilities that lie before this country as a producer of sugar, and equally the great and the concerted effort that is called for, in the laboratory, in the field and in the factory, if those possibilities are to be realised. We have indicated the two fundamental requisites for a prosperous sugar industry: organisation and co-operation in the industry itself, and recognition of the essential community of interests between the grower of cane and the manufacturer of sugar. The Java industry with its positive record of achievement points the one moral, while the existing Indian industry with its negative record of stagnation points the other. We have recognised the many difficulties that beset the industry in India, and we have framed our recommendations accordingly, with a view rather to steady development than to an immediate transformation. We cannot conclude our Report, however, without a reference to the strangely disturbed conditions which have prevailed throughout the period of its compilation. *Qui s'excuse s'accuse*; but it is due to the Indian public no less than to ourselves that the extraordinary difficulty not only of forecasting future developments but even of gauging present circumstances correctly should be realised. Our enquiries and deliberations have extended over exactly twelve months; and in the course of that time sugar has been quoted in New York at as high a rate as 23 cents per lb. and at as low a rate as 7 cents. The United States of America have reappeared after many years as competitors for the Java crop. Estimates for a thousand ton sugar factory were quoted at £220,000 in January and at £350,000 in September. The price paid by the Upper India factories for their cane has risen from 4½ annas to 12 annas per maund. A large proportion of the beet sugar industry in Europe, which only a few years ago threatened the very existence of the cane industry in this country, has been completely disorganised, and he would be a bold man who would foretell either the extent or the rate of its recovery. The exchange value of the rupee has fluctuated between such widely divergent limits as 2*s.* 11*d.* and 1*s.* 5½*d.* Political and industrial unrest have acted and reacted on one another until it is impossible to distinguish cause and effect. Strikes among coal-miners and railwaymen, among transport workers and dockers, in the electrical and the cotton trades, in England, in America, in India, in Java, nay, in almost every manufacturing country of the world, have crowded one upon another in this eventful year. Ideas of internationalism, of supernationalism and of no nationalism at all are struggling to find more or less coherent expression; and there is hardly a principle governing the relations between one country and another which is secure in any sanctity it ever had. These violent storms have wrapped the industrial future of the world in a cloud of obscurity; and it is

when they were at their height, and while the very facts of our enquiry were being blown hither and thither, that we have had to found our conclusions and to build on them our recommendations. Given, however, a return to ordered progress, whether under new rules of life or under the old, we are confident that sugar will form an increasingly important part of the dietary of the human race, and that India must be looked to as a large contributor to meet this need. It is in the firm belief that ordered progress will be resumed that we have written ; and we trust that there will be few to challenge our confession that this belief is the corner-stone of all our proposals.

F. NOYCE,
President.

J. MacKENNA.

J. W. MACDONALD.

W. W. CRAIB.

FRANK CARTER.

JOGENDRA SINGH.

B. J. PADSHAH.*

G. CLARKE.

M. WYNNE SAYER. †

A. E. GILLIAT, *Secretary.*

*Subject to a Supplementary, note pages 317 to 358.

† Subject to a note of dissent pages 359 and 360.

Supplementary Note by Mr. B. J. Padshah.

I.—General remarks.

1. I have signed the Report subject, of course, to the reservation and supplementation of my various notes below on the several subjects—of land acquisition, relation of the price of cane to the price of sugar, the licensing of factories, drainage and irrigation, the tariff, land revenue, the cost of research, the structure and functions of the Sugar Board, and weights and measures. But besides the special reservations there is one general reservation which must be assumed for all Reports but which it may be worthwhile to make clear in this.

2. It is generally assumed that a Report signed by all Members of a Committee should be taken as unanimous, and it is so in a general sense. But a Chapter of a Report has to be written by some one Member ; and however much it may be revised in the Committee, the revision will not entirely eliminate the individual spirit of the first draft ; even if words and sentences be changed, the structure of the Chapter as a whole and the sequence of sentences and paragraphs and arguments will still retain the original spirit. It is impossible for all Members to be in total agreement with this spirit, unless the Members be all dry-as-dust experts who have no mind or heart beyond their profession, or unless Members be taken from the same race, class or vocation. This has been forcibly brought to my mind by the concluding Chapter which, along with other matters, was discussed just before our signatures were affixed to the Report. The general argument of the Chapter seemed to me sound, the facts worth pointing out, but if I discussed the implications of every phrase there used, I should have kept the Committee going for a fortnight longer, whereas it was important to release one Member who was that very afternoon leaving for England ; so I let the Chapter go, on obtaining permission to put in this note.

3. That Chapter uses such phrases as ' Ordered progress,' which I understand to mean the return of the world to some condition understood as beneficial from the present discontents and torments, and implies a preference for methods of progress which are remote from what would amount to a transformation. Now, as it happens, these phrases are capable of being interpreted in the sense that the whole of this Report and its recommendations are informed by the atmosphere which considers that all would be right with the world and God would return to his heaven, if the Excess Profits Tax were abolished and if the labour world would cease from striking. As my colleagues say that there is no such implication, I have affixed my signature to the Report very readily ; but I cannot shut my eyes to the fact that the reader may infer such an implication, and such readers as are not of this way of thinking may object to the recommendations of the Committee as reactionary because tied to a reactionary mental prepossession. The whole argument of the concluding Chapter is only a lament over the incalculable factors presented to the Committee, so that the judgment and recommendations of the Committee have been

based on large elements of the unknown. So much is irrefutable ; but any judgment on strikes as a weapon under the present conditions of industry, or any condemnation of present discontents, or the suggestion that biological or sociological progress is best based on steady even if small steps and should avoid Mutation,—these are propositions on which the Committee cannot speak with authority, and which are entirely beyond their province. They cannot assume them, because there is no consensus of respect-worthy opinion in their favour.

II.—Statement of the problem.

4. I realise the propriety of the Committee not committing themselves to propositions about which complete assurance of safety is not established, and yet it has seemed to me that the object of a Committee to whom a whole question is referred is not merely to examine that question and to shew what action could be taken with safety but also to exhibit what problems open out and what measures are suggested, what are simply arguable and what have been rejected after a balance of arguments. The balance may change under different circumstances, or the balance may appear different to the statesmen to whom will belong the execution of the Committee's recommendations and who may have considerations entirely outside sugar to put against the balance of advantages or disadvantages exhibited by the Committee. Nor do I hesitate to point out that the problem of sugar does branch out into touch with the problems of the poverty of India and of rural organisation, and it has to be approached not more with caution than with hope.

5. To me rural re-organisation would not mean a warning signal to keep hands off ; it would mean to me an opportunity. I would not shed tears over the alteration of the rights in land as at present exercised. I would not forget that land is useless except as an opportunity for the creation of products, and that land is only one element of the opportunity, water, air, science, capital each being a no less essential ingredient. To consider rights in land as unmodifiable and as paramount would be, therefore, neither just nor progressive. This is not to deny the need of tenderness to existing rights in land nor to suggest the degradation of the status of the cultivator. But in forbidding a reconsideration of Land Tenure one may at least make sure that the cultivator has a status left to him ; that he is not already a simple serf of the moneylender or *rentier*. The absolute sacredness of contracts or of property rights is a Red Rag waved before now to intimidate and trample down champions of reform, but the world has now learnt better. The origins of property rights are anything but sacred ; the legal recognition of those rights is founded on their utility and cannot prescribe any obligation where the utility is on the other side.

6. Where the cultivator is not a serf already it is not to be assumed that there is no other way of maintaining his status and indeed of improving it beyond that of blessing the established usage. It is surely a question of balancing the advantages of proposed changes with the advantages of the present ; and, if there be objections to alternative courses, it is not to be assumed that the established method is free from objections. I admit the obligation to exhibit the practicable alterations to the present systems of Land Tenure, and I have laid them before the Committee. I would, therefore, attack the problem of sugar and be prepared to suggest the necessary changes in Land Tenure wherever the existing incidents of that tenure are adverse to the establishment of large sugar factories.

7. And, if I urge the statesmen of India to be open-minded about Land Tenure, so would I urge them to be open-minded regarding the provision of water facilities. The Irrigation Department is presumed to be run as a business Department. But is it ? Why should the value of all commodities, including rights in land, change and yet water rates be sacrosanct ? Why should it be possible to obtain Rs. 45 an acre for irrigation in the Deccan and only some Rs. 7 in Northern India ? Why should land revenue be a fixed share of the value of the aggregate product ?And why should water rate be independent either of the price or of the amount of the product ? Why should it be independent of the amount of water required for different crops ? And, to look at the other side of the question, why should Government, conducting a business Department, fail to ensure regularity of supply without which sugar at least is suffering ? Why should Government be at liberty, as in the Deccan, to waterlog land on canals and damage private property ? Why should not Government supplement the provision of canal water with wells and reservoirs, or through the saving of waste by the lining of canals ? It is true that such supplementation would cost money ; but, on the other hand, this supplementation would bring advantages to the cultivator who would presumably be sensible enough to be willing to pay for these advantages. Why should not there be a decentralisation of water supply, so that the Irrigation Department may supply in bulk to local bodies on whom would devolve the distribution of water to individual cultivators ? Why should not there be a sort of Whitley Councils constituted by seller and buyer alike so as to adjust the differences between seller and buyer of such unequal economic strength ? Why should not there be a constant unbending of the Irrigation Department to consider sympathetically the grievances of irrigators who have been compelled to form themselves into an Irrigator's Association ? Why were not the profits of the Irrigation Department constantly converted into new capital for new canals if, as in times of stringency, Government are unable to find funds ? Why is not private enterprise invited to cooperate and divide with Government surplus profits over guaranteed dividends ? Why should Irrigation Schemes be shelved, as I was informed they have been in the Madras Presidency, because at the present rates, which the cultivator might be willing to double or treble, the canals cannot pay owing to the much higher cost of building them since 1914 ? In other words, if irrigation had been done by a private Company instead of by Government, that Company would have been conceded superior rights to the cultivators, because security of water supply is so much more essential than mere soil. On the other hand, if it had been a private Company which had supplied water, its obligations to do its utmost to branch out and give all the canalling or well-building necessary, and to do its utmost by supplementation of irrigation to secure regularity would have been considered indisputable, and would have been imposed on the Company by Government as mere Government and not by Government as a business body.

8. I wish to impress on those who will have the applying of the information contained in this Report not for a moment to forget that the sugar industry has in it many unique features which the familiar industries—textile or metallurgical—have not. The manufacturer of sugar is far more dependent upon the cane-grower in his neighbourhood than cloth or steel is dependent upon raw cotton or iron-ore in its neighbourhood. Cane deteriorates in transport and the factory has to be in the neighbourhood of the cane as no other industry needs to be in the neighbourhood of its raw material. Again, the manufacture of sugar has to be seasonal during the harvesting season of cane. If cane be not regularly fed to the factory, and the factory not kept fully employed night and day, capital and labour charges become prohibitive. Again, all the advantages of modern

sugar manufacture arise from production on a large scale. The factory, therefore, has to *control* cane from a sufficient area in its neighbourhood. In the absence of the most developed communications the area on which the factory depends has to be compact, whereas with the present system of Land Tenure, with small holdings continually sub-divided in each generation and each small holding consisting of half a dozen patches, the required compactness is unattainable. If, in addition, anybody be free to enter any cane area, the amount of cane that can get into a factory will be so small as necessarily to prohibit the sinking of large capital in an economic factory.

9. No progress can be made with the understanding of the real problem, unless the advantages of India for sugar are definitely stated and unless one discovers why, with all these advantages, India is still a country importing sugar. India is said to have had during the last ten years an average of over 2½ million acres under sugarcane and something like three millions in the year 1918-19. She is said to have raised 31 million tons of cane annually, of which some 26 million tons may be said to have been converted into gur. Thus she has had not far short of 2½ million tons of cane gur annually of which three-fourths has been directly consumed as gur, while the remaining one-fourth has been converted by *khandsars* into sugar and molasses. Thus, the total annual consumable output of India averages as 1,800,000 tons of edible gur, directly consumed as confectionery, 250,000 tons of sugar made by *Khandsars* and about 250,000 tons of molasses and about 30,000 tons of sugar made in factories. In addition to this India manufactures palm gur and sugar to the extent of some 300,000 tons in all, and imports an average of over 600,000 tons of sugar from abroad, though in one year she seems to have imported as much as 900,000 tons. Roughly speaking, then, India's consumption may be taken to be two million tons of gur and a million tons of sugar, and she will need large quantities of molasses for conversion into rum, for cattle food, for cane manure on sandy soils and for sweetening tobacco. Molasses may yet become a direct human food or sweetener of human foods. From these figures it would appear that India has the largest area under cane—six times as much as that of Java—is the second largest consumer of sugar, and is one of the largest importers of sugar. Yet the sugarcane area of India is hardly more than 1 per cent. of the total cropped area, and, except in the United Provinces (3¾ per cent.), in no Province does it exceed 1¾ per cent. of the cropped area as compared with some 3 per cent. in Java. In Java recently a Government restriction has been placed on enlarging the sugarcane area, probably in the interests of food crops ; and it is, of course, important that any extension of the sugarcane area in India should not trench on the food crops of our country.

10. On the other hand, it is necessary that India in her own interest, and also in the interest of service to the world, should very considerably enlarge her sugar production. When the price of sugar today in India is *about 50 per cent. over the world price of sugar it is time to enquire whether something should not be done to stimulate local production to reduce the price to the Indian consumer. When the recent world price of sugar has been about five times the pre-war world price, it is time to investigate whether something done in India may not bring relief to unfortunate families all over the world to whom sugar is almost a necessity of life. The price of sugar in India cannot be reduced appreciably below the world price of sugar, since sugar would always be exportable to earn the higher prices abroad. The only way to cheapen Indian sugar is to cheapen the world sugar which cannot be done unless and until

**Rs. 31 per maund at Calcutta* $= \frac{31 \times 16}{82}$ *= 6 as. per lb. against 7 cents per lb. quotation in the U.S.A.*

production of the world sugar is brought to the level of consumption at the required cheap price, and the most hopeful way of enlarging production is the enlargement of cane areas in India and improving India's agricultural and manufacturing processes. The production of sugar in the world just now is 20 per cent. below the pre-war production largely due to the shrinkage of the beet sugar that used to come from Central Europe ; but it has been estimated that by 1932 the total consumption of the world should not be below 32 million tons, if sugar could be produced within the means of families with moderate incomes. This estimate is probably conservative, as it expects the growth of consumption in the principal sugar consuming areas according to the old rate of growth, and most probably ignores the new consuming centres of the world like China and the Soudan and the poor all over the world. Therefore, as a matter of business, all territories which have areas available for the cultivation of sugarcane should bring them into use as rapidly as possible in order to relieve the burden of the high price of sugar, and to stimulate consumption of an important nourishing article. Our main Report considers what available areas there are for extension in India which can be looked to for new production of sugar. Reclaimed jungle tracts in Burma and Assam and canal tracts in the Punjab and in the Deccan between them promise large extensions. The new Sarda canal in the United Provinces is calculated to bring 100,000 acres additionally under cane in that Province. The canal districts of the Punjab could most probably bring 200,000 acres under cane, if projected extensions and new works are carried out. Hundreds of thousands of acres in the Bombay Presidency, and the reclaimed forest lands of Burma and Assam may easily, within the next 30 years, provide half a million new acres under cane. It seems not a wild estimate that, with a favourable conjunction of circumstances, and with proper enterprise and organisation, half a million to a million additional acres may be brought under cane cultivation in India which, properly developed, may mean a million to three million tons of additional sugar annually.

11. But increase in production of sugar may also result from organised improvement in present cultivation. The present yield of cane per acre in India is the lowest in the world. The average yield for all India is one-third of the best done on Government farms such as Shahjahanpur and Manjri, and in Northern India the yield per acre is much less than the yield in Southern India. The difference is partly due to climate, Northern India being sub-tropical and Southern India being tropical, but it is also due to difference in processes of cultivation. The deficiencies of soil and climate are in a large measure capable of being made up by science and capital ; for example, deficient rainfall can be supplemented by irrigation from canals and wells, and the chemical deficiencies of soil might be supplied by fertilisers ; and also scientific investigation shews that, partly by breeding and partly by acclimatisation, new varieties of cane could be introduced into tracts where they have not been tried before. It has thus resulted that there is more cane grown in the North of India than in Southern India, and it is worth while enquiring whether the drawbacks of frost and short hot seasons cannot, in the North, be overcome by such expedients as at Peshawar have been successful under the guidance of Mr. Robertson Brown—expedients called wind-rowing and clamping.

12. It seems a not unsafe estimate to suppose that, on the present areas in the North, the quantity of cane raised might be increased by one-third and that the quality of the cane owing to the introduction of new varieties may raise the sugar contents resulting from improved processes altogether by a half. That is to say, the sugar equivalent of 13 million tons of the present quality of cane, or say about 8-900,000 tons of sugar would be in prospect, which might be raised,

to a million tons or more, if organised campaigns, as in the Deccan, should save so much of the cane now destroyed by wild animals, or should save the cane now lost by disease.

13. The production of sugar may also be increased by releasing some of the cane now required for gur through an improvement in the gur processes, and also by making sugar direct from cane by the most approved processes instead of making it from gur. In Chapter XVII the savings of sucrose which can be effected by converting cane into raw material for large, numerous, up-to-date sugar factories have been considered. I agree with the Chapter as far as it goes, but it does not go far enough. The conclusion of the Chapter of a loss of a million tons of sucrose or more calculated as in that Chapter as arising from the existing cane being converted into gur when it might with much pecuniary advantage be converted into sugar is both interesting and instructive. It is particularly instructive because there is some reason to believe that the consumption of gur in India per head of population is not a fixed quantity ; that for many purposes there is a tendency to substitute sugar as a sweetener for gur, and that in Northern India the substitution will go very far as the means of the population increase. But I do not agree with the Committee that money calculation of this loss could not have been instructively made, and, therefore, I supply what the Committee have omitted. As the calculation would anyhow be very approximate, I shall take only round figures, and I shall make my assumptions clear :—

(*a*) that nearly all the present cane is, in the first instance, converted into gur or rab ;

(*b*) that of this quantity 700,000 tons is refined into sugar by country methods by small people ;

(*c*) that 1,800,000 tons of edible gur will still continue to be made, but by better methods of milling and at lower cost, from four-fifths of the cane used for present extraction of gur, so that 3 million tons of cane could probably be released for the manufacture of sugar in factories which, with an extraction of 8 per cent., would mean $\frac{1}{4}$ million tons of white sugar added to the production of the country without any extra cost ;

(*d*) that the cane from which the 700,000 tons of gur or rab is made from which the *Khandsar* makes sugar by country methods would, if taken into factories, make probably 700,000 tons of sugar instead of 250,000 tons as at present, that is to say, would add 450,000 tons of white sugar to the production of the country.

Therefore, if the system of Land Tenure in the country permit the putting up of large factories and if the requisite enterprise, capital and science be forthcoming, the modern method of attacking the sugar problem would in India without the addition of a single acre of cane lands and without any improvement in methods of cultivation continue to give the present supply of gur and add 700,000 tons of white sugar to the production of the country without extra cost.

14. This, it seems to me, is a more instructive and understandable method of statement than the Committee's statement in the Chapter under review that the present methods of using cane involve a loss of a million or a million and a half tons of sucrose. Nor is it a wild assumption that the addition of 700,000 tons of white sugar to the market will not appreciably affect the price of sugar, or that, since the consumption of sugar in 1932 may be double that of to-day, the price of sugar may be safely estimated at an average of Rs. 12 per maund or Rs. 330 per ton. Taking then Rs. 330 per ton as the price of white sugar on an average of years to come, we get the result of a saving of Rs. 23,10,00,000,

or in round figures Rs. 20 crores, a year from changes in the methods of making sugar in India and bringing them up-to-date without improving the present quantity and quality of cane. If the price of sugar at the time of writing had been taken, namely, Rs. 31 per maund, or Rs. 850 per ton, this saving would have amounted to over Rs. 59 crores a year.

15. It is not suggested that this gain will be realised in the year 1921 or even in the year 1931. What is insisted on is that, if courageous remedies be applied to Land Tenure and if all that can be done to encourage the newest methods of factory production of sugar be not omitted, the annual increase of income to the country from factory improvements only and disregarding agricultural improvements should run into tens of crores.

16. To bring into play these improved factory processes for making gur or sugar, large plants have to be laid down involving a lock-up of capital which would be foolish unless a regular supply of cane is made secure to the factories. For this secure supply it is necessary to make convenient transport and agricultural organisation. Other sugar countries have the capitalist farming system where the capitalists being substantial men may be trusted to picked up knowledge which is profitable to them and to apply it because they have the means. In Java regular supply is secured by the factories themselves conducting cultivation, usually by renting lands from the small cultivators. In India nearly everywhere there is a complexity of land tenure which leaves the control of cultivation in incapable, unthrifty and impoverished hands. There is not the knowledge of the newest processes. There is not the knowledge of the cane to be obtained from pursuing these processes ; there is the small men's view of driving the hardest bargain and suspecting any concessions made, and the cultivation of cane itself is very scattered. The cultivation is made by borrowed money which usually does not exceed two-thirds of the selling value of the rights of the cultivator. When costs of cultivation increase, as they have recently done, the selling value of the cultivators' rights does not immediately follow suit ; and the cost may easily be more than what the cultivator can borrow, or furnish out of his own pocket, so the newer processes of manuring, watering and deep-ploughing do not easily come into force.

17. A factor not to be ignored is that the increased wealth which the new organisation may create should not be allowed to go past the cultivator whose social and moral condition a portion of the wealth would so much improve. An estimate made by me would seem to shew that in Java the production per acre last year might be worth Rs. 2,800 (on the basis of the guilder being taken at 20 annas) of which less than Rs. 800 remained in the country and the Rs. 2,000 or more per acre went as dividends on capital chiefly coming from Holland. Seeing that there were 400,000 acres under sugarcane cultivation in Java, this would mean Rs. 80 crores sent last year as a tribute by Java to Holland. These Rs. 80 crores would have meant an addition of Rs. 20 per head of the population of Java. It is, of course, perfectly proper that the factory which in Java produces twice or three times the cane per acre that the cultivating owner would have done should benefit to the fullest by the result of its own skill and enterprise. At the same time, it seems not unessential that the cultivator should have as large a share of the good fortune in prices brought about by war and scarcity, or at least that the community as a whole should have the largest share of this good fortune. Hence, I have added a section showing how the price of cane can be regulated so as to bring the largest yield to the cultivaton without impairing the just profits of the factory. Since results in India have to be obtained by organisation, the organisation should aim at social results some of which have been indicated above. They are that

the community should have cheaper sugar and in larger amounts per head ; that this cheapness should be ensured by India exporting sugar and thus cheapening the world price of sugar ; and that the income per head of the country should be enhanced by vastly increasing the production of sugar without trenching upon food crops, combined with an organisation, co-operative or contractual, which would give the bulk of the increased production to the cultivator. It may be further mentioned that, as the sugar factory has to be in the midst of the cane, in its very nature it has to be in the midst of rural surroundings. It should help to urbanise the country-side, as contrary-wise it would ruralise the factory town. Again,since cane is one of the crops in a rotation cycle, cane cultivation should be co-ordinated with other cultivation ; and this co-ordination not only means more scientific agriculture but more co-ordinated manufacture, if the principle were grasped and acted upon. It seems possible not only to rotate cane with other crops but to secure further co-ordination by juxtaposing oil cake manure for cane side by side with the cane fields. Finally, there are tracts in the country where the palm is the only profitable crop. If organisation could make a much larger use of this raw material of sugar, there would be a still further large supply of sugar in and from India.

18. As the sugar industry of India has to be considered partly from the Indian point of view and partly from the world point of view, partly as India supplying its own wants and partly as India supplying the world's wants, so also the purely Indian aspect has to be considered from two points of view : the all-Indian aspect and the provincial aspect. The people of one Province are not directly enriched by the growth of cane and manufacture of sugar in another Province, though India as a whole is enriched ; and provincial departments of agriculture will find it necessary to pay attention to cane to enrich their Province, even though cane might be more profitably grown and of better quality in other Provinces. The various drawbacks of the agricultural problem of sugar have been dwelt on in the chapters of the Report describing the agriculture of cane in the various Provinces. It has been remembered there that cane is the largest factor in the manufacture of sugar and that land or soil is only one necessary factor of cane ; that water is its life-blood as it is of no other crop ; that it is not supplied usually by the cultivator ; that cane may be spoilt by bad drainage, and that drainage is not an operation which a small cultivator can undertake himself or can undertake without relation to rights of other cultivators and other lands.

19. In the year 1917 the United States Department of Commerce published a brochure on the cane sugar industry, giving valuable information regarding the agricultural, manufacturing and marketing costs in Hawaii, Porto Rico, Louisiana and Cuba. Again, in the present year an Australasian Royal Commission on sugar has produced a report regarding the condition and cost of sugar production in New South Wales and Queensland. These permit a comparison with conditions in India, and I submit below some notes which I have taken. The figures are round figures :—

For several years before the war the production of beet sugar ranged from 40 to 51 per cent. of the total manufacture of sugar. The largest production appears to have been in the year just preceding the war when cane sugar was 54½ per cent. and beet sugar 45½ per cent., the total production of sugar being somewhat less than 20 million tons. Of the cane sugar the island of Cuba furnished about 26 per cent. and British India 23 per cent. The United States is said to be a consumer of about one-fifth of the entire estimated amount of sugar produced in the world, but the per capita conumption is highset in Denmark,

eing 96 lbs., the United Kingdom following with 93 lbs., the United States with 9 lbs. and Switzerland with 74 lbs. The average of all Europe is 37 lbs. The west consumption is that of Greece, 8 lbs. If the production of British India e taken as in the report as 2¾ million tons and, if ½ million tons of import be dded, the total consumption of British India would be 3¼ million tons which ould be probably one-hundredth of a ton or 22 lbs. per head of the population.

The average cane production per acre in Hawaii is 44 tons ; in Porto Rico 0½ tons; Louisiana 18 tons; in Cuba 21 tons; in Australia 18½ tons; in India would probably be 10 tons. The average sugar yield per acre of cane was 11,000 s. in Hawaii 4,500 lbs. in Porto Rico ; 2,600 lbs. in Louisiana and 5,000 lbs. in uba. The highest production was 16,800 lbs. in Hawaii and the lowest was 1,800 s. in Louisiana. (The gur production in British India may be taken to e a ton per acre and hardly any sugar factory gets more white sugar than iis, if so much, anywhere in Northern India.) The tons of cane required produce one ton of sugar were 8 in Hawaii, 9 in Porto Rico, 14 in Louisiana, ½ in Cuba ; the best in British India would be 12½ and in some cases 20.

The average cost of cane at Mill per ton was in Hawaii $4⅔ ; in Porto Rico 4⅔ ; in Louisiana $4¼ ; in Cuba $2⅓ ; which converted into rupees at the ien exchange of Rs. 3 per dollar would be respectively Rs. 14, Rs. 14, Rs. 13, and s. 7. In Java today it would probably be Rs. 10 per ton and in British India in ie year before the war it might be Rs. 7. In Queensland it is said to be 28s. a n, the reason being that only white labour is permitted for the growth of cane id the wages of agricultural labour are something like 15s. a day as contrasted ith less than 8 annas in rural India. A protective duty of £6 per ton of sugar, wholly given over for the benefit of cane, would amount to 14s. a ton. As it appens, the sugar duty in Australia has recently been ineffective, the control rice within Australia being lower than the world price, sometimes being as low s a half of the world price.

The average cost of the cane used to make one ton of sugar was $38 in awaii ; $41⅔ in Porto Rico ; $60 in Louisiana and $20½ in Cuba. In the best idian factory it would be Rs. 85 just before the war and might be Rs. 170 today ; Java today it would be 90 guilders.

The ratio of the cost of cane to the total of all the sugar production cost was Hawaii 80.6 per cent. ; in Porto Rico 76.75 per cent ; in Louisiana 75.7 per nt. ; in Cuba 68.6 per cent. and in Java and in India before the war it was probbly 70 per cent. In Queensland too the price of cane to the factory was 32s. nd, as 9 tons of cane went to one ton of sugar and the controlled price of sugar as £21, the same ratio of 70 per cent of the agricultural cost to the total cost ay be observed. Of the agricultural cost the fertilising cost varied from a aximum of $42⅔ in Hawaii to $2½ in Cuba ; irrigation varied from $68 in awaii to $2 in Cuba per acre.

The average wages in Hawaii were about a dollar a day ; in Porto Rico twoirds of a dollar ; in Louisiana three-fourths of a dollar ; in Cuba $ 1⅓. In dia manuring per acre would cost about Rs. 100 ; irrigation costs vary from s. 5 to Rs. 9 acre in the Punjab to Rs. 45 an acre in the Deccan. Agricultural ages may be taken to be about annas 8 to Re. 1 a day.

The harvesting and crushing season extends from 208 to 306 days in awaii ; 130 days in Porto Rico ; 60 to 90 days in Louisiana ; 156 days in Cuba ; 26 days in Java. In India the season may be taken to be 90 to 120 days.

The period of growth of cane from planting to harvesting averages about months in Hawaii ; 12 to 18 months in Porto Rico ; 9 months in Louisiana ; months in Cuba ; 10 to 18 months in India.

20. It would seem, therefore, that India has the largest acreage under sugar ; that it contests with Cuba the primacy in production of sugar ; that, while its consumption per head is very low, yet its aggregate annual consumption of sugar is only exceeded by the United States and exceeds its own production by something like 25 per cent. The conditions of climate and soil under which sugar is grown in India vary immensely from the frosty conditions in the Frontier Province to the very high tropical conditions in Southern India and Burma, just as outside India they vary from the sub-tropical conditions of Louisiana to the very tropical conditions of Java and Cuba. Outside India cane is grown in the highly arid districts of Hawaii by irrigation and is independent of rainfall. In Cuba the cane crop is grown almost entirely by rainfall during the regular rainy season of four months. Again lime seems to be the most prized constituent of the soil in order to neutralise acids which are generated in the natural decay of vegetable matter in the soil and which, if not neutralised, both prevent the growth of bacteria which render available the organic material in the soil and reduce the supply of available nitrogen on which sugarcane is dependent for its best development. The Cuba lands are largely derived from lime-stone, and, therefore, are independent of lime fertilisers. In India soil and rainfall vary very largely and cane is capable of growth only in so far as the natural deficiencies can be supplemented by irrigation and fertilisers ; but since India is a pioneer in irrigation and since fertilisers are a matter of international science and can be imported and since the yield per acre in India is small owing to recognisable and remediable causes, since the cost per ton of cane, even under present conditions of low capital and bad science, is not the most unfavourable in the cane-growing countries ; since the whole cane acreage in any tropical Indian Province does not exceed ½ per cent. of the whole cropped area as compared with 3 per cent. in Java ; since un-reclaimed lands exist in abundance in several Provinces which could be brought to the cultivation of cane and since the continuous opening of new canals will make it profitable for new cultivators to grow cane ; since an enterprising Government and even more enterprising capital are ready to look after communications wherever they are profitable ; since canal irrigation can be profitably supplemented everywhere by masonry and tube-wells, the problem of growing cane and, therefore, of factory sugar is distinctly a hopeful one. If this hope be realised, not only will there be a considerable increase of produce per head in India but also the equally important matter, namely, reduction of prices to the enormous number of sugar consumers in India coinciding with the reduction of the world prices of sugar. Taking an Indian family to be a family of 3½, the average consumption of sugar per family would be nearly a standard maund per year, which at present costs Rs. 31 and is three and a half times the pre-war cost. The relief to poor families whose annual income before the war did not exceed Rs. 100 seems worth while. The agricultural problem of sugar touches the problem of the poverty of the country and, though nothing that can be looked for from sugar alone will abolish poverty, yet there is hope of reducing the rigour of poverty partly by reducing cost of living, more largely by added agricultural income. Though half the previous poverty be poverty still, and regrettable at that, yet it is greatly reduced poverty, and that is worth trying for.

21. Any recommendations which purport any adequate solution of the problem must contemplate bringing new areas under cane cultivation, the improving of the yield on existing areas, partly by new irrigation construction, and partly by remedying the irregularity of water-supply, and also by researches and demonstrations of new varieties of cane ; improved processes and extirpation of disease and extention of communications. They will also refer to remedies against frosty conditions or deficient humidity of climate. They will also investigate what re-organisation of rural industry would be necessary

to give opportunity to Organisation and Enterprise to play their full part in the contemplated immense extension of cane.

III.—The magnitude of the problem.

22. It has been seen above that—

(*a*) 700,000 tons of white sugar a year can be additionally manufactured by improved processes of gur making and by abandoning the country method of making sugar ;

(*b*) that a further million tons of sugar could be made in India by improving the yield and quality of cane from the existing cane lands ;

(*c*) that from half-a-million acres to a million acres of new lands might, in due course, be put under cane, if factories be forthcoming to work them, yielding anything from a million to 3 million tons of additional sugar. We may, therefore, say that about three million tons of additional sugar per year could be made in India, if capital, science, courageous statesmanship and enterprise were forthcoming. It remains now to ask whether it would pay to produce so much new sugar in India alone, and if it would, what are the conditions under which new cultivation, improved processes and up-to-date factories could be created.

The Report has shewn that the best use of land for sugar would be the production of cane for supply to large factories crushing about a thousand tons of cane a day. Assuming such factories, the Balance-sheet shews that they would pay 10 per cent on the capital, calculated at about Rs. 700 per ton of sugar produced, when the price of sugar is Rs. 12 a standard maund, and would naturally pay much more, if the price of sugar be Rs. 20 a standard maund, or as now Rs. 31 a standard maund, or Rs. 40 a standard maund, the price sugar once touched last summer. The capital assumed, Rs. 700 per ton of sugar produced, is at least three times as great as the capital which would have sufficed before the war, that is to say, if a thousand ton sugar factory had been erected in India before the war, it would have paid 40 per cent. even when the price of sugar fell to Rs. 12 a standard maund. It is not unlikely that, if the price of sugar should fall to Rs. 12 a standard maund, the price of machinery and other things too would fall proportionately ; but nothing definite can be laid down as both the price of machinery and the price of sugar will depend on erratic incalculable factors such as exchange, deflation of currencies and an arrest in the growing costs of production. In Java, for example, the cost of production in 1921 is estimated to be twice as much as it was before the war; but it can be more or less confidently asserted that the costs of production in India will not be affected to a greater degree than those in Java or Cuba, and that, if factories be planted in the consuming centres in promising cane areas, their costs would not much exceed the costs of Java sugar delivered at those centres. In view of the increased world consumption of sugar that would result from lowering of prices to Rs. 12 and in view of the increased consumption per head of the population of the world that looks likely, one does not expect prices to go below Rs. 12 a standard maund for any long period of time, nor must we be apprehensive of any staggering blows to cane sugar from substitutes for cane such as beet or palm or malt. Beet is much more likely to be affected by the growing scarcity of fuel, and in any case the panic into which people are put by the discovery of substitutes is not always justified. Even synthetic indigo has not ruined natural indigo. Gas illumination still survives electrical illumination ; coal is still rising in spite of fuel substitutes. Therefore

it is not a too sanguine view to take that, if the conditions for the production in India of an additional three million tons of sugar a year be present and taken advantage of, it would pay the country to produce this sugar.

23. How much is involved in the production of an additional three million tons of sugar? If capital be taken, as above, at Rs. 700 per ton of sugar produced, this would mean over Rs. 200 crores of capital for factories only. If factories seek to control land producing cane, leaving the land for rotation in the hands of cultivators, it might probably be necessary to control 1¼ million acres, and the control may mean an additional capital of about Rs. 50 crores invested in land and machinery. A great deal of new irrigation and drainage works would be required to bring the lands into the best use, and perhaps we may assume Rs. 100 crores to be the cost of the new canals which will irrigate not only the cane lands but also ten or twenty times that acreage of other crops. A large additional amount will have to be spent on opening up communications ; working capital both for agriculture and manufacture would have to be added. The value of the product would be, at the lowest rate of Rs. 12 a standard maund, about Rs. 100 crores a year, and would be about Rs. 350 crores, if the highest price reached by sugar be taken. It is to be feared that it is far too sanguine an anticipation that all this capital would be forthcoming. Though the redistribution of wealth caused by the War upheaval may have, last year, released about Rs. 100 crores of the accumulated wealth of the country for capital investments, yet much of this has already been ear-marked for the new Companies floated ; and, after all, Rs. 100 crores is only a fourth of the Rs. 400 crores estimate above as required, and the sugar demand for capital would be only one of the many demands for capital in India. In the present financial condition of the world, as revealed at the Brussels Conference, in spite of the recuperation of Belgium and France and, to some extent, of Germany, one may not expect much help from Europe or America, and it is to be noted that, if the capital cost of a sugar factory be now three times as much as it was before the War, the interest charge per cent. has practically doubled, so that the capital charges per ton of sugar must now be taken to be six times what they were before the War. If, indeed, the peasantry of India had been like the peasantry, say, of France with capital of its own, financial genius might organise that capital into *co-operative* agricultural and manufacturing Corporations, and much of the problem might be solved rather rapidly ; but the Indian cultivator is financed by the money-lender, and the genius for co-operative finance is not in the blood of the people. We may take it then that the factor of capital will impose a showness of speed on the sugar development of India.

24. Further, the introduction of improved processes of cultivation, new varieties of cane and new areas for cane would all mean a tremendous increase in the fertilisers, particularly nitrates, required for land in India. This question has been discussed at length in the Report, and here it will suffice to say that about Rs. 12 crores of additional value of nitrates would be required to enable the production of 3 million additional tons of sugar. Measured in Sulphate of Ammonia, it would mean about 300,000 tons which is about 100 times the present production in India, and 12 times the estimated production at the end of the next five years. The production of Sulphate of Ammonia in a country is limited, on the one hand, by the amount of coke that is made in the country, and, on the other hand, by the amount of coking coal available in the country. In both these ways India is very much limited. The metallurgical industries, foundries and Railway Works where coke is chiefly consumed are yet in their infancy in India. The only coal-field where coking coal may safely be looked to is Jherriah, and Jherriah coal finds a

most profitable sale at Calcutta for ordinary steam coal. Still, the shortage of Sulphate of Ammonia made in the country would not restrict the sugar industry because it can be imported, because vegetable oil industries might supply cake fertilisers which are good nitrifiers, and there is a prospect of cheap power enabling the derivation of nitrogen from the atmosphere.

25. There is not sufficient capital either in the country or in the world to be spared for sugar development to the fullest extent, and such capital as will be available would be further restricted, unless the attraction of investment in sugar be greater than in investment elsewhere. This attraction would vanish, unless 10 per cent. on the highest capital expected be looked forward to after paying the cane-grower an adequate recompense for his trouble. This is not a question of ownership of capital ; it may be that in some cases it would be for the advantage of the community that the community itself should be the owner of the capital ; but whoever is the owner of the capital, that party must be compensated by an expectation of 10 per cent. on the capital that party advances ; otherwise, the capital would be better put into gilt-edged securities such as the issue by the Calcutta Municipality of 7 per cent. stock. It has been observed above that an economically large factory can reach this point of 10 per cent. when the price of sugar is Rs. 12 a standard maund. It should be definitely understood by those who take interest in sugar that the recommendation to grow cane and make sugar depends upon a plexus of considerations such as sterling exchange for the rupee, the fluctuations in the sterling prices of sugar, the sterling prices of machinery, costs of erection and costs of production both agricultural and manufacturing—on all of which the view three years hence may be very different from what it is today. For example, we had all, before the war, been looking to replacement of much of agricultural and manufacturing labour by labour-saving mechanical devices. The need for such replacement has become greater since the war, the influenza epidemic and the famines which have destroyed so much of the labour force of India and which have made the position of labour supply exceedingly difficult. Wages, however, have not increased to the extent one would have anticipated from the shortage of labour caused by these calamities. Let us suppose wages have doubled or trebled ; but, if the capital charges in the matter of sugar be six times what they were before the war, the most philanthropic employer would hesitate to replace labour with labour-saving devices twice as costly as the dearest labour. In this way the embarrassment of the increased capital cost of a sugar factory may be seen to be greater than one thought at first.

26. The additional three million ton of sugar a year would probably need three million agricultural and factory labourers and an immense army of chemists, engineers, managers, accountants, clerks, secretaries—none of whom can be found in the numbers required today. In this matter what has been happening in large cities is a warning ; new Companies floated weaken old Companies, carrying away their best clerks, cashiers, share-transfer clerks and even engineers, chemists and Bank managers. On the other hand, if the magnitude of the problem is seen, the opportunities which a correct and courageous solution of the problem opens of careers to people trained in science, technology and accountancy are also obvious. No more shall we hear for some time the sneer "Made in Germany" of a starving educated proletariat. Further, there would be need for Banks to supply the tens of crores of working capital required ; there would be need for a whole troop of agricultural advisers and canal engineers of whom there is already a shortage, of large foundry works and mechanical workshops in the service of sugar factories as in Java. It should be noted that, while in Java there are only 186 factories, here in India for three million additional tons of sugar there should be at least 400 new factories which would require 800

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chemists, 1,000 engineers, 1,000 managers and Assistant Managers, 400 secretaries and perhaps 1,000 accountants.

27. The most serious part of the sugar problem in India is that, while favourable circumstance exist, they do not exist in conjunction. North India, the greatest sugarcane grower and the greatest sugar consumer of the country, is more or less put out of court by its sub-tropical climate and its system of land tenure and microscopical individual holdings and its ill-success in Co-operative Credit Societies. The cane is found on scattered holdings which give a poor yield, and it is of a poor quality, and is liable in the Northernmost part to complete ruin by frost. The cane lands in Southern India, while very generous in yield and quality of cane, suffer from want of regular water, unless artificially supplied, from very irregular rainfall, in some places from a very scanty supply of labour and from the difficulty of schemes for artificial supplies of water.

28. The magnitude of the problem, then, consists in attracting capital which is insufficient anyhow to the growth of cane and the manufacture of sugar, in attracting labour where labour is insufficient and constructing public works for the supply of water and transport and communications. More even than capital and science and public works is required the courageous statesmanship which shall face the problem of small holdings and the defective genius for co-operation. Organisation is what is wanted, and where organisation will not grow from within, it will have to be imposed from above.

IV.—The Factory and its Cane.

29. Our experts advise that the best use of cane lands would be in conjunction with factories crushing 1,000 tons of cane daily. Any size bigger than this would not reduce factory costs sufficiently to compensate for the higher transport charges which would result from attaching to the factory a controlled agricultural area much larger than would support the economic unit accepted by the Committee. As a matter of fact, even a daily thousand-ton factory can look for saving only in factory costs ; other things being equal, the advantage in cane cost would belong to the smaller factory, because transport to the factory would be minimised, and the cost of cane has been shewn above to be about 70 per cent. of the cost of sugar. It seems a fairly correct estimate to say that the difference in the factory costs of a 100 ton factory and a 1,000 ton factory would not be more than Rs. 30 per ton of sugar produced ; and a difference of 1½ annas per maund of cane might nearly compensate for the extra factory cost. The real advantage of a large factory is that by controlling cultivation it would diminish the cost of growing cane, get improved varieties, eliminate disease, arrange for transplantation of seedlings, make campaigns against wild animals, provide necessary capital and stocks of manure, secure a regularity of supply of cane to the factory. Therefore, it would seem that the question of putting up of large factories is also the question of the relating of the factory to cane cultivation. On this point there is much agreement and some little divergence. I have already said that the proper relation of the factory and the cultivator may require rural re-organisation, and I would treat that re-organisation as not an evil necessity but a good opportunity. I would make the re-organisation as voluntary as possible, but I would not over-look the fact that for a factory crushing daily 1,000 tons of cane there have to be tens of thousands of acres of land under the control of that factory. Under favourable circumstances, 4,000 acres of cane might be sufficient ; with rotation and fallow 12,000 acres would be necessary. As continuous and suitable blocks might not always be obtainable, as they might be interrupted by hollows, wastes, and swamps, the area needed for

control might become 25,000 acres. In North India where, owing to the sub-tropical climate, the yield is smaller, the area required may be larger still, one estimate making it out to be as much as 70,000 acres. Seeing how many of the holdings are only ½ acre in size and how many holdings are broken up into patches, the difference between cane cultivation in North India and, say, in Java where cultivation is without machinery, may be easily gathered, as also the difficulty of the voluntary organisation of thousands of peasants either co-operatively or by private agreements for the supply of cane or for the obtainment of leases. The Java Chapter of the Report shews that ordinarily a large factory need not make more than 60 agreements, and, while the temper of the people has already adjusted itself to such agreements, they readily make the agreements without much negotiation, so that 60 agreements are not worse than one. The case would be different in India, and the capitalist, obliged to negotiate hundreds or thousands of agrements, might be deterred from the sugar adventure merely by the thought of the appalling task awaiting him.

30. It is obvious, therefore, that some machinery should be provided to encourage the factory to plant itself in such uncompromising surroundings of a complex tangle of landlord rights, tenant rights, intermediate rights, joint rights, uncertain and undisclosed rights. The Committee suggest some machinery when they recommend Government to lend their officers for the purpose of ascertaining whether agreements are desired by cultivators and, in the event of the desire being ascertained, of helping the making of such agreements ; but the Committee seem to me to under-rate difficulties at the present stage. Even in Java there is alarm as to what is to happen when the present agreements run out. My impression about the Nellikuppam model, which encourages the Committee, is that the area there leased is comparatively small, under two thousand acres ; and what might not have been repellent in days when the outlets for capital might be measured by 2½ per cent. Consols at 114 might be positively repugnant when the demand for capital is to be measured by the issue of 8 per cent Debentures in so many industries in England. Again, I do not draw the same encouraging conclusion that the Committee draws from the success of the existing sugar factories. They have not been all successful, and not one of them has got all the cane that it needed. Both North and South India have asked for protection to sugar factories in the areas serving them from being poached on by other factories. The sugar factories in India have had a standing of many years, and the only production to their credit is about 23,000 tons a year in a country with the largest cane area in the world. I consider it a very lucky thing that the law and practice of the country have permitted one Government to enforce the Land Acquisition Act for the promotion of the sugar industry. We have had before us in evidence the statement of another Government that their law officers did not think the present Land Acquisition Act gave them the power of using it for an industry. But the witness added that when the Government of India amended the present Act he would like to see the power given to his Government to use the Act, though he would not use it uniformly ; he would treat each case on its merits. The witness was quite cognisant of the retardation of progress in agriculture generally due to the land tenure system of the most important sugar province of India. The majority of the Committee, however, wished to pronounce against compulsion in any form, and therefore they want to pronounce against the principle of the Land Acquisition Act as applied to industry. Here they come in contact with the recommendations of the Industrial Commission, and maintain their position by means of a declaration that two of the conditions laid down by the Industrial Commission as necessary to justify compulsory acquisition are not applicable in the case of

sugar. It would probably surprise them that the members of the Commission with whom originated these restrictions on the application of the Land Acquisition Act might not be so sure that the conditions they lay down are not applicable to sugar. The Committee express their alarm that, if the application of the Act in the case of sugar be admitted, it would be extended to other crops, though they knew perfectly well, and, indeed, they stated, that the case of sugar is very different from the case of other crops. Industries based on other crops as raw material can get on without being planted in the rural areas where the raw materials grow, but a cane factory must be in the centre of cane. The Committee also lay great stress on the argument that the cultivator ought not to be compelled to grow cane, if he does not, though there was no suggestion that there should be any such compulsion beyond the compulsion there is on anybody, entering into a contract to supply raw material, not to fail to supply that raw material. I do not think that compulsion in any large measure will be required, nor are the Committee averse to the principle of compulsion, since they themselves have recommended the exercise of the Land Acquisition Act in certain cases. When a penal law is enacted it is not supposed that everybody will incur the penalties. The restrictions of the law are against a small number of people whose interest it may become not to act on the law precisely because a great majority will. The enforcement of the Land Acquisition Act, therefore, would be against such people, and that after proof that there is no alternative. I could not deduce any intelligible reason for the Committee's opposition to a well-understood principle and the actual practice of Government; so I submitted a note which I here reproduce *in extenso*.

V.—Compulsory acquisition of land for cane cultivation.

31. The difference between the Committee and myself is small and I must make my acknowledgments of the Committee's generous quotation of my arguments. Nevertheless, I must put upon the Committee the responsibility for emphasising this small difference in the Report.

The situation is that the Land Acquisition Act is the law of the land which can be applied by a Local Government for all purposes which it declares purposes of public utility. The Industrial Commission has emphasised the need of applying this Act to all industries, and suggested certain restrictions which Local Governments should observe in declaring purposes of public utility. One Local Government has applied the Act to acquisition of land for the growth of cane. I have myself, as the Report shews, suggested quite a number of further restrictions, and would have been prepared to accept any other suggested, provided the principle of the Act was not interfered with or censured. The majority profess that several measures of a purely voluntary nature which have been suggested in this Report would suffice to introduce the organisation of large factories with reasonable rapidity ; I consider that the weapon of Land Acquisition should be held in abeyance till all voluntary expedients are exhausted ; but that it should not cease to be available as now, in case ignorance and obstinate misconception of interest or disregard of the community's best interest by unenlightened obsession of self-interest should prompt resistance to the most reasonable organisation by voluntary expedients. I hold that the efficiency of the said voluntary expedients would be greater for the present Act looming in the back-ground as a corrective of anarchic unreason ; the majority seem to repudiate the corrective as poisonous to the social body, however effective for its object it might be. The difference, though small, is significant.

32. The majority of the Committee condemn the principle of the Act as applied to cane agriculture generally, though they would not hesitate to apply it

to acquire the sites for sugar factories, or to acquire agricultural areas for the growth of cane seedlings. Their objection semes to be that the principle once accepted might be applied to cotton or oil seeds and to the acquisition of agricultural land generally. I do not follow this, seeing that the Committee themselves acknowledge that the position of a sugar factory in relation to its raw material is special and entirely different from that of any other kind of factory. And since it is not proposed that all factories should be encouraged to get land acquired for then, since I have expressly stated that the whole object is that the factory should obtain control over cane cultivation as in Java and that other means of acquiring that control should be preferred to the control by acquisition of land and that not 5 per cent. of the cane area would be so acquired, it is difficult to understand how the proposition to keep the Land Acquisition Act as now available in the last resort should lead to the control of agricultural land generally passing to capitalist enterprises, or why such a result, provided the status of the cultivator is not degraded, is to be considered a danger. Tenderness to a small cultivator is a very different thing from tenderness to other landed interests ; nor is land the only interest in the cultivation of cane. The actual cultivator has, perhaps, the smallest interest even in land in nearly all parts of India. He is liable to ejection for one reason or another ; he is not capable of understanding the alternative policies open to him until those policies have, in several cases, been in practice demonstrated to be good. Then he imitates and follows, if he has the means and the freedom which he rarely has. The Committee mention that one Local Government has applied the Act to cane areas in just one instance. Their shiver before the principle of Land Acquisition as applied to cane is tantamount to a declaration that this application in one particular instance was an oppressive act. I consider this judgment thoroughly unjust. There was no evidence before the Committee, and before committing themselves to such a declaration it was the duty of the Committee to obtain the proceedings of the Court of Enquiry which recommended the acquisition so as to see what was put forward on behalf of the discontented ones as the gist of the oppression. The Committee relies on the few factories that have been established during the last five years for the hope that with patience more factories will be established without resort to Land Acquisition; but this reliance is groundless, because when things are booming there always are some financial people willing to sink their monies in enterprises dealing with the things that boom. The Committee themselves shew that the old established factories have been more or less starved of cane under the old regimé, and that, if we may hope that a better price of cane will induce cultivators to supply the full amount of cane, yet a factory needs more than the mere hope of this Committee. A factory would be wrong to establish itself without assurance of raw material, whose owners might hold it up at any time.

33. The Committee seem to me to forget here that the mere supply of cane is not the only desideratum, if the cane industry is really to get a spurt ; cultivation processes have to be altered ; new varieties introduced ; campaigns organised against disease and wild animals ; deficient and irregular water supplemented ; depôts of fertilisers established ; transport and communications improved before much progress can be made ; and the small cultivator has very small holdings becoming smaller and smaller with each generation. These holdings are scattered ; he cultivates with borrowed capital ; he has no credit and no science and no large views, but a great suspicion of being swindled at every turn. Therefore, the organisation, science and large capital applied to agriculture which are essentials of a large sugar factory can never materialise in India, unless the small cultivator submits to be organised. If the organisation can be

voluntary, well and good ; and we all rejoice. We all agree that much progress has not been made by voluntary methods ; and, if some pressure looming in the back-ground can help the lame dog over the stile, I see no reason to eliminate that pressure and that possibility. The organisation need not be, and preferably would not be, by the transfer of ownership from cultivator to factory. The Committee should have suggested alternative possibilities of organisation. Government should offer to facilitate such organisation at the cost of the factory, even to take an interest in negotiating such an organisation. Land Acquisition has been considered because it is the only weapon that the law allows. It has been very sparingly used : in fact, only in one instance for cane. It is understood that Local Governments are known to be very shy of using it. They have been shy of using it even for the acquisition of sites for their own agricultural farms. No land acquisition proceedings can take place without Local Governments publicly declaring that such acquisition would be of public benefit and after public investigation of the whole question. The Industrial Commission and the Committee are giving further guidance to Local Governments as to how public utility might be prejudiced by land Acquisition, unless certain suggested restrictions are observed. If after all this it is assumed by the majority of the Committee that any interest might be presumed to suffer, the presumption can only be that they have no confidence in Government judgment, or Government enquiry. I am very glad to say that I do not share this distrust of Government intelligence or integrity where Government action is taken after an open enquiry and contrary to the normal Government bias.

34. I do not think the Committee need have worried themselves about unpopularity and disorders, because the machinery of Land Acquisition will only be put into operation by the Indian Minister responsible to an Indian Legislative Assembly who might be supposed to be sensitive to the possibilities of disorder. It is the Committee's business loudly to assert the need of sugar cultivation in India as required by India's poverty and by India's possession of suitable land, water and labour ; to explain that the best use of sugar growing land is in connection with large and scientifically organised factories ; that these factories would find it very difficult to live except by controlling organised scientific agriculture ; that the probablities are that, in the first instance, the transition to the establishment of large factories would be impeded by prejudice and by the want of long vision and want of resources of a small peasantry under the thumb of money-lenders. If the Indian Minister and the Indian Legislature find it necessary to use weapons which the existing law puts at their disposal, the Committee's Report, at all events, should give them the necessary courage, warning them only that the transfer of ownership of rights in land is not the only way of rural re-organisation which must be followed to allow land and water and labour in the country to be put to their best use. To rule out the pressure of existing law to guide the transition from the present anarchical rural industry to a more organised and higher condition is to bring into play the prejudice of Western politics where holders of large estates have not unoften stood on the shoulders of a small proprietary peasantry to assert the unlicensed rights of property. I sincerely trust that Indian Ministers and Indian Legislatures will not be put off from their plain duty to face the question of relieving poverty and pushing industry, from any plans of re-organisation, by any tale of dangers to liberty from the organisation of co-operation among interests to the largest benefit of industry and community. Let me repeat that India can do much more in the matter of sugar than she has done ; that the only promising way of doing it is through *large* sugar factories. The experience of the world shews that large sugar factories can only have an assured success, if they control agricultural

operations in connection with them ; that the sufficiency and regularity of the supply of raw material which every factory of any sort needs can only, in the matter of sugarcane, be obtained by the factory controlling the growth of cane and by introducing agriculture on a large scale ; that the co-operation required among small cultivators to bring about scientific cultivation and the regularity and sufficiency of supply is a most difficult thing to organise voluntarily ; that this voluntary organisation would become easier after the demonstration of the success of the first few trials for which compulsion may be necessary. The compulsion need not be used, if the law looms as at present as a bare possibility ; and the compulsion would only be used, if at all, under safeguards suggested by the Industrial Commission and enlarged by this Committee. There is no reason whatever to suppose that such sparing use in the last resort or the possibility of use would result in any abuse whatever or any deterioration of the condition of the cultivator or any hardship except to people who look to squeezing the public to take advantage of its interests. Any compulsion used for this purpose and on such people is, to my mind, not a hardship but a plain duty of administration.

35. Let it be never forgotten that a continuous, regular as well as abundant supply of cane from the least distance is all-essential to a large factory ; that neither the compactness of the agricultural area required nor the regularity of supply could be obtained from the present rural organisation ; that the factory by its very presence enters into an agreement to buy all the cane produced at the highest possible price, and that the cultivator cannot be let off from the agreement to supply the cane required at the price and no more ; that the science of the cultivator is far below the science of organised agriculture in securing a regular supply of cane whatever the season ; that with the best science Java has often found years in which the cane has fallen short of the quantity required by the factory ; but that with the small cultivator the supply of cane would be habitually short, and would be from longer distances than needed and in a state of unripeness or overripeness that sound agricultural knowledge could obviate. Organisation is the right word ; and to shirk organisation in the name of mystic words like Freedom is to give up the problem. However meritorious be the recommendations of this Committee, yet without rural re-organisation, whether spontaneous and voluntary or with a little direction from the Indian Minister and the Indian Legislature, these recommendations by themselves can produce no perceptible progress. The Committee forget that the world's want of sugar is not of the order of the 23,000 tons made by the present factories ; that in 1932 the estimated requirement is 32 million tons, while only 15 million tons were produced last year ; and that to this immediate high requirement of sugar by the world India has to make a tremendous contribution and that it can do so, if we would only will it. To renounce this will at the bidding of some exploded formula of anarchic freedom is neverlessness.

36. I have reason to believe that it is possible to have Land Acquisition *by consent* of the factory and of the cultivators together, provided two-thirds of the land be released to the cultivators on favourable terms. The advantage to both parties is that the price need not be haggled about. It would be appraised by an independent judicial authority. The advantage to the cultivator is that he gets 15 per cent. over the market price of his land. It should be open to the cultivator to take any proportion or the whole of his price in the shares of the factory.

37. I have also reason to believe that the application for Land Acquisition will not often be made without the consent of the cultivating owners, because in

that case the factory would have labour troubles. In Bihar, for example, the tenantry have such a high idea of their social status that, even if bought out, they would, rather than work as labourers, migrate ; as one of the conditions laid down by the Industrial Commission is that they should not be bought out unless other lands be appropriated to them, the migration would be easy enough. If the factories, on the one hand, be loth to apply for the enforcement of land acquisition if they are likely to lose the existing occupiers for the cultivation, the Local Governments, on the other hand, are very reluctant to apply the land acquisition machinery even for Demonstration Farms, and are not likely to receive applications of factories favourably against the very strong will of the cultivating owners. In fact, I am willing to agree to make it a condition of Land Acquisition for the benefit of a factory that it should not be granted unless a majority of cultivators and a majority of villages agree. I would not be tender to the rights of the absentee land-owner or the money-lender ; but, though I would make this restriction my recommendation to the Local Governments, I would leave the Local Governments free, and would not fetter them even by this restriction. Generally speaking, rules should not be obligatory. They should be only guides.

38. No doubt the Committee's Chapter on Land Acquisition and this note upon it will be referred to Local Governments for advice. It is, therefore, fair to say here that the Committee had evidence not only that one Government had used the Land Acquisition Act on agricultural lands for the service of a sugar factory, but that it intends to use it again, and considers that its reasons for the use are irrefutable and that no progress, not even 'ordered progress,' can be made without the use of the instrument the law has put in its possession. It would be unfair to omit to say further that a senior official from another Province, and that the most important from the point of view of sugar, has in his evidence explained clearly how much the land tenure in his Province hampers progress. That Government has not used the instrument of Land Acquisition largely because its law-officers have considered it not permitted by law ; but, as I interpret the evidence of the officer referred to, he clearly said that, if the Land Acquisition Act is to be amended, be hoped that power might be unambiguously given to Local Governments to use this instrument, when needed, not to use it generally but to use it or not to use it in each case 'on its merits." I suggest that the reference should clearly point out my argument, that the Land Acquisition Act need not be always used even in the matter of agricultural land connected with a sugar factory, and that the considerations which make it useful sometimes to use it in the case of sugar do not apply in the case of any other crop. In the case of sugar the connection between the factory and cultivation at its door is simply vital. It has also to be pointed out that, unless factories be secure of a regular cane supply, factories would be foolish to start business ; but that, if factories can be got to start with security of supply, a price could be paid for cane of which the cultivator at present has not dreamed.

39. Similarly, I could not see why the Committee resisted the application of the principle of licensing of sugar factories which exists in Java and which I wished to make permissive in British India on the application of factories, provided an undertaking could be enforced that the license was not to be used to pull down the cane-growers' prices. I was particularly anxious to connect the scale of prices on which the Committee were working with the principle of licensing ; I was anxious to give something for something against the Committee's principle of nothing for nothing, or something for nothing, or nothing for something. The factory needs security in regularity and abundance of the supply of cane. The cultivator needs protection against being exploited for the benefit of

a monopolist factory. If the cultivator gives the security, he should receive the largest price that the factory can afford ; if the security be withheld, the factory cannot afford that price. I argued the whole question in two notes one on licensing of factories and the other on prices of cane which again I sub-join in full.

VI.—The scale of prices for cane.

40. The Committee's scale is not a scale obligatory on factories or on cane growers, but it is good evidence of the contention of the Committee that sufficient cane has not been grown for factories because an adequate price has not been paid to the growers. At the same time the problem has not been stated with sufficient definiteness and concreteness. When the price of sugar is low the problem becomes definite of itself. How much can the factory afford to pay ? how little can the cultivator afford to take ? The two figures would be more or less coincident, provided the cultivating process and the factory process were both the most efficient. When the price of sugar is not low, there would be surplus profits, if cane were supplied at the same figure as when the price of sugar was low and, if the efficiency of the factory continued ; and a further question arises how these surplus profits are to be divided. In any case the price that a factory can give when its supplies are irregular and the quality of the cane poor is not the same that it can afford to give when there is greater regularity or better quality. It might have been observed above (section II, paragraph 19) that the actual cost 3-4 years ago in the principal sugar countries of the world, when the price of sugar was low, was over two-thirds of the whole cost of sugar. I also observe that, taking the price of sugar at Rs. 10 and deducting from this price the factory cost, including profits and depreciation on the same basis as those of Java, the margin available for paying for cane would be more than 70 per cent. of the price of sugar. When the price of sugar is trebled, as it was this year, the price of cane may still remain 70 per cent. of this increased value of sugar ; the factory cost may be trebled and the profits of the factory would be more than trebled. I have, however, taken note of the fact that there is a general feeling that capital would not in ordinary times be attracted to the sugar industry in India. I, therefore, not only agree with the Committee in proposing a minimum price for cane and in fixing it at 6 annas per standard maund, but also in recommending that only 6 annas should be paid for cane so long as this represents not less than 50 per cent of the gross value of the sugar obtained from it. This mean that 6 annas only would be paid for cane so long as sugar did not sell for more than Rs. 10 in the case of a factory extracting 7.5 and Rs. 8.82 in the case of a factory extracting 8.5 parts of sugar per 100 of cane. Thereafter, however, I would go further than the Committee in giving two-thirds the additional value of sugar above this point to the supplier of cane instead of half. The two scales can be stated algebraically as following :

Committee's scale	(a) With 7·5 extraction	$\frac{100}{7·5 \times 16} Y = \frac{1}{2}(10) + \frac{1}{3}(X-10)$	
	(b) With 8·5 extraction	$\frac{100}{8·5 \times 16} Y = \frac{1}{2}(8·82) + \frac{1}{3}(X-8·82)$	
My scale	(a) With 7·5 extraction	$\frac{100}{7·5 \times 16} Y = \frac{1}{2}(10) + (X-10)$	
	(b) With 8·5 extraction	$\frac{100}{8·5 \times 16} Y = \frac{1}{2}(8·82) + \frac{2}{3}(X-8·82)$	

where Y is the price of cane in annas per maund and X is the price of sugar in rupees per maund. At the same time I expect the cultivator in return for this

high value given to bind himself legally to supply cane for series of years on contract. Where any advantage is asked of Government so as to facilitate such contracts or so as to restrict an area to one factory only, then Government should insist that such a price be given to the cultivator. I would not base the price on *actual* extraction (as the Committee's scale proposes) but on the analysis of cane in sucrose and fibre ; if 84 per cent. be taken as the sugar extractable out of the sucrose in the cane, then I would say that the standard price is for 9 per cent. sucrose and 16 per cent. fibre. I would fix a maximum of 20 per cent. fibre and a minimum of 8 per cent. sucrose in the cane ; and I would fix, as in contracts for ores, a penalty of premium for each one-tenth per cent. of excess or defect of sucrose or fibre. There is no difficulty about these contracts, and the cultivator understands the principle in the matter of seeds, for example. If the price of sugar fell below Rs. 10, the contract would have a clause enabling the factory on a year's notice to cancel the contract for one season and for as many seasons as separate notices are given on a penalty of, say, Rs. 50 an acre to the cane contractor to compensate him for diversion of his land from cane to less profitable crops. I also feel that it would be serviceable to have in each contract some clause varying the prices with the months of delivery during any season according as a factory wishes to encourage delivery of cane earlier or later, or to discourage deliveries during any but the middle months.

41. Thus, then, the value of the scale of prices will depend upon the purposes to which it is applied, and it is not to be compulsorily applied to any purpose whatever. Large factories have to be planted wherever possible and profitable. They need control of cultivation and certain assured advantages of supply and scientific processes from the cultivator. In return for this the cultivator has the right to see that he can get the highest price possible, and that the factory is conducted in the most efficient manner and on the most profitable scale of largeness. The factory is entitled to expect from the cultivator readiness for the most efficient organisation and for the most scientific processes of cultivation and this mutual readiness of both factory and cultivator for the highest efficiency is to the advantage of the community.

42. It does not follow, however, that this is the only principle of prices which will yield the best results or which the Committee is prepared to recommend. So long as cultivation is efficiently organised it is for the cultivator to say which of the many possible principles for the determination of price he will once for all accept. One principle recommended to the Committee was that he should be given one-tenth of the prevailing price of the same weight of gur on the presumption that it takes 10 tons of cane to make one ton of gur, and that the more advanced methods of a large sugar factory should enable the factory to make profit without deducting the cost of conversion of cane into gur. Another proposition before the Committee as the best principle for the price of cane was that the cultivator should be assured every year the highest profit obtainable from his land by cultivating any other crop than cane or by the conversion of cane into gur, if cane was the most profitable, that is to say, the cultivator would get the benefit of the freedom to grow any crop he pleases, or put the crop to any use he pleases. If the *benefit* were assured him, he would grow cane regularly for the factory, if the factory took the risk. This last principle is capable of extension. If the cultivator would consent to be controlled in his processes, the factory might assure him the regular profits by the ordinary process and divide with him any extra profits arising from practising the new processes ; and in fact, villages or unions of villages might be organised as units of going concerns on this principle.

VII.—Licensing of factories.

43. In this note I have to repeat that the difference between the majority and myself on this question, though significant, is small. The Report considers that the measures it suggests will deter cane-growers in the neighbourhood of an efficient factory paying in accordance with their scale from selling cane to anyone but that factory ; hence that the protection to the factory which the licensing system is designed to ensure would automatically be secured without the compulsion of licensing. But, if the suggestions of the Committee are not adopted by the authorities on whom the Report counts to give them force ? or if these suggestions turn out in practice to operate differently from the design ? Will Governments allow factories to refuse to sell seed or water to cultivators who sell cane to rival factories or refuse rival factories the same facilities of land acquisition for seed and water ? Why pronounce against the protection which might be wanted after all ?

But if, on the other hand, the protection to factories which licensing is designed to confer, should arise from the measures suggested by the Committee, is not the second case worse than the first ? For licensing was recommended as a simultaneous protection both to factory and *cane-grower*. In the absence of regulation, competition alone can be trusted to render the most efficient use of cane, and bring it the highest price. If the recommendations of the Committee eliminate this competition, and confine the cane-grower to a single factory for his market, he cannot force the factory to be efficient or generous. The utmost that he can do is to cease to grow cane, when its price pays him to grow another crop in preference. But this possibility is not sufficient to force the factory to pay the cultivator the highest price it can afford with the largest efficiency. The refusal of a license to a factory, unless it undertook to pay such a price, (determinable under one or another of the scales suggested in this Report, or other scales which might be mentioned) would secure to the cultivator protection against being left to the mercy of a monopolist factory. This apprehension of regulation is surely excessive, this rapture over the mystic virtues of non-regulation unwarranted. The problem remains unsolved ; the shadowy palliatives come and pass and fly.

44. The Report emphasises that the Java licensing system is not intended for the protection of factories and cultivators at all, but to prevent more land from being diverted from food crops to cane. The Report omits to say that no such protection is needed by Java factories which are the heirs of old compulsory leases which have been continued by custom. And is there no present trepidation among factories in Java as to what is to happen when the present leases run out and the cultivators awake to possibilities ? Indian factories gave evidence that there is need of a regulation of the cane supply so that factories do not insanely compete for the limited quantities grown within an area. It was felt on the Committee that this regulation would put the cultivator at the mercy of the factory, and remove such small possibilities of competition as at present help him to make any stand. Unless regulation can protect *both* interests, regulation is not to be thought of. The licensing system submitted for consideration to the Committee harmonises the two interests, by making the advantage to the factory dependent on the factory paying the proper price which the Committee profess to be able to indicate ; and licenses are not to be forced on factories that can look after themselves. Where factories own land or long leases of land or have effective long period contracts for supply of cane, they will look after themselves ; even there it will

be a question whether the validity of transfers or leases or contracts should not, as in Java, be subject to exploration by Government officers and their certifying that the interests of no parties have been neglected. Nowhere outside India is the *need* of regulation so great. On the one hand, a factory of a given size in India needs far more land tributary to it than in Java or Hawaii ; the yield of cane is miserably poor, the quality of the usual cane is low, the extraction is inefficient, the holdings are small and scattered ; the factory has to forage far for its supplies. If interlopers may poach on these preserves, the foraging would have to be on further areas, and the primitive transport system and the deterioration of cane over long transport impose sharp limits on the areas of dependence. On the other hand, the cane-grower, because he is small, suspicious and without long views, is a weak bargainer ; the Committee are well aware how generally low the prices of cane have been, and what a small proportion of the rise in sugar has accrued to the grower ; how different have been the prices secured by sugar planters in other sugar countries. And the Committee have before them a scheme which promises to help both factory and cultivator ; and all that they can say is a formula ! Schoolmenwise, they repeat *Vis Medicatrix Naturae* ; or, as they English it, Beware of drastic compulsion !

45. People unquestioningly accept the municipal regulation that no new buildings are to be put up without the Municipality passing plans ; yet they object to a regulation that no new sugar factories are to be put up without license. Yet the principle underlying both regulations would be the same. In a building the foundation (land) is not the only basic utility ; air, light, heat are equal considerations ; and experience shews that without regulation, a builder might be disregardful how these conveniences of other people might be affected. Similarly, a new sugarcane factory cannot be trusted, as Indian experience has shown, to keep from fouling the cane supply interests of existing factories ; and regulation has to provide against this demonstrated contingency. Such a regulation is no more a drastic innovation than the accepted Municipal regulation ; and it is equally necessary to bring into relation the interest of the owner of land rights with the interest of the separate owner of water-rights and the interest of the community. More generally, it is the interest of the community that a factory should have a regular assured supply of its raw material, and that the fullest science and the largest capital be applied to the working of the raw material. It is also the interest of the community that the factory should not, on the one hand, be held up by the supplier of the raw material, and that this supplier, on the other, be not exploited by the factory. Where the two interests are not unified, normally competition of many factories, and many suppliers of raw materials, in all parts of the world, ensures the largest price for the raw material and largest efficiency of the factory and efficiency of supply to the factory. Where, as in cane and sugar, neither the supplier of raw material nor the manufacturer can rely on competition to produce the normal efficiency, the interest of the community requires regulation to step in where competition cannot work. Regulation is delicate work, and inexperience may aggravate evils which regulation sets out to remedy. This is an excellent reason for severely scrutinising easy panaceas lightly offered ; but it is no reason for leaving alone all schemes for suggested regulation. The conscience of mankind has repudiated as *damnosa hereditas* the legacy of *Laissez Faire*, derived from Victorian Liberalism. The need for regulation has been felt ; regulation has been asked for ; regulation need not be imposed, unless asked for. The mode of regulation has been before the Committee in the shape of one of its own schemes on which the Committee has spent a great deal of time, and yet regulation has to be discarded, because regulation is contrary to some occult principle!

46. It will thus be seen that what I am anxious about is that the condition wh experts declare to be essential, namely, the putting up of large factories in c junction with cane lands and the control of those lands by the factories, sho be somehow fulfilled ; that voluntary methods of organisation of a village of c tivators into cultivating units and unions of them and giving them proprieta rights in factories, or leasing of lands from the cultivators without dispossess them or divesting them of interest in cane should all be tried, but that the press to discuss matters reasonably which is given by existing legislation, or mi be given by legislation amended, should not be withdrawn. And, similarly am anxious that the importance of water to the growth of cane as co-equal that of land ownership should also be emphasised. The Committee h spent much time and trouble upon problems of irrigation a drainage. If I proceed again to supplement the Committee's deliverances is not as an expert on the technical aspects of irrigation, but only to bring how much more could be done (according to the judgment of a layman inter ed in economic, commercial and financial problems) by development of implications involved in the professions of the Irrigation Departments that t are business departments. My note reproduced hereunder should be read o in that light.

47. My personal experience with the distribution of electric currents in b supply as well as individual supply and different charges according to lo factor has greatly helped me in the composition of this note ; for example was suggested to me that the volumetric rate would, in seasons of abund rainfall, kill the solvency of canal finance, since nobody would use a drop water, and so no water rate would be payable. My reply was easy. Th should be a standing charge merely for the construction of the canal and me for the availability of water, when needed. Then there would be an additio charge in proportion to the water taken. This additional charge would help save waste of water, and the standing charge would secure that the canal fina was not insolvent. I have also been helped by the economics of Railway r to which I happened some years ago to give some attention.

VIII.—Drainage and Irrigation.

48. I agree with the Committee's recommendations on drainage, irrigat lining of canals and redistribution of lands in the Deccan. If the Deccan la have water and are preserved from water-logging the Deccan is the most p mising tract for cane ; and enough cannot be done.—

(*a*) But I wish to go further than the Committee, in the matter of acq ing lands for drainage and redistribution of drained lands consider that the scheme put before the Committee by Mr. In Executive Engineer, Special Irrigation District, Poona, shoul adopted as a whole. I would have the lands, acquired and rev by Engineers, leased out again in compact areas to the most cap new or old tenants alive to progressive methods of cultiva There are no legal rights to be tender to, and moral right, su is predominantly with those who can make use of the land to best advantage of the community.

(*b*) I understand, that in the Sind-Sagar-Doab Colonisation Act (Pu Act I of 1902) the Irrigation Department annex a portion of Betterment due to the construction of canals on waterless s This is done with the consent of the land-owners who, in return the construction of the canal, hand over three-fourths of t

waste lands to the Irrigation Department. I think it a sound *principle* to be desirably a part of all canal constructions and trust that the community will be enabled to harvest what it alone sows. Canals, not profitable enough without this crop of Betterment, may prove profitable both to the Department and the cultivator. The principle of Betterment is a part of the Law of Great Britain.

(*c*) The inflexibility of canal rates prevents progress in irrigational construction. I agree with the recommendation made by the Committee that volumetric rates should be charged, so that crops bear a water-rate in proportion to the water they consume. There is reason to believe that over-watering to the detriment of both soil and crop is a very prevalent sin ; and a volumetric rate should act as a penalty on careless use. On the other hand, I am entirely in favour of the much censured basic principle of railway rates, to charge in accordance with what the traffic can bear. Crop growers can afford to pay rates, not in proportion to the quantity of water they use, but in proportion to the *utility of the water* to the crop. If a gallon of water add increased value to cane double of what it adds to wheat, the cane water rate should be twice as great as the wheat water rate. And the water rate should be specially large during special months when it is very difficult for the canals to supply water, and yet when every drop of water obtained is the lifeblood of a crop like cane. The peasant of the Deccan understands the matter so well that he offers to pay 33 per cent. more rate per acre, if he be guaranteed regularity and abundance of supply. It is worth while asking why the Deccan pays a rate of 45 rupees per acre against less than 10 rupees in the Punjab and the United Provinces. So far as cane is concerned, Deccan grows 40 tons of cane an acre against 10 tons in North India ; so that disparity per ton of cane is greatly reduced as compared with the disparity of irrigation rate per acre. The remaining disparity may possibly be accounted for by the possible lower cost of production of well-water in the North as compared with the Deccan. When irrigated crops rise in value, the owner of water has as much right to a share in the increase as the owner of land. There is no reason why there should be the same water rate in a Province, or even on the whole length of a long area ; the utility of water to some soils may be greater than to others, and the cost of construction of canals per unit of water may be different. Flexibility in water rate may enable the construction of beneficial canals where the present uniformity of low rates forbids. This, I hear, is the case in the Madras Presidency. The rule that the rates should be accordingly to the number of waterings would in another way greatly reduce the disparity between the Deccan rate and the North India rate. The Deccan waterings are said to be 40 per acre in a year and the North India waterings may be anything from 8 to 15, so that, while the Deccan rate is Rs. 1-2-0 per acre per year per watering, the North India rate of Rs. 9 for 8 waterings would be the same, and for 15 waterings would be about 9 annas, or half of the Deccan rate.

The principle that the rate should be what the traffic can bear would, as explained, partly involve a charge of water rate per ton of cane. In the Deccan it would be about a rupee per ton of cane and in North India it would be much the same. It should be remembered that without water the Deccan would yield no cane at all, or so very little that it would not pay, so that the charge on this principle, the additional value due to water, might be taken to be almost the whole or at least half the value of the cane. In practice the rate has to be adopted by attention not to one principle but to all, and there is a decisive factor which cannot be ignored, namely, the cost of alternative water in the shape of wells to the cultivator.

(*d*) The Irrigation Departments profess to be run on business lines, and they certainly earn good *dividends,* and render immense public service. Nevertheless, as the discussion of water rates shows, they are not flexible enough, they are apt to forget that being *monopolist*-businesses, they have to undertake *obligations,* such as *regularity* of service, supplementary sources of supply as stands-by, prevention of seepage and salination of lands, advice against water-logging. I think that, just as hydro-electric companies have steam stands-by, so canals should have supplementing wells, tube wells, masonry wells, reservoirs, and should explore *all* the good, invisible as well as visible, to be obtained out of canal linings. All these mean increased costs, but the discussion under (*c*) in this note should show that they would mean profitable investiments as well as cost.

(*e*) Moreover, there is too much business by rules to make good business at all. Regulation is a thing good in itself, where there are many minds behind the execution of regulation ; and it is a strange thing Irrigation Departments do not avail themselves of the expedients of electric companies to ensure intelligent execution of rules. Electric companies sell in bulk to middlemen, and canal water can be sold to Irrigation Associations or Village Panchayats who might be supplied volumetrically, and who would do the thinking to secure the distribution of water without complaints. The Irrigation Departments are not business concerns if one or two failures dishearten them, or if they wish to settle down to contented administration of old rules, where fertility of new expedients is the test of a living business. The Deccan has led the way in the matter of Irrigation Associations presided over by the Director of Agriculture ; Dr. Harold Mann could have alleged the discontent about bunds referred to in the Report, by the Irrigation Association under his advice acting as a reliable intermediary, and undertaking the expense of determining where bunds can be dispensed with.

(*f*) It all resolves itself into this ; that a Government department is apt to say " take it or leave it ; what we have spoken we have spoken. " A business company, unless demoralised by fatty degeneration of the heart, will conciliate its customers, try to understand even their idiosyncracies, give them seats during discussion, usually end with " What you have spoken today, that we shall speak tomorrow. " If one expedient fails to serve, another would be forthwith tried ; above all, men on the spot would have authority to conciliate, would not *wait* for reference to the gods on Olympus. While tendering my unstinted admiration of the services of British Indian Irrigation, I strongly urge engrafting on the Departments

local and individual initiative, emancipation from rigid rules, greater use of intermediate interpreters, variation of rates according to service, tireless attention to even the whims of customers—which constitute Business Methods. If a larger and more educated staff be found necessary, the customers' appreciation of business adaptability will bring appropriate increase of revenue.

49. The Committee say that certain aspects which I have discussed in this note are beyond their province ; with this deliverance I do not at all agree. It seems to me quite pertinent to point out that the Irrigation Department should be a business department, as it claims to be, and that its method of charging rates, if it should bring insufficient revenue, might postpone canal schemes whose postponement might be very injurious to sugar, while not only sugar but all crops might be able to pay the full rates necessary to make the scheme self-supporting. There is, I am glad to see, more diversity and flexibility in the determination of canal rates even within a Province than I had anticipated ; but that is not saying that there might not be more diversity and flexibility than now to the great benefit of new canal construction and benefit of special crops without injuring other interests. I have, therefore, urged on the Committee to recommend that the system of charging rates for canals should be compared with the system of charging rates on Railways where the sort of commodity supplied is much the same under much the same sort of restricted monopoly conditions, where public advantage has to be considered as well as profit and where the economics of rates seem to have been worked out to general agreement. The Committee was certainly not called upon to discuss all these aspects in full detail ; but I submit that the Committee might have, with advantage, made the recommendation that the Irrigation Department would become a more efficient business Department, if it compared its system of rates with the principles of rates found efficient on Railways, and also if it compared its own methods of supplementing water supply in certain lean months with those found useful in hydro-electric supplies. There is no suggestion that this supplementing of water supply should be pushed even where cost might be prohibitive. The only suggestion is that the Department, being used to a fair revenue and a fair contentment with existing methods, might not look out for new methods as a business concern would, to increase the contentment and benefit to the public including cane-growers and sugar factories, if Committees like the Sugar Committee did not press new methods on their attention.

50. I rejoice to see that in Northern India the principle of betterment argued for in this note has received unconscious acknowledgment to a limited extent. The land revenue on irrigated lands is more than the land revenue on unirrigated lands, sometimes double or quadruple, and this is in addition to the water rate. The trouble is that this increase of land revenue on irrigated lands makes a present of an equal amount to the landlord whose rent is twice the land revenue ; or, in other words, the cultivator is mulcted of a considerable fraction of the additional value of the land he cultivates due to the canal ; but the landlord who gets a half of this additional contribution has done nothing for the canal, and the owner of the canal who has done everything receives only a half of the contribution. This is an illustration of how the procedure of the Irrigation Department calls for re-examination in the light of business principles.

51. And if I look to rural re-organisation for the development of agriculture in this country generally and of sugarcane particularly, I also look away from the other and very familiar expedients of spoon-feeding industries by tariff, or by manipulations of land revenue. In my tariff note I only emphasise the Committee's conclusions that there is no room for protection in the sugar industry.

I put aside Preference as unworthy of a Member of the League of Nations, and I shew not only how excise duty above a certain limit of price could guard free trade, but how its realisations should be used for the help of the sugar industry.

IX.—The Tariff and a suggested excise on sugar.

52. I agree with the conclusions of the Report—

(*a*) that the sugar tariff is primarily a revenue tariff, and is not protective in intention ;

and (*b*) that, so far as it operates protectively, this protection is not at present needed.

But (*c*) I do not agree with the further suggestion that when sugar prices fall protective duties at a higher rate than 10 per cent. might be considered.

I hold that the whole duty is paid by the consumer whenever the price in India is equal to the world-price plus freight to the consuming centres *plus* duty ; but that the Indian consumer pays an additional tax to the native sugar producers as well as to the factories, to the extent of at least as much as goes to the revenue. Very little or nothing of this tax has gone to the cultivator or the labourer ; the consumption of a very useful and serviceable article has been, to some small extent reduced ; the profits of sugar manufacturers, anyhow very high, have been increased. It is obvious that, if sugar manufacturers had any sense of decency, they would make a large reserve fund of their own from which they would grant bounties to themselves in times of falling prices, in the same way as German and Austrian Cartels fed exports in the past ; and that they would ask for an Excise Duty from the proceeds of which Research and Sugar services could be paid, instead of burdening the taxpayer with the support of them. But in the present day Business Ethics of "the Devil take the hindmost," such decency is past praying for ; the Committee might have led the way and pointed out where decency lay, even if they forbore to make recommendations of compulsory decency ; they have, by proposition (*c*) given positive recognition to indecency. To ask the taxpayer and consumer to shoulder heavy risks of business in slack times, without participation in the profits of brisk times, to put upon the community the expense of the manufacturer's inefficiency and ignorance ; is a time-dishonoured way of encouraging industries with which the Sugar Committee has unwisely associated itself. Protection is given to the weak by the strong, either as *charity,* or as a recognition that, the weakness being the act of the community, the community should come to the rescue of the weakness it has itself created ; but Business Ethics demand support of the *strong* by the *weak,* as a business right. It is not the interest of the community to consume bad, dear, home-made sugar ; the Empire which has assented to the League of Nations cannot cultivate business antipathies to citizens of other lands ; experience has shown that national "self-containment" may break down by a strike of transport workers in peace as well as by war, and that the Protective systems of the European Central Powers actually put them at a disadvantage in the matter of sugar and agricultural supplies during the Great War, compared with Free Trade England. I am further of opinion that the Sugar Industry could provide against the fall of prices by dumping, as against the fall of prices in the course of nature ; moreover should so organise its autonomy that cheap dumped sugar might be bought up for developing the confectionery business or for new uses of sugar. On all these points, my evidence for facts stated and my arguments and proposals in detail were early laid before the Committee.

53. (Parenthetically. I wish to recognise that the management of one important group of factories are so adjusting their price of cane to price of sugar that half the benefit of duty may go to the cultivator. This is considerable progress in decency. Nor do I ignore that occasionally there will be periods when the price would depend entirely on abnormal stocks or abnormal demand, and not at all on cost of production, therefore, not at all on duty. The consumer would, in such cases, pay the same price, with or without duty ; the speculating seller pays the duty, and not the consumer of sugar. But these considerations do not affect the manufacturer as manufacturer ; and he can always set apart from high prices a reserve fund to support him in low prices ; and the duty always helps him in his bargaining with the speculator, or his competition with the foreign manufacturer). The Committee glimpse their problem as one of attracting capital to sugar factories, and everything else as subordinate to this problem ; to me the problem is supplying *cheap* sugar to the world, and large sugar factories as only an instrumental good. If capital be not so attracted to Indian sugar factories, if piratical ideas have to be indulged in order to create sugar factories as the supreme good, I unhesitatingly declare that India does not want or need them ; they are not good enough. So far as revenue is concerned, the greater the sugar production in India, the less the revenue. So far as Protection is concerned, *Bounties* on sugar marketed would be more effective than *Protective* customs duties, and these bounties could be furnished by the trade itself fattened by 200 per cent. profits, as the Central Europe Cartels have found Bounties for Export.

54. The omissions of the Committee in this regard are that in adopting conventional opinions on tariff, they have not investigated the actual operation of Duties and Bounties, not dispelled the flim-flam about Dumping and Self-containment, not discerned in the manipulation of tariff large opportunities for social ends, have condoned present inefficiency of sugar methods and offer to encourage them, have turned away from an Excise Duty on sugar because of the unjust unpopularity of the Excise Duty on cotton. They misconceive the problem as one of capital and factories, whereas the main problem is that of cheap sugar for the world, a problem which can be compassed only by so extending Indian sugar cultivation that India should become a large sugar exporting country. This result is not to be achieved by pre-occupation with Sugar Research and sugar tariffs, but by the courage of a far-reaching vision of rural reorganisation. And the Empire's commitment to the League of Nations and India's acknowledged place in the League ought to have given the Committee the daring to ask Government and the people whether Preference as a principle ought not to be relegated to the limbo of past futilities, as inconsistent with the spirit without which Leagues of Nations cannot work.

55. Generally speaking, it may be laid down that, if a tariff be entirely for revenue, customs duties with corresponding excise would be most effective ; if entirely for Protection, bounties should be most serviceable ; if both protection and revenue be the object, higher protective duties than excise would be the policy. But as statesmanship has learnt that taxation is not merely the instrument of revenue and of equitable incidence, but may be made an organ of redistribution of wealth, of repairing inequalities unavoidably caused by the social structure, and of a general promotion of well-being, so the ends of a tariff should not be limited by its professed objects of revenue or Protection. This aspect is usually alive when people discuss Preference ; and I have adverted to it in this note above ; but a portion of the tariff revenue, preferably the portion contributed by excise, may become utilisable for social objects in connection with the industry subjected to a tariff. It becomes important, therefore, to develop this discussion constructively. I have no hesitation in laying down that, even if it be an object

rotect the sugar industry, the funds for Protection should, as far as possible, e from the industry itself which should be definitely organised for that pur-. The nature of this organisation will be discussed in my separate note h will deal with Research and my conception of what the Sugar Board should (*vide* Section *XII* below). But the principle is indisputable. No stry should be allowed to levy a toll on the people as a whole, ther as consumers or taxpayers, for help in low times, with- the industry contributing in good times adequate premiums towards assistance. Protective tariffs should be in the nature of insurance n industry. I suggest that the sugar industry is not worth encouraging in a, unless, with present costs, it can earn a living profit at Rs. 300 per ton. figure then may be taken as the *datum line*. The Sugar Board should make ant-in-aid when the price falls below this *datum line*, and the funds for this ld be created by the factories (which wish to be beneficiaries of this grant id) contributing a substantial part of the excess over the *datum line* when es are high—a graded proportion of the excess as prices rise, highest when es are highest as *e.g.*, when they reached 1,100 rupees a ton this year. Where ultivator participates in this fluctuation of price, the price of sugar taken for rmining the scale should be the *net* price to the factory, *i.e.*, the market e *minus* the contribution to the Sugar Board, or the market price *plus* the t-in-aid by the Sugar Board.

56. If the tariff be by a customs duty, the duty should be balanced by an equint excise, which would be levied only when the price of sugar is above the *m line*. I am of opinion that a fixed duty of 30 rupees per ton would be er than the present sliding scale ; and that the excise should be the excess he market price above the *datum line*, with a maximum excise equal to the oms duty. I further suggest that sugar refineries be exempt from this excise lready they would have paid duty on the raw sugar they import and refine. excise realisation should be handed over to the Sugar Board, along with the te share of the surplus profits of the State-guaranteed sugar factories, for enditure on Research and other elements of well-being of *all* the sugar insts.

57. And in this connection, I am for a Government Factory conducted by oard of Directors and a managing Director all partly remunerated on a system onuses. I agree with the Committee that the conduct of such a factory should without regulation by Accounts Office rules, or by references to the Headquars of Government. All the control should be exercised by the Board of ectors acting through their Managing Director, and there should be the al commercial audit and control. It seems to me that this object could be t achieved by converting the Government Factory into a joint-stock Comy, Government holding shares or debentures, whole or part as they please, t as the British Government does in the Suez Canal Company or in the glo-Persian Oil Company. Government interference then will be merely guarantors, as on private guaranteed Railways, or as shareholders, as on leased Railways, that is to say, they would appoint Directors and ask for cial enquiries as shareholders when things do not go well. To put it in other way : the Government sugar factory will be conducted not on the lines Post and Telegraph Offices, Ordnance Factories or Military supplies, but the lines of the Anglo-Persian Oil Company, or the State-owned leased Rails in India. This would simplify the recommendations of the Committee ich might otherwise be up against some unknown or unseen rules. For the rpose of this factory, and I should say for the purpose of the Report as a

whole, there should be no bar on the employment of citizens of States outside the British Empire. The Government Garden at Buitenzorg and factories in Java have been obliged recently to employ American botanists and Danish chemists because Hollanders cannot be obtained. I understand that there has recently been a great difficulty in recruiting for the Agricultural Service in India ; a difficulty which is sure to remain outstanding for years because the training of professional people in every department has been arrested by the War : the young men who would have joined the Colleges went to the battlefields.

58. Similarly, I proceed to point out how much land revenue is misjudged as if it was a tax very different from the postage stamp, or water rate—that is, anything else than payment for service, and I draw out the full consequences of the two attitudes of the critics of the land revenue system and my own. I am given this opportunity of dealing with this subject by the recommendation in the Agricultural Chapter on Burma for a temporary reduction in the assessment on cane.

X.—Land Revenue.

59. I agree that cultivation of cane by small cultivators should be encouraged. Even if the areas be scattered and do not permit a Sugar Factory to be based on them, still it is an advantage for the greater production of sugar that gur should be made in such areas, so as to relieve the strain of gur on cane in more conveniently situated areas, and release this cane for sugar.

But I do not think that this object would at all perceptibly be attained by manipulations of land revenue. The whole revenue for cane purposes in Burma is Rs. 10 an acre ; supposing the revenue be halved, it is only a matter of Rs. 5 an acre on an output ranging in value from Rs. 300 to Rs. 1,800 an acre ; and this saving is not likely to serve as an encouragement for the growth of cane. To expect encouragement is of the same order of ideas as that which 30 years ago sought encouragement to the iron industry in diminishing the royalty on iron ore by ¼ anna per ton or ½ anna per ton. Remembering that even in Ryotwari tracts the ryot paying revenue tends to become a middleman, and that cultivation is done at rackrent by temporary holders, any alleviation of revenue amounts to a present to such middlemen. If encouragement is to be given to the growth of cane by the small holder, and if also the principle is to be accepted that for a given area the land revenue payment should be the same, whatever crop be grown, I suggest that at the settlement the Officer should consider what is the most profitable crop that the land might be expected to yield during the period of settlement, and base his calculation of revenue on the most profitable crop being chosen by the cultivator. Thus, lands most suitable for cane would bear the cane revenue, even if the the cultivator chose to grow rice. The revenue would gain and the cultivator would have an inducement to grow the most profitable crop, and cane would thus become encouraged where it deserves to be encouraged. If, on the other hand, the State finds it essential to grow certain food crops, even if other crops be more profitable on certain areas, then a license would be granted by Government remitting the revenue, if the particular food crop found necessary by Government be grown.

60. In this connection I may once for all enunciate a proposition which is not popular, but which is essentially true. Land revenue is only revenue in the same sense as the profits of the Post Office or salt or tobacco monopolies are revenue. The revenue is really rent. The abolition or mitigation of revenue would be no boon to the community, because the price of food depends on the cost of production on the least productive lands which practically pay neither rent nor

revenue. The revenue-paying lands are of different qualities, and the differences of revenue are to equalise the advantages to the different cultivators ; the State being the real owner, the cultivators being owners only of tenant rights, Taluqdars and others, wherever they be, being middlemen to whom a portion of the State rights has been handed over. Reduction of land revenue is, therefore, only an advantage to middlemen and neither to the cultivator nor to the buyer of food. The cultivator may be a middleman himself possessed of favourable lands and thus may benefit, but not as a cultivator. To reduce land revenue would mean increasing taxation, and as the taxpayer in India is essentially poor, a reduction of revenue would mean hardship to the poor man.

61. All revenue is *rent,* and rent should be no burden to the rent-payer, if it be no more than the equaliser of opportunities of cultivation on lands of unequal fertility and favourableness of situation. It is perfectly true that it is not an advantage to the community that rents should hereditarily fall into private pockets ; but no more should they be presented to cultivators or Taluqdars, who by the remission or abolition of land revenue would receive presents (from the sorely burdened tax-payer) in proportion to their wealth and not in proportion to their need. The abolition or reduction of land revenue would present no compensatory moral or material advantages, as the abolition of Opium Revenue did or seemed to do ; and the tinkering with any large source of revenue always entails resort to questionable new taxes which would create far more discontent than would be allayed by the reduction of land revenue. The real complaint of the people of India is rather against the mistaken, though well-meaning, policy which has made the most flexible and equitable source of revenue in the country the least elastic and least productive, at least in certain Provinces. Bihar and Orissa, industrially the most progressive of Provinces, will find its industries an expense to its finance and will be reduced to a condition of unprogressivity by the stationary character of its land revenue. Therefore, I say to critics of Land Revenue—it is the backbone of progress, it belongs of right to the community as nothing else does, the community badly needs it all and more ; this Land Revenue ' fear to touch.'

XI.—Some Miscellaneous Recommendations.

62. Of course, I have submitted all my recommendations, in the first instance, to the Committee, and I would deal here only with those which have not been adopted in the Report. Some of these recommendations have already appeared in the notes above ; others now I submit tentatively, for consideration, to a wider tribunal than the Committee—

(A). My first recommendation is that the best use should be made of existing institutions and instruments, and one of these is the Courts of Wards ; a second is the Indian Institute of Science, and a third concerns the manufacture in India of sugar machinery and, indeed, of all agricultural implements.

(*a*) I find a consensus of opinion that, while the administration of the Courts of Wards might be improved, all estates that have fallen under the Courts of Wards have immensely benefited by their administration even as at present. These Courts of Wards control cane lands and it should be possible for them to lease areas to factories for long periods so as to reproduce the Java system. These leases should be subject to confirmation by the Local Government. As I understand it, the view at present taken is that neither the Local Governments nor the Courts of Wards have the power to give

leases which the Wards might not disown on coming of age. The principle suggested is that the Court of Wards is a Trustee, and Trustees are not, in any system of laws, allowed any latitude in investment or administration. If we go behind these laws to their object, one sees that the Trustees did not prove trusworthy, and so their latitude as Trustees was restricted. I understand that wider powers are given to the Public Trustee in England. In any case, the Courts of Wards have not proved untrustworthy Trustees, though, of course, they are liable to make mistakes, as the Ward himself when grown up would be liable ; but where there is a proposition which brings more revenue to the Ward than any existing use of land and any reasonably prospective use, in such cases, where a reasonable owner would gladly enter into contractual obligations, tying his own discretion for a period of years, there the Courts of Wards, subject to appeal to Government, should have the opportunity of improving the Ward's Estate with public benefit besides. The present restriction on the discretion of the Courts of Wards and of Government surely results in more loss by loss of opportunities than any loss by mistakes.

(*b*) I need not pursue the advantages of making useful the Indian Institute of Science, chiefly its well-developed chemical branches, in the service of an all India Sugar Research Organisation. It may require an alteration in the constitution and administration of that body ; but it should not be allowed to escape the duty of doing service to the country, particularly at a time when the War has given it a large windfall of additional income.

(*c*) An Agricultural Implements Company has already been started at Jamshedpur, and for some time negotiations have been pursued to introduce the manufacture of sugar machinery. It may be that the burden of capital charges on sugar manufacture might come to be reduced by a Sugar Company on the spot, and it may be that agricultural implements specially for the service of cane in India might be more readily manufactured by a Company in India whose *raison d'etre* is to serve the special requirements of India. In this connection, I am glad to pass on to the Agricultural Implements Company the wise suggestion of my colleague, Sardar Jogendra Singh, that its Directorate should not be entirely a Bombay institution, but should be composed of agricultural experts from several Provinces.

63. (B) I would further suggest the principle of a Government factory in every sugar growing Province, making use of Crown lands. The lands would be prepared by Government at a certain large capital cost. The Government would not work the factory itself, but hand its land to a Corporation which would put up and conduct the factory. Of the capitalisation of the Corporation the monies expended by the Government on preparatory processes would form a part, that is to say, the Government should receive shares equal to the monies expended with interest and even with proper profit. Government should have the option of taking any portion, or the whole of the remainder of the capital of the Corporation. On the whole capitalization Government would guarantee, say, 7 per cent. dividend ; would enforce depreciation, set aside at 5 per cent., and of the surplus profits, if any, there would be a division, Government as guarantor getting two-thirds and the shareholders including Government getting one-third. In return for such concessions Government may

stipulate that the Corporation should carry out any duties which the Local Government may put upon it in the matter of sugar research, or sugar schooling, or taking apprentices.

64. The principle of the suggestion is that, if it be considered that sugar manufacture is a very profitable business and that to make it in quantities large enough to affect world production Government have to spend heaps of money in reclaiming, drainage, irrigating, sanitating, colonising, Government might as well take all the risks and escape the deficiencies of Government administration by managing through a Corporation, as in the case of leased Railways, and create a Development Fund from the surplus earnings of sugar factories which the State alone makes possible. There is no question here of the State interfering with private enterprise. The State summons private enterprise, takes in hand regions which private enterprise cannot touch, and produces sugar which the world very badly wants and which private enterprise can create elsewhere without Government interference. It may be added that the management by the Corporation would not be under any Managing Agents, but only under Managing Directors, experts in their line specially brought out who would run the Corporation, as they would run any commercial Corporation.

65. (C) The above principle may be extended in such favourable positions as the Crown lands in Burma or in the Agency Tract. I suggest that, if and when lands have been suitably prepared for cane and its rotation crops, about 100,000 acres should be kept separate for Governmental or semi-Governmental operations as a model to the industries of the country. They would be conducted for profit, of course, and a sufficiency of profit would be insisted on, but profit would not be their primary object. Cane, with its rotations and its need of factories right in the heart of villages, gives an opportunity for village planning, village sanitation and village civilisation, introduction of schooling and hospitalling and introducing the principle of selection for residents which possibly no other industry affords. Here would be co-ordination of industries and cultivation. Rice fields and rice mills, oil seed cultivation and oil mills would be side by side with cane fields and sugar factories. They would all be driven by electric power, the surplus of which would be used for village reorganisation ; the factories might be seasonal, and the power plant would be common to them all, so that the power would be used all the time, night and day, for different factories at different seasons of the year. The work would be done by Corporations to avoid the overdone and tiresome objections made against Government management. Dividends would be guaranteed by Government and surplus earnings divided as in (B) above. Investment in such factories would be a new means of thrifty employment of savings held out to men of small means. Financiers and the larger public outside the Province would only come in after the small investor has been satisfied ; but, of course, nothing should be done except after the calculation of the remunerativeness of such schemes, a calculation as complete as would be made before a canal is sanctioned.

XII.—Sugar Research and the Sugar Board.

66. The Committee recommend research on the model of Java, and that is well. They depart from the principle of Java where sugar research is supported by the sugar industry, and that is not well. In the first place it should be recognised that the research to be done need not be of the same order as the research of Java or Hawaii which would remain available to the Indian cane-grower or manufacturer. All the research that India needs, in the first instance, is on varieties of cane and extermination of disease, and those, can be carried on

various means of harmonising the cultivators' and factory interests, and yet securing the most efficient cultivation ; negotiate with departments and firms for the publication of maps of lands available to factories on terms in various localities in India and Burma, discuss with engineers where improved irrigation or drainage would increase the sugar production of the country, bring the agricultural and industrial parts of the industry into touch with Co-operative Agricultural and Industrial Banks, induce Local Governments or enlightened firms to take apparent risks when they might be legitimately taken, *e.g.*, establish factories in areas from which ordinary enterprise shrinks, to demonstrate how much could be done under conditions of freedom. The Sugar Board would see that consulting engineering, sugar machinery, agricultural machinery for sugar, tramways engineering, general engineering for repairs and replacement of parts are available *in India* to the sugar industry ; would be able to guide factory owners and planters to secure the best expert help, foreign and Indian ; would establish sugar schools, and Sugar Research, both agricultural and industrial ; would urge irrigation and drainage where they can be profitably undertaken by Governments or private firms ; would discover new markets and new uses for sugar and new economics in production and new sources ; would create Insurance Funds against dumping of sugar, and against supplantation by new methods or substitutes. There seems no end to the functions under this head, and no restrictions should be put by statute ; new uses may be shown by experience for the instrument of the Sugar Board itself. Generally it would interrelate the Central Board with its own offshoots, the whole organisation with outside departments of State and other industries, the Indian sugar industry with Java, Cuba, Hawaii ; factory with cultivation on the one hand and markets on the other ; science with industry ; general engineering with factory production ; apprehensions of the future with present prosperity ; raw material and stores with the finished product ; production with finance and banking. In this inter-relation, it would be a referee of Government for taxation, of plantations for Land Acquisition, of factories for engineering, of cultivators for the best protection of their rights, of capital and labour to avert strikes, of factory and cultivators for the proper price of cane, of the community for pushing cane and sugar, in the Central Provinces by the creation of water supply or in the Deccan by the supply of drainage.

72. (*ii*) *General.*—It is difficult to separate functions (*i*) and (*ii*). Still some may here be indicated. Negotiating transport rates for machinery, cane, stores, outgoing products ; provision of independent transport facilities by land and water ; supply of Group Advisers as in Java to become referees for the solution of daily problems of scientific routine in factories and fields ; dealing with the question of labour supply and labour bonuses ; arranging for economical banking facilities ; treating and looking after questions of housing and comfort ; seeing into sanitation and health.

73. It will be seen that the above quoted note does not expound completely the details of the whole organisation. In fact, the note was never completed, because the Committee preferred simple lines to complex living lines, and it was no use wasting thought further upon the problem ; but, if the principles of the scheme commend themselves to people whose duty it would be to organise the sugar industry of India, (and by these people I do not mean Government or Government alone, since Sugar Boards or Sugar Syndicates elsewhere have been entirely the concerns of sugar manufacturers) then the rest of the sketch will be fully worked out by themselves.

XIII.—Weights and Measures.

74. I laid before the Committee on the day our signatures were affixed a Chapter on 'Weights and Measures.' As there was no time to discuss that Chapter, it was arranged that the Committee as a whole would shortly express the handicap on their investigations arising from want of fixity of standards bearing the same name in different parts of India, Var, Bigha, Seer or Maund, and that I should in this note submit my specific proposals on my own responsibility. I may say that, though I am aware that much useful work has been done on this subject by the Agricultural Board and by the 'Weights and Measures Committee,' I have not had the opportunity or the time to consult the work already done. I sub-join that part of my note which (*a*) lays down three general principles and (*b*) applies those principles to think out a brief workable scheme.

Some principles of procedure may be laid down :—

(*a*) The change should be voluntary (and induced by persuasion and propaganda) ; except in State and State-aided department such as statistics, village administration, education about tables of weights and measures, correspondence with Government, Municipalities and District Local Boards.

(*b*) The change should retain existing *names* as far as possible.

(*c*) The change should achieve as many as possible of the advantages of the Metric System, short of universal acceptance of the same standards. These are that the sub-multiples should be easily calculable, and that the different standards should have an easy relation ; *e.g.*, the unit weight is the weight of the unit volume of water

(*d*) To attain the advantages of (*c*) it may be desirable not to assimilate the 99 standards of India to the hundredth, but to assimilate the whole hundred to some external standard which promises to be universal. The approximation to the Metric System without using foreign names seems to promise results.

75. These principles may find various applications and, if I proceed to submit one below, it is not to suggest that it is the best that can be done, but to put forward something definite for consideration. Let us take weights first ; I would retain the names tola, seer, maund, khandi. The tola also is generally standardised already at the weight of a rupee, or 180 grains, and should certainly be retained. A seer varies from about 25 tolas in Western India and the South to 120 *tolas* in some parts of Bengal ; the maund and khandi vary only less widely. The reforming practice has tended to assimilate all maunds to the Bengal or railway maund of 82^{2} lbs., which in our Report has been called the standard maund, but the process is far from complete. This is equivalent to 40 standard seers of 80 tolas each. But there will be no more opposition by conservatism in different parts of India to making a *seer* 86 tolas (the equivalent of a kilogram) than to making a seer 80 tolas. The adoption by the railways of this slightly overweighted *seer* would alone go a long way to ensure its rapid adoption by the public. Luckily also the word *seer* is used for measurement as well as weight ; and it should be possible to take the *seer* measure so that a *seer* measure of distilled water weighs a *seer* in weight ; and this can be effected by making the *seer* weight the equivalent of a kilogram, and the *seer* measure the equivalent of a cubic decimetre. A thousand *seers* by weight would be a metric ton ; 40 as at present would make a maund, and 200, or 5 maunds, would make a khandi.

76. Similarly, I suggest the unit of length to be called a *var*—the present name of a yard which may be of various lengths in different parts of the country, —the *gaj* of Gujarat being 24 inches, the *var* in other places being 32 to 36 inches. This variation is the opportunity for creating a standard *var* of the length of a metre, with its divisions by tenths and hundredths, as customary in Indian calculations. The square *var* which is the unit of urban lands would then be the size of a square metre—between 19 and 20 per cent. bigger than the present square yard. Ten thousand such square *vars* may be called a *bigha,* (the size of nearly two and a half acres or one hectare). A *bigha* would then be an area equal to 100 *vars square.*

77. If Standard Time has come to stay, wherever it has been adopted, standard weights and measures, too, must stay, if employed courageously and intelligently. The local weights and measures would remain for some time ; they would be called *kachha seers, maunds, khandies, bighas* or *vars,* and the new standards would be called *pakka seers* or *bighas* or *vars.* The terms *kachha* and *pakka* are already in use to imply similar distinctions. Railways, Banks, Patwaris and the Statistical Department would immediately adopt the scientific standards ; schools in their *koshtaks* (tables of conversion) for one generation would teach both *kachha* and *pakka* standards ; then, when the new generation finds out the advantage of the new standards, the calculations they save and the perplexing variety of meaning they escape, the old implications of the names still in existence would be forgotten as the Julian calendar has been forgotten—except when courts have to interpret title-deeds where the old meanings of old terms have to be maintained.

78. I urge Government to take this matter earnestly in hand ; if the nuisance of the present system be not clamorous, the nuisance is none the less there ; and the trouble of reform is not obvious, nor would reform on the line here indicated be provocative of any discontent. No mobs will storm Government Houses with the cry " Give us back our Eleven Days," as English mobs cried in protest against the introduction of the Gregorian Calendar.

XIV.—Conclusion.

79. I may now bring this long note to a close. It has been a somewhat weary work stringing up into a whole fragments which were originally independent wholes. I regret I have not had the time, the patience and the literary gift to convey to the reader the magnitude of the problem in the fullness in which I have felt it. I have watched the sub-conscious of my colleagues all the time the Report was being drafted and I do not think I exaggerate when I say that fundamentally they share my view that without Land Acquisition or equivalent State regulation looming in the back ground the control of agriculture which is needed by a large up-to-date factory cannot be obtained ; and that without this control the future of sugar in India is not bright. Having dropped resort to what they would consider a heroic remedy, the Committee's recommendations are of the work-a-day order, and, while I have agreed with them as far they go, I cannot agree not to go further. Indeed, I have gone further than my own original intentions ; I feel that the problem of Indian sugar is not the problem exclusively of India, or exclusively of sugar ; to make sugar cheap in India it has to be made cheap all the world over, and it cannot be made so cheap without India contributing her best cane and her largest cane area to the solution of the problem. The bringing of India into this solution is only the revival of India's function in the sugar world ; for India has still the largest cane area and is still nearly the

largest consumer ; and India probably taught the world the making and eating of sugar. She retained this primacy up till historical times, until science, capital and enterprise and development of transport altered conditions. It is the business of courageous statesmanship to re-adapt India to these altered conditions, and win back for her the position she has lost. Statesmen should not, like my colleagues, behave like shame-faced school-boys in presence of large ideas ; they should not change colour as if they were detected growing too big for their boots, and they should not shiver because people criticise those ideas as transformation and not reformation. Surely the whole trend of the reconstruction of India is to transform it from a country of small producers into a country of large producers, to revitalise agriculture as well as manufacture by bringing to bear upon it both science, enterprise and capital. If Governments take a hand in such a transformation at all, it should be not to impede but to promote this natural tendency which, if regulated by reason, promises benefit to the cultivator, promises to reduce poverty, promises prosperity to the cultivator, and promises to find careers for trained national scientists ; promises employment for all the capital and thrift that could be brought to the service of sugar. If Government take care here, as Government in Java do, to control negotiations as between cultivator and factory, there need be no degradation of the status of the cultivator, and by a persuasive urging of the scale of cane prices on the factories they might prevent the drain of profits as a tribute from the land to shareholders of factories. Governments might make use of concessions of Crown lands, or make use of contributory utilities like water, drainage, reclamation, sanitation, to impose on the new factories standards of well-being for the economically weak—cultivators and labourers. Governments might take advantage of the fact that the sugar industry is unique (in being tied down to the land where the raw material is grown) to bring the essentials of urban progress to the country side without losing the fresh air and open sky of rural industry ; and all this Government may do without flirting with the delusive snares of protective tariffs and without reversing the tendency of the world to work as a whole, to work as a unit, to compete in well-doing as well as in well-being, to denounce national barriers which provoke and are the products of national hatred. I have, therefore, not hesitated to describe preferential and protective tariffs for what they are in the scheme of the life of the world.

80. I rejoice that it falls to me to vindicate the brave wisdom of my own provincial Government in the matter of the regulation of land for purposes of industry—wisdom justified by results, as the Hon'ble Member who gave evidence before us testified with unbending conviction. I have also gladly given my testimony of the inestimable services of the Irrigation Department to the agriculture of the country and particularly to the cane agriculture without which there would be no prospect for the sugar industry of India, and I now gladly add how much sugar as well as general agriculture owes to the Agricultural Departments of the country which I have learn to feel are the best investment of the money of the community with illimitable possibilities of dividend not only in cash but in human happiness, if these Departments be worked and used with vision, and not merely as departments to be organised for research.

In conclusion my own warmest personal acknowledgments are due to the Government of India who nominated me on this Committee, enlarging my experience and thought.

B. J. PADSHAH.

POSTSCRIPT.

The Report was signed and my note supplementary to the Report was handed over to the Secretary on November 6th, 1920. Since then several things have happened. The price of cane in Bihar today, as I am dictating, (January 27th, 1921) is Re. 1 per standard maund as against annas 5 which was the rate when the Sugar Committee started. The price of sugar which was Rs. 40 per standard maund in June last is today Rs. 17. The price of machinery does not appear to have yet given way ; exchange which was in March last year at Rs. 7 per pound sterling is now Rs. 14 per pound sterling. The outlook for sugar, I am credibly informed, is that the price in New York, which was 21 cents per lb. in June last, will now stabilise round anything between 4 and 5 cents. per lb. which, if the Rupee were to go up to 2*s*. and the dollar to return to the normal of 4*s*. 2*d*. would mean a price not exceeding Rs. 9 per standard maund in New York ; adding 20 per cent. for duty and freight and handling it would mean a price not exceeding Rs. 11 per standard maund in India. I am glad to be allowed to add a postscript shewing how the pronouncements of the Sugar Committee would be affected by this state of things.

The main thing, of course, is that, unless the price of land, the cost of erection, the value of machinery, the rate of exchange, the price of cane, the wages of labour and the price of sugar all work in together, the outlook for a sugar industry in India or anywhere else cannot be bright. Steamer freight permits a coal ship to be chartered at the rate of 20*s*. per ton from an English port to Bombay. To make the outlook as bright as possible the factors with which Governments and manufacturers, Associations and workmen's Unions can deal should be dealt with courageously. A sugar factory business being revealed as more or less incalculable and involving risks, no Government should touch it unless it is willing to take risks and provide, out of the profits of good times, a fund to take care of those risks. Above all, it should not be a temptation to Government to manipulate the sugar tariff in order to save its own losses. The reservation in section IX of my note that excise should automatically disappear when the price of sugar touches Rs. 11 or Rs. 12 a standard maund is now seen not to be merely academical but an efficient instrument to meet contingencies not improbable. The exhortation in my note to sugar producers to create a fund against dumping and against fall of prices will unfortunately come too late, but should not be missed for the next rise of prices of sugar. If the prospects of sugar be not bright, it is worth while considering at a time when Government are feeling the greatest possible financial pinch and when the country's existing industries are starving for want of Railway facilities, whether such expenditure on a Sugar Board and for sugar experts can be rightly undertaken. If the prospects of a sugar industry be not brilliant, all my suggestions for Government reclamations of waste lands with a view to prepare them for sugarcane fall to the ground. On the other hand, my suggestions for irrigation rates and conducting the Irrigation Department on business principles will stand. Personally I believe that there is some automatic operation by which exchange, wages, prices, capital cost and cost of living will all adjust themselves at no distant date. The world will sacrifice much of other things rather than sacrifice its sugar which is an article more or less of necessity, and sugar cannot be given in the quantities required except at prices which provide a moderate profit over cost. Therefore, either costs will have to go down, or prices rise. The circumstances of India for the production of sugar are not much inferior to the circumstances of the rest of the world, and, therefore, all that can be said is not that the prospects of the sugar industry are gloomy for India but that they are gloomy for a world demoralised with profits counted by 100 per cent.

B. J. P.

Note of dissent by Mr. M. Wynne Sayer.

I find myself unable to agree with the rest of the Committee over the question of demarcating areas to factories. I consider that in each cane growing tract the State or some similar authority should determine the number of sugar factories the aforesaid tract can carry by allotting a definite area to each factory for its cane supply, the object being to avoid ruinous competition and to encourage the management of the factories to take a personal interest in the improvement of the cane cultivation in the particular area from which their cane supplies are drawn.

In making this proposal I am fully aware of the argument which is likely to be advanced by some that it is a curtailment of public right and an interference with trade and secondly that the cultivator will be deprived of higher prices engendered by competition between factories. The answer to the first contention is that, if sugar is going to be manufactured in India at the cheapest possible rate, every reasonable facility for cheap production should be afforded by the State, and first among such facilities is a full supply of cane, for it is obvious that factories working with only half their full supply of cane cannot manufacture as cheaply as a factory working full time. Thus it is clear that the ultimate benefit of the whole community, that is, cheaper sugar, is obtained best by a reasonable curtailment of public right in this respect. Secondly we have indicated a scale of prices representing the utmost which can be paid for cane consistently with the interests of both cultivator and factory. Any attempt to force a price higher than that figure can only result in loss to the factory or a higher price for the sugar it manufactures. In these days of competition this will only result in the failure of the factory and the cultivator will lose his market. The scale of prices we have laid down insists on the efficiency of the factory, and the world competition will force it to keep efficient and endeavour to improve in every way possible. I wish to make it perfectly clear that my suggestion in no way involves any compulsion on the cultivator either to grow cane or sell it to the factory in preference to making gur. The scale of prices laid down for cane is such that he will find it to his own interest to grow cane and sell it.

I attach the greatest importance to the scheme we have enunciated for the improvement of the cane cultivation around factories. I cannot, however, disguise the plain fact that it is only by the active personal co-operation of the factory staff with the Agricultural Department that this propaganda will become a living force in the near future. To ensure this co-operation a definite area must be secured to each factory from which they will reap the reward of their active labours ; and only with that full assurance will they give that active assistance without which any improvement will be slow. Each factory, situated as it is in the midst of a cane area, can with its staff, its oil-seed crushing plant, its repair shops and its resources on the spot produce more effect on the local agriculture in a short time, if it is to its interest to do so, than the Agricultural Department can possibly achieve unaided. At present a new factory can establish itself anywhere near a railway station and buy cane at station weigh-bridges up and down the line without paying the least attention to its local cultivators

or spending a penny in endeavours to improve the cane cultivation in its vicinity. With such a possibility ever before it, no factory is likely to spend time and money on its cane area until it has a guarantee that a rival factory will not step in and benefit by the improved yield.

Both Java and Formosa have this system of licensed areas ; the former as a legacy from the old laws, the latter as a result of examination of the conditions under which the sugar industry has been successfully built up in other parts of the world where the factories do not own their own land, but have to depend on the cultivators for the supply of cane. In Formosa, where the factories own no land, advances in improved canes, manures and implements for improved cultivation are made to the cultivators by the factory ; and the success of this system is shown in the fact that the sugar industry has made substantial progress in a very few years. Such a system is what we want in India. Its success in Formosa is proved and its introduction was dependent on the assurance that each factory would benefit by its own efforts in the direction of improved cane. Such personal unofficial work on the part of the interested parties in conjunction with the Agricultural Department has done and is doing more towards improving cane in Formosa than anything else.

To recapitulate : the scale of prices we have proposed gives the ryot full value for his cane and prevents his being exploited in any way. He is also free to make gur if it suits him. The efficiency of the factory will also be kept at a high standard by the prices fixed for cane. If it does not keep efficient, the withdrawal of its privilege over the cane area could be considered. The factory will of its own accord increase its capacity as soon as it sees that more cane is likely to be offered as a result of its agricultural improvements than it can deal with. This increase in size will mean a corresponding increase in efficiency and lower costs. The scope of the industry will be extended and greater use made of the present area under cane, which under the new scale of prices should, to an ever increasing extent, be available for manufacture of sugar in factories.

M. WYNNE SAYER.

APPENDIX I.

Itinerary of the Indian Sugar Committee.

PART I.

Delhi ...	...		October 26th.
Meerut ...	...	(U. P.) ...	„ 27th to 30th.
Bareilly	...	„ ...	„ 31st to November 3rd.
Pilibhit...	...	„ ...	November 4th.
Shahjahanpur	...	„ ...	„ 5th.
Rosa ...	...	„ ...	„ 5th and 6th.
Cawnpore	...	„ ...	„ 7th to 11th.
Partabgarh	...	„ ...	„ 12th.
Benares	..	„ ...	„ 13th and 14th.
Gorakhpur (including visits to Bubnowlie and Purtabpore).		„ ...	„ 16th to 21st.
Sipaya and Siwan	...	(B. and O.)	„ 22nd.
Marhowrah	...	„ ...	„ 23rd.
Bettiah (including visit to Pursa).		„ ...	„ 24th to 27th.
Muzaffarpur	...	„ ...	„ 28th and 29th.
Pusa (including visits to Lohat and Ryam).		„ ...	„ 30th to December 5th.
Patna	...	„ ...	December 7th and 8th.
Shahjahanpur	...	(U. P.) ...	„ 9th.
Peshawar	...	(N.W.F.P.)	„ 11th to 13th.
Marala	...	(Punjab) ...	„ 14th.
Gujranwala	...	„	„ „
Lyallpur	...	„	„ 15th.
Iqbalnagar	...	„	„ 16th.
Lahore	...	„	„ 17th and 18th.
Amritsar	...	„	„ 19th.
Pathankot	...	„	„ 20th.
Gurdaspur	...	„	„ 21st.
Delhi (adjourned for Christmas holidays.)			„ 22nd.

PART II.

Calcutta (re-assembled).	...	(Bengal) ..	January 3rd.
Kamrup	...	(Assam) ...	January 5th and 6th.
Jorhat	...	„ ...	„ 8th and 9th.
Jaypur Hat	...	(Bengal)...	„ 12th.
Rajshahi	...	„ ...	„ 12th and 13th.
Calcutta (including a visit to Kotchandpur).	...	„ ...	„ 14th to 20th.
Rangoon	...	(Burma) ...	January 23rd to 26th.
Pilin	...	„ ...	„ 27th.
Moulmein	...	„ ...	„ 28th.
Toungoo	...	„ ...	„ 30th.
Pyinmana	...	„ ...	„ 31st.
Tatkon	...	„ ...	February 1st.
Mandalay	...	„ ...	„ 2nd to 4th.
Thangaing (for a visit to the Mon Canal area.)		(Burma)	February 6th and 7th.
Magwe	...	„ ...	„ 8th.
Rangoon	...	„ ...	„ 11th to 13th.
Calcutta	...	(Bengal) ...	„ 16th and 17th.
Aska ...	...	(Madras) ...	January 18th.
Anakapalle	...	„ ...	„ 19th.
Samalkota	...	„ ...	„ 20th.
Kamaredy	...	(Nizam's Dominions).	„ 21st.
Hyderabad	...	„ ...	„ 23rd to 25th.
Madras ...	...	(Madras)	„ 27th to 29th.
Nellikuppam	...	„ ...	March 1st to 3rd.
Mangalore	...	„ ...	„ 6th to 8th.
Coimbatore	...	„ ...	„ 10th to 14th.
Bangalore (including a visit to Goribidnur.).	...	(Mysore) ...	March 15th to 17th.
Mysore ...	...	„ ...	„ 19th.
Marikanave	...	„ ...	„ 20th and 21st.
Karad	...	(Bombay)	„ 23rd.
Poona	...	„ ...	„ 24th to 26th.
Baramati	...	„ ...	„ 27th and 28th.
Belapur ...	...	„ ...	„ 30th.
Kopergaon	...	„ ...	„ 31st.
Nasik	...	„ ...	April 1st.
Bombay	...	„ ...	„ 2nd to 6th.
Dumraon	...	(B. and O.)	„ 8th and 9th.
Dehri on Sone	...	„ ...	„ 10th.
Gaya ...	...	„ ...	„ 11th to 13th
Patna ...	...	„ ...	„ 14th.
Simla ...	...	(Punjab)	„ 15th.

PART III.

Calcutta	...	(Bengal)	May 13th.
Soerabaia	...	(Java) ...	June, 1st and 2nd.
Pasoeroean (including a visit to Djatiroto).		(Java)	June 3rd to 7th.
Malang	...	„ ...	„ 9th.
Blitar	...	„ ...	„ 10th and 11th.
Semarang	...	„ ...	„ 13th to 15th.
Djokjakarta	...	„ ...	„ 16th to 22nd.
Batavia (including a visit to Buitenzorg).		„ ...	„ 23rd to 26th
Madras	...	(Madras)	July 5th.
Calcutta	...	(Bengal)	„ 7th to 9th.
Ranchi	...	(B. and O.)	„ 10th and 11th.
Tatanagar	...	„ ...	„ 12th.
Nagpur	...	(C. P.) ...	„ 13th to 16th.
Pilibhit	...	(U. P.) ...	„ 18th.
Simla	...	(Punjab)	„ 19th.

APPEN
Statistics of the world's sugar
(Reference Chap
A.—PRO
I.—World's cane sugar

Countries.	Harvesting period taken for 1st year. (1913-14).	1913-14. Long tons.	1913-14. Yield per acre (where available) long tons.	1914-15. Long tons.	1914-15. Yield per acre (where available) long tons.	1915-16. Long tons.	1915-16. Yield per acre (where available) long tons.
United States :—							
Louisiana ...	October 1913—January 1914.	261,300	1·17	216,700	1·01	122,800	0 60
Texas ...	Ditto ...	7,100	·91	3,600	·92	1,000	·9
Porto Rico ...	January 1914—June 1914.	325,000	2·02	309,400	1·52	431,800	2·12
Hawaiian Islands	November 1913—July 1914.	546,400	4·91	576,800	5·09	529,300	4·58
West Indies :—							
St. Croix ...	January 1914—June 1914.	5,800	...	4,500	...	14,800	...
Jamaica ...	Ditto ...	13,400	·43	23,100	·73	22,000	·65
Trinidad and Tobago	Ditto ...	55,500	1·23	58,800	1·16	64,200	1·31
Barbados ...	Ditto ...	33,400	1·11	32,600	1·02	37,200	1·09
Other British West Indies.	January 1914—August 1914.	24,000	...	24,000	...	35,400	...
Cuba ...	December 1913—June 1914.	2,581,200	2·19	2,640,500	1·87	3,034,300	2·01
Martinique ...	January 1914—July 1914	38,400	...	39,300	...	39,900	...
Guadeloupe ...	Ditto ...	39,300	...	39,300	...	35,100	...
Dominican Republic (San Domingo).	January 1914—June 1914.	104,500	...	106,300	...	125,400	...
Mexico	December 1913—June 1914.	127,700	...	108,000	...	64,000	...
Central America (excluding Mexico).	January 1914—June 1914.	22,000	...	22,000	...	35,000	...
British Guiana (Demerara).	October 1913—December 1913. / May 1914—June 1914.	107,100	1·46	122,200	1·67	116,200	1·53
Dutch Guiana ...	October 1913—January 1914.	13,500	...	11,600	...	13,000	...
Venezuela ...	October 1913—December 1913.	3,000	...	3,000	...	7,000	...
Ecuador ...	October 1913—February 1914.	...	...	7,100	...	7,600	...
Peru	October 1913—February 1914.	224,500	2·23	258,700	2·45	248,000	2·46
Argentina ...	May 1913—November 1913.	271,400	1·03	330,600	1·22	146,900	·46
Brazil	October 1913—February 1914.	203,600	...	240,200	...	194,000	...
India including Burma and Native States.	December 1913—April 1914.	2,052,000	0·905	2,182,000	1·057	2,342,000	1·101
Java	May 1913—November 1913.	1,407,600	3·84	1,382,800	3·70	1,299,300	3·19
Japan and Formosa ...	November 1913—June 1914.	204,000	·84	262,000	1·0	405,200	1·18
Philippine Islands ...	November 1913- June 1914.	364,300	·86	375,900	·88	368,100	·83
Australia ...	June 1913—November 1913.	265,200	2·43	245,600	2·15	159,600	1·59
Fiji Islands ...	June 1913—November 1913.	98,200	2·04	95,400	1·51	85,000	1·37
Egypt ...	January 1914—June 1914.	67,900	1·36	74,500	1·37	81,300	1·32
Mauritius ...	August 1913—January 1914.	215,500	1·53	215,800	1·48	211,100	1·24
Reunion,... ...	August 1913—January 1914.	36,600	...	39,300	...	45,000	...
Union of South Africa Natal.	May 1913—October 1913.	86,600	...	98,400	·69	100,000	·62
Mozambique ...	May 1913—October 1913.	33,000	...	40,200	...	50,000	...
Spain	December 1913—June 1914.	7,100	1·54	5,500	1·17	4,200	1·4
Total	(including India) ...	9,877,000	...	10,235,000	...	10,476,300	...
Total	(excluding India) ...	7,825,000	...	8,053,000	...	8,134,300	...

* Refined Sugar.
† Raw Sugar.
‡ Figures for Native States incomplete.
§ Raw and refined Sugar.

Note 1.—Figures taken from several authorities, mainly the Year Books of the United States, Department of Agriculture, Truman G. Palmer's "Concerning Sugar", the Journal of the Society of Chemical Industry for August 15th, 1919 and the International Sugar Journal.

DIX II.
production and consumption.
ter I, paragraph 4.)
DUCTION.
production, 1913-1920.

1916-17. Long tons.	1916-17. Yield per acre (where available) long tons.	1917-18. Long tons.	1917-18. Yield per acre (where available) long tons.	1918-19. Long tons.	1918-19. Yield per acre (where available) long tons.	1919-20. Long tons.	1919-20. Yield per acre (where available) long tons.	Countries.
								United States :—
271,300	1·23	217,000	·89	250,800	1·08	108,000	...	Louisiana.*
6,300	·9	2,000	·9	3,100	·88	...	...	Texas.
456,100	2·22	401,800	...	362,600	...	433,800	...	Porto Rico.†
575,600	4·64	514,900	4·29	536,000	4 47	505,500	...	Hawaiian Islands.†
								West Indies :—
7,800	...	5,400	...	9,000	...	12,400	...	St. Croix.
28,300	·84	32,000	·87	43,000	...	46,900	...	Jamaica.†
70,900	...	70,900	...	45,300	...	58,4 0	...	Trinidad and Tobago.†
35,300	1·04	60,800	...	75,000	...	56,000	...	Barbados.
30,000	...	35,000	...	31,300	...	31,200	...	Other British West Indies.
3,055,000	1·89	3,446,100	1·93	3,971,800	2·10	3,730,100	...	Cuba.†
34,400	...	20,900	...	10,000	...	22,000	...	Martinique.
31,900	...	27,600	...	22,400	...	31,000	...	Guadeloupe.
133,900	...	154,300	...	106,700	...	175,700	...	Dominican Republic (San Domingo).
49,200	...	34,400	...	70,000	...	92,000	...	Mexico.
25,000	...	25,000	...	30,000	...	35,000	...	Central America (excluding Mexico).
101,700	1·29	108,200	1·39	107,600	·1	96,000	...	British Guiana (Demerara).
15,000	...	11,000	...	7,000	...	12,000	...	Dutch Guiana.
15,000	...	15,000	...	17,000	...	18,000	...	Venezuela.
7,000	...	8,000	...	7,000	...	7,000	...	Ecuador
250,000	2·23	246,900	...	300,000	...	350,000	...	Peru.
82,700	·39	115,000	·59	130,300	...	292,100	...	Argentina.
300,000	...	270,200	...	293,700	...	177,200	...	Brazil.
2,453,000	1·130	3,049,000	1·206	2,200,000	0·850	2,681,000‡	1 133	India including Burma and Native States.†
1,592,200	4·02	1,833,500	4·55	1,749,400	5·15	1,335,800	...	Java.§
436,000	1·11	397,600	1·59	415,700	...	283,500	...	Japan and Formosa.
379,700	·82	192,300	...	195,300	...	203,000	...	Philippine Islands.
193,000	2·38	327,600	2·86	202,100	1·72	175,000	...	Australia.
95,000	1·71	70,800	...	80,000	...	60,000	...	Fiji Islands.
82,800	1·28	79,500	1·20	82,000	1·38	90,000	...	Egypt.
213,600	1·22	221,000	1·26	248,800	...	235,000	...	Mauritius.*
42,200	...	50,000	...	50,000	...	40,000	...	Reunion.
101,800	·62	106,300	·57	146,500	...	150,000	...	Union of South Africa Natal.
55,000	...	50,000	...	20,600	...	35,000	...	Mozambique.
6,000	1·3	5,600	...	6,600	...	6,100	...	Spain.
11,232,700	...	12,206,500	..	11,986,600	...	11,548,700	...	Total (including India).
8,779,700	...	9,157,500	...	9,786,600	...	8,897,700	...	Total (excluding India).

Note 2.—The total production of sugar in India has been calculated as follows. The average yield per acre for each year has been ascertained from those territories which report both area and yield, *i.e.*, all the major Provinces and Administrations of British India except Burma, and also the Native States of the Bombay Presidency. The same acre yield has been assumed for all territories which report area under cane only, *i.e.*, Burma, the minor Administrations of British India and all other Native States including Hyderabad. From the total yield so arrived at 16 per cent. has been deducted on account of cane for eats and chewing for reasons explained in Chapter XVII, paragraph 274.

(*Vide* also Chapter XXII, paragraph 359), 99 per cent. of the yield is represented by gur.

II.—World's beet sugar pro

Countries.	Harvesting period taken for first year (1913-14).	1913-14. Yield of Refined Sugar in long tons.	1913-14. Yield per acre in long tons.	1914-15. Yield of Refined Sugar in long tons.	1914-15. Yield per acre in long tons.	1915-16. Yield of Refined Sugar in long tons.	1915-16. Yield per acre in long tons.
Germany	September 1913 —January 1914.	2,413,700	1·83	2,214,400	1·63	1,200,100	1·33
Czecho-Slovakia	Do.	1,498,700	1·38	1,419,300	1·36	895,800	1·27
Austria							
Hungary							
France	Do.	691,800	1·29	268,400	1·10	120,400	·77
Belgium	Do.	204,000	1·57	181,300	1·39	119,200	1·01
Netherlands	Do.	202,500	1·36	267,900	1·79	215,000	1·54
Russia, with Ukraine, Poland, etc.	Do.	1,541,600	·88	1,765,200	·91	1,299,500	·69
Sweden	Do.	121,400	1·71	136,300	1·71	112,800	1·43
Denmark	Do.	129,300	1·71	135,500	1·71	110,900	1·42
Italy	Do.	290,400	1·9	147,700	1·47	203,500	1·66
Spain	Do.	149,200	1·05	89,100	1·03	91,100	·92
Switzerland	Do.	3,900	1·25	2,600	1·3	3,500	1·75
Bulgaria	Do.	7,200	·85	20,500	...	19,500	...
Great Britain	Do.	4,100	1·0	1,800	·78	2,200	1·1
Roumania	Do.	33,100	1·03	29,200	·80	27,500	·81
Servia	Do.	5,800	...	1,800	...	...	...
United States	July 1913—January 1914.	654,800	1·13	644,700	1·33	780,500	1·27
Canada	October 1913—December 1913.	10,500	·61	12,000	1·05	15,900	·87
Australia	March to June	900	·9	1,200	1·2	600	1·3
Total ...	.....	7,962,900	...	7,339,500	...	5,209,000	...

III.—World's sugar production

Grand total cane and beet sugar (including India).	.....	17,839,900	...	17,574,500	...	15,685,300	...
Percentage of the above total represented by beet sugar.	.....	44·6%	...	41·8%	...	33·2%	...
Grand total cane and beet sugar (excluding India).	.....	15,787,900	...	15,392,500	...	13,343,300	...

NOTE.—Figures taken mainly from the same authorities as those for cane sugar production. All returns have

duction, 1913-1920.

1916-17. Yield of Refined Sugar in long tons.	1916-17. Yield per acre in long tons.	1917-18. Yield of Refined Sugar in long tons.	1917-18. Yield per acre in long tons.	1918-19. Yield of Refined Sugar in long tons.	1918-19. Yield per acre in long tons.	1919-20. Yield of Refined Sugar in long tons.	Countries.
1,328,700	1·34	1,365,100	1·43	1,188,300	1·29	675,000	Germany.
837,100	1·73	603,000	·83	630,000	...	526,500	Czecho-Slovakia. Austria. Hungary.
163,900	·96	202,500	1·23	99,100	·67	139,000	France.
88,600	...	117,000	...	66,800	...	132,200	Belgium.
239,200	1·52	180,200	1·57	156,100	1·65	214,800	Netherlands.
1,107,200	·67	990,000	·9	302,900	...	202,500	Russia, with Ukraine, Poland, etc.
132,600	1·43	117,900	1·51	114,700	1·52	130,500	Sweden.
106,300	1·4	108,000	1·42	102,100	1·14	144,000	Denmark.
132,600	1·08	90,000	·75	96,000	·9	164,500	Italy.
97,400	·72	103,500	·71	125,500	·77	73,500	Spain.
3,500	1·75	7,900	...	9,700	...	7,700	Switzerland.
13,300	...	19,800	·65	...	...	9,900	Bulgaria.
...	...	...	...	...	...	...	Great Britain.
13,300	·4	...	...	...	...	...	Roumania.
3,500	...	...	...	...	...	...	Servia.
732,700	1·1	683,000	1·03	679,400	1·11	653,000	United States.
11,200	·75	11,200	·82	22,300	1·24	16,500	Canada.
1,900	1·44	1,600	1·33	1,300	1·3	...	Australia.
5,013,000	...	4,600,700	...	3,594,200	...	3,089,600	Total.

(both beet and cane) 1913-1920.

16,245,700	...	16,807,200	...	15,580,600	...	14,638,300	Grand total cane and beet sugar (including India).
30·8%	...	27·40	...	23·1%	...	21·1%	Percentage of the above total represented by beet sugar.
13,792,700	...	13,758,200	...	13,380,800	...	11,987,300	Grand total cane and beet sugar (excluding India).

been converted where necessary into terms of refined sugar at the rate of 100 tons raw sugar = 90 tons refined sugar.

B.—Consumption.

World's annual per Capita consumption of sugar.

(Figures for United States from Statistical Abstract; European figures, 1904-05 to 1907-08, from F. O. Licht; 1908-09 to 1913-14 from O. Licht; Indian figures calculated by the Committee.)

Countries.	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
United States	71·66	75·74	81·19	74·11	80·43	79·90	77·15	82·43	85·04	89·14
United Kingdom	81·35	92·64	93·50	92·15	90·68	86·49	91·64	85·54	95·52	93·37
Germany	32·96	43·50	40·92	42·13	43·54	43·54	47·89	41·27	49·26	45·13
Austria-Hungary	20·52	23·92	24·32	24·76	24·78	25·20	28·52	24·82	28·14	29·17
France	34·41	36·24	36·05	36·38	37·28	37·88	42·82	39·41	43·47	43·85
Russia	19·51	19·36	20·55	19·51	20·11	22·91	22·48	22·81	24·31	25·43
Netherlands	35·67	39·24	41·40	41·40	43·67	43·63	45·64	46·33	40·90	50·09
Belgium	25·66	33·11	29·70	31·90	33·42	32·43	28·35	33·10	39·20	36·08
Denmark	60·63	71·36	73·68	76·21	78·35	77·91	84·19	98·30	98·16	95·57
Sweden	42·68	47·07	47·88	45·94	54·03	54·01	57·97	54·22	57·09	57·73
Norway					39·29	41·87	46·09	41·96	45·83	46·64
Italy	7·28	7·47	7·63	8·25	8·64	9·35	10·09	10·47	11·05	11·68
Roumania	7·41	7·54	7·83	9·57	9·15	9·50	10·58	11·11	8·89	9·26
Spain	12·08	10·30	11·38	10·98	11·86	14·22	13·69	13·16	15·62	14·19
Portugal and Madeira ...	14·68	15·72	15·61	15·48	13·67	14·15	14·48	13·47	13·57	14·17
Bulgaria	6·53	7·80	7·98	8·22	7·98	7·05	8·57	10·27	7·83	9·61
Greece	8·25	10·10	10·16	10·47	8·36	7·54	8·99	8·79	11·57	7·68
Servia	5·49	6·77	6·92	7·23	7·69	7·58	7·03	10·89	9·33	10·03
Turkey	8·53	9·77	11·73	12·79	12·50	12·92	14·61	18·62	19·84	21·93
Switzerland	44·14	53·46	55·23	54·70	66·65	64·24	76·30	70·68	77·24	73·55
All Europe ...	27·93	31·38	31·61	31·64	33·28	32·67	35·31	32·93	36·61	36·83
India ...	19·4	16·8	20·9	20·1	19·5	21·5	22·7	20·7	23·0	22·3

APPENDIX III.

Java factory results.

(Reference Chapter II, Paragraph 31.)

TABLE I.

1.—Synopsis of results obtained with canes of high and low purity.

Classification of cane crushed according to polarisation.	No. of factories.	Average polarisation (with maximum and minimum).	Average purity of mixed juice (with maximum and minimum).	Average density of mixed juice. Brix.	Average fibre per 100 cane.	Average sugar produced per 100 cane.	Average molasses produced per 100 cane.
A.—Season 1915—based on the returns of 138 factories.							
Above 14 ...	3	14·85 (15·27 to 14·42)	88·13 (89·6 to 86·4)	17·56	10·54	12·93	3·12
13 to 14 ...	5	13·27 (13·66 to 13·02)	85·0 (86·3 to 83·7)	16·45	12·97	11·02	2·92
10 to 11 ...	24	10·62 (10·99 to 10·06)	79·75 (83·6 to 75·6)	14·58	13·39	8·37	3·45
Under 10 ...	10	9·14 (9·94 to 6·75)	75·94 (81·5 to 67·1)	13·28	12·80	7·04	3·30
The cane crushed by the remaining 96 factories polarised between 11 and 13.							
B.—Season 1916—based on the returns of 145 factories.							
Above 14 ...	6	14·57 (15·13 to 14·22)	87·70 (9·5 to 85·4)	17·22	11·07	12·48	2·57
13 to 14 ...	29	13·30 (13·97 to 13·01)	85·91 (88·2 to 82·2)	16·20	12·83	11·04	2·69
10 to 11 ...	3	10·83 (10·93 to 10·66)	82·33 (85·3 to 78·6)	14·26	13·38	8·52	3·17
Under 10 ...	4	8·76 (9·88 to 7·39)	75·35 (79·3 to 68·4)	12·17	12·74	6·81	3·17
The cane crushed by the remaining 103 factories polarised between 11 and 13.							
C.—Season 1917—based on the returns of 143 factories.							
Above 4 ...	17	14·47 (15·7 to 14·0)	88·70 (91·4 to 87·0)	16·81	12·23	12·41	2·38
13 to 14 ...	41	13·51 (13·99 to 13·0)	86·94 (89·8 to 81·3)	16·32	12·90	11·28	2·60
10 to 11 ...	3	10·80 (10·95 to 10·7)	81·53 (82·4 to 80·9)	13·69	12·14	8·81	3·52
Under 10 ...	1	8·59	72·70	12·70	11·37	6·59	3·34
The cane crushed by the remaining 81 factories polarised between 11 and 13.							
D.—Season 1918—based on the returns of 143 factories.							
Above 16 ...	3	16·22 (16·34 to 16·14)	90·80 (91·6 to 89·9)	18·36	11·69	14·34	2·09
14 to 16 ...	46	14·72 (15·88 to 14·04)	87·80 (90·1 to 83·3)	17·48	12·64	12·30	2·59
13 to 14 ...	55	13·52 (13·98 to 13·01)	86·29 (90·2 to 81·7)	16·56	13·17	11·17	2·72
Nothing under 11·0 polarisation this year.							
The cane crushed by the remaining 39 factories polarised between 11 and 13.							
E.—Season 1919—based on the returns of 142 factories.							
Above 14 ...	6	14·34 (15·11 to 14·04)	86·40 (89·4 to 84·3)	17·17	12·36	12·19	2·83
13 to 14 ...	34	13·57 (13·96 to 13·04)	85 17 (87·6 to 81·5)	16 56	12·62	11·05	2·97
10 to 11 ...	4	10·60 (10·84 to 10·26)	80·30 (81 9 to 78·4)	14·38	12·63	8·5	3·32
Under 10 ...	1	9·93	77·10	14·90	12·94	7·31	2·94
The cane crushed by the remaining 97 factories polarised between 11 and 13.							

TABLE II.

Results for the season 1918 according to the process of manufacture.

(*Being the returns of 143 factories out of 185 working.*)

—	Defecation factories.	Sulphitation factories.	Carbonatation factories.	All factories.
1. Number of factories	71	53	19	143
2. Percentage of total weight of cane crushed	47·4	39·4	13·2	100
3. Average weight of cane crushed per factory—long tons.	84,168	93,719	87,455	88,145
4. Weight per 100 cane of—				
(*a*) Mixed juice	87·85	87·08	88·05	87·57
(*b*) Fibre	12·99	12·94	13·14	12·99
(*c*) Press cake	1·57	1·90	5·80	2·23
5. Polarisation of—				
(*a*) Cane	13·17	13·71	14·03	13·63
(*b*) Megasse	4·40	4·31	4·20	4·34
(*c*) Press cake	5·80	6·37	0·85	4·36
6. Analysis of exhausted molasses—				
(*a*) Sucrose	33·91	33·30	33·19	33·82
(*b*) Purity	37·2	36·8	36·4	36·9
(*c*) Glucose	26·56	27·00	24·66	26·55
(*d*) Ash	9·50	9·19	9·38	9·36
7. Weight per 100 cane of—				
(*a*) White sugar ...	*Nil*	10·13 (Poln. 99·60)	10·17 (Poln. 99·61)	5·30 (Poln. 99·60)
(*b*) 16-20 Dutch Standard ...	6·83 (Poln. 98·59)	0·14 (Poln. 98·60)	*Nil*	3·33 (Poln. 98·59)
(*c*) 14 Dutch Standard ...	4·14 (Poln. 97·56)	0·13 (Poln. 97·95)	*Nil*	2·03 (Poln. 97·57)
(*d*) Second boilings	*Nil*	0·50 (Poln. 98·36)	1·16 (Poln. 98·32)	0·35 (Poln. 98·34)
(*e*) Molasses sugars	0·34 (Poln. 87·30)	0·20 (Poln. 88·07)	0·31 (Poln. 87·67)	0·28 (Poln. 87·57)
(*f*) Black stroop	0·05 (Poln. 83·45)	*Nil*	0·03 (Poln. 80·52)	0·03 (Poln. 82·71)
(*g*) All sugars	11·36	11·10	11·67	11·32
(*h*) Molasses	2·63 (Poln. 30·16)	3·04 (Poln. 30·24)	2·46 (Poln. 30·73)	2·78 (Poln. 30·26)
8. Percentage of total sugar production represented by—				
(*a*) White sugar	*Nil*	91·26	87·15	46·82
(*b*) Raw sugar	100·00	8·74	12·85	53·18
9 Percentage of total sugar produced to sugar in the cane.	84·34	80·96	83·18	83·05

Poln. = Polarisation.

APPENDIX IV.

List of Indian sugar factories and refineries which employ the Vacuum pan process.

(Reference Chapter XIX, paragraph 303.)

(*Note.—The arrangement throughout is Alphabetical.*)

Serial No.	Province or State.	District.	Name of factory or concern.	Managing Agents.	Remarks.
			A.—Factories crushing cane (22).		
1	Assam	Kamrup	Assam Sugar Estate and Factories, Ltd., Kamrup.	Bird and Company, Calcutta.	In process of remodelling and enlargement.
2	Baroda	...	Gaekwar Sugar Works and Distillery Company, Gandevi.	...	In liquidation and not working. Also refines cane gur.
3	Bihar and Orissa.	Bhagalpur	Behar Sugar Company, Supaul (late Seeraha).	Octavius Steel and Company, Calcutta.	Moved from Seeraha, Champaran district, during 1920. Also refines cane gur.
4	,,	Champaran	Champaran Sugar Company, Ltd., Burra Chakia.	Begg Sutherland and Company, Cawnpore.	...
5	,,	,,	Pursa Sugar Factory, P. O. Lauriya.	...	...
6	,,	Darbhanga	Darbhanga Sugar Company, Ltd., Lohat.	Octavius Steel and Co., Calcutta.	...
7	,,	,,	Ryam Sugar Company, Ltd., Ryam.	Begg Sutherland and Company, Cawnpore.	...
8	,,	,,	Samastipur Central, Samastipur.	Ditto ...	Under construction. To open at the end of 1920.
9	,,	Muzaffarpur.	Japaha Sugar Concern, Bhicanpore.	...	...
10	,,	Saran ...	Cawnpore Sugar Works, Ltd., Marhowrah factory.	Begg Sutherland and Company, Cawnpore.	Also refines cane gur.
11	,,	,,	New Savan Sugar and Gur Refining Company, Ltd., Siwan.	Kilburn and Co., Calcutta.	,,
12	,,	,,	Purtabpore Sugar Factory, P. O. Mairwa.	Begg Sutherland and Company, Cawnpore.	...
13	Madras	Ganjam	Aska Sugar Works and Distillery, Aska.	...	Unique in employing the diffusion process.
14	,,	Godavari	Deccan Sugar and Abkari Company, Ltd., Samalkot.	Parry and Company, Madras.	Also refines palmyra gur.
15	,,	South Arcot.	East India Distilleries and Sugar Factories, Ltd., Nellikuppam.	Ditto ...	,,
16	Mysore	Kolar ...	New Pioneer Sugar Mills, Ltd., Gori-bidnur.	T. Wilberforce & Co., Calcutta and Cawnpore.	Just reopened under new management. Also refines cane gur.

Serial No.	Province or State.	District.	Name of factory or concern.	Managing Agents.	Remarks.
17	Punjab	Gurdaspur	Punjab Sugar Works and Patent Carbonic Acid Gas Company, Ltd., Sujanpur.	...	Not working in 1920.
18	United Provinces.	Gorakhpur	Cawnpore Sugar Works, Ltd., Gauri factory.	Begg Sutherland and Company, Cawnpore.	Worked experimentally only in 1920.
19	,,	,,	Saraya Sugar Factory, Chauri Chaura.	...	Also refines cane gur.
20	,,	,,	United Provinces Sugar Company, Ltd., Bubnowlie.	...	...
21	,,	Pilibhit	L. H. Brothers' Sugar Factory, Pilibhit.	...	Also refines cane gur.
22	,,	Shahjahanpur.	Rosa Sugar Works and Distillery, Rosa.	Lyall Marshall and Company, Calcutta.	Also refines cane gur.
			B.—Raw Sugar Refinery (1).		
1	Bengal ...	24 Parganas.	Cossipore Sugar Works, Ltd., Cossipore.	Turner Morrison and Co., Calcutta.	...
			C.—Gur Refineries (10).		
1	Bihar and Orissa.	Saran ...	Siwan Desi Sugar Factory, Siwan.	...	Uses cane gur.
2	Madras...	Coimbatore	Sri Ram Sugar and Distillery Works, Podanur.	...	Not working. Uses cane gur.
3	,,	Tinnevelly	A. R. A. R. S. M. Sugar Mills, Tachanallur.	...	Uses Palmyra gur.
4	,,	,,	East India Distilleries and Sugar Factories, Ltd., Kulasekharapatnam.	Messrs. Parry and Company, Madras.	Uses Palmyra gur.
5	Punjab...	Amritsar	Harkishan Sugar Mill, Amritsar.	Amar Singh and Company, Amritsar.	Uses cane gur.
6	United Provinces.	Allahabad	Tribeni Desi Sugar Works, Naini.	...	Uses cane gur and *rab*.
7	,,	Cawnpore	Baijnath Juggilal's Sugar Factory, Anwarganj.	...	Uses cane gur.
8	,,	,,	Cawnpore Sugar Works, Limited, Cawnpore Refinery.	Begg Sutherland and Company, Cawnpore.	Uses cane gur and *rab*.
	,,	,,	Union Indian Sugar Mills Company, Limited, Nawabganj.	...	Uses cane gur.
9	Perc... suga...	Unao ...	Pioneer Sugar Mills, Limited, Unao.	T. Wilberforce and Company, Calcutta and Cawnpore.	Uses cane gur.

APPENDIX V.

Records which Indian Factories should maintain.

(Reference Chapter XX, paragraph 337.)

FACTORY———

Crop———*Report No.*———*for period*———*to*———

—	Maunds cane.	Maunds sugar.	Maunds molasses.
Period	.....	.....	.....
To date	.....	.....	...

—	Fuel—Maunds.		Fuel per cent on cane.		Hours mill worked.
	Wood.	Coal.	Wood.	Coal.	
Period	.....	.....	.....	.....	.....
To date	.....	.....	.....	.....	.....

Sucrose Account.

—	Cane 100.		Sucrose in cane 100.		Sucrose in juice 100.	
	Period.	To date.	Period.	To date.	Period.	To date.
Mixed juice	...	...	...	...	...	...
Dilution	...	...	...	...	...	...
Normal juice	...	...	...	...	...	...
Added water	...	...	...	...	...	...
Commercial sugar	...	...	...	...	...	...
Commercial sugar calculated to standard 96°	...	...	...	...	...	...
Molasses	...	...	...	...	...	...
Megasse	...	...	...	...	...	...
Sucrose in cane	...	...	100·00	100·00	...	...
Sucrose in megasse	...	...	...	...	...	...
Sucrose in mixed juice ...	...	...	...	...	100·00	100·00
Sucrose in sugar	...	...	...	...	...	...
Sucrose in final molasses ...	...	...	...	...	...	...
Sucrose in press cake	...	...	...	...	...	...
Unaccounted losses	...	...	...	...	...	...
Sucrose lost in manufacture ...	...	...	...	...	...	...

Analyses of products.

		Brix.	Polarisation.	Sucrose per cent.	Glucose per cent.	Water.	Fibre.	Apparent purity.
Cane	Period ...							
	To date ...							
Normal juice ...	Period ...							
	To date ...							
Mixed juice ...	Period ...							
	To date ...							
Last mill juice ...	Period ...							
	To date ...							
Thick juice ...	Period ...							
	To date ...							
Massecuite, I ...	Period ...							
	To date ...							
Massecuite, II ...	Period ...							
	To date ...							
Massecuite, III ...	Period ...							
	To date ...							
Molasses, I ...	Period ...							
	To date ...							
Molasses, II ...	Period ...							
	To date ...							
Final molasses ...	Period							
	To date ...							
Press cake ...	Period ...							
	To date ...							
Megasse ...	Period ...							
	To date ...							
Sugar... ...	Period ...							
	To date ...							

APPENDIX VI.

Estimate of the capital cost of establishing the Imperial Sugar Research Institute (including the Sugar School) and its sub-stations.

(Reference Chapter XXIII, paragraph 380).

A.—The Institute and Sugar School.

Head.	Number and designation of officers.	Buildings and equipment required.	Estimated capital cost.
			Rs.
I.—Director's Office ...	1 Director	Office accommodation and Library	1,00,000
	1 Secretary... ...	Two Officers' quarters ...	80,000
II.—Agricultural Division	1 Chief of Division ...	Experimental farm of 500 acres ...	1,00,000
	1 Assistant Chief of Division in charge of the experimental farm.	Farm buildings and equipment ...	1,50,000
	1 Assistant Chief of Division in charge of cane breeding.	Office, Laboratory and Lecture Room of Agricultural Section.	50,000
	1 Assistant Botanist for teaching.	Office, Laboratories (one for research and one for students) and Lecture Room of Botanical Section.	1,00,000
		Four Officers' quarters ...	1,60,000
III.—Engineering Division	1 Chief of Division ...	Demonstration sugar factory ...	5,00,000
	1 Assistant Chief of Division.	Workshop	1,00,000
		Drawing Office, Office and Lecture Room.	50,000
		Two Officers' quarters ...	80,000
IV.—Chemical Division ...	1 Chief of Division ...	Laboratories (one for research and one for students) and equipment.	3,00,000
	1 Assistant Chief of Division.	Office, Lecture Room and Store Room	50,000
		Two officers' quarters ...	80,000
V.—Mycological and Entomological Sections.	Officers to be deputed from Pusa, as required.	Mycological Laboratory, Office Room and Store Room.	50,000
		Entomological Laboratory, Office Room and Store Room.	50,000
VI.—Miscellaneous ...	.....	Quarters for subordinate staff ...	1,00,000
		Students' Ho s, dispensary, servants' quarters, etc.	1,50,000
		Total capital expenditure ...	22,50,000

B.—*Cane Research sub-stations.*

Province.	Station.	Land or equipment required.	Estimated capital cost.
			Rs.
Madras	Coimbatore ...	30 acres additional (for cane breeding).	16,000
		50 acres additional (for local research).	
		Additional equipment for Laboratories, local research, quarters for officer in charge and staff, etc.	50,000
	Second cane breeding station.	50 acres (for cane breeding) ...	20,000
		50 acres (for local research) ...	
		Equipment, laboratories, quarters for staff, etc.	40,000
	Samalkota	160 acres additional ...	32,000
		Additional equipment, laboratories, quarters for officer in charge and staff, etc.	40,000
	Station for Vizagapatam and Ganjam.	200 acres	40,000
		Equipment, laboratories, quarters for staff, etc.	40,000
United Provinces ...	Shahjahanpur	150 acres additional ...	30,000
		Additional equipment, laboratories and quarters for officer in charge and staff.	40,000
	Station in the Meerut tract.	200 acres	40,000
		Equipment, laboratories, quarters for staff, etc.	40,000
	Station in the Gorakhpur tract.	200 acres	40,000
		Equipment, laboratories, quarters for staff, etc.	40,000
	Station for hill sets ...	29 acres	4,000
		Equipment, etc.	7,500
Bihar and Orissa ...	New station in the Tirhut division.	200 acres.	40,000
		Equipment, laboratories, quarters for officer in charge and staff.	60,000
	Sipaya ...	(Additional land not required) ...	20,000
		Additional equipment, etc. ...	
Punjab	Gurdaspur ...	(Additional area not required) ...	40,000
		Additional equipment, quarters, etc.	
	Station in the Canal Colonies.	200 acres	40,000
		Equipment, etc.	40,000
	Station for hill sets.	10 acres	2,000
		Equipment, etc.	7,500
Assam ...	Possibly two stations.	400 acres	80,000
		Equipment, quarters, etc., for two stations.	1,00,000
	Station for hill sets ...	10 acres	2,000
		Equipment, etc.	7,500
		Total carried over ...	9,58,500

B.—*Cane Research sub-stations.*

Province.	Station.	Land or equipment required.	Estimated capital cost.
		Total brought forward ...	Rs. 9,58,500
ırma	Possibly two stations ...	400 acres...	80,000
		Equipment, quarters, etc., for two stations.	1,00,000
	Three stations for hill sets.	30 acres	6,000
		Equipment, etc.	22,500
ombay	Manjri	140 acres additional	28,000
		Additional equipment, quarters, etc.	40,000
	Station in Gujarat ...	50 acres	10,000
		Equipment, etc.	15,000
	Station in the Konkan...	50 acres	10,000
		Equipment, etc.	15,000
		Total capital expenditure ...	12,85,000
		Grand total capital expenditure ...	35,35,000

NOTE.—It has been assumed throughout that all new land will have to be compulsorily acquired, though in rovinces such as Assam and Burma Crown waste land may well be taken up. A flat rate of Rs. 200 per acre as been assumed as a fair average.

APPENDIX VII.

A typical balance sheet of the Shahjahanpur cane research station, United Provinces.

(Reference Chapter XXIII, paragraph 380). Year 1919-20. Area 50 acres.

Expenditure. (Being all monies actually drawn from the Treasury against the annual grant allotted by Government, the disbursement of which is audited by the Accountant General.)				Receipts. (Being all monies actually paid into the Treasury on account of the Station).			
Item.	Amounts.			Item.	Amounts.		
	Rs.	A.	P.		Rs.	A.	P.
1. Wages of daily labour ...	1,904	8	11	1. Sale of *rab* ...	6,304	15	6
2. Pay of permanent staff (*a*)	2,311	14	2	2. Sale of cane sets ...	925	2	0
3. Feed of cattle ...	613	0	3	3. Sale of wheat ...	2,525	14	0
4. Oil fue (*b*) ...	967	0	9	4. Sale of gram ...	553	14	6
5. Repairs to machinery ...	40	14	6	5. Miscellaneous receipts...	664	1	0
6. Repairs to buildings ...	190	13	9				
7. Purchase of implements ...	160	4	0				
8. Manures	935	10	0				
9. Miscellaneous (*c*) ...	349	1	6				
Total ...	7,473	3	10				
Add credit balance ...	3,500	11	2				
Grand Total ...	10,973	15	0	Total ...	10,973	15	0

(*a*) Includes pay of office staff and mechanic, but excludes cost of superior control, that is, pay of Mr. Clarke only, who supervised the station in addition to his other duties as Agricultural Chemist and Principal of the Agricultural College, Cawnpore.

(*b*) Includes oil fuel used for irrigation and crushing cane.

(*c*) Chiefly expenditure on work in connection with the experimental study of canes.

N. B.—It should be borne in mind that this is not the balance sheet of a commercial concern and is therefore no guide to the profits obtainable from cane growing. The sole object of its reproduction here is to show that a cane research station, incurring its full share of expenditure on unproductive experiments, should be able to meet out of receipts the whole of its recurring charges.

APPENDIX VIII.

List of Conclusions and Recommendations.

PART I.

Chapter III.—The United Provinces.

No.		Para.
1	The United Provinces furnish more than half the acreage under cane in India; but sub-tropical conditions render their cane problems of great complexity.	35
2	Existing canals here, unlike those in the Punjab, are designed for an intermittent discharge only; and there is no prospect of a material extension of cane on any of them except the Upper Ganges canal, which has new permanent head-works under construction,	40—44
3	The execution of the Sarda canal project, one part of which, the Sarda Kichha feeder canal, has now been sanctioned, should, however, give an increase of 100,000 acres under cane, besides creating great possibilities of introducing improved varieties and methods of cultivation.	46
4	A small increase under existing canals might be obtained, if the system of distribution of water could be modified to enable the needs of cane to be met during the hot weather months and breaks in the monsoon.	47
5	The feasibility of giving more reliable notice to cane growers of the supply of canal water should be investigated.	47
6	The system of distribution on the Sarda Kichha feeder canal should be worked out with special reference to the needs of cane; and the Agricultural Department should try to secure concentration of the cane areas in the interests of efficient irrigation.	47
7	The provision of adequate drainage is of great importance and should be constantly borne in mind; and a drainage survey should be carried out in the submontane districts.	48
8	Wells are a most important source of irrigation; and the development of pump irrigation would confer great benefit, especially to cane.	49
9	There is already a fair demand for such installations; and an entirely separate branch of the Agricultural Engineering Department should be formed to deal with well boring and pumping installations only.	49
10	The work should be concentrated in selected tracts, *e.g.*, the Kheri district, and combined with active propaganda.	49
11	If electric power is generated from the falls on the Upper Ganges canal, it might well be used to work tube wells in the areas not irrigated by the canal.	50
12	Surplus power from the falls on the Jumna might be used for the same purpose in the Saharanpur, Muzaffarnagar and Meerut districts.	50
13	The grant of loans to individuals for the installation of tube wells and power-pumping is preferable to encouraging co-operative societies to undertake them.	50
14	The separate consideration of the two main branches of agricultural improvement should not obscure the fundamental principle that in Upper India improved methods of cultivation must accompany the introduction of improved cane varieties.	51

No.		Para.
15	The Agricultural Department's work on the isolation of pure races of indigenous varieties should be decentralised in recognition of the adaptation of particular groups to particular tracts.	52
16	The work on Coimbatore crosses and importation of exotics should be extended and field trials should be carried out on a large scale.	53
17	A station should be opened for the supply of hill sets and should provide for the needs of Bihar as well as the United Provinces.	53
18	Though the enhancements of yield obtainable by the application of improved methods of cultivation to local canes are limited, they are still appreciable and improvement in this direction is likely to be more rapid than in the direction of introducing better varieties.	54
19	Instances of such improvement are the dissemination of pure races of the best indigenous varieties, better ploughing, a summer fallow, more scientific rotations, planting fewer sets in rows, and the use of oil cake manures.	55—59
20	Superior thick and medium varieties with the greatly improved system of cultivation they require must, however, be introduced, if India is to supply her own sugar requirements.	60
21	The feasibility of their successful introduction, given adequate supplies of water and manure, has already been demonstrated at Shahjahanpur; and a great improvement in general agricultural practice will be promoted thereby.	60
22	The suitability of several thick and medium varieties for the Provinces has already been established.	60
23	The best system of cultivation is the trenching system adopted in Java, but until trenching by mechanical means is adopted it requires a large and reliable labour supply.	61
24	For medium canes and wherever labour is not plentiful sowing on the flat in rows four feet apart after deep cultivation may be adopted.	61
25	Whichever method is adopted, earthing up of the young canes is essential.	61
26	In addition to Shahjahanpur, which should be enlarged to 200 acres, two new stations of similar size devoted exclusively to research work on cane should be immediately opened in the Meerut and Gorakhpur divisions.	63
27	Demonstration parties of fieldmen under Class II officers of the Agricultural Service should be trained at the cane research stations and posted solely for demonstration work on cane in the Meerut, Rohilkhand and Gorakhpur divisions.	64
28	All cane research work, both chemical and agricultural, should now be placed under the undivided control of a whole-time officer, without awaiting the constitution of the Sugar Research Institute.	65
29	In the interests of the cane crop it is suggested that, when the impending redistribution of the Circles of Deputy Directors of Agriculture is carried out, the Kheri and Sitapur districts should be included in the Rohilkhand Circle.	65
	Chapter IV.—Bihar and Orissa.	
30	The special features of Bihar are that its climatic conditions are transitional between the tropical and the sub-tropical, that much of its cane is grown without irrigation and much by European planters and that it is the chief centre of white sugar manufacture direct from the cane in India.	68—70
31	Orissa is essentially a rice-tract and offers no prospects for cane.	72
32	The Sone canal system in South Bihar offers the best prospects for cane, if the area can be drained.	72
33	A drainage survey of this tract is urgently required; as, until this problem is solved, no agricultural improvements are possible.	72
34	A drainage survey is also desirable with a view to the reclamation of the flooded areas of North Bihar.	73

No.		Para.
35	Pending action on recommendation (33) above, improvements are only to be looked for in North Bihar.	74
36	The Agricultural Department's interrupted work on the identification and classification of indigenous varieties should be resumed.	75
37	The propagation and distribution of pure sets of Hemja and other superior varieties among the ryots should now be undertaken.	75
38	Dr. Barber's crosses and indigenous varieties of other Provinces should be tested for their suitability to ryots' conditions, and special attempts should be made to secure a good early ripener.	75
39	The importance of a prolonged fallow or green-manure crop before cane is planted should be demonstrated to the ryot; and he should be urged to introduce a fodder crop into his cane rotation to benefit his small cattle and improve their capacity for agricultural work.	76
40	The ryot should be taught to select his sets, to plant them less thickly and in lines, to improve his after-cultivation and to use oil-cake manures.	77
41	The great need of the European planters is improved varieties responding to intensive cultivation.	78
42	The Agricultural Department should take steps, with the co-operation of the planters, to meet this need and to work out the best methods of cultivation for these varieties.	79
43	Through the planters a beginning may be made in introducing these improved varieties and methods to small cultivators.	79
44	The co-operation of the planters should be enlisted in obtaining supplies of oil-cake manures.	80
45	Work on the improvement of agriculture in the Tirhut division is now of the greatest urgency; and a Deputy Director for this division should be appointed at once with a strong subordinate staff and a net-work of Circle farms.	81
46	The substitution of an Agricultural Chemist for an Economic Botanist is suggested to take charge of the cane research station for North Bihar.	82
47	The proposal to locate this station at Sipaya in Saran district should be reconsidered.	83—86
48	The future of the central factory industry is in the districts east of the Gandak river; and the main research station should be located in one of those districts, possibly near Pusa.	87
49	Sipaya might then be retained as a sub-station for Saran district only.	87
50	A special demonstration staff for cane will be required as soon as appreciable practical results have been obtained at the research stations.	88
	Chapter V.—The Punjab.	
51	The short monsoon period and the extremes of temperature must always be a serious handicap to cane in the Punjab; and it will remain of less importance than wheat and cotton.	94
52	Nevertheless the cane area is large and likely to expand and lower costs of cultivation compensate for lower yields than in tropical India.	94
53	The importance of the crop therefore warrants much greater attention being paid to it.	94
54	Given the stimulus of high prices, there are prospects of considerable extension on the Upper Bari Doab and the five linked canals.	98—99
55	A considerable extension may be anticipated also, if the Sutlej Valley canals project is carried out.	100
56	Large areas of Crown waste land suitable for cane are said to exist in the commanded area on the right bank; and this should be investigated with a view to the location of a central factory controlling its own cultivation.	100

No.		Para.
57	The possibilities should be ascertained by the grant of land for cultivation of improved canes by intensive methods on the lines of grants already made for the growth of improved varieties of cotton.	100
58	There should be a further appreciable increase in the came area, if the Thal project is carried out.	102
59	The Agricultural Department should promote concentration of the cane areas under new irrigation systems.	104
60	Cane should also be included in the experiment shortly to be carried out on the Indian Cotton Committee's recommendation with a view to promoting concentration on existing canals by means of increased water supplies to selected distributaries in the *kharif* season.	104
61	The comparative cost of irrigation from canals, from wells worked by bullock power and from wells worked by power pumps should be investigated.	106
62	A separate branch of the Agricultural Engineering Department should be created to deal solely with well boring and pumping installations.	106
63	Hydro-electric schemes may provide the means of tube well irrigation worked from central power stations.	106
64	It is useless to suggest improvements in the cultivation of unirrigated cane.	107
65	The work on trials of superior varieties from other Provinces, exotics and crosses from Coimbatore should be extended; and Paunda should be included in the experiments.	108
66	A station for the supply of hill sets will be required, but is not an immediate necessity.	108
67	Greater care in the selection of sets, the adoption of planting in lines, economy of canal water and the practice of earthing up should be advocated.	109
68	There should be a future for the trench system of cultivation in the canal colonies.	109
69	Experiments should be initiated to test the advantages of clamping and windrowing as a protection against frost.	109
70	Gurdaspur should be restored as a research station for work on cane only; and a second such station should be opened in one of the canal colonies, preferably some distance from Lyallpur.	110
71	The research station recommended for the Meerut division of the United Provinces should deal with the problems of the eastern districts of the Punjab.	110
72	A whole-time post should be created for the supervision of all cane research work in the Province and a second Agricultural Chemist should be recruited to fill it.	111
73	A special demonstration staff for cane is not immediately required.	111
	Chapter VI.—The North-West Frontier Province.	
74	It is remarkable that the chief cane grown in the North-West Frontier Province, despite its northerly latitude, is a thick cane. This is apparently connected with the high humidity in the Peshawar valley.	114
75	Cane cultivation here is of an unusually high order, especially in respect of rotations and green manuring and the preservation of sets by clamping.	116
76	Experiments in windrowing show that it preserves cane from deterioration for a maximum period of one month, but that it involves comparatively little loss of sucrose up to as much as three months.	117
77	There is little prospect of extension of cane under the Public Works Department canals except under the Kabul river canal.	118

No.		Para.
78	The limiting factor on the district canals is not the water supply but the lack of labour for making gur and of markets for selling it.	119
79	The tract commanded by these district canals seems suitable for the establishment of a central factory, particularly if it could combine beet and cane sugar manufacture.	119
80	The Agricultural Department should demonstrate the importance of care in selecting sets and windrowing.	120
81	Unless political objections exist, the subordinate staff of the Department should be increased to admit of more widespread demonstration work.	120
82	The great need of the Province is an early ripening cane.	120
83	A separate cane research station is not justified; and cane work should continue under the control of the local Agricultural Department.	120
84	An appointment of Agricultural Chemist should be created, and a Class II I officer should be appointed to it.	120
	Chapter VII.—Bengal.	
85	There is little prospect of any considerable expansion of cane in Bengal or of the development of a factory industry.	126—129
86	Work on agricultural improvements should be concentrated on lands which are above flood level.	129
87	The first requirement is a botanical and chemical survey of the canes present grown.	129
88	Trial of superior exotic varieties should be continued.	129
89	The importance of care in the selection of sets should be demonstrated.	130
90	Experiments should be made to ascertain the proper applications of manure for each variety of cane grown or recommended.	130
91	The establishment of a special research station for cane cannot be justified.	131
92	The proposal to increase the provincial cadre of Deputy Directors of Agriculture from three to five should be revised.	131
93	There is reason to believe that parts of Bengal might be well adapted to the rapid propagation of sets of new varieties on the Java system.	132
	Chapter VIII.—Assam.	
94	The climatic advantages of Assam as a cane growing tract are the absence of dry hot weather, the humidity and the copious rainfall between March and May.	133
95	The inefficiency and indolence of the small grower, the scattered nature of his cane cultivation and his failure to adopt new methods render improvements in ryots' cultivation unlikely.	139
96	Progress must be along the lines of promoting a central factory industry controlling its own cultivation, and the possibility of growing heavy crops of superior varieties of cane, the large extent of waste land available, and the prevailing policy of developing agriculture by capitalist grants are all favourable to such progress.	139
97	A Committee of three should be appointed to survey likely areas for development on these lines, and selected areas should be reserved for allotment in large grants.	140
98	The standard provisions regulating concessions for special cultivation should be amplified to prevent alienation or encumbrance without previous sanction in writing and to prescribe for bringing the concession area under cane cultivation within a specified term and at a specified rate.	141
99	It is in the interests of large estates that the cane research work now centred at Jorhat should be continued and extended.	142

No.		Para.
100	The evolution of the commercially best rotation and the discovery of good ratooning varieties are of special importance.	142
101	Jorhat is not, however, the best centre for the work which should only be continued there till a new research station is opened.	142
102	So large a station as Kamrup is not required, nor should the attempt there made to establish commercial as well as agricultural results be repeated.	143
103	One or two stations of 200 acres each should suffice ; and the question of number and location should be referred to the proposed survey committee.	143
104	The establishment of them should, however, await the creation of the Sugar Research Institute recommended in Chapter XXIII, as they should form an Imperial and not a provincial charge.	143
105	Meanwhile the Local Administration should push on the provision of adequate communications in newly exploited areas.	143
106	There is no justification for placing the recruitment of labour for sugar estates outside the scope of the Assam Labour and Emigration Act.	144
107	Government should assist estate managers by the provision of cheap *anti*-malarial remedies and the loan of members of its Medical Department.	144
108	With the opening of the new cane research station or stations a nursery for the supply of hill sets will be required, and the proposed survey committee should advise regarding a site for it.	145
	Chapter IX.—Burma.	
109	It is solely from the point of view of possible future developments that Burma is important as a cane-growing country.	146
110	The old alluvial soil of Lower Burma is unsuitable for cane, and its predominance prevents Burma from becoming as important a cane tract as the Gangetic plain.	146
111	Nevertheless, the occurrence of other more suitable soils is in the aggregate extensive and the abundant rainfall in many districts and the absence of extreme temperatures render the climate generally favourable.	146
112	These features, and the facts that excellent thick canes are already grown without irrigation, that there are vast areas of culturable waste land, and that the Local Government already recognises the need for capitalist grants in the case of special staples are highly favourable to the development of sugar cultivation on a plantation scale.	151
113	A committee of three should be appointed to conduct an agricultural and soil survey of likely areas for this purpose.	152
114	The existing rules for initial exemption from land revenue and a scale of privileged rates of assessment thereafter on certain special crops should be applied to cane.	152
115	Grants are preferable to leases, and allowance should be made for rotations and home plots for field labourers in fixing the rate at and extent to which the concession should be brought under cane.	152
116	Separate research stations specially for cane will be required and the proposed survey committee should advise regarding the number and location of them, as well as of the stations for the supply of hill sets.	153
117	Bilin, Pyinmana and the Namyin Valley are likely areas for the location of research stations, but the Mon canal tract should be finally rejected as unsuitable.	153
118	These stations should be opened without delay and placed initially under the Deputy Directors of Agriculture of the respective Circles, who should be required to visit at least one of the main cane research stations in the United Provinces, Assam and Bombay.	154
119	On the creation of the Sugar Research Institute the cane research work should be concentrated under a single whole-time officer.	154

No.		Para.
120	Important lines of work in the interests of large estates are the evolution of the best commercial rotations and the discovery of a good ratooning cane.	154
121	There are good prospects of improving the small grower's cane cultivation.	155
122	These improvements should be worked out both on the cane research stations and on the ordinary Circle farms.	155
123	Pure line cultures of the Toungoo Yellow and Pyinmana Red varieties should be made and multiplied for distribution.	155
124	With a view to popularising cane cultivation among small growers it is suggested that the present rate of assessment on cane might be temporarily reduced, a specially low rate being fixed for a ratoon crop	156
	Chapter X.—Madras.	
125	Despite its tropical advantages Madras offers very limited prospects for cane.	162
126	This is mainly due to the widespread preference for rice wherever supplies of irrigation water are assured, and to the very scattered area on which cane is now grown.	162
127	Material expansion can, therefore, only be expected along the line of developing a factory industry growing its own cane on leased lands.	164
128	Ganjam and Vizagapatam are likely districts for such a development.	164
129	Work on the introduction and acclimatisation of exotic varieties should be continued and extended into the Ganjam, Vizagapatam and Bellary districts.	165
130	Reduction in the number of sets planted per acre is of special urgency.	166
131	The possibility of adopting the Manjri method of cultivation should be tested wherever there is sufficient concentration of cane.	166
132	The experiments with the wrapping and propping of cane on the Samalkota farm should be carried to a definite conclusion.	166
133	The cane-breeding station at Coimbatore should become a cane research station for the southern districts of Madras.	167
134	If a second cane-breeding station is opened in the Chittoor neighbourhood, it should also serve as a cane research station for that locality.	167
135	The Samalkota farm should be enlarged to 200 acres and become purely a cane research station for the Godavari delta.	167
136	Another cane research station should be established north of Anakapalle for the Ganjam and Vizagapatam districts.	167
137	This station and Samalkota should be placed in charge of an officer working directly under the Sugar Research Institute.	167
138	The needs of other districts must be met by the ordinary Circle farms working in conjunction with the research stations.	168
139	Circle farms are specially required in Ganjam, South Kanara and western Bellary.	168
140	Cane work on the Palur farm should be conducted in close co-operation with the management of the Nellikuppam factory.	168
141	Cane should form an important part of the work of the general demonstration staffs in the Godavari delta, Ganjam, Vizagapatam and Bellary.	169
	Chapter XI.—Bombay.	
	A.—Bombay proper—	
142	The Deccan canals and their projected extensions afford the brightest prospects for the extension of cane in Bombay.	175
143	It is not improbable that nearly 150,000 acres of cane will be grown under these canals in the near future.	176

No.		Para.
144	Water-logging is, however, a serious problem on some of these canals and is partly due to seepage.	177
145	The possibility of lining the canals should, therefore, be carefully considered ; and the fact that they were originally constructed as protective rather than productive works should not be lost sight of.	177
146	The Committee prefer to express no opinion on the general contention that redistribution of agricultural holdings should be undertaken to enable drainage schemes to be carried out.	178
147	They do, however, support compulsory acquisition, redistribution after reclamation and enforcement of intensive irrigation in concentrated areas in the special case of land which has gone out of cultivation through water-logging.	178
148	The movement towards the formation of Irrigators' Associations should be encouraged.	179
149	Outside the Deccan, there is great scope for the improvement of well irrigation, and a separate branch of the Agricultural Engineering Department should be created for the purpose.	180
150	Ultimately this branch will require an Agricultural Engineer of its own.	180
151	The main problem of agricultural improvement here is to reduce the high cost of cane cultivation.	181
152	Much has been done to solve this problem by the improved method of cultivation worked out at Manjri.	181—182
153	The active promotion of this method throughout the Deccan canal areas is of the most urgent importance.	183
154	A special demonstration staff of two parties should be created and trained at once to popularise the method, one on the Godavari and Pravara canals, and one the Nira and Mutha canals.	183
155	Similar demonstrations should be organised on new canals as soon as they are opened.	183
156	Experiments should be continued with a view to discovering new thick varieties to supplement or replace the local Paunda, and the cane-breeding station at Coimbatore should co-operate to this end.	184
157	Pure line sets of superior varieties should be propagated at Manjri, and the classification of indigenous canes should be completed.	184
158	The present high yields, the prospects of extension and the possibility of a factory industry developing in the Deccan canals tract justify the creation of a whole-time post for the supervision of cane research work.	185
159	Mr. Knight, Professor of Agriculture, Poona Agricultural College, should be appointed to this post, and the Manjri farm should be extended to 200 acres and form the centre of his work.	185
160	As a special case Mr. Knight should control the demonstration staff recommended above (item 154).	185
161	Subsidiary cane research stations of 40 to 50 acres each should be opened in Gujarat and the Konkan under the cane research officer.	186
	B.—Sind.—	
162	There is no future for cane in Sind until the Sukkur Barrage project is carried out.	189
163	Even then it may be necessary to restrict the cultivation of cane under it in order to economise water and prevent water-logging.	189
164	The decision of this question depends on the water requirements of cane.	189
165	An investigation of the water requirements of different varieties should be undertaken at the agricultural stations shortly to be opened in pursuance of the recommendations of the Indian Cotton Committee.	189
166	The need for further agricultural work will depend on the result of these investigations.	189

No.		Para.
	Chapter XII.—The Central Provinces.	
167	Cane is at present an unimportant crop in the Central Provinces, and the area grown is less than one-third what it was 50 years ago.	190—191
168	It is and will always be grown almost entirely under irrigation.	195
169	All Government irrigation works are protective in character, and the present policy is against encouraging the cultivation of cane under them until a large proportion of the food-crop area has been secured against failure.	196
170	So long as this policy is pursued, there is no future for cane except under well irrigation, despite the excellent yields obtainable.	197
171	Unless, therefore, the Local Administration is prepared to undertake a well-sinking campaign, all agricultural work on cane should be stopped.	198
172	The newly appointed Agricultural Engineer should be entrusted with the organisation of such a campaign as his first duty.	198
173	The work should be concentrated in selected areas, preferably in the Bhandara district, and cane should be accorded a prominent place in the scheme.	198
174	Given this campaign, the agricultural work on improved varieties should be devoted to meeting the needs of the small cultivator.	199
175	Until fencing can be generally introduced hard-rinded varieties should be preferred, and indigenous varieties should be classified and Coimbatore crosses tested with special reference to this quality.	199
176	Meanwhile the introduction of exotics, other than 247B, should be held in abeyance.	199
177	The present lines of work on improved methods of cultivation should be followed up, but the work should be concentrated.	200
178	It should be centred at a station in or near the area selected for the well-sinking campaign, and cane should be declared the chief crop at that station.	201
179	Other farms should then confine themselves to the multiplication of improved varieties and to co-operation in classifying local canes.	201
180	Prospects of development being limited, the special station proposed for research work on cane must be left under the control of the Deputy Director of Agriculture of the Circle, but he should be given a reliable officer of the Class II Service to hold whole-time charge of the station.	201
	Chapter XIII.—Hyderabad.	
181	The provision of new and improved irrigation facilities is the first essential for the extension of cane in Hyderabad.	207
182	Except to a limited extent on the Gangawati canal there is little prospect of extension under canals in the near future.	208
183	A considerable extension under tanks in Telingana may be expected, particularly in the Nizamabad and Medak districts, if the prevailing assessment on cane is reduced.	209
184	Until an Agricultural Engineer is appointed, no change in the existing system of promoting the sinking of wells is required.	210
185	The Committee's recommendations for expansion of cane work presuppose the adoption of a definite policy of encouragement.	211
186	The expert staff of the Agricultural Department should be strengthened and an Agricultural Chemist should be appointed to supervise all research work on cane.	212
187	Experiments with a view to the elimination of cane props should be continued, and work on other lines of varietal and cultural improvement should be started.	212

No.		Para.
188	Sub-stations for research work on cane should be opened in the Bidar district and the canal irrigated area of the Raichur district.	212
189	For the present, demonstration work should be confined to the distribution of disease-free sets and to reducing the necessity for annual replacement of cane props.	213

Chapter XIV.—Mysore.

190	The chief obstacle to extension of cane in Mysore is the need for perennial irrigation.	219
191	Extension under the Cauvery dam project is improbable until the second stage of the project is carried out, and even then is not likely to be rapid.	220
192	The limited perennial water supply, shortage of labour and salinity in the soil are obstacles to extension under the Marikanave reservoir.	221
193	The reclamation of saline lands under this reservior should be undertaken and an attempt made to combine it with a scheme of intensive cultivation on the lines proposed for the Bombay Deccan.	221
194	The Sulekere tank area is probably too small for development as a central factory area, but the possibilities of introducing small power gur factories there should be investigated.	223
195	The installation of power pumping plants should be carried out either by or in close consultation with the Agricultural Department.	225
196	A factory industry must be organised, if any material extension is to be effected and the bright agricultural outlook justifies special efforts to this end.	226
197	The Goribidnur taluk of the Kolar district appears a favourable tract for development on these lines.	226
198	The Malnad and some of the State's Date palm groves may provide equally suitable areas for such development.	226
199	The possibility of concentrating and improving sources of irrigation in such tracts should be investigated, and suitable areas should be reserved for allotment as sugar plantations.	226
200	If cane growing on a plantation scale is organised in any locality, the transfer of cane research work to that locality should be considered.	227
201	Limitation of supplies of commercial manures is an important factor in the conduct of manurial experiments.	227
202	Problems of drainage, water requirements and rotations remain to be dealt with.	227
203	Withdrawal of the stipulation that the Babbur farm be run at a profit is recommended.	227

Chapter XV.—General Agricultural Recommendations.

204	The provision of a cheap supply of nitrogenous fertilisers is the most insistent problem of Indian agriculture.	229
205	Before the war oil-cake meal was the cheapest and commonest form of nitrogenous manure used in India, but its use was mainly confined to the planting districts of Bihar, Assam and South India.	230
206	Since the war oil-cake meal has cost more per unit of combined nitrogen than Indian sulphate of ammonia.	231
207	If cane were intensively cultivated on a sufficient area to produce a million tons of factory sugar, cane alone would require 92,960 tons of sulphate of ammonia or 375,200 tons of oil-cake meal a year.	232
208	The war has created new sources of supply through the perfection of synthetic processes for the production of combined nitrogen, and these threaten severe competition with the nitrate and by-product sulphate of ammonia industries.	233

No.		Para.
209	So long as sugar does not fall below Rs. 15 per maund the cane grower can profitably buy sulphate of ammonia at Rs. 315 per ton and oil-cake meal at Rs. 2-13-4 per maund to manure his crop.	234
210	The Departments of Industries should investigate the problems of transport of vegetable oils with a view to the promotion of oil pressing in India and so increasing local supplies of oil-cake.	236
211	Five years hence the annual production of by-product sulphate of ammonia on the Indian coalfields should be 20,000 tons.	237
212	The possibilities of utilising the power from hydro-electric schemes in India for nitrogen fixation by the cyanamide and other processes should be investigated.	238
213	Deeper ploughing is the first essential of improved cane cultivation.	239
214	The ordinary type of cultivator's plough is in present circumstances the best that his cattle can draw ; and the first step necessary is to relieve the plough cattle of much of the other work they now do.	240
215	The introduction of power plants for cane crushing, threshing and pumping would enable improved ploughs to be adopted.	240
216	On large estates, and particularly where new lands are opened up, cultivation by mechanical means will be required.	241
217	Experiments at Pusa indicate that cane cultivation with steam tackle is both effective and economical.	241
218	Motor tractors are better suited to smaller estates, and there should be great scope for their use.	242
219	If preliminary cultivation is done mechanically, the cane must be so planted as to admit of all subsequent operations being performed similarly or by bullocks.	242
220	Field experiments with cane varieties should be conducted on test plots of not less than $\frac{1}{10}$ of an acre and should be repeated for each variety over two or three plots.	243
221	Chemical tests in varietal experiments with cane are so important that such experiments should be abandoned on all farms which cannot furnish the equipment and scientific control necessary for conducting these tests.	243
222	The most important work of the Agricultural Department is the demonstration of improved agricultural methods and the spread of better implements.	244
223	Even outside areas for which the Committee have recommended special demonstration staffs for cane, staffs similarly organised for general propaganda should be created and given instruction at the cane research stations before undertaking cane work.	244
224	Demonstrations must be carried out on cultivators' own fields.	244
225	The importance of agricultural engineering should be recognised by the incorporation of Agricultural Engineers in the Indian Agricultural Service.	245
226	This section of all provincial Agricultural Departments should have a special demonstration staff to inspect and repair all machinery issued or recommended by it.	245
227	Subsidiary centres for the carrying out of minor repairs will be required as the work of the Engineering section develops.	245
228	The indigenous canes of Upper India are remarkably free from disease.	246
229	No cure has been found for the more important fungus diseases, and they are best dealt with by the exercise of control measures, such as the introduction of new varieties, careful set selection and cultivation and efficient drainage.	246
230	The mycological needs of cane will be met, if laboratory facilities are provided at the Sugar Research Institute and, when necessity arises, a Mycologist from Pusa is lent to the Institute.	246

No.		Para.
231	Cane borers are the chief insect pests of cane and an additional Entomologist should be appointed to the Pusa staff principally for the investigation of cane pests throughout India.	247
232	The power of the Imperial Sugarcane Expert to import cane from other countries without a certificate of freedom from disease should be transferred to the Director of the Sugar Research Institute when it is created.	248
233	Till then the power should also be given to the officer in charge of the Research Station at Shahjahanpur.	248
234	The water requirements of cane should be investigated on all agricultural stations working on cane.	249
235	The establishment of the proposed research station in the Punjab for the investigation of the water requirements of all crops should be expedited and a Soil Physicist or Physical Chemist should be placed in charge.	249
236	The possibility should be considered of meeting the cost of lining canals on which a concentrated cane area is to be served by increasing the water rates.	250
237	The system of selling irrigation water by volume has great advantages and conditions are more favourable for its adoption than when the Irrigation Commission first expressed their preference for it when practicable.	251
238	The possibilities should be investigated of reclaiming and developing Government waste lands by Government corporations for subsequent disposal to cane factories and similar enterprises.	252
239	Early action on the recommendations of the Committee on Weights and Measures is required in the interests of the cultivator.	253
240	Lack of capital is one of the main obstacles to the proper cultivation of cane, and outside factory areas co-operation must contribute to remove it.	254
241	The co-operative credit societies and depots for the sale of gur and supply of oil-cake manures on the Deccan canals in Bombay furnish an object lesson both of the possibilities and of the difficulties.	255—257
242	Co-operative advances to cane growers should be on a more liberal scale and for longer periods than to growers of other crops.	258
243	Factories are advised to make advances to cane growers wherever possible through their co-operative societies.	258
244	If co-operative trading societies are to succeed, much closer touch must be maintained between the Agricultural and Co-operative Departments, and such societies must be given their own expert organisers.	259
	Chapter XVI.—Other Sources of Sugar.	
245	With the possible exception of the Nipa palm, which may in the future repay investigation in Burma, the only alternative sources of sugar in India of practical interest are the Palmyra palm, the Indian Date palm and the sugar beet.	260—261
246	Of the two main centres of Palmyra gur manufacture, South Madras suffers from shortage of tappers and Upper Burma from shortage of fuel.	262—263
247	In the absence of scientific investigation, the extent to which the existing industry can be improved is unknown ; but it is unlikely that its decline could be arrested in any event.	264
248	Difficulties of tapping, fuel, and transport of the juice, and the impracticability of concentrated and scientific cultivation owing to the prolonged unproductive period of the tree preclude the organisation of a central factory industry for the manufacture of Palmyra sugar.	265
249	Eastern Bengal is by far the most important centre of Date palm gur and sugar manufacture.	266
250	Much light has been thrown on the industry by Mr. Annett's investigations which indicate that, while here also the fuel problem is acute, there are great possibilities of improving both the yield and quality of gur turned out.	267—269

No.		Para.
251	These possibilities, combined with the short unproductive period of the Date palm, the inexpensiveness of its cultivation, its comparative immunity to seasonal vicissitudes and its bearing season of four months, justify great hopes either of an improved gur and sugar refining industry or of a central factory industry for the direct manufacture of Date palm sugar.	269
252	Further investigations are still required, particularly on the agricultural side, and these should now be prosecuted to a conclusion.	269
253	Other Date palm areas offer definitely less prospect of development than Eastern Bengal, and investigation of their possibilities should be deferred until the improvement of the industry in Eastern Bengal has been attempted.	270
254	The future of the sugar beet in India lies, if anywhere, in the North-West Frontier Province and the Punjab.	271
255	In the Punjab results are so far discouraging but inconclusive, and further experiment should await the results obtained in the North-West Frontier Province.	271
256	Very favourable yields both of roots and sucrose per acre have been obtained on the Tarnab farm, and fertile seed has been produced.	272
257	The cultivation of the crop, however, presupposes a central factory to deal with the outturn.	272
258	An unique opportunity appears to be afforded of a combined cane and beet sugar factory in the Peshawar Valley.	272
259	The beet experiments should, therefore, be continued under more diversified agricultural conditions and with closer chemical supervision.	272
	Chapter XVII.—The Problem.	
260	Of the total quantity of cane sugar produced in India 99 per cent. is turned out primarily as gur or *rab* against only 1 per cent. produced direct from the cane as factory sugar.	273
261	In gur manufacture 34 per cent. of the sucrose in the cane is lost or inverted compared with the results obtainable by an up-to-date sugar factory.	274
262	The Committee calculate that this means for all India a loss of 1,068,960 tons of sucrose.	274
263	Sugar factories in India, mainly owing to inefficient milling, lose on an average about 29 per cent. of the sucrose in the cane as compared with the results obtainable by an up-to-date factory.	275
264	The Committee calculate that this means for all India a loss of 10,534 tons of sucrose.	275
265	These figures represent the theoretical limit of possible improvement ; but this cannot in practice be even approximately attained.	276
266	The manufacturing problem is to decide by what lines of improvement these losses can be most materially reduced.	277
267	The manufacture of white sugar from *rab* is most wasteful and cannot survive, if the prejudice against factory sugar disappears and the cane-grower is enabled to sell his cane elsewhere.	278
268	The direct manufacture of white sugar in small factories with open pan boiling must also be condemned on the grounds of high cost of production, heavy losses of crystalline sugar and an unduly high proportion of molasses.	279
269	This conclusion is supported by the results obtained at the small Government factory at Nawabganj, United Provinces, which has proved a commercial failure despite the excellence of its design and equipment.	280—283
270	The Nawabganj factory should now be closed, use should be found locally for its highly efficient milling plant and such parts of the rest of the plant as are of standard pattern should be sold.	284

No.		Para.
271	Gur refining in large factories has also no future before it; as the low quality of its raw material and the heavy losses inevitable with the combination of processes by which the sugar is manufactured render the industry incapable of withstanding efficient competition in normal times.	285
	Chapter XVIII.—The Manufacture of Gur.	
272	Properly adjusted and worked, there is probably no more efficient single crushing mill than the three roller iron bullock mill, but the strain on the bullocks renders proper adjustment and working impossible.	287
273	The rollers are, therefore, deliberately slackened, and on the average not more than 55 parts of juice are extracted per 100 of cane.	287
274	The chief defect of the country gur furnace is the irregularity of air supply and the consequent waste of heat and fuel.	288
275	The first essential for improvement is the introduction of power crushing with small plant.	291
276	The attempts to do this in the United Provinces were nullified by their attachment to a scheme for the manufacture of white sugar with open pan boiling.	293
277	The correct line of advance is power crushing for the manufacture of gur and this has been attempted in Madras and Mysore.	294
278	In Madras the plant has proved defective, the cane having to be passed twice through the mill and too many furnaces being required to deal with the juice, and it has consequently worked at a loss.	294
279	Only three out of ten installations in Mysore survive; and failure seems to have been due mainly to the choice of unsuitable localities for them.	295
280	The experience thus obtained indicates that, if power crushing is to succeed, the plant must be capable of turning out as much gur and as cheaply as the cultivator's plant.	296
281	This means that the plant must be able to turn out gur at not more than 1.8 annas in Madras and 2 annas in Upper India per maund of cane crushed.	296
282	There should be a special opening for such installations on large estates in Upper India.	297
283	To ensure efficient extraction the small power crusher should have a pair of splitting roll crushers in front of the three roller mill.	298
284	The Agricultural Engineering Department of each Province should evolve a standard design for small power mills to crush one and two tons of cane per hour.	298
285	The improved furnaces so far designed are all defective in the arrangement of the pans and the incomplete combustion of the gases.	299
286	A plan of a new furnace designed to eliminate these defects is attached to the Report.	299
287	The Industrial Commission's recommendations for the grant of loans for small or cottage industries are well suited to encourage the gur making industry, except that the disposal of these loans should be entrusted to the Agricultural Department and not to the Department of Industries.	300
288	It is doubtful whether gur manufacture in large factories is a commercial proposition; but the problem should be investigated in the Government sugar factory.	301
289	The practicability of manufacturing muscovado sugar or some other intermediate product direct from the cane in small factories is also doubtful; but should be investigated.	302

No.		Para.
	Chapter XIX.—The Sugar Factory and its Raw Material.	
290	The smallness and inefficiency of Indian factories are mainly attributable to their difficulties in obtaining adequate supplies of cane.	304
291	No factory works up to its full capacity, and half of them crush only half the cane their mills could deal with.	304
292	The problem is to concentrate the area on which the factory draws for its cane and to ensure supplies at the right time.	304
293	There is little likelihood of factories solving this problem by purchase of compact blocks from existing landholders.	305
294	The grant by Government of Crown waste lands to factories is strongly recommended; but the opportunities for development on these lines are restricted to the undeveloped Provinces and occasional waste areas coming under the command of new canals.	305
295	Compulsory acquisition by Government of cane lands for factories would afford the speediest solution of the problem and weighty arguments can be urged in support of it.	306
296	Except in certain special and restricted cases, however, the majority of the Committee are opposed to such compulsory acquisition as being dangerous in principle and unnecessary in practice.	307
297	Their objection to Mr. Padshah's scheme for compulsory acquisition in the last resort and subject to certain safeguards is that the safeguards would either nullify the scheme or themselves prove illusory.	309
298	It is at least doubtful whether compulsory acquisition for such a purpose is contemplated by the existing law.	310
299	In so far as this is necessary, however, in order to enlist the co-operation of factories in effecting improvements in cane cultivation, compulsory acquisition of small blocks is recommended for use as centres of demonstration and improved set supply.	311
300	The limit of area might be so much as is required to provide sets for half the cane the factory can crush, or, allowing for rotations, 600 acres in all preferably in several blocks of not more than 100 acres each, for a factory producing 10,000 tons of sugar a year.	311
301	These blocks should be leased to the factory by Government for short terms subject to specific conditions of local public service.	312
302	Plots of one or two acres each should also be acquired, when necessary, and leased to a factory which undertakes to instal tube wells and pumping plant of an approved capacity for the supply of irrigation water to cane growers.	313
303	Greater efforts should be made by factories to obtain cane lands on lease; and Government should be prepared to assist the factory by lending the services of one of its officers to explain the terms offered.	315
304	The Java system of handing the land back to the lessor in intermediate years between two crops of cane is recommended for trial.	315
305	Cane supplies might be increased by the grant to cane growers of shares or of a participation in the profits of the factory.	316
306	The great need is, however, an adequate scale of payment for cane.	317
307	A sliding scale based on a price for cane equal to one half the price of the sugar produced from it is recommended.	318
308	In considering how this scale would work in practice it must always be remembered that the cane-cultivator has in gur an alternative outlet for his produce.	319
309	In the tracts where the best eating gur is made the price under this scale could not always be counted on to be as high as the corresponding gur value of the cane; and these are not promising areas for sugar factories so long as the pre-war ratio between the prices of such gur and factory sugar is maintained.	320

No.		Para.
310	In tracts where most of the gur made is of inferior quality the price paid under the sliding scale should always be well above the gur value of the cane.	321
311	The scale should be subject to a minimum price for cane of 6 annas per maund.	322
312	An alternative system worth trying is an initial payment on a somewhat more moderate scale combined with a bonus at the end of the season equivalent to not less than the difference between the initial payment and the amount due under the half sugar value scale.	323
313	To enable monthly settlements to be made under the scale proposed the Director of Statistics should issue monthly a statement of the average wholesale price in the principal markets of white sugar manufactured in India.	224
314	Factories should also allow their books to be examined to enable an independent assurance to be given that their payments for cane have been duly based on the sliding scale.	324
315	Payment should be made on a more liberal scale for canes of low fibre content.	325
316	A comparison of the costs of producing sugar in India with the costs in other countries shows that it is in respect of cost of manufacture rather than cost of cane that Indian factories have to fear foreign competition.	326
317	A factory should also assist local cane cultivators with the advice of its agricultural officer, and, even if it has no cane land of its own, should employ such an officer for this purpose.	327
318	In view of the difficulties of concentrating the factory's area of supply railways can contribute materially to solve the supply problem.	328
319	There are several projects for new lines in North Bihar the execution of which would be of great benefit to the factory industry there.	328
320	Other schemes that should be proceeded with are for branch lines or extensions in Gorakhpur (United Provinces), Kamrup (Assam), Ganjam (Madras) and Poona (Bombay).	328
321	On existing lines the chief need is a prompt service of open trucks with low sides.	329
322	With the development of the industry there will be a growing need for privately owned light railways to convey cane to the factory; and the authorities controlling existing roads and railways should as far as possible afford the necessary facilities.	330
323	The licensing of factories by Government is not recommended, as no efficient factory paying full value for cane and entering into close relations with its cultivators need fear competition; while the possibility of competition is a valuable stimulus to efficiency.	331
	Chapter XX.—The Manufacture of Sugar.	
324	The present methods of handling the cane in Indian factories are particularly defective and injuriously affect the milling results.	333
325	Great improvements could be effected if steps were taken to regulate deliveries and the Java system of lifting cane loads on to the carrier by mechanical means were adopted.	333
326	The commonest defects in the mills are inadequate preliminary crushing, the driving of each mill from a separate engine and the faulty designing of the juice pans and strainers.	334
327	For the high fibred Indian canes two crushers in front of a train of three, three-roller mills with two macerations is probably the most efficient plant.	334
328	The juice pans should be self-cleansing and mechanical juice strainers should be used.	333

No.		Para.
329	The high proportion of fuel consumed in addition to megasse is a direct consequence of the irregularity of the cane supply and constitutes a serious item in the costs of manufacture.	335
330	In the sugar house the arrangement and balance of the machinery are frequently faulty.	336
331	For white sugar manufacture the sulphitation process is best suited to India, being more economical than the carbonatation process.	336
332	What is mainly responsible for losses in the sugar house is not the machinery but the control that is exercised over it, and the incompleteness of the chemical and analytical records maintained.	336
333	Losses chiefly occur from sugar lost in the filter mud and left in the molasses and from pilfering.	336
334	The first essential for improvement is better supervision and above all more efficient chemical control.	337
335	The chemical and analytical records which a sugar factory should maintain are exhibited in Appendix V.	337
336	There is considerable room for economy in labour by the use of labour saving appliances and the exercise of systematic control.	338
337	The Indian gur refineries are small and turn out sugar of low quality.	340
338	The percentage of recovery in the North India refineries is specially low.	340
339	Owing to the poor quality of the raw material worked, there is little prospect of material improvement in the refining industry.	340
340	Several of the Committee's conclusions regarding the prospects of sugar production in Upper India are inevitably speculative; yet this all important cane tract must contribute, if India is to become self-supporting.	341
341	Unless initiative is forthcoming, capital is likely to concentrate only on new and undeveloped areas such as Burma and Assam.	341
342	Government should, therefore, erect a pioneer factory in Upper India outside the present factory zone, possibly in the Karnal or Rohtak district of the Punjab.	342
343	It should be run on purely commercial lines by a directorate of five—a managing director, the Director of the Sugar Research Institute (*ex-officio*), another official nominated by Government and two non-officials nominated by the Sugar Board.	344
344	The managing director and factory staff should be recruited on special agreements and participate in profits.	344
345	Should Government be unable to provide the funds, a loan should be raised in the form of debentures carrying a guaranteed interest of 7 per cent. free of income-tax and a half share in all profits above 7 per cent. up to 13 per cent.	345
346	The factory should be required to carry out general experiments for the benefit of the sugar industry and should receive no privileges which would not be given to a private factory.	345
347	The grant of Government loans or guarantee of dividends for the promotion of private factories is not necessary.	346
348	Most of the distillery buildings attached to sugar factories are too low-roofed and unventilated for rapid and complete fermentation.	347
349	India's present normal annual consumption of molasses is about four times the 30,000 tons she produces; and the demand, especially for use as a cattle food, should steadily expand.	347
350	Government's Excise policy is not, therefore, likely to handicap the sugar industry for a long time to come.	347

No.

351 The objections to the length of the term of distillery contracts are based on temporary causes and have in several Provinces already been met.

352 The period of notice for the submission of tenders should not exceed six months.

353 The possibility should be considered of adopting as the contract rate a sliding scale based on the market price of the distiller's basic material.

354 Such criticisms of the system of distributing distillery contracts as the Committee received were opposed to the deliberate policy of Government and did not justify its reconsideration.

Chapter XXI.—The Tariff Question.

355 Apart from the more or less abortive measures taken against bounty-fed sugar in 1899, 1902 and 1904, the tariff on sugar imported into India has hitherto been purely for revenue and not for protective purposes.

356 In view of the impending investigation of the general policy of revising the Indian tariff to protect Indian industries, it is difficult to discuss this question for sugar separately; nor does the conflicting evidence received or the abnormal state of the indigenous industry and the import trade afford any reliable guidance.

357 The present tariff combined with ocean and railway freights should provide ample protection to the Indian sugar industry; but, if the question of general policy is not meanwhile investigated, the particular case of sugar should be reconsidered when normal condititions are restored.

358 A quantitative duty is preferable to an *ad valorem* duty; but the present time is not opportune for the change.

359 The only party of the Empire which would benefit from an Imperial preferential rate on sugar imported into India is Mauritius.

360 If Imperial preference is adopted generally, it should be adopted in favour of Empire sugar by means of a proportional reduction on the present tariff.

Chapter XXII.—Statistical.

361 Of the three essential factors for an accurate estimate of the cane crop of India, the area estimate is fairly accurate outside the permanently settled tracts, where a revision of the land records system is required to improve it.

362 There are, however, certain unexplained discrepancies in the area as recorded in (1) the "Agricultural Statistics of India" and (2) the "Estimates of Area and Yield of principal crops in India," which should be reconciled.

363 Little reliance can be placed upon the figures at present adopted for the second factor, the standard normal outturn of gur per acre.

364 The Board of Agriculture's recent proposals for arriving at an average yield are unsuitable for cane, and its standard normal outturn must continue to be ascertained directly from crop-cutting experiments.

365 These should be more numerous, more systematic and carried out by the Agricultural Department in each Province, and the results should be reported in terms of weight of cane.

366 The average proportion of gur to cane should be ascertained by a few carefully selected and supervised boiling tests in representative tracts.

367 When reliable figures for a sufficient number of years are available, the average yield of the ten preceding years should be adopted in place of the standard normal outturn.

368 Yields obtained on Government farms should be rejected for statistical purposes.

369 The third or seasonal factor as operated under the present system, tends to persistent under-estimation of yield, and should be corrected by reference to the condition figure reports of the previous ten years.

Para.

As the Agricultural Department expands it should take over from the Revenue Department the duty of supplying the condition figure. 335

The Board of Agriculture's recommendations are supported for comparing previous and present forecasts with actuals and for the appointment of an Agricultural officer with statistical training to each provincial Agricultural Department for statistical work, which should include forecasts and costs of cultivation. 362

The second cane forecast should include a condition figure and the final forecast should be published not later than the end of January. 363

A certain amount of rearrangement would considerably improve the "Agricultural Statistics of India." 364

The "Commercial Statistics of India" should include statistics of cane crushed and sugar and molasses turned out by sugar factories. 365

The monthly sugar price returns recommended in Chapter XIX should be reproduced in "Prices and Wages in India." 366

The Table of up-country wholesale sugar prices should include quotations from other Provinces besides the United Provinces. 366

The chief defects of this Table and the Table of up-country wholesale gur prices are the unreliability of the statistics and the inadequate classification of the commodities quoted. 366—367

A more detailed classification will enable a more rational reporting system to be adopted with regard to the comparisons between reporting centres required. 367

The necessary supervision and direction of the primary reporting agency should be provided by placing it under the control of the special statistical officer of the Agricultural Department recommended in item (371) above. 367

Detailed improvements are suggested in other Tables of "Prices and Wages in India." 368

Imports and exports of sugar should be recorded in tons in the "Annual Statement of Seaborne Trade." 369

Chapter XXIII.—Formation of an Indian Sugar Board.

Organisation of the Indian sugar industry on the Java model is essential to progress. 370

At the outset this organisation must be largely official; but the object should be eventually to hand it over almost entirely to non-official control. 370

It should take the form of an Indian Sugar Board with five official and six non-official members. 371

In the first instance all members will have to be nominated by Government; but the first duty of the Board should be to evolve a scheme to secure representative appointments. 371

Members should then hold office for three years and their tenure should be honorary. 371

An Imperial Sugar Research Institute should be established with three divisions, agricultural, chemical and engineering, each with its own independent head; and it should control the work on the various research stations already proposed for the Provinces. 372

A Director is required for the administrative control of the whole Institute and to keep in touch with the sugar work of the Provinces. 372

In addition to the more obvious lines of work the Institute should consider the needs of the small gur manufacturer, investigate the possibilities of beet sugar production and assist the palm sugar industry. 373

The first Director and heads of divisions should be recruited on special terms, and other officers of the research organisation as members of the 373

No.		Para.
391	Subsequent Directors and heads of divisions should be appointed by promotion and given the status and pay of provincial Directors of Agriculture and officers in the selection grade of the Indian Agricultural Service respectively.	373
392	It is only research work on cane that would be taken over by the Institute and its sub-stations ; and the local Agricultural Departments would remain responsible for distribution of improved varieties, demonstration and propaganda.	374
393	As an exceptional case, the Institute might, with the knowledge of the local Department, issue canes direct to factories controlling their own cultivation.	374
394	The objection that the Committee's scheme would be difficult to work because it involves a separation of functions (*a*) between Imperial and provincial and (*b*) between research and demonstration is met (*a*) by the provision for local research stations and equality of pay and status in the two branches and (*b*) by the facts that in Indian agriculture demonstration is as important as research and requires equally high attainments, so that no invidious distinctions are involved, and that separation is now essential to progress in agricultural improvement.	375—376
395	Factories should be encouraged to maintain their own agricultural advisers provided and controlled by the Sugar Research Institute.	376
396	The sugar industry should be expected to contribute towards the cost of the Institute from the outset ; and the first representative Board should evolve a practical system of contribution.	377
397	Peculiar conditions in India, especially the importance of the gur industry, preclude the complete elimination of Government interest in the Institute ; and when the industry is in a position to take over the main control, its funds should be provided by a voluntary levy on factories supplemented by a Government subsidy to ensure consideration of the interests of the small grower.	378
398	The functions of the Sugar Board would be to control the policy of the Resarch Institute and the administration of its funds, to advise Government on matters affecting the sugar industry, and to supervise the issue and receipt of returns by the Institute.	379
399	The cost of the Sugar Board would be negligible : that of the Research Institute, the sugar school and the sub-stations is estimated at 35½ lakhs non-recurring and 12 lakhs recurring, but the latter should be largely reduced by the earnings of the sub-stations.	380
400	Profits on the research stations should be devoted to the expansion of the activities of the Institute.	380
401	The submission by factories to the Institute of returns approved by the Board should be made compulsory by legislation ; but proceedings for default should only be taken on the complaint of the Board.	381
402	The Research Institute should be located where it can serve not only the existing factory industry of Upper India but also the great cane tract further west and north ; and a site in the Basti or Kheri district of the United Provinces would fulfil these requirements.	382
403	The same place should be adopted as the head-quarters of the Board, though the Chairman should have power in case of necessity to convene meetings elsewhere.	382
404	The Sugar Bureau should be continued pending its absorption in the Research Institute.	383
405	Native States should not be asked to contribute to the maintenance of the Research Institute, but should be encouraged to seek the help of its officers and to open research stations under it.	384

No.		Para.
	Chapter XXIV.—Coimbatore.	
406	The Coimbatore cane-breeding station and the post of cane-breeding expert should now be made permanent.	387
407	The station should be transferred to Imperial control.	387
408	The main lines of work now in progress should be continued, except that the attempt to evolve improved varieties of cane for Upper India which will withstand the indifferent usage of the ordinary cane grower should be abandoned as impracticable.	388
409	Seedlings should only be distributed for trial to farms on which cane is an object of special study.	389
410	The selection work at Coimbatore should be confined to a purely general and preliminary survey, detailed selection being transferred to the cane research stations in the various Provinces.	390
411	The acclimatisation of imported canes at Coimbatore for direct distribution to other parts of India should be discontinued except for South Madras.	391
412	More attention should be paid to the breeding of new varieties of thick canes for Peninsular India, Burma and Assam.	392
413	The area of the station should, if necessary, be increased by some 25 or 30 acres for this purpose.	392
414	Coimbatore should also become a cane research station for South Madras.	393
415	Separate land will be required for this purpose, but 50 acres should suffice.	393
416	In addition to undertaking the branches of work indicated in Chapter X, the research station should carry out special investigations into the water requirements of cane.	393
417	A second cane-breeding station is required mainly for the raising of seedlings from parents that will not produce fertile seed at Coimbatore.	394
418	A suitable site might be found in the Chittoor District of Madras, but its selection should await the creation of the Sugar Research Institute.	394
419	If located in the Chittoor tract, the station should also serve as a cane research station for Central Madras.	394
420	An area of 100 acres in all should suffice for both purposes.	394
421	The cane research officer recommended for Madras in Chapter X should control the cane work in the northern districts only ; the cane work in the southern districts being controlled by the cane-breeding expert.	395
422	The cane-breeding expert should control both breeding stations, making Coimbatore his headquarters.	395
423	He should be provided with a thoroughly competent staff of Botanical and Chemical Assistants, the rates of pay for whom should be raised.	395
424	His senior Botanical Assistant should hold charge of the second breeding station under his control, and should receive a special allowance.	395
425	A Chemical Assistant is also required for the second breeding station ; and the cane research work there should be entrusted to the charge of a separate Assistant.	395
	Chapter XXV.—Sugar Schools.	
426	One of the greatest needs of the Indian sugar industry is a properly trained staff of chemical, engineering and agricultural assistants.	397
427	The specialised technical training which will qualify men to enter the sugar industry as competent workers should be provided in the country.	398
428	Of the educational institutions in other countries which give courses of instruction in sugar technology the Audubon Sugar School of the Louisiana State University and the College of Hawaii furnish the most instructive precedents for India.	399—404

No.		Para.
429	The School for India should provide a thorough training in sugar agriculture, chemistry and engineering and should form an integral part of the Sugar Research Institute.	405
430	The ultimate standard of training to be aimed at should be worked up to gradually with due regard to the immediate needs of the industry.	406
431	Prior to admission students should have taken the first two years' course of an Agricultural or Engineering College with some additional instruction in chemistry and physics.	407
432	The Sugar School course should extend over 2½ years and three crushing seasons ; and should be conducted in two sections, an agricultural section and a chemical and engineering section, though a part of the training will be common to both.	408
433	Practical field and factory work should form the most prominent feature of the course ; and for this purpose the school should have its own farm and small model factory.	409
434	The last cane harvesting season of the course should be spent either on the Government factory or on large private factories by arrangement with the companies.	409
435	A diploma should be granted to students passing the final examination until the school is affiliated to a University, when the B. Sc. degree should be awarded.	409

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