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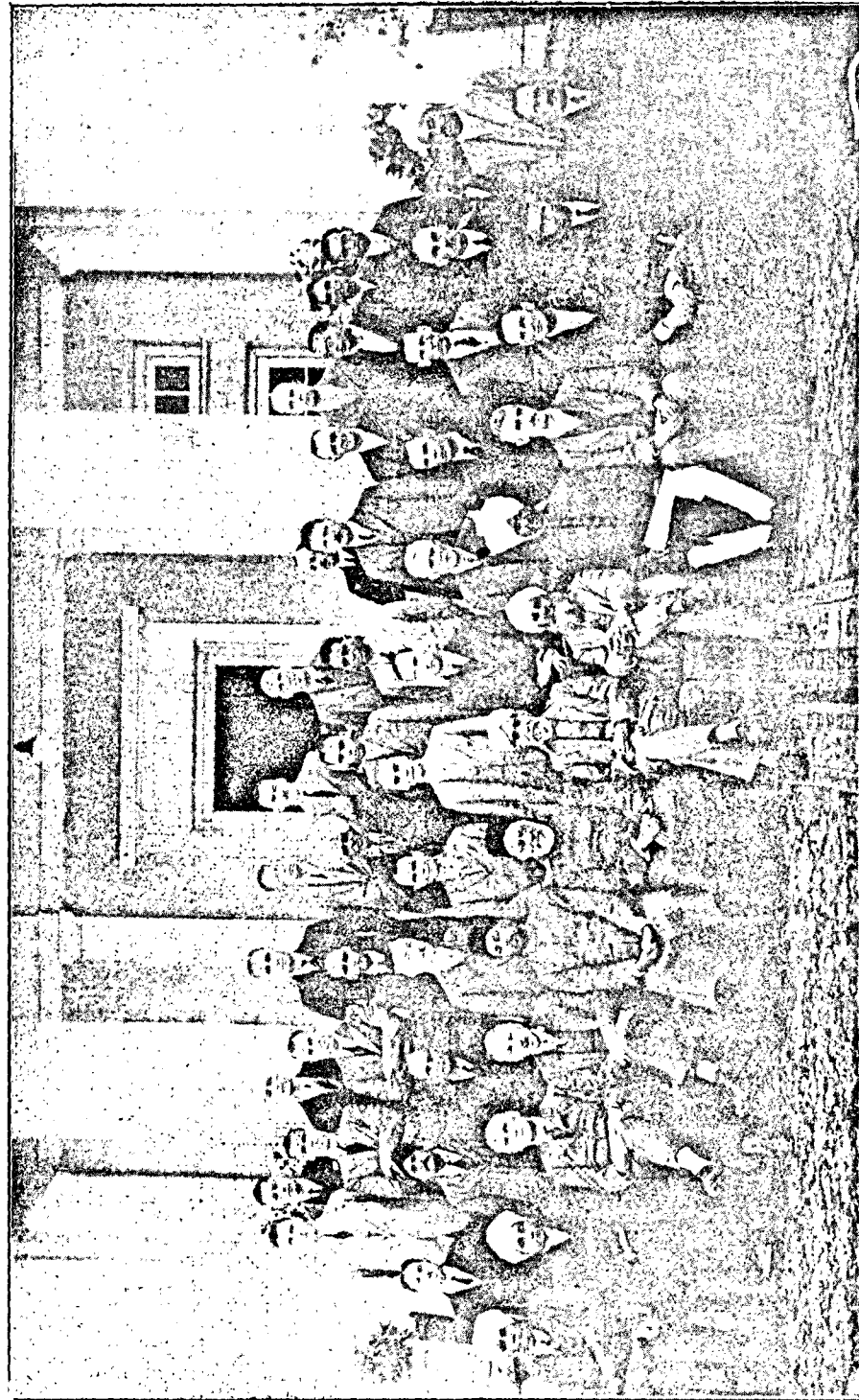
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THE INDIAN AGRICULTURAL CONFERENCE, SIMLA, 1ST—6TH OCTOBER 1928.

ORIGINAL ARTICLES

THE INDIAN AGRICULTURAL CONFERENCE.

[Simla 1st—6th October 1928]

The Indian Agricultural Conference which His Excellency the Viceroy opened at Simla on the 1st October, 1928, met on the 2nd, 3rd, 4th, 5th and 6th October under the Chairmanship of the Hon'ble Sir Muhammad Habibullah. The main recommendations made by the Royal Commission on Agriculture in India in regard to research, agricultural education, agricultural improvement, the distribution of agricultural implements, seed and produce, animal husbandry, horticulture, improvement of statistics and the reorganization of the Agricultural and Veterinary Services were discussed. Provincial representatives explained the action already taken by their respective Local Governments in regard to one or more of these recommendations, and their probable attitude towards those proposals which were still under consideration. While emphasis was laid on the variety, number and financial implications of the Commission's proposals which made immediate or simultaneous adoption of them impossible, there was complete unanimity among those assembled as to the desirability of accepting the Commission's report as a basis for rural reconstruction and agricultural advance, and for the progressive application of the main recommendations as the circumstances of each province might permit. As regards the Commission's proposals for reorganizing the Services engaged in the agricultural and veterinary fields, the general view was that the discretion of the provinces should be left unfettered, in respect both of recruitment and of regulation of the terms of service. The Conference also approved the principle of promoting and guiding agricultural (including veterinary) research throughout India on a footing of voluntary co-operation between the Government of India, and Local Governments through an agency representative of all-India as well as provincial interests, which would be set up and financed by the Government of India.

The Government of India had arranged that the resolutions adopted by the All-India Co-operative Conference which sat in Simla from the 28th September to the 1st October, 1928, in so far as they related to or arose out of the recommendations of the Royal Commission on Agriculture, should come before the Agricultural Conference. The latter took note of these resolutions, and provincial representatives promised that they would receive careful consideration.

His Excellency the Viceroy's Opening Speech.

In opening the Conference, His Excellency the Viceroy delivered the following speech :—

"GENTLEMEN,—Let me wish you a cordial welcome to Simla. When the Report of the Royal Commission on Agriculture in India reached us, we undertook a rapid examination of its contents in order to decide what would be the best way of securing prompt and fruitful consideration for the Commission's proposals. It was clear from the wide ground covered by the recommendations as well as from their nature that the first necessary step was to determine the relative urgency of the main recommendations and the authority, Central or Provincial, or both Provincial and Central acting in concert, by which individual recommendations were to be carried out. My Government felt that, if this task was to be completed expeditiously, we must convene a Conference at which these important matters could be discussed face to face. The active sympathy with which each Local Government had received the Commission's Report, the declarations made by various Provincial Governors and Ministers of their readiness to consider it and act upon it as expeditiously as the importance of the subject and their resources permitted, encouraged us to hope that our invitation would evoke cordial response. Your presence here to-day, gentlemen, afford gratifying proof of the correctness of our expectations. May your deliberations, which it gives me great pleasure to inaugurate, result in a united understanding and a common resolve to further the beneficent objects which the Commission's labours have helped to bring into definite form and clear perspective.

"It is a pleasure to include in my welcome the principal Ministers of Patiala and Kapurthala who, owing to their presence in Simla, have been able to attend this morning's proceedings. My Government did not officially invite Indian States to send their representatives to this Conference because we felt that the stage for seeking the co-operation of States in the task of India's agricultural advancement would be after the Governments of British India had consulted together and reached definite conclusions as to the action to be taken on the Report of the Royal Commission on Agriculture. I avail myself, however, of this opportunity to express our appreciation of the valuable assistance which we have received from Indian States in the past in helping forward India's staple industry, and I hope that in such new activities as may be started hereafter as the result of the deliberations of this Conference, we may, if necessary, count upon the cordial support of the Durbars.

"Before I proceed further, gentlemen, let me endeavour to express what, I am sure, you all fully share, namely, our appreciation of the work accomplished by the Commission. The importance of agriculture to this country has often been emphasized; it can never be exaggerated. Agriculture is the mainstay of 71 per cent. of the population of India. The practice of centuries has taught the Indian cultivator much that is of value in agriculture. But a great deal that science has brought

to light in recent years is unknown to him. And the growing pressure of population on land of which the area is limited has created fresh problems for agricultural science to explore and solve. If the ryot's standard of living is to improve, the quality of his produce and the return which his toil brings him must be improved also. That was the main economic problem to which the Commission had to address themselves. But they took a wider view of their responsibilities. They applied their minds to the whole question of rural reconstruction. They recognized that the conditions of rural life have to be viewed and studied as a whole; that there is an organic affinity between rural education, rural sanitation and rural economics; that material prosperity will not, by itself, complete the ryot's happiness; indeed, that such prosperity can only be achieved if education widens his horizon; if improved sanitation makes his life healthier and longer; if his environment is so improved as to send him with a cheerful mind, a quickened interest and a zest for work to his daily task in the field. Their enquiry, therefore, embraced the whole field of rural life. It was careful and intensive. The Commissioners sought not only to investigate all the relevant facts in India. They also tried to ascertain conditions abroad which might help them to complete their survey of the problem and present a comprehensive Report. The result, gentlemen, is a massive volume, full of useful and illuminating facts and of stimulating suggestions. I use no language of exaggeration when I say that it represents the most complete and creative document affecting the welfare of the agricultural population in this country that has hitherto been published. My Government and I—and, gentlemen, I hope, I may associate in this observation the Provincial Governments whom you represent—wish to express to Lord Linlithgow and his colleagues our grateful appreciation of their sustained, sympathetic and strenuous endeavour, and our congratulations on the valuable contribution which they have made to the furtherance of a vital and beneficent activity.

"Gentlemen, you have a varied and full agenda before you. I do not intend to prevent you from getting to grips with it as quickly as possible. Nor do I propose to select any one of the items on your list of business for detailed comment. I would leave that to Sir Muhammad Habibullah and to other members of the Conference whose expert knowledge fits them for the task. But I shall permit myself a few remarks on the broad unity of outlook which is the outstanding feature of the Commission's Report—a feature to which I have already referred. As the Commission point out, the problem of agricultural improvement is identical with the problem of rural reconstruction. Amelioration of the agriculturists' lot cannot be effected without co-ordinating activity in several fields of administration, besides agriculture proper, particularly in the fields of education and public health. Now, gentlemen, each one of these departments of Government is now under the control of popular Ministers. Initiative to secure such co-ordination rests with them. I have no doubt that such initiative will be forthcoming. The form which it may take and the rate at which co-ordination may progress will depend on conditions and circumstances

which, I recognize, vary from province to province. I would only ask Hon'ble Ministers to remember that co-ordination offers the one magic key to success in the object which the Commission have described for us. The emphasis laid by Lord Linlithgow and his colleagues on the value of combined activity will, I hope, be appreciated at its true value and their various recommendations carried out in an endeavour to move forward together over the whole wide front which we desire to attack. Much of the work must fall directly upon Local Governments, for we recognize the existing constitutional position and have no desire to interfere in any way with their discretion. But whatever assistance by way of counsel and the supply of information the Government of India can render will be willingly and readily given.

"There is, however, one other matter with which the Government of India is immediately concerned, and on which I should like to dwell briefly. I refer to agricultural research. The Commission have rightly placed the guidance, promotion and co-ordination of research in the forefront of their recommendations. Scientific research is the life-blood of economic progress. Knowledge of the processes of nature must be progressively improved and applied in order to stimulate her bounty. Nature must be led, not driven; and if we, by study of her ways, lead nature by the hand, she will join hands with us in placing new treasures at our disposal. If therefore we wish the land to yield to us a harvest richer in measure and quality than what she does to-day, we must call science more and more to our aid. Scientific research is largely responsible for the agricultural prosperity of Java. The same is true of all nations with a developing and progressive agriculture. In this country, the improved varieties of Pusa wheat and Coimbatore sugarcane have added materially to the prosperity of the agriculturist in the wheat and cane-growing provinces of India. The veterinary work done at Muktesar has saved and is saving the lives of hundreds of thousands of cattle every year. I have mentioned these instances not to glorify the institutions devoted to research which the Government of India maintain, but only because they are most familiar to me. I have no doubt that in the provinces work not less valuable has been and is being done. But as the Commission have pointed out, in India endeavour has so far lagged behind the exigencies of the situation. More must be done if we are to cope with the demand made by a growing population and by the increasing stress of competition in the markets of the world. Both factors emphasize the need for increasing the output from land and the quality of the yield. Agricultural research offers a sphere in which the Central Government can help the provinces, both through the existing agencies which they now control and, if the provinces are willing to co-operate, in the manner recommended by the Commission. As you are aware, gentlemen, in Chapter III of their Report, the Commission have made proposals for setting up a Central Council for Agricultural Research. These proposals will doubtless be discussed by you, for I observe that the establishment of such a Council is the first item on your agenda. I shall not attempt to anticipate the results of your deliberations on the subject.

I shall only say that my Government and I are strongly of opinion that some such organization should be brought into being as soon as possible. India urgently wants a body which will be thoroughly representative of all-India as well as of provincial points of view; which will be able to ascertain and appraise, with the aid of the best scientific advice available in the country, the requirements of the different agricultural tracts; which will be endowed with adequate funds to guide, promote and co-ordinate agricultural research throughout the country and with sufficiently elastic powers to utilize these funds as its collective judgment may suggest. The scheme drawn up by the Commission is based on principles which appear to fulfil these conditions and will, I hope, receive your earnest consideration. You will have observed that the Commission's plan does not, as the constitution stands at present, contemplate any call on the provinces for financing the proposed Council. The Government of India accept this position, and, subject to the approval of the Legislative Assembly, will endeavour to provide any central organization that may be set up with such funds as their resources might permit. But apart from the question of finance, the whole principle of co-ordinated activity in this sphere requires to be discussed. It is for the provinces to decide whether they will or will not accept this principle. We do not desire to impose on them any scheme built up on this principle if they do not want it. For, it is obvious that co-ordination cannot be achieved without the co-operation of the provinces. There is one more important point which I should like to make clear. My Government and I have no intention that, if a central organization is set up on the lines recommended by the Commission, it should in any way curtail or restrict the freedom which the provinces now enjoy in regard to agricultural administration and policy. Indeed it is our wish that, if any such organization materializes, it should be so devised as to enlist the interest and the willing support of the provinces no less than of the Government of India. We seek voluntary co-operation, not an infringement of provincial powers and rights.

"I had intended, gentlemen, to touch briefly also on the part which the co-operative movement can play in enlarging the happiness and material prosperity of the countryside. Any such observations would be superfluous now after the speech which the Hon'ble Sir Muhammad Habibullah delivered the other day when inaugurating the tenth session of the All-India Co-operative Conference. I can add nothing to the sagacious and practical suggestions which he made on that occasion for broadening the scope of this movement and for infusing into it fresh energy and fresh vigour.

"Gentlemen, I shall not detain you much longer. I have tried to explain to you the objects with which this Conference was called and to make a few observations on the importance of the Report and on the attitude of my Government towards the principal recommendation which concerns us as well as Local Governments. I shall be interested to learn from day to day, as your deliberations proceed, what each province thinks of the many and varied proposals made by the Commission;

what action it proposes to take on them. We recognize, as the Commission recognized, that it is impossible in a day to give effect to recommendations so numerous and so far-reaching. Time is necessary for the mobilization of the resources and the men, and for accelerating the momentum of public opinion, without which proposals so comprehensive in their range and effect cannot attain full fruition. But I am confident that the resolve to work for the uplift of the rural population, with which each one of you has come to this Conference, will derive inspiration and strength from meeting others who are moved by the same impulse and engaged on a similar task in different parts of this great country. May the contact, which these meetings are intended to provide, infuse new life into your efforts and lend new vigour to your purpose. No ideal could be more humane in its nature, more moving in its appeal than the ideal of kindling in the breasts of seven-tenths of the inhabitants of this sub-continent the desire for a "better and a fuller life," no duty nobler or more powerful as a spur to action than the duty of working with sustained energy and steadfast faith to see your ideal realized. It is my firm conviction that the duty will be willingly and worthily discharged, as it is my earnest hope that the discussions which start to-day may help to bring the ideal nearer to fulfilment."

WOMEN'S SHARE IN RURAL RECONSTRUCTION.

BY

MARY E. H. MACKIE.

"THE Samitis have made the life of women in the villages happier, more hopeful and more useful than it was three years ago A new social life has made its appearance. Meetings, lectures, classes, study groups, domestic and cottage industries have come to form so important a part of almost every Mahila Samiti that a Mahila Samiti can be truly described as a real educational centre for the rebuilding of national life."

After this extract from the 1927 Report of the central body of Women's Institutes (or "Mahila Samitis") in Bengal, it will be well to turn to another Report, that of the Linlithgow Commission on Agriculture, and see how far this women's movement is needed in rural areas of India at the present time.

Among its many recommendations the Royal Commission indicates the necessity for improvement in the matters set out below.

1. *Medical relief and public health.* Much stress is laid on the need for a strong forward policy in these respects: on the supply of water, clean roads, tanks, wells and sanitation; and on the deplorable condition of six million deaths every year from preventable disease and malnutrition. "The tragedy," says the Report, "is that such a state of affairs should exist when, with corporate action on the part of the villagers, the evils would be so easily remediable."

Under the heading of health come also child welfare, lady health visitors and the training of midwives, at present confined very much to the large towns, but proved, in the few rural districts where they obtain, to be very beneficial institutions. Regarding nutrition, it is found that locally grown food, though usually enough for local needs, by no means contains sufficient nutriment to promote physical health. Moreover, economic changes such as the establishment of factories and mills in some country districts, cause such demands on fruit, vegetables, milk and other agricultural produce that increased food production is becoming a necessity in those places.

2. *Education.* A very definite recommendation is made for *systematic effort* regarding the teaching of women, particularly of mothers, in view of the inevitable spread of literacy among children of cultivating families in which the mother is literate. The difficulties are recognized: "conservatism and prejudice, reinforced by the purdah system and the custom of early marriage;" difficulties in obtaining qualified teachers, and in making satisfactory arrangements for transit

of the girls ; and financial difficulties ; but the value of women's education to rural reconstruction and the necessity to find means of overcoming obstacles, are very strongly emphasized.

3. *Rural industries.* The villager has leisure, and he needs more money, two circumstances pointing to the development or revival of silk-making, lace, pottery and other local industries and spare time employment. The necessary capital and help with marketing are already available through co-operative credit societies and further use of these facilities is urged by the Commissioners.

4. "*Better living.*" Before standards can rise, the will to live better needs to be cultivated, and more organizations are needed such as those in the Punjab, already endeavouring to reform old uneconomic ways, to restrict expenditure on marriage, women's jewels, and trivial litigation. The Report has accounts of social welfare already being carried on by the Y. M. C. A., Seva Sedan and Rural Community Councils, but urges a general extension, with State assistance at the start, and adds the important remark that the rural community movement will gain power for good if it develops a women's side to its activities. There follows a definite recommendation as to the establishment of Women's Institutes, to serve as centres for various activities enumerated above, and help in the problem of women's education.

Now let us see how far these needs and recommendations are being met already by women's rural movements.

First, there is an experiment being carried on by a few members of the Delhi Women's Educational League, in a village near Delhi. A group of volunteers is tackling such problems as ignorance, lack of sanitation, and eye trouble (prevalent in nearly 90 per cent. of the children). Mrs. Chatterjee, Secretary of the League, gave in a recent¹ publication a bright and illuminating account of how this little group not only overcame the women's shyness and suspicion, and the husbands' fear of resulting taxation, but even gained the confidence of the villagers to the point of enlisting their active help. Those women are now learning with zeal and happiness, knitting, health work and reading, while cottage industries are being revived to occupy leisure moments (especially frequent among girls of 12 until marriage) and to alleviate the poverty of most of the homes. Among these forgotten crafts are embroidery, printing on cloth, basket-making and spinning. "The most encouraging features of village work," says Mrs. Chatterjee, "are an almost entire absence of the restrictions of the purdah and of social snobbery."

Work in Bengal, properly organized by a central body, has been running for the last three years. This is known as "The Saroj Nalini Dutt Memorial Association for Women's Work in Bengal," having been founded to perpetuate the work and the memory of an arduous and farseeing friend to rural women, who died in 1925 after starting five Women's Institutes by her own efforts. Mrs. Dutt (wife of

Mr. G. S. Dutt, I.C.S.) visited the London Headquarters of the Women's Institute movement, and based the Bengal movement as far as possible on what she learned there. Details had obviously to be adapted to suit local conditions, but the real Women's Institute spirit has undoubtedly been conveyed to Mrs. Dutt's successors, and through them to the branches scattered throughout Bengal.

Lack of leadership, remoteness, transfer of helpful individuals to other districts, were some of the causes of failures and lapsed branches in the first years, but gradually the Samitis, like the Institutes at home, are ceasing to be "one-man-shows," and are learning to co-operate, and to distribute duties and responsibilities throughout the members, who (as is so often found) rise to the occasion and display unexpected abilities. Moreover, being now affiliated to a central organization, local Institutes are able to obtain help in difficulties, trained instructresses to run various classes and stimulation when necessary.

The seven Mahila Samitis of three years ago have swelled to 158 in 1927 ; every district but one in Bengal has one or more. The Association's Patronesses are Lady Jackson and the Maharani Adhirani of Burdwan ; the President is Mrs. J. N. Gupta. Committees deal with finance, entertainment and publicity, and run the Industrial School. Over Rs. 22,705 was expended in 1927 over the school, propaganda, journal, instruction, travelling in the mofussil and general organizing work. It is thus evident that the movement is thoroughly established. Income is derived partly from the Provincial Government (grant-in-aid Rs. 1,365 and monthly grant to Industrial School) and partly from subscriptions. Headed by Mr. G. S. Dutt, a large number of Indian ladies and gentlemen are enrolled as donors, life or ordinary members, subscribing from Rs. 7,000 each, downwards. The European community have also helped, one firm in particular and the Calcutta Turf Club giving generous sums ; whilst active help in central organizing and in district work is gratefully acknowledged from English ladies. Financial support or help with lectures, etc., is also acknowledged in the Report, from the Public Health Department, Director of Industries, Calcutta Corporation, Indian Football Association, Social Service League, Local Government institutions and from Civil Surgeons and District Officers.

It will be interesting perhaps to refer at this point to the position of our National Federation of Women's Institutes of England and Wales, since for several years they received an annual grant from H. M. Treasury on the condition that they took steps to make themselves independent within a given period. At the present time they are not only self-supporting, but, in spite of their many undertakings, were able to show a credit balance last year of no less than £2,938. They continue to owe a very large degree of their efficiency and success to the support and co-operation, always readily offered by various Government departments, and are, in fact, "established in conjunction with the Women's Branch, Ministry of Agriculture and Fisheries," and their Executive Committee includes representatives of the Ministries of Agriculture, of Health and of Education.

¹ *Times of India Illustrated Weekly*, August 5th, 1928.

The present Viceroy was in close touch with the Institutes during his successive appointments at two of those departments, and he probably still remembers the occasion a few years ago when—the only man present—he was called upon to address 2—3,000 country women, gathered in the Queen's Hall in London for their Annual Conference, and delighted them by his sympathetic understanding of their aims and needs.

To return to the Mahila Samiti. If anyone who is interested will write for the 1927 Report,* he will read therein quite amazing accounts of what is being done to promote health, education, rural industries and better living. He will read of 14 *dai* training classes opened, maternity wards established (by locally raised funds), child welfare centres, baby weeks and clinics started, quinine distributed under the Anti-Malarial Society's scheme, and all sorts of sanitary and health lectures organized. Here is the year's record from Baraset—picked at random from many reports:—

"Number of members, 40. The Samiti started three years ago, has introduced spinning, sewing and cutting, *asan* weaving, making of earthen moulds, chutney and various kinds of food. About 15 ladies earn Rs. 2 each per month by making sacred threads in their leisure hours. Several poor women earned their living by dressmaking. The Samiti opened an adult education class with 21 women. The teaching of music also forms a special feature. A girls' school of about 70 girls is being conducted for the last three years. As a result of discussion in the meetings members have been awakened to a keen desire for transforming their respective families by the practical application of the rules of hygiene and health. An old lady delivered a course of lectures on domestic economy and sick nursing to the young women. A remarkable act of social service was when a fallen woman of the untouchable class was given shelter; the members took great care in nursing her and when she died they arranged for her last rites. The Samiti has given a great impetus in organizing kitchen gardens in the respective houses of members. They regularly collect old clothes for poor nursing mothers. A *dai* training class, consisting of 15 ladies as well as professional *daïs*, was organized with the help of the Central Association."

Regarding education, the Association boasts that for the first time in the history of the country an effective machinery for the dissemination of cultural education among adult women has been provided. A remarkable instance is that of a class of 50 Mahomedan women at Margram, conducted by two Mahomedans, who are president and secretary respectively of the Institute. The very popular monthly Journal, "Banga Lakshmi," is read throughout the Samitis.

Bearing in mind the remarks of the Linlithgow Commission on education, let us take a further extract from the Association's Annual Report:—

"The efficacy of educating girls and keeping them for a longer period in schools is urged at meetings. Mothers are induced to take a keen interest in the education of their girls. This in turn quickens in them a desire for their own education also. Soon after a Mahila Samiti is started the members become very keen and show greater interest in the management of girls' education. Where there are no girls' schools the Samitis have in many instances started one,

and when the school is large enough have handed it over to a Committee in which the Mahila Samiti has representation Even where these are well established the Samitis keep in touch with them encourage the teaching of cooking and domestic arts by giving prizes and bear the cost of poor girls in prosecuting their studies The members of some Samitis are themselves teaching in the schools."

The promotion of cottage industries naturally takes an important place in the objects of the Association, and the Industrial School in Calcutta is a remarkable institution. One hundred and twenty-six students (29 widows, 51 married and 46 unmarried women over 12) are now at the school, taking such subjects as sewing, embroidery, chikon work, lace making, carpet weaving, cane work, raffia work, painting and drawing. Started in December, 1925, in co-operation with Singer's Sewing Machine Company, it has already turned out 17 fully qualified instructresses for work amongst the mofussil Samitis, but many of the 300 women who have been under training are indigent widows or deserted wives, sent to the school by their local Samiti, to learn to make an honest living and to become literate at the same time. "If," says the Secretary, "one were to witness the eagerness and the clinging tenacity with which these unfortunate country women of ours embrace this opportunity, there would not be a shadow of doubt as to the great utility of the school."

One effect of its activities and of much propaganda is that there is not one out of the 158 Mahila Samitis without a class for cottage industries. Starting on a capital as low sometimes as Rs. 5 these classes not only provide great interest to the members, but also swell the Samitis' funds considerably. Prizes have been won in outside competition, handicrafts sold, and exhibitions held by groups of neighbouring Samitis. An interesting development of the movement is its extension to Hill women among Sikkimese, Nepali and Bhutia races.

Under the same heading of rural industries we may record the care of goats and cows, by some of the Samitis, and co-operative gardens, of which the most notable is that at Talla. This large kitchen garden, worked by 10 members, provides fresh vegetables for themselves and for sale to others, thus contributing to the nutrition problem and adding to the family budget. Development of schemes for Samiti farms, run in a similar way, is expected very soon.

Better living is summed up in the following homely sentences:—

"After the performance of their daily household duties, they (the members) gather together at the Samiti's meeting where they enjoy a refreshing atmosphere specially conducive to health and cheerfulness of spirit, instead of spending the hours in idle gossip as before. The members go home feeling friendly and cheered that they have learned some practical method of economy, or making something useful for their children or their husbands or some new, practical hint in public health, child welfare, or maternity."

Sometimes they have lectures pointing out the evils of the purdah system, and generally urging the ideal of Indian womanhood, and one Samiti records that it has entirely abolished the purdah system in that district. They recognize no communal

* Address: The Secretary, Saroj Nalini Dutt Memorial Association, 45, Beniatola Lane, Calcutta.

or racial boundaries, and all communities and classes of social rank meet, in the true spirit of the Women's Institutes throughout the world, on a basis of equality and in a democratic spirit.

A probable point of objection which may be raised is that most of these Bengal Institutes are not in actual villages, but in small towns. This, however, seems to be the best system. A central Association in a big city directs local branches in the mofussil, among small towns, which in their turn spread to such villages as are able to maintain them. Thus the idea becomes familiar in a district; individuals are at hand to help the smaller places and the Samitis start just when the villages are willing and able to welcome them.

Indeed, if the Bengal Samitis follow the lead of our Institutes at home they will play a large part in obtaining for rural areas better facilities for telephone, rail and motor services and communication generally, thus enabling their organization to extend to districts hitherto inaccessible to it.

Cannot this work amongst women be started in other provinces? The Bengal Association has no funds for propaganda elsewhere; nevertheless their Publicity Officer went by request to Ranchi, a Bengal Institute paying his travelling expenses, whilst a few ladies who had come in contact with the Association in Calcutta have managed to inspire other districts with the same ideals, isolated Samitis having thus been formed in Bombay, Bihar and Orissa and Central Provinces.

This flourishing organization has learned by experience the first steps and pitfalls, and how to adapt the world-wide movement to local needs. It should be easy for other provinces to benefit thereby. After a visit to the pioneer Association, the next step would probably be to get in touch with at least three departments—Agriculture, Industries and Public Health—with a view to co-operation and possibly financial help. Once a scheme was accepted it might be possible for two or more provinces to combine in obtaining from London Headquarters one of their highly-trained members, known as "Voluntary Organizers," who would tour in India, or a part of India, explaining the movement to high authorities and to future district organizers, encouraging existing Samitis, and providing the guidance and stimulation that is always to be drawn from the visits of experienced workers. The Federation* at home is sympathetic; it has already published an account of the movement in Bengal; the question of expenses of such a visit could probably be settled if all bodies interested would combine. The Scouts and Guides provide an example of this procedure.

Once started, there should be no difficulty in keeping the movement going. Wives or daughters of European officials in mofussil stations have every opportunity of learning Women's Institute work when home on leave, for there are over 4,000 Institutes in England and Wales alone. Training courses for organizers are run by the National Federation on a thorough and comprehensive scale. Would not

six months' training before joining parents in India furnish a girl who had just left school with equipment for a far more interesting life than she would otherwise have? Thus Europeans on leave and Indian ladies visiting England could bring out knowledge and new ideas to be grafted on to the movement.

"Village Uplift" is becoming a byword. The Gurgaon experiment is known in two continents. Mr. and Mrs. Brayne's wonderful example is being followed elsewhere in the Delhi Province. But there are two special points about the Women's Movement. One is that, side by side with rural reconstruction, goes the advancement of women, so universally desired. The other is that the organization is such as to ensure the greatest possible degree of permanence. The work is in the hands of the many. Individuals may depart, but the "uplift" continues. It is essentially a women's organization and must remain so, but example is the quickest way of teaching, and in many villages in Bengal as well as in England, the men have been stimulated by a flourishing Women's Institute to found a similar association to meet their own needs.

Women's Institutes, or their counterparts, flourish in Canada, Africa, France, Sweden, Great Britain and many other countries. No one who has watched them grow in numbers, usefulness, and influence, can doubt that in every country where they exist they are supplying a demand; that country women have need of a movement of this sort, seize on it when offered, and turn it to the best advantage, benefiting themselves, their menfolk and children, and, indirectly, the whole province or country in which they live.

* Address: The National Federation of Women's Institutes, 39 Eccleston Street, London, S. W., or Scottish Central Council, 8 Kinnoull Street, Perth.

THE EARLY HISTORY OF COTTON.*

BY

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Director, Technological Laboratory of the Indian Central Cotton Committee,

AND

A. N. GULATI, M.Sc.

Until recently the earliest known record of cotton has usually been ascribed to the Hindu Rig Veda. According to some authorities these references have a date of about 1500 B.C., but according to A. B. Keith in "Religion and Philosophy of the Veda and Upanishads," it is not possible to assign any exact date to the Rig Veda, except to say that it is not later than 800 B.C. Moreover, the references in the Rig Veda are to "threads" or to "clothes," and although these were very probably made of cotton, we cannot of course be sure of the fact from these references. The reference to the sacred Brahman thread in Manu Smriti appears to be the earliest specific reference to cotton.

In his account of the early history of cotton, Baines in "The History of the Cotton Manufacture" says:

"It is in the highest degree probable, that cotton was manufactured in India, as early as linen in Egypt. If the opinion is correct, that the arts of spinning and weaving were known to the founders of all the Eastern nations, the Indians would be quite as likely to make cloth of the woolly produce of their cotton plant, as the Egyptians of the fibrous bark of their flax. In the days of Herodotus, the father of history, who wrote about the year 445 B. C., it is evident that cotton was the customary wear of the Indians, for among the particulars which his keen and universal curiosity gleaned concerning that remote nation, he records, as one of the beautiful and wondrous things that distinguished them,—'They possess likewise a kind of plant, which, instead of fruit, produces wool, of a finer and better quality than that of sheep: of this the Indians make their clothes.' (Herodotus, book iii. C. 106.)....."

"It should be remarked, that the Greek historian mentions this plant as peculiar to India. He gives no hint of a vegetable wool being made into clothing elsewhere. Of the Babylonians he says, distinctly, that their dress was of linen and of wool, (book, i.e., 195;) and of the Egyptians, that their dress was only of linen, except that the priests wore a white woollen shawl when not engaged in their ministrations, (book ii. c. 37,81). It may therefore be concluded with certainty, that at this time the cotton manufacture prevailed generally in India, and also that it existed in no other country westward of the Indus.

"We are led to the same conclusion by the statements of Nearchus, the admiral whom Alexander the Great employed (327 B.C.) to descend the Indus, and to navigate the coast of Persia to the river Tigris. From the interesting and obviously faithful narrative of this observant navigator, substantially preserved in Arrian's History of Alexander, we learn that, 'the Indians wore linen garments, the substance whereof they were made growing upon trees; and

this,' he says, 'is indeed flax or rather something much whiter and finer than flax. They wear shirts of the same, which reach down to the middle of their legs; and veils, which cover their head and a great part of their shoulders.' (Arrian's Indian History, c. xvi)."

NEW DISCOVERIES AT MOHENJO-DARO.

But now all the speculation about the antiquity of these literary references and their interpretation gives place to recent discovery of cotton materials among the remains of the prehistoric civilization at Mohenjo-daro in Sind.* Mohenjo-daro lies in the Valley of the Indus some 200 miles from Karachi, slightly east of north thereof. That remnants of cotton materials should be found at such a place in Sind is perhaps not really surprising, for, as Sir John Marshall, Director-General of Archaeology in India, says in "The Illustrated London News" of January 7th, 1928, "The Babylonian and Greek names for cotton (*Sindhu* and *Sindon* respectively) have always pointed to the Indus Valley as the home of cotton-growing."

As to the very important question of the date to be assigned to the buildings revealed at Mohenjo-daro, Sir John Marshall says:

"The date of the buildings described is determined within tolerably narrow limits by the discovery at Susa and several sites in Mesopotamia of typical Indian seals inscribed with Indian pictographic legends, in positions which leave no doubt that they belonged to the period before Sargon I—that is, before about 2700 B.C. On another seal of the same pattern recently unearthed at Ur, the legend is in cuneiform characters of about 2700 B.C. It may be inferred, therefore, that this class of Indian seal is to be assigned to the first half of the third millennium B.C., or earlier; and inasmuch as seals of this class are associated with the three uppermost cities at Mohenjo-daro, we may confidently fix the date of these cities between 3500 and 2500 B.C. How many centuries were covered by the erection and destruction of these cities, it is difficult to estimate. From a constructional point of view the buildings of the first city are markedly different from those of the second; and of the latter, again from those of the third. On the other hand, the minor antiquities found in the three strata are all but indistinguishable, which is hardly likely to have been the case if the lapses of time between them had been very prolonged. Taking everything into consideration, a period of six centuries may reasonably be allowed for the rise and fall of the three cities, and we shall probably not be far wrong if we provisionally assign the first city to about 2700 B.C., the second city to about 3000 B.C., and the third city to about 3300 B.C."

DESCRIPTION OF SAMPLES OF COTTON MATERIALS FOUND AT MOHENJO-DARO.

As previously mentioned, all doubt as to whether fibre from species of *Gossypium* was really in use in early times has now been set at rest by the discovery of cotton materials at Mohenjo-daro. The first sample of material made of cotton was a small fragment of cloth found by Mr. D. R. Sahni, of the Archaeological Survey of India; Mr. E. J. H. Mackay, of the Archaeological Survey of India, describes this sample as having been "found adhering to the lid of a small silver vase, in association also with gold jewellery of the intermediate period," so that it can

* Abstract of "A Note on the Early History of Cotton," by A. N. Gulati and A. James Turner, *Indian Central Cotton Committee Bulletin* No. 17, October 1928.

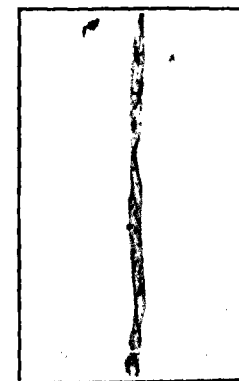
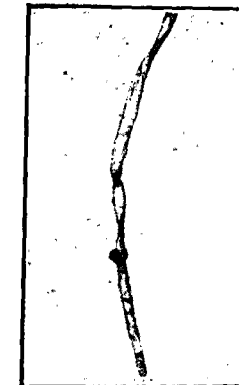
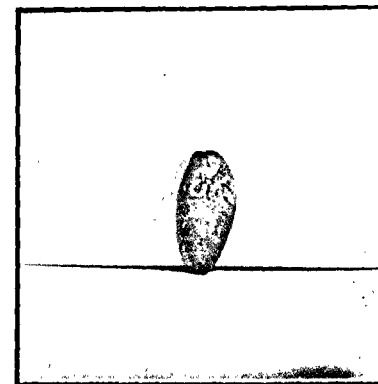
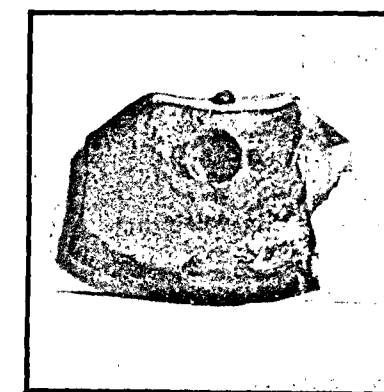
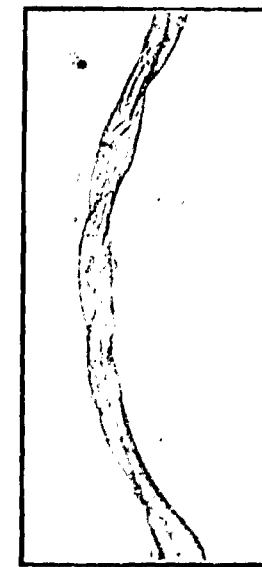
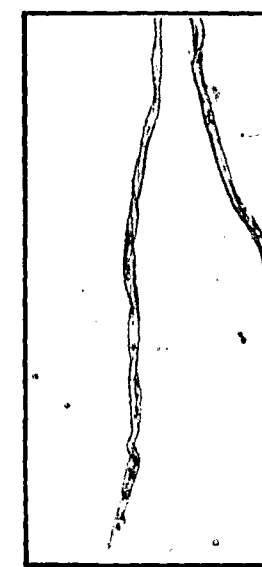
* Formerly written "Scinde," a spelling still retained in the Weekly Circular of the Liverpool Cotton Association.

safely be stated that cotton cloth was in use in the Valley of the Indus at this period, viz., 2750-3000 B.C. The preservation of the small fragment appears to have been due to an extremely fortunate accident, viz., the formation of silver salts from the silver of the vase, and their preserving action; as Mr. Mackay says, "if it had not been for these silver salts, the fragment would have perished long ago."

On discovery, the fragment of fabric was embedded in paraffin wax and sent for examination to the Technological Laboratory. Here the wax was carefully dissolved in benzene, the specimen being placed in a bottle and allowed to remain in the solvent overnight. The fragment of fabric which was recovered had a dark creamy colour and measured about one-tenth of an inch in one direction and one-third of an inch in the other direction. The appearance of this fragment is shown in Fig. 1. Unfortunately no photograph was taken of the original fragment and Fig. 1 merely represents a fragment of a cotton fabric shaped from memory to the shape possessed by the original. The material was exceedingly tender, and the greatest possible care had to be exercised in its manipulation. In fact, in teasing the fibres of the yarns apart for the microscopic examination it was impossible to avoid breaking them, so that all the microscopic observations were made on minute lengths of fibre. However, examination under the microscope showed that the sample was undoubtedly made of cotton fibre, the typical convoluted structure of cotton being plainly visible in a number of preparations. Figs. 2 and 3 are photomicrographs of the fibre. The tenderness of the material is no doubt partly explained by the fact that it was much penetrated by fungal hyphae, traces of which can be discerned in the photomicrographs (Plate II).

The specimen was so small that all possible measurements were made on it before the examination of the fibre under the microscope. In all there were five threads in each direction. The weights of the whole specimen and also of separate threads were determined by means of a torsion micro-balance. The distribution of the threads was also measured. It was finally concluded that the fragment was a plain cotton fabric weighing about 2 oz. per square yard, made from 34's warp and weft, and having 60 ends (of warp) per inch and 20 picks (of weft) per inch.

At a later date further samples were recovered from Mohenjo-daro and submitted for examination. These samples were small pieces of string found attached to some pottery. In one case, A, the piece of string passed through a small hole in an ovoid piece of pottery, and had its ends splayed out for half an inch or so and pressed on to the surface of the pottery as shown in Fig. 4. In the other case, B, the string passed through a small hole about half an inch long in a larger piece of pottery, and was knotted at the top as shown in Fig. 5. Both samples of string proved to be made from the cotton fibre. The string of Fig. 4 proved to be a twentyfour-fold cotton cord, made apparently by the twice doubling of six-fold cords, the count of each of the six strands of which was 14's. The string in the other sample (Fig. 5) was also a twentyfour-fold cotton cord, made by doubling two twelve-fold cords, the counts of a single strand in this case being 18's. The

Fig. 1. $\times 3$.Fig. 2. $\times 80$.Fig. 3. $\times 80$.Fig. 4. $\times 7$.Fig. 5. $\times 7$.Fig. 6. $\times 300$.Fig. 7. $\times 300$.Fig. 8. $\times 80$.

photomicrographs of fibres taken from these samples are given in Figs. 6 and 7 (from Sample A, Fig. 4), and Fig. 8 (from Sample B, Fig. 5). The six strands of the single cord of Sample A had been doubled together with about $3\frac{1}{2}$ turns per inch, and the two twelve-fold cords of Sample B had been doubled together with about 4 turns per inch.

It may be added that these samples were both embedded in earth and the counts of the single strands were determined from the fibre-weights, as explained below, after the material had been cleaned. The first sample had a creamy colour like that of the earth surrounding it. The other sample however had a purple colour, and from the extent of the penetration of the dye it was clear that the whole string had been dyed after being manufactured. From a few tests made on the dyed fibres it appeared that the dyestuff which had been used was probably of a madder type.

COMPARISON OF FIBRE-PROPERTIES WITH THOSE OF SOME PRESENT-DAY COTTONS.

A further examination was made of the dyed sample of string in order to ascertain if possible how the properties of the fibre compared with those of present-day cottons. It might be thought that even if cotton was in use among the early inhabitants in this Valley, they may have used the cotton from certain wild species such as *Gossypium Stocksii*, which is found growing wild in Sind at the present day. But the fibre of *Gossypium Stocksii* is not more than a quarter of an inch long, and like many other wild cottons is distinguished by having no convolutions; in this respect it resembles "vegetable down," or Bombax cottons, obtained from Bombax species and other plants, such as the so-called cotton-tree, *Bombax malabaricum* (from which most of the Indian kapok is obtained rather than from the true kapok tree *Eriodendron anfractuosum*). Bombax cotton, it may be noted, is very different from tree-cotton; the well-convoluted fibre of the perennial, *Gossypium arboreum*. The non-convoluted fibres cannot be spun by modern processes on account of their extreme brittleness and smoothness, and the physical properties of the Bombax cottons render them unsuitable for ordinary textile purposes; hence *primâ facie* it appears very unlikely that the ancient peoples will have used them. This view is confirmed by the fact that the fibres of the materials discovered at Mohenjo-daro are very distinctly convoluted.

But although the material found at Mohenjo-daro cannot have been made from any Bombax cotton, or unconvoluted cotton like *Gossypium Stocksii*, the question still remains: From what particular species of *Gossypium* was the cotton obtained? We may at once rule out the typical species of the Western Hemisphere—*hirsutum*, *peruvianum*, and *barbadense*—for not only is it inherently most improbable that India can have been the native habitat of these species, which differ so enormously in lint and external appearance from the Indian cottons, but recent cytological research has demonstrated conclusively that the external differences are associated

with vital internal differences, the chromosomes in the nucleus of American cottons being twice as numerous as those of Asiatic cottons. De Candolle, in discussing at length the origin of the two oriental species of cotton, *Gossypium herbaceum* and *Gossypium arboreum*, in his "Origin of Cultivated Plants," ascribes the *herbaceum* cotton to India and the *arboreum* cotton to Africa. Watt, in "The Wild and Cultivated Cottons of the World," considers *Gossypium arboreum* may have been indigenous both in India and Africa, and says:

"So far as present known the arboreous form (which may be called the typical condition) can hardly be said to be cultivated as a source of fibre to-day, though, according to Indian tradition, it is the cotton that should be selected in preparing the Brahmanical string, as also for the wicks of lamps to be burned in temples."

It may be observed, however, that in his *Gossypium arboreum* (and the varieties of it—*sanguinea*, *neglecta*, *rosea*, and *assamica*) Watt includes also the Indian cottons which, after Gammie, are now commonly described as separate species, viz., *G. sanguineum*, Hasskarl, *G. neglectum*, Todaro, *G. indicum*, Lamarek, and *G. cernuum*, Todaro. Gammie, in "The Indian Cottons" (Memoirs of the Department of Agriculture in India, 1907, Volume II, No. 2), prefers to multiply the number of species and varieties as leading to simplification for the agriculturist though he indeed believes that both the *arboreum* and *herbaceum* types are derivatives of a still more ancient type, *Gossypium obtusifolium*, stating that "all the evidence available to me appears to prove, almost without the probability of a doubt, that *Gossypium obtusifolium*, Roxb., the *Rozi* of Gujarat, the most widely distributed wild and cultivated cotton in the old world, is the parent from which all our present forms have sprung." He further says that "from a botanical point of view it is clearly evident that we have at the most only one true species of cotton in India, *Gossypium obtusifolium*, with its two sub-species, *G. arboreum* and *G. herbaceum*. All other forms should be treated as derivatives of these." The more detailed examination of Sample B was therefore undertaken with a view to comparing the fibre with the present-day Indian cottons in the hope that it would at least become possible to assign the cotton either to the *herbaceum* or the *arboreum* class.

First the fibre-weight was determined, and from the values obtained it was clear that the cotton is quite unlike the present-day American cotton (*Gossypium hirsutum*) or any of the finer types of cotton, and can only be compared with the coarsest varieties of Indian cottons now extant, as shown in the table on page 19.

The results given in this table show that the fibre-weight alone does not enable us to distinguish between cottons of *herbaceum* and *arboreum* types. For this reason the fibres of Sample B were also examined for certain other properties, measurements being made on 50 fibres for the number of convolutions per inch, the ribbon-width, the fibre-rigidity, and the fibre-strength. The mean results obtained have been included in the table. The value for fibre-strength is lower than that obtained for any of the standard Indian cottons,—no doubt as a consequence of tendering

Fibre properties of some coarse Indian cottons.

Botanical species	Cotton	Where grown	Season	Fibre-weight per inch (10 ⁻³ oz.)	Fibre-rigidity (oz. in. × 10 ⁻³)	Fibre-rigidity ÷ (Fibre-weight) ³	Ribbon- Width (10 ⁻³ inch)	Convo- lutions per inch	Fibre- Strength (oz.)
<i>G. obtusifolium</i> 171 N. F.	..	Madras	1925-26	2.10	2.48	0.614	0.55	51	0.208
<i>G. obtusifolium</i> 332 N. F.	..	"	1925-26	2.05	2.12	0.526	0.59	62	0.204
<i>G. arboreum</i>	..	Cawnpore (U. P.)	1925-26	2.35	2.12	0.384	0.64	58	0.187
<i>G. arboreum</i> narrow-lobed leaf	..	Nagpur (C. P.)	1925-26	2.53	3.24	0.503	0.79	74	0.155
<i>G. arboreum</i> broad-lobed leaf	..	"	1925-26	2.44	2.51	0.422	0.67	81	0.191
<i>G. cernuum</i>	..	"	1926-27	3.37	9.30	0.819	0.90	46	0.241
<i>G. neglectum</i> Maltese	J. N. 1	Cawnpore (U. P.)	1927-28	2.25	2.45	0.478	0.71	74	0.184
<i>G. neglectum</i> roseum	Aligarh A. 10	Aligarh (U. P.)	1927-28	3.04	4.50	0.487	0.82	72	0.101
<i>G. indicum</i> Mollisoni	Mollisoni	Khanawal (Punjab)	1927-28	3.34	4.63	0.415	0.98	114	0.168
<i>G. herbaceum</i>	Wagad 4	Vitranagan (Bombay)	1926-27	2.57	1.89	0.286	0.68	46	0.184
<i>G. herbaceum</i>	Wagad 8	"	1926-27	2.63	2.21	0.319	0.72	45	0.183
Mohenjo-daro sample of cotton	..	(Sind ?)	3000 B. C.	2.84	4.48	0.551	0.79	73	0.095

having taken place. In fibre-weight, number of convolutions, ribbon-width, and fibre-rigidity, the cotton of Sample B is strikingly similar to the very coarse Indian cottons of the *arboreum*, *neglectum*, and *indicum* types; its fibre-weight and ribbon-width are decidedly greater than those of the two *obtusifolium* cottons. The ratio of the fibre-rigidity to the square of the fibre-weight per inch (expressed in ten-millionths of an ounce) is 0.55; this is within the range found to apply to modern *neglectum* and *indicum* types, but much greater than the value (0.3) found for the *herbaceum* types among standard Indian cottons; moreover, the convolutions of the Sample B cotton are much more numerous than those of the *herbaceum* (Wagad) cottons. While the values obtained for the various fibre properties may have been affected by the tendering or the presence of the fungal hyphæ, to which attention has already been directed, nevertheless on the whole it seems most likely that this early coarse cotton has been produced from a plant closely related to one of Watt's *arboreum* types: but there is no evidence available which will enable us to distinguish it as any particular present-day type—either *arboreum*, *sanguineum*, *neglectum*, *indicum*, or *cernuum*.

SMALL SCALE MANURIAL EXPERIMENTS.

THE HONEYCOMB METHOD.

BY

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EVERY agricultural chemist is annually faced with the necessity of restricting his programme of manurial experiments in accordance with the limitations imposed by his budget. This generally means that he cannot secure sufficient field space or labour for his requirements and is consequently either compelled to reduce them considerably or to fall back upon pot experiments with their acknowledged limitations.

In the present stage of development of Indian agriculture the increasing importance of the use of fertilizers makes it necessary to obtain more accurate information as to the best methods of applying them to various crops and soils; this can only be satisfactorily obtained by actual experimental trial of the fertilizers upon the soils and crops to which they are ultimately to be applied. Field experiments designed for this purpose generally aim at discovering the relative efficiencies either of different fertilizers or of varying quantities of one in particular. Owing to the very large experimental errors arising in India from the great variations in soil even within small areas, it is necessary to reduplicate treatments in order to minimize these; this inevitably increases the area and the expense involved; faced with this difficulty the agricultural chemist, rather than do without information altogether, falls back upon the method of pot experiment with all its limitations and sources of error. It is perhaps unnecessary to enumerate these or to refer to them more specifically than to point out that the principal source of error and the chief condition which causes divergence from field conditions is actually the smallness of the pot and its content of soil relative to the root system of the plant. Other sources of divergence from natural conditions exist such as restricted movements of soil moisture and soil air, and extreme variations of temperature incident to the large outside surface relatively to the soil volume, but the principal abnormal factor is undoubtedly the smallness of the possible root range in the pot. On the other hand the great advantage of the pot experiment lies in the possibility of eliminating the factor of soil variation entirely, by careful mixing of the whole quantity of soil to be used in the experiment; this advantage, together with the control of

the water supply and the possibility of carrying out a large number of variations of an experiment in a comparatively small space, have gone far to justify and popularize the method.

Recognition of the weaknesses of the pot experiment has led to the alternative use of the lysimeter and of its variants, in which much larger soil masses are used and outside surfaces are avoided; these alternatives, however, are expensive and although they offer the advantages associated with the use of thorough mixture of the soil, yet their costliness frequently prevents the desired number of variations from being carried out.

The following method in use at the Tollygunge Agricultural School of the Fertilizer Propaganda of India, Ltd., offers a compromise between the large scale field experiment and the unduly small pot experiment whilst retaining the advantages of the latter in respect of the even quality of the soil in all the plots:—

A suitable piece of ground, level and well drained, having been selected, a rectangular area is marked out and the soil down to a depth of 2 ft. is removed. The size of this area will be regulated by the requirements of the experiment but a square 20 ft. $\times$ 20 ft. will provide 100 plots each of four square feet area. The surface 2 ft. of soil having been removed and put on one side for mixing, a second or subsoil layer also of 2 ft. depth is similarly removed, thoroughly mixed, and returned to its original position as subsoil. This is intended to remove as far as possible inequalities in the subsoil with their effect upon water movements and upon deeper portions of the root system; it is in many cases subsoil rather than surface soil differences which interfere with the results of field experiments; it may be necessary or advisable to carry subsoil mixing to a greater depth than four feet in order to eliminate inequalities; this should be a matter for local determination.

Mixing. In order to secure thorough admixture and evenness the operation of mixing must be carried out with comparatively dry soil and should therefore be done at a time of year when this can be secured by exposure of the soil to the air. Complete mixing can easily be secured by various methods; division into separate heaps and the division of the contents of one heap equally between the others, followed by thorough mixing of each heap, and a repetition of this process until the whole of the soil is in one heap is a simple and effective one. It is necessary to weigh an aliquot portion of the top soil in order to secure even redistribution in the plots. This should be done, if possible, on the same day as that on which this redistribution takes place in order to avoid loss of weight by drying.

The subsoil having been mixed, returned to its original position in the experimental area, levelled and compacted, taking care that its top surface is not above its original level, which should be marked at the time of removal, the top soil may then be returned to position. Additions of fertilizers may, if necessary, be made at this stage so as to secure even distribution.

Return of the top soil is made as follows:—

A thin sheet of iron measuring 4 ft. $\times$ 2 ft. is bent at a right angle so as to form two sides of a square mould 2 ft. $\times$ 2 ft. This when placed in a upright position in one corner of the excavation will form a square cell into which a weighed quantity of the mixed top soil can be filled. After placing the iron mould in position and before filling in the soil a piece of stout waxed paper measuring 4 ft. 6 inches $\times$ 2 ft. 2 inches is introduced into the cell in contact with the iron sheet so as to form a lining to the cell with 3 inch margins bent at right angles to the two long sides; this margin serves to hold the waxed paper in position when the iron sheet is removed. Two inches of the paper will project above ground level and serve to demarcate the plots.

The function of the waxed paper is to separate one plot from those surrounding it so as to prevent both diffusion of fertilizers and invasion of neighbouring plots by roots. By the use of hard paraffin wax (58° C.), and by dipping the paper in formaldehyde solution before waxing, it may be made sufficiently resistant to decay and attack by soil flora and fauna to ensure its survival long enough to secure these objects, and to assist in demarcating the plots. It will be realized that in order to secure similar conditions in all the plots it is necessary also to line the outside walls of the experimental area with paper, as otherwise the outside or marginal plots would each have one unenclosed surface, whereas the interior plots are each of them surrounded on all four vertical faces with paper partitions.

An aliquot weighed portion of the mixed soil, with or without admixture of fertilizers, is then filled into the corner cell and if necessary consolidated by ramming. If the soil is sufficiently moist and adherent the iron mould may then be moved into the next adjacent position and the operation of paper lining and filling repeated. If, however, the soil in use shows a tendency to displace the paper lining by its weight on removing the iron mould, this latter may be left in position and another one brought into use; the first one after filling the second cell can be drawn up out of the soil without disturbing it and again placed in position for cell No. 3. This can be done more readily if the iron sheets have one or two holes punched close to their upper edges through which wires or hooks can be inserted for lifting. These operations are repeated until all the soil has been replaced, when a complete set of one hundred plots will have been secured occupying only 400 sq. ft. of ground. It may be pointed out that this small area may be completely enclosed with wire netting if necessary, and if protection from rain or sun is required this can be secured by a removable roof of canvas, tarpaulin, or thatch grass at small expense.

In selecting the site for this cellular field experiment it would be advisable to take borings or dig holes at the four corners of the proposed area in order to make certain that no unduly high variation in the character of the soil or subsoil exists

within the area, which would make equalization by mixing a difficult operation, or would set up serious differences of texture or drainage rate between the mixed subsoil and parts of the unremoved basal portion. With such a small area to deal with it should not be difficult to find one of fair uniformity in this respect.

It may be pointed out that the dimensions given above need not be adhered to and in fact might be usefully varied in most cases in the direction of larger plots of lesser number. The actual depth of excavation should be determined by the local character of the soil and subsoil, and of the crop. Some judgment must be exercised in determining the degree of compaction used in replacing the soil; this will depend largely upon its physical character and its moisture content at the time of replacement; a heavy soil will require less ramming than a light one to regain its normal degree of compaction.

Planting. With cells or plots 2 ft. $\times$ 2 ft. plants can be spaced so as to have 28 plants in each plot in four rows with 6 inches between rows and 3 inches between the plants in the rows and a 3-inch margin all round; this will afford plenty of space for growth and tillering and will compare favourably with circular pots in this respect.

In the arrangement of the plots themselves with regard to varying treatment, manurial or otherwise, this can be done without any necessity for adopting the random distribution required in field experiments, owing to the equalization effected by mixing of the soil. This will allow of arrangement in lines under similar treatment for purposes of photographic record and comparison of results.

MOSAIC AND ITS CONTROL IN OTHER CANE GROWING COUNTRIES.

BY

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IN view of the interest mosaic disease on cane is now arousing in India, it will not be out of place here to give a short resumé of the damage this disease has done in other cane countries, how it is being controlled and the possibilities of its final extermination as a disease of cane.

Mosaic, though probably widespread in the past, never attracted much attention until the epidemic outbreak which played such havoc in Porto Rico in 1915-19 resulted in the focussing of attention on this disease. Previous to this, the action of the disease being slow, it did not attract the same attention as such rapidly working epidemics as gumming and sereh. The mosaic disease was first discovered in Porto Rico in 1915 by Dr. J. H. Stevenson of the Insular Experiment Station. In 1917 he published in "Phytopathology" an account of this mottling disease which seemed to him a new one. Dr. Lyon of Hawaii thereafter declared it to be the same as "Gelestrepenziekte."

In 1917 mosaic was authentically recorded from Hawaii, Fiji, Australia, New Guinea, Java, the Philippines, Egypt, Cuba and Porto Rico; subsequently the Argentine and Natal were added to the list and now the disease has been noted in India, Formosa, Louisiana, Santo Domingo, Haiti, the British West Indies¹ and Brazil. So it is now evident that only a very small portion of the cane-growing world is free from it, Peru and Mexico being the chief representatives.

1. JAVA.

Under the name of Gelestrepenziekte, a yellow stripe disease, mosaic was first noted in Java in 1892. It was considered of minor importance and the fact that it was infectious was overlooked. As at the time the seed selection and special cultivation practices used in combating sereh were sufficient to control mosaic, no serious losses from it have occurred in Java.

¹ *Facts about Sugar*, dated 16th July, 1927, and 8th October, 1927.

2. HAWAII.

In Hawaii in 1908 it was recognized as Gelestrepenziekte, but was considered of secondary importance and at first accepted as a non-infectious abnormality. It was Dr. Lyon who in 1917 recognized its true nature by characterizing it as "an infectious chlorosis akin to the mosaic disease of tobacco." It has never taken an epidemic form in Hawaii, but has always been troublesome. It should be carefully remembered that in both Java and Hawaii it has never assumed an epidemic form. *In each case the agricultural organization has been brought to such a high pitch of efficiency that control has been possible.* In these countries their insular position and the fact of their cane area being concentrated has undoubtedly been of great assistance in control measures.

In the words of the Station Record of 1926, losses from mosaic in the 1926 crop were negligible in Hawaii. There are still sources of infection where with the proper chain of circumstances an outbreak could occur, but these are being reduced with each planting season.

3. PORTO RICO.

In Porto Rico, however, it considerably reduced the total yield of sugar* for the island and produced from 1915-1918 a state of things which called for instant attention. The disease was finally brought to heel by planting Kavangire, a practically immune cane, from 1919-1922 and later by B. H. 10(12) and S. C. 12(4), two high yielding varieties, coupled with rigorous seed selection and roguing.

4. SOUTH AFRICA.

In South Africa the Otaheite and Cheribon canes went out with mosaic and had to be replaced by Uba. Here the cane growers were mainly big farmers and control by legislation was possible. South Africa has enacted a set of regulations given here for the Province of Natal and Zululand, an example of strict action for a definite purpose.

	Area in acres	Yield in tons of 2,000 lb.
*1915	211,110	346,490
1916	203,491	483,589
1917	205,106	505,081
1918	256,431	453,793
1919	238,901	406,002
1925	240,010	660,411
1926	242,745	603,250
1927		626,080

C. E. Chardon in "Facts About Sugar", dated 10th September, 1927.

The following notice appears in the "Government Gazette," dated 14th January, 1927 :—

For the purpose of dealing with the outbreak of mosaic disease in sugarcane in the areas restricted by Proclamation No. 12 of 1927, the Governor-General has been pleased, in terms of section twenty-eight of the Agricultural Pests Act, 1911 (Act No. 11 of 1911), to make the following regulations:

Regulations.

1. For the purpose of these regulations, the expression "variety Uba" means any sugarcane plant which has the characters of leaf and stalk of the cane recognized in Natal as Uba and has not been raised from seed cane derived from any plot or field which the Government Mycologist has certified to be wholly or in part infected with Mosaic Disease.

2. From and after the date of publication of these regulations no person shall plant or cause to be planted in any area restricted by Proclamation No. 12 of 1927, which areas are set out in the Schedule to these regulations, any sugarcane of a variety other than the variety Uba without a written permit from an officer appointed by the Minister of Agriculture.

3. From and after the thirtieth day of June, 1927, no person shall keep or cause to be kept in the said area any sugarcane of a variety other than the variety Uba without a written permit from an officer appointed by the Minister of Agriculture.

4. Where under sub-section (2) of section fifteen of Act No. 11 of 1911, the Minister specially empowers an officer to take such steps as may be necessary for eradicating the disease on any premises, the said officer may require by fourteen days' notice the destruction of sugarcane of any variety other than Uba, and the destruction shall be carried out in the manner prescribed in the said notice.

Schedule.

The following is the area restricted by Proclamation No. 12 of 1927. The Province of Natal and Zululand.¹

5. ARGENTINE.

In the Argentine, the Ribbon and Purple canes began to go out in the year 1910 and thereafter, due to the effects of mosaic as now understood, and were replaced by the Java canes P. O. J. 36 and P. O. J. 213, both tolerant to and carriers of mosaic which have undoubtedly put the local sugar industry on its feet again.

6. LOUISIANA.

Here a very serious state of things existed. D. 74 and Louisiana Striped and Purple (Cheribon), the standard canes, had become so heavily affected as to reduce the industry virtually to the last ditch. The spread of mosaic was complete and the yield of sugar which was 289,669 and 263,478 tons in 1921 and 1922 respectively was reduced in 1924 to 79,003 and in 1926 to 42,112² tons. In this connection

¹ The South African Sugar Journal, dated 31st January, 1927.

² The introduction of Java canes P. O. J. 36 and 213 and 234 in Louisiana promises to be a success and a recovery may be expected in the Louisiana sugar production in the near future.

the following extract from A. H. Rosenfeld's article on "The Present Status of the Louisiana Sugar Industry" in the "International Sugar Journal" of July, 1927, is of interest, more especially in view of its applicability to India.

"The reason for the rapid and complete spread of mosaic in Louisiana is attributed to the practice of farmers of growing about half cane and half maize, and interplanting corn and cane in comparatively small fields. *Owing to the low value of sugar, it is unlikely that the farmers will be persuaded to give up the growing of maize, and this will be an ever present force militating against complete control of the mosaic in cane.*"

The North Indian problem as regards mosaic is depicted above in a nutshell. The Louisiana farmer also in common with the Indian grower uses cane for seed which is unfit for the mill. According to Mr. Rosenfeld there can be no doubt that the persistent selection of the unfittest for seed of the old varieties (Louisiana Striped and Purple and D. 74) in Louisiana during the past century has materially weakened the stock and thus made it a far easier prey to the ravages of the mosaic disease than would otherwise have been the case. He notes that he had repeatedly seen cane which the owners frankly admitted was not worth crushing, put down for seed, and expresses surprise that the very antithesis of the old theory of seed selection has been fairly generally practised in Louisiana.

7. FLORIDA.

On the other hand, F. S. Earle points out that Florida, which discovered mosaic in 1919 at the same time as Louisiana, at once took the strongest measures through the State Plant Disease Board, which had been granted ample powers for eradicating citrus canker, and stamped out the disease in a few months, this being about the only known example of successful eradication measures and clearly proving that where the powers exist, no disease of this kind need be feared.

8. CUBA.

Cuba is now considering the position but although she has some of the largest factories and plantations in the world, she is the home of the independent small grower, and it must be obvious that no measures for dealing with mosaic can be successful unless they embrace all classes, otherwise the Colono cane will re-infect the mill cane every time and partial measures will be doomed to failure. Fall planting has been put forward as a remedy on the ground that the *Aphis maidis* does not attack grown cane and the secondary infection will thus be lessened. Cuba's position is similar to that of India as regards control measures with one important difference in that a large portion of India can grow the tolerant North Indian hybrid canes as an improvement on their present cane, while in Cuba the growing of any of these canes of lower quality than Co. 281 would almost be a retrograde step.

On the other hand in South India similar conditions to Cuba exist and similar difficulties may be looked for.

MOSAIC AND THE THREE CLASSES OF CANE.

How different countries with their different agricultural and climatic conditions which enable them either to grow the best class of thick canes or force them to keep to hardy drought resistant medium canes are liable to be affected by mosaic will be clear from the following.

We can virtually divide canes into three classes:—*I* Wild, *II* Noble, *III* Chinese and North Indian. Now excluding class *I* entirely as regards sugar content, class *II* represents the optimum cane for sugar and is at the same time the class of cane which suffers most heavily from mosaic. Class *III* is either immune or highly tolerant but lacks a good many of the high sugar qualities which distinguish class *II*. Class *III* includes canes which take mosaic, but suffer very little from it, but can certainly act as hosts for secondary infection and are not up to class *II* as sugar producers.

It is thus clear that, by crossing among the three types given above, it might be possible to produce a cane very like a noble cane either resistant to mosaic or so tolerant as not to be definitely affected in tonnage or sucrose by the disease and thus eliminate the risk of an epidemic without having to drop down to planting an inferior immune cane with its resultant loss in tonnage and sugar.

At present the methods of controlling or eliminating mosaic are three in number:—

I. Planting of a practically immune type in place of the cane affected—as done at first in Porto Rico and South Africa.

II. Bringing in a tolerant cane as in Argentina and Louisiana.

III. Rogueing the standing crop and selecting seed as in Cuba and India.

These methods have the following disadvantages:—

The first entails a big loss of sugar and may require radical alterations in mill equipment; control of all land and growers is essential.

The second method is less drastic and may effect an improvement in countries where cane already grown is very badly affected, *but will not get rid of the disease.*

The third method is adopted or advised in countries where no organized effort or control is possible at present, and is a doubtful remedy.

It should, however, be noted that the first method has distinct advantages in that after all mosaic infected cane has been done away with, and the tract has had a couple of years to settle, a first class noble cane, liable to mosaic but drawn from disease-free stock, may be introduced and grown on from uninfected material.

It will then possibly remain free and the sugar yields can be brought up to their former level, but strict control and legislation are required.

The second method can only be adopted at present with success where large yields are not obtained, as the tolerant canes are not an improvement in tonnage or sugar on the noble canes at their best and no susceptible noble cane can be introduced and planted.

Rogueing the standing crop and selecting the seedcane is the real problem which affects India, Cuba and all countries where a lot of small, poor, ignorant, independent growers exist, over whom no organized control is possible. Previous to the discovery of mosaic there was a definite belief that canes 'ran down' or 'deteriorated' after a course of years. This has now been proved to be incorrect. A definite cause must be present and this cause was found to be mosaic.

At the bottom of all the talk about the deterioration of cane was mosaic and now it looks as if once we have a good cane established, we can plant it for ever under proper control and proper conditions.

Disease as such has generally been produced by forcing cane into unsuitable lands and localities; when removed to its ideal conditions, it invariably recovers its tonnage and the disease is no more seen, *vide* the Otaheite cane in Peru.

Now in this connection we may divide up cane growing countries into 3 classes :—

- I. Small or comparatively small islands where the crop is grown by factories and big plantations only.
- II. Countries and large islands where the crop is grown by big planters only.
- III. Countries and islands where the crop is grown by free agents as well as by the mills and the small independent grower is in the majority.

Class I have never had trouble with mosaic in epidemic form, but have always maintained control and their insular situation has assisted them materially.

Class II have dealt with it in most rigorous fashion, by legislation and otherwise. Class III can only watch its approach and hope for the best.

In class III no radical cure is possible. An immune cane cannot be forced on the growers if it is not a good tonnage cane. A tolerant cane can be given out but it is an open question how long it will be grown unless it is a marked improvement. No possible chance of stopping secondary infection exists. Regular rogueing is impossible. Every possible mosaic host crop can be grown and it would appear that the only hope for an industry dependent on free and ignorant growers is to supply tolerant canes and hope for the best.

Obviously in such countries any attempt to introduce irrigated exotic varieties is doomed to failure, and the class of the cane grown will be limited to the best tolerant cane produced by plant breeders, for as yet none of the best sugarcane in the world are tolerant or immune. India's position is in class III above and India's problem is summed up there, and nothing but a radical realization of the facts will

enable us to view the position in its proper perspective. Not one of the exotic canes at present grown in Tropical India can be regarded as safe and not one if generally grown can be kept clear of mosaic by any existing means. Until a noble cane bred tolerant makes its appearance, the portion of India growing thick cane will be liable at any time to join those countries which have had an epidemic. Only in her case I can see no possible chance of the successful remedies mentioned above being brought into play.

A CULTIVATION EXPERIMENT AT THE GOVERNMENT EXPERIMENTAL FARM, CAWNPORE.

BY

T. R. LOW, B. Sc.,

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AND

M. NIZAM UDDIN HYDER,

Superintendent, Experimental Farm, Cawnpore.

IN 1882 an investigation was commenced at Cawnpore to ascertain the effect of deep ploughing and sub-soiling on the yield of the wheat crop. This experiment was carried on with many modifications for 27 years and finally closed down in 1909. As stated in the Annual Reports of the time, the conclusions arrived at were briefly as follows :—

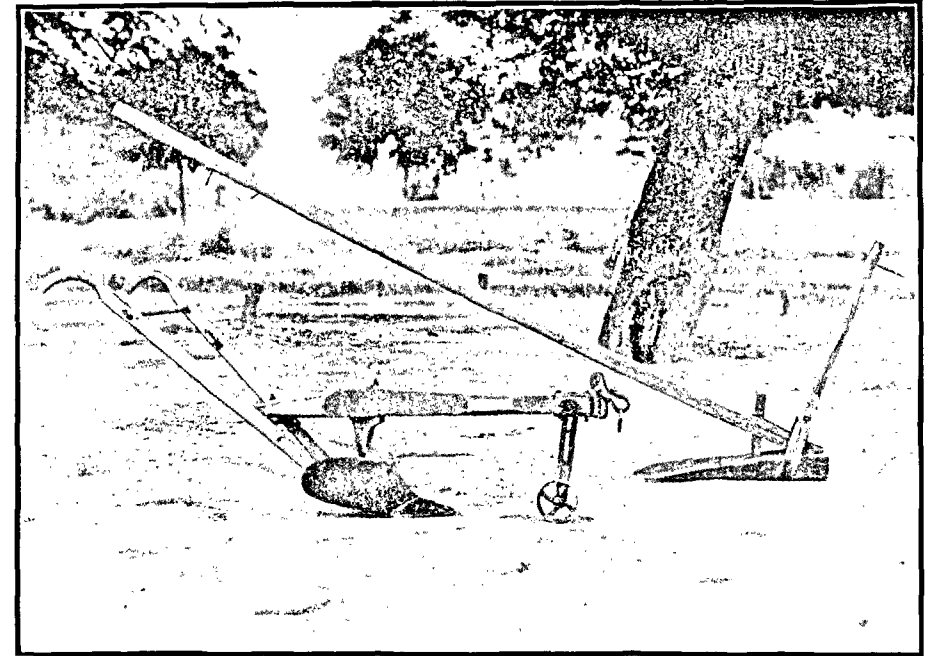
- (1) That sub-soiling and deep tillage gave a considerably increased yield over ordinary cultivation with a country plough.
- (2) That the effect of sub-soiling was not equal to that obtained by the use of a soil inverting plough.
- (3) As far as soils of the Cawnpore type were concerned, the statement that Indian soils were not suitable for comparatively deep tillage was disproved.

During the course of these trials investigation appears to have been confined to the question of depth of cultivation alone. The results of soil inversion are not dealt with in the reports in any detail.

Of late years the adoption by the cultivators of these provinces of the various types of soil inverting ploughs has increased considerably. Over 3,500 ploughs and 3,200 spare shares were distributed by the department alone during 1927. This is exclusive of a large number that are sold by private agencies.

With a view to ascertaining the increase in yield obtained by the use of these soil inverting ploughs and to find out whether the increase obtained was due to soil inversion or to increased depth of ploughing, a somewhat similar series of experiments was started by the writers in 1922. It was also desired to collect some reliable figures by which the use of these ploughs could be substantiated.

(32)



Punjab Plough.

Egyptian Plough.

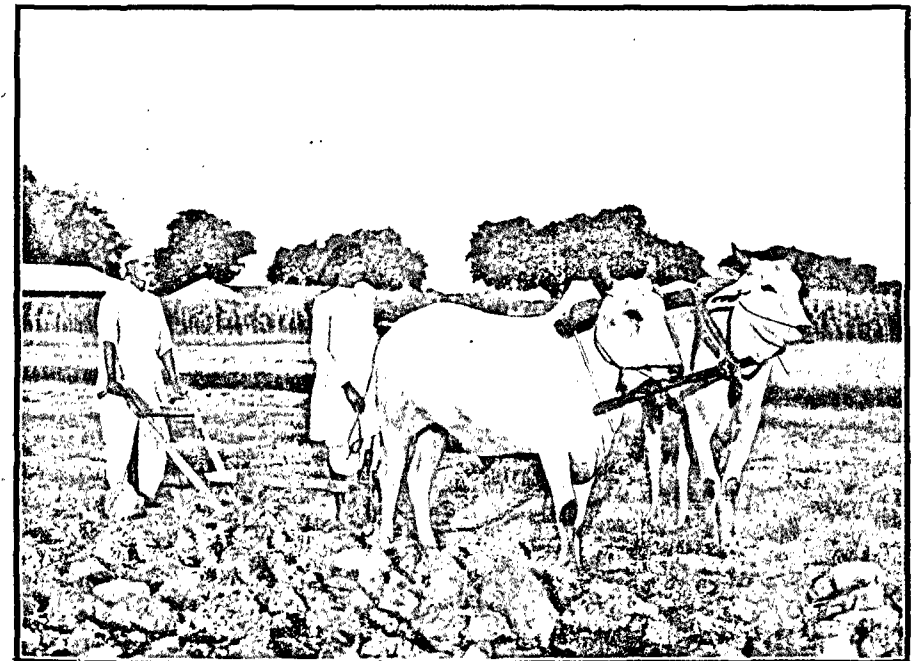
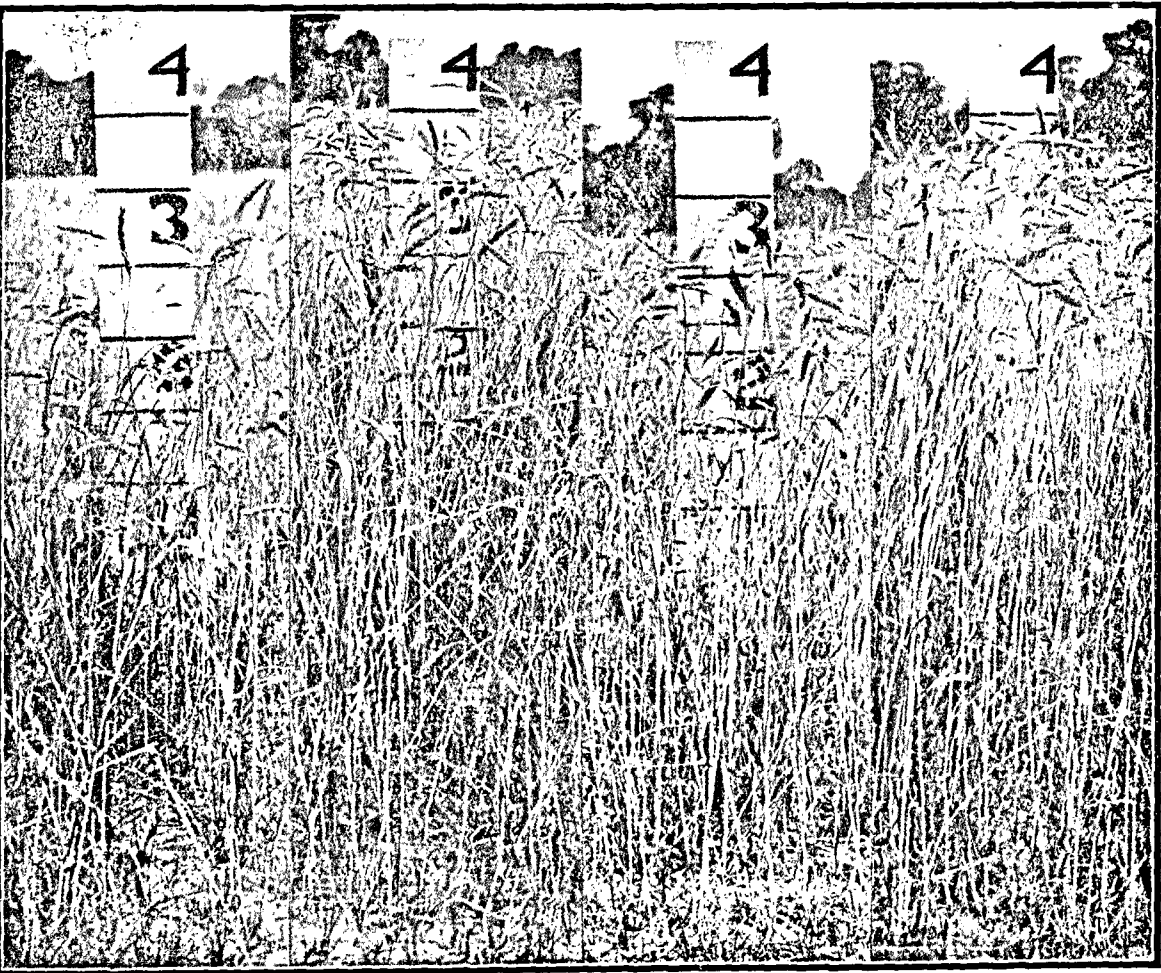


Fig. 2. Punjab Plough.

PLATE IV.

CULTIVATION EXPERIMENT AT CAWNPORE EXPERIMENTAL FARM. WHEAT PUSA 12.



Shallow ploughing without inversion. Shallow ploughing with inversion. Deep ploughing without inversion. Deep ploughing with inversion.

To do this four plots (duplicated) for wheat and gram were taken yearly and cultivated as under :—

- (1) Deep ploughing with inversion.
- (2) Deep ploughing without inversion.
- (3) Shallow ploughing with inversion.
- (4) Shallow ploughing without inversion.

The experiment with gram was not commenced till 1925. For the inverted ploughing a Punjab plough was used in all cases as being more easily adjustable, and to ensure that while depth of tillage could be altered the nature of the tillage remained the same.

The tillage without inversion was carried out with the Egyptian plough. This plough is in all essentials the same as a *desi* plough but better able to cope with deep ploughing. The deep ploughing with the Punjab plough and the Egyptian plough (Pl. III) was done to a depth of 6-7 inches and the shallow ploughing to a depth of 4-5 inches. The latter is approximately the same depth as that attained by the Meston plough which is the most popular type of improved plough in use in these provinces.

The ploughings were made in accordance with the usual routine of preparation for wheat and gram sowing in this part of India, and the seed-bed was prepared in all cases by harrowing and the use of the *pata* (levelling and clod-crushing beam).

Pusa 12 wheat and Pusa 25 gram were sown in each case and no manure was applied to any of the plots. The rotation adopted was gram following wheat and in the case of wheat irrigation was given whenever necessary.

The results obtained are given in the following statement.

WHEAT.

Yields in lb. per acre.

Harvest	WITH INVERSION				WITHOUT INVERSION			
	6"-7" deep Deep ploughing.		4"-5" deep Shallow ploughing		6"-7" deep Deep ploughing		4"-5" deep Shallow ploughing	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1923. . . .	1,337	2,960	1,430	2,810	1,187	2,230	1,100	2,067
1924. . . .	1,410	2,330	1,235	2,157	1,012	1,722	845	1,427
1925. . . .	1,837	3,175	1,932	3,475	1,593	2,611	1,638	2,479
1926. . . .	1,946	3,544	1,565	2,948	1,516	2,645	1,363	2,522
1927. . . .	1,720	2,840	1,635	2,601	1,301	1,972	1,110	1,738
1928. . . .	1,243	2,663	1,008	2,432	881	1,971	725	1,687
Average . . .	1,582	2,919	1,468	2,737	1,248	2,192	1,130	1,987

GRAM.

Yields in lb. per acre.

Harvest	WITH INVERSION				WITHOUT INVERSION			
	6"-7" deep Deep ploughing		4"-5" deep Shallow ploughing		6"-7" deep Deep ploughing		4"-5" deep Shallow ploughing	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1925. . . .	2,360	2,513	1,858	2,004	2,203	2,090	1,860	2,032
1926. . . .	2,350	2,322	2,506	2,826	2,460	2,210	2,460	2,877
1927. . . .	1,844	2,523	1,348	1,981	1,354	2,074	1,147	1,442
1928. . . .	2,069	1,928	2,236	2,109	2,100	1,683	2,263	1,907
Average . . .	2,156	2,322	1,937	2,305	2,029	2,239	1,932	2,214

In the case of wheat it will be seen that the inversion plots have in every year and on the average yielded more than the non-inversion plots. Even shallow ploughing with inversion has been more productive than deep ploughing without inversion.

It, therefore, appears clear that the inversion of the soil is undoubtedly a more important factor than depth of tillage.

Deep ploughing without inversion has resulted in a slight increase in outturn in accordance with the results obtained at the close of the old investigation in 1909, but this increase is not sufficient to justify the extra labour on the part of the cattle.

The average percentage increase in outturn of grain and straw, assuming the yield from shallow ploughing without inversion to be 100, is as follows:—

Deep ploughing with inversion	45 per cent.
Shallow ploughing with inversion	33 per cent.
Deep ploughing without inversion	13 per cent.

The monetary aspect of these increased yields is striking. The average increases over the ordinary *desi* type of ploughing are:—

Increase per acre in lb.

	Grain	Straw	Gain per acre in rupees
Deep inverted ploughing—Punjab plough type. .	452	931	Rs. 38-8-0
Shallow inverted ploughing—Meston plough type .	338	750	Rs. 29-7-0

This is taking the price of wheat grain at Rs. 5 per maund and *bhusa* (straw chaff) at Re. 1 per maund.

The figures for the Meston plough are particularly noticeable when one considers that a complete plough with wood work now costs only Rs. 12-8 in Cawnpore and a spare share annas eleven.

The aggregate gain to cultivators from the use of improved ploughs all over India must indeed be a striking figure when the profit on one acre of wheat alone is over Rs. 20.

The explanation of these increases in yield may be due partly to the increased formation of soil nitrates consequent upon the better breaking up and aeration of the soil by the mouldboard ploughs, the mechanical texture of the soil thus being in a more favourable condition for biological activities leading up to the formation of nitrates, and also to the better mechanical condition of the soil resulting in increased tillering.

As already mentioned, no manure was applied to any of the plots. The crops, therefore, during their growth would be dependent on the inherent fertility of the soil and anything affecting this would react on the yields obtained. One of the factors most readily affected by variations in methods of tillage is the amount of nitrogen available in the soil.

The figures obtained from the gram plots are somewhat inconclusive, the only outstanding feature being the increased average yield obtained from deep ploughing. An explanation of this result may lie in the difference in the root systems of wheat and gram.

Gram, in common with other dicotyledonous plants, possesses a generalized root system consisting of a tap root and a well developed system of lateral roots. It may thus be enabled to draw food materials from deeper layers in the soil than wheat which normally has a net-work of fibrous roots near the surface. Under these conditions deep cultivation would be favourable to gram. Also by the association of nitrifying bacteria in the root nodules of gram it would possibly not be dependent on soil nitrates to the same extent as wheat.

It is to be regretted that while making these trials no nitrate estimations were made in soil samples from the various plots at intervals during the year, particularly in September and October, when preparation for *rabi* sowing is carried out. At this time biological activity in the soil is intense and it is one of the periods during which the accumulation of nitrates occurs in the cultivated soil of the Gangetic plain as pointed out by Clarke, Banerjee and Naib Husain (*Agricultural Journal of India*, Vol. XVII, page 463). Indeed it seems probable that the soil reactions at this period are closely correlated with the yield of the subsequent *rabi* crop.

The nitrate estimations in such samples would be of interest and would possibly give a clue to the variations in yield.

This cultivation experiment is being continued and it is hoped that it will be possible to arrange for nitrate estimations to be carried out in conjunction with the filed work.

THE VOCATIONAL AGRICULTURAL EDUCATION MOVEMENT IN THE UNITED STATES.

BY

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"It was a great thing when the common man first lifted up his head and said 'I, too, will be educated'."¹ It ran counter to the whole philosophy of education which was designed to meet only the needs of the exceptional and specially privileged five per cent.

The common man has been a long time in making his needs and wants in education articulate. To-day, however, we seem to be entering an era where universal education is being demanded. This brings with it many problems. It means that education must prepare not only for the so-called learned professions but it must train for the other common professions and trades as well.

LINCOLN'S MUDSILL THEORY OF EDUCATION.

In 1859 Abraham Lincoln gave his philosophy of education in a public address. The main points of his "mudsill theory of education" can be summarized as follows:—

"Educated people must labour, otherwise education itself would become a positive and intolerable evil. No country can sustain in idleness more than a small percentage of its numbers. The great majority must labour at something productive. From these premises the problem springs: 'How can labour and education be the most satisfactorily combined'?"

"By the 'mudsill' theory it is assumed that labour and education are incompatible, and any particular combination of them impossible. According to that theory, a blind horse upon a treadmill is a perfect illustration of what a labourer should be—all the better for being blind, that he could not kick understandingly. According to that theory, the education of labourers is not only useless but pernicious and dangerous. In fact it is in some sort deemed a misfortune that labourers should have heads at all. Those same heads are regarded as explosive materials,

only to be safely kept in damp places, as far as possible from that particular sort of fire which ignites them. A Yankee who could invent a strong-handed man without a head would receive the everlasting gratitude of the 'mudsill' advocates.

"As each man has one mouth to feed, and one pair of hands to furnish food, it was probably intended that that particular pair of hands should feed that particular mouth, that each head is the natural guardian, dictator, and protector of the hands and mouth inseparably connected with it; and that being so, every head should be cultivated and improved by whatever will add to its capacity for performing its charge."¹

Lincoln was many years ahead of the educational thought of his day. So-called leaders in education scorned his ideas as impractical.

ROOSEVELT'S EDUCATIONAL CREED.

Several years later but still more than a quarter of a century ago, Theodore Roosevelt asked his compatriots to commit the following educational creed to memory:

"I believe in the free public training of both the hands and the mind of every child born of woman. I believe that by the right training of men, we add to the wealth of the world. All wealth is the creation of man and he creates it only in proportion to the trained uses of the community; and the more men we train, the more wealth everyone may create."²

AGRICULTURAL EDUCATION A NEW MOVEMENT.

Different countries of the world are adjusting themselves to this new need in various ways. I want to review the development and present tendency of this movement as it relates to rural agricultural sections in America to-day. I recognize very well that conditions in America are very different than those in India. Naturally a system that works efficiently there cannot be expected to function here in India without alterations and adjustments. However, I do believe that the experiences there may be somewhat indicative of difficulties India may encounter in the same field. We should gather together information from all sources in order to find ideas and ideals that we can apply here. True vocational agricultural education is still in the experimental stage everywhere. Probably nowhere has a system been developed that can be said to be quite adequate for farmer education. It is relatively a new movement but is rapidly gaining recognition.

¹ Federal Board for Vocational Education Report, 1923, p. 3.

² Prosser and Albin, *Vocational education is a democracy*, p. 97.

¹ Davenport, *Education for efficiency*, p. 1.

THE FIRST AGITATION IN THE UNITED STATES.

Prior to 1900, the teaching of agriculture had been introduced into but 19 public schools in America. It was introduced into 33 more from 1901-1905, and in 413 more from 1906 to 1910. In the summer of 1916, according to the United States Bureau of Education, 2,981 high schools reported pupils in agricultural courses.¹ Of these, only 25 per cent. were vocational in purpose. This shows how recent the movement for vocational agricultural education is in America which truly is an agricultural country.

Several States and agencies had been advocating that our American educational system should be revised in such a way as to care more adequately for the many boys and girls who never would be able to follow the academic road to its end. This sentiment caused many experiments to be made in an attempt to find a satisfactory solution. Special agricultural schools were started in many States which were entirely separate from the other public schools. Some of them were residential schools in a rural district with farms completely equipped with live stock and machinery. There the boys could use these facilities for laboratory work. One of the difficulties encountered there was the fact that it took the boys away from the home at a time when the parent could ill spare the boy's assistance. The schools were also quite expensive to maintain and at best could reach only a very small percentage of the adolescent farmer boys.

Other States, instead of establishing special farmer schools, built up a non-collegiate department in the College of Agriculture at their Universities.

VOCATIONAL EDUCATION ACT.

These various experiments finally led the Federal Government to appoint a commission in 1916 to investigate the situation and make recommendations. The Vocational Education Act known as the Smith-Hughes Act was the result.

Under the provisions of this Act the Federal Government did not propose to undertake the organization and immediate direction of vocational training in the various States. Each State was given the greatest freedom in developing her own system. The Federal Government agreed to provide substantial financial contributions for the support of the work. The fund for agricultural teachers was allotted to the States according to their rural population; for trade and industrial and home economics teachers, according to their urban population; for teacher training, according to their total population. By a graded system, the total Federal appropriations have reached an annual maximum of \$3,000,000* for agriculture, \$3,000,000 for trades, industries and home economics, \$1,000,000 for the training

of teachers in all those subjects. This makes an annual grant from the Federal Government of \$7,000,000 for the promotion and encouragement of vocational education in the public schools of America.

VOCATIONAL AGRICULTURAL SCHOOLS.

From the beginning there has been a very strong difference of opinion as to the type of school that should be used to give the agricultural education to the farm boys. One group of men contended that the rural high schools were the logical agencies to add such teaching to their curriculum. These public schools were already established and had the full support and confidence of the people. They were supported by public taxation and were thus responsible to give secondary education for all who cared to avail themselves of its facilities. These schools were widely and almost universally distributed and therefore were in the best position to reach the maximum number of prospective farmers with the least additional cost.

The other group of vocational education advocates maintained that general education and vocational education were incompatible and should not be conducted under the same roof. If agricultural education was admitted into the regular high school system, it would be so completely overshadowed by the literary subjects as to make its usefulness of no account. They strongly advocated separate agricultural schools for such training.

As the system progressed, the tendency has been very decidedly in the direction of the establishment of departments of agriculture in the rural high schools. The boys who enroll in the agricultural classes have to have facilities for carrying on their project work on the home farm. This project work was in the nature of a laboratory to supplement the class room instruction. The teacher of agriculture visited the boy on his home farm and assisted him with his problems. The boy is given credit for this work toward his certificate in agriculture as well as his high school diploma. In most cases these departments offer two, three or four year courses for the regular school year of 36 weeks with half of the boy's time given to the vocational work and the other half to some of the regular high-school subjects. In other words, the work in agriculture has replaced half of the ordinary high school subjects but counts the same towards graduation.

The advantages of this system as compared with the special agriculture school are obvious. It enables the boy to stay at home under the parental roof during his early teens. The home farm provides the best kind of laboratory because it is an actual farm situation and not an artificial structure as so often is the case on the school farms of the special agricultural school. It is a very cheap form of providing laboratory facilities. The parent also has been brought into touch with the United States Department of Agriculture, the State Experiment Station and the Agricultural College through the boy and the teacher of agriculture. It also means

¹ Report U. S. Federal Board for Vocational Education, 1918, p. 37.

* One dollar, \$1.00, American = approximately Rs. 3-0-0.

that the maximum number of farm boys can be reached with a minimum of expense.

Very few special schools of agriculture have been established since the advent of the agricultural departments in the rural high schools. Many of these special schools that were already established have been forced to close their doors, while the graphs presented in Charts I and II show how rapidly and persistently the vocational departments in agriculture have grown in numbers reached as well as in schools established.

THE TEACHER OF AGRICULTURE.

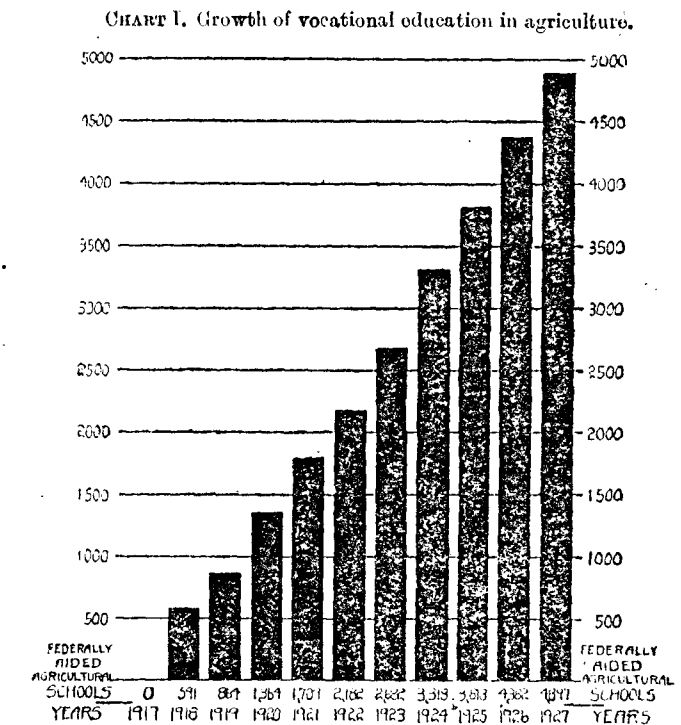
The framers of the Vocational Education Act very wisely foresaw and appreciated the vital position of the teacher through whom the instruction would be given. They realized that he was the key man and that if the teaching were to be effective, teachers must necessarily be especially trained for this special form of educational work. They set aside a yearly sum of approximately \$1,000,000 to aid in the training of the vocational teachers. It is seen to-day that the successful teacher of vocational agriculture must be qualified in three special fields:

1. He must have a practical knowledge of the subject he is to teach. This means actual farm experience of more than a passing sort. He must understand farm problems; he must be rural minded; he must be conversant with rural psychology and sociology; he must be able to meet his pupils and patrons satisfactorily in their own field.

2. The teacher must have a technical knowledge of agriculture and related subjects. A large part of his work is to link up the United States Department of Agriculture, the State College of Agriculture and Experiment Station, and other research organizations with the farmer for whose benefit they were established. It is the job of the teacher to introduce and sponsor any new practices that have been worked out by these organizations.

3. The teacher should be trained in the technique of teaching. Professionally he must be a teacher first of all.

It can readily be understood that no magic wand existed to cause such trained men to spring into existence overnight. The teacher with this three-fold qualification, however, was the ideal and the standard that was set. Many teachers of general subjects who seemed interested in this new movement, were recruited and given a partial training in agriculture. Many graduates from colleges of agriculture were recruited into the teaching field. Good, bad, and indifferent teachers were lined up and eliminated by natural processes. A great deal of very poor teaching was done the first few years. Some were not interested in agriculture and taught it in a perfunctory way, often doing much more harm than good for the cause of vocational agriculture.



Numbers of students going out from secondary schools with one or more years of vocational instruction in agriculture.

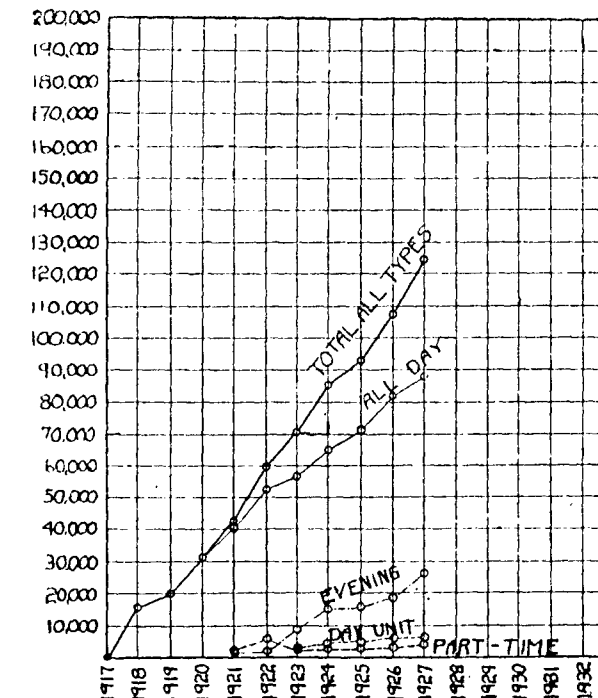


CHART II. Enrolment in federally aided vocational agricultural schools by years —1918—1927.

TYPES OF TRAINING INSTITUTIONS.

Early two types of training institutions were developed. Type one was conducted at the Agricultural College where so-called "residential courses" were run from one to four years. These courses included considerable training in technical agriculture, as well as professional training in teaching. Practical farm experience was further insisted upon to meet the third requirement. This is the type of teacher training that has been adopted almost universally at the present time.

The second type used to meet the immediate need, was that given to teachers already on the job by experts sent out from the teacher training institutions. By this system the work could be cared for during the early days.

An increasing tendency has been towards devoting a liberal amount of the teacher training fund in providing training for teachers subsequent to their actual employment. This has proved to be of relatively greater usefulness than the amount spent previous to the teacher's employment.

METHODS OF TEACHING.

It is interesting to follow the development of new teaching methods in this field. The old established recitation method was first used as it was then in vogue. It early proved inadequate. It was recognized that at least in the field of agriculture, making walking encyclopedias out of the boy was not the most desirable end to attain. What was wanted was a knowledge of where and how information could be obtained when wanted. It, therefore, was not to "pump" the learner full of facts or ideas, but to get him to think through life situations as they came up. In the class, therefore, advantage was taken of what the boys already knew on the subject, and by discussion get them to share it with the others.

The further development of this idea has been to conduct the class in the nature of a conference. The teacher leads the trend of thought by well chosen problems while all in the group are given a chance to make their contribution. By this method a much greater responsibility is thrown on the teacher, but it has proved the ideal way to put across vocational teaching. The class members have their projects at home to try out and test the new ideas as they are brought out in the discussions.

EQUIPMENT FOR VOCATIONAL AGRICULTURE.

As I mentioned before, one of the advantages the agricultural department in the high school has over the special school of agriculture, is that it is cheaper to operate and maintain. Usually a good light room is set aside for the class in agriculture. Pictures and charts on the wall, a survey map of the community, a good agricultural library and rack for current magazines, and equipment as a milk tester, soil sampler and tester, samples of seeds and fertilizers, etc., give the room a real agricultural atmosphere. The cost of the entire equipment is very small because the home farm itself is the laboratory with the more expensive equipment. This

of course is no expense to the school. Every boy must carry on a supervised practice programme in order to get credit for the work done. This project is planned and discussed in the class while the teacher makes frequent visits to the pupil's home to supervise and check up the work being done.

The teacher of agriculture is usually employed on a 12 month basis. He is relatively well paid. The price varies from \$1,800 to \$3,000 per year. He costs the local community comparatively little however, because the Federal Government pays one-half of the salary and either the State, or local funds or both together, the other half.

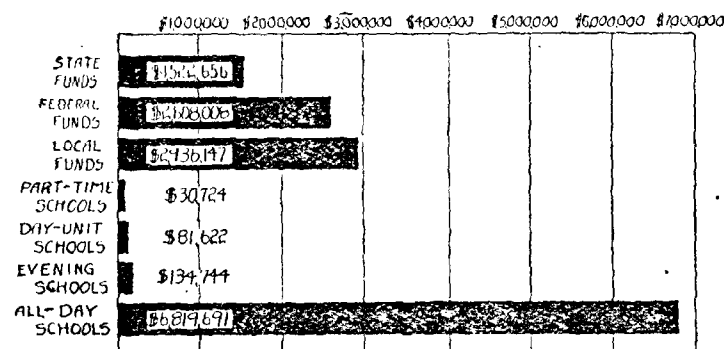


CHART III. The total amount of money raised from Federal, State and local funds for vocational agricultural education and the proportionate amount spent on various types of schools.

By referring to the upper half of Chart III, we can see that in 1926 the amount of money raised locally to support the vocational agricultural movement, was greater than either the Federal or State subsidies received. This goes to prove that local communities realize the importance of this work and are willing to tax themselves to prove their interest.

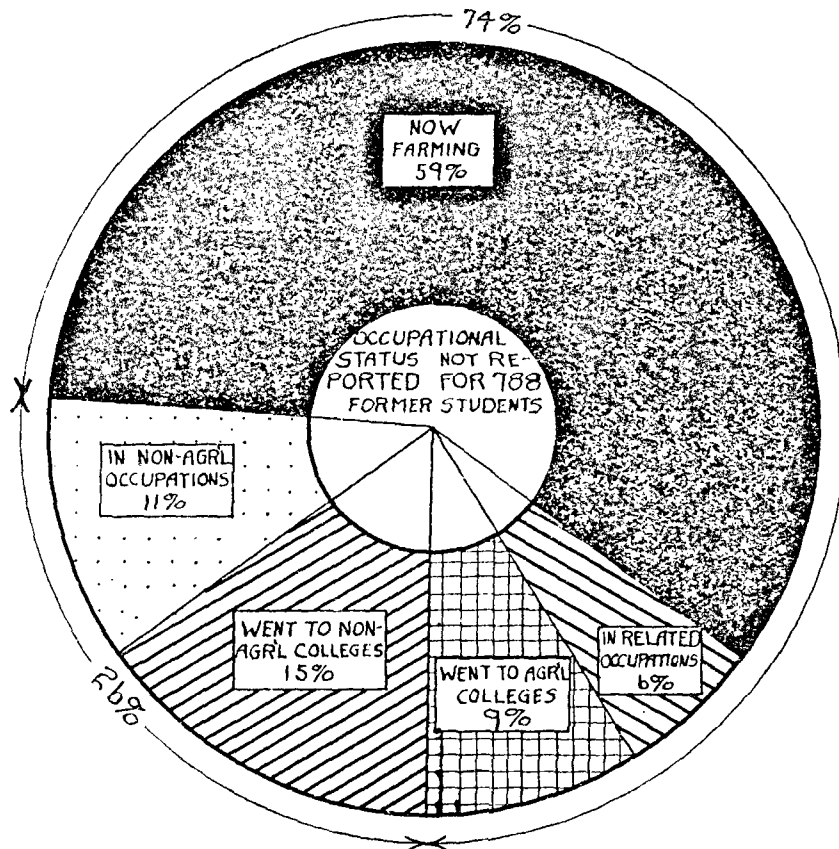
RESULTS OF VOCATIONAL EDUCATION IN AGRICULTURE.

It is now about ten years that the movement has been in operation. Anyone at all conversant with matters of education, recognizes that tangible results that can be measured are slow in presenting themselves and being of a social nature, are difficult to measure. It may further be stated that no authority will claim that agricultural education is the thing above all else for rural communities. It is still, to a large extent, an interesting experiment. It has not been tested sufficiently to warrant any sweeping statements. However, certain indications do seem to justify the interest and enthusiasm of its supporters who are quite willing to meet any other educational system in a test of results obtained.

In the first place, the movement was specially designed to provide educational facilities for those already engaged in a profession, or for those who are preparing

to enter it. To what extent, therefore, has it served its purpose in sending real farmers back to the farm or into related occupations? By referring to Chart IV,

CHART IV. OCCUPATIONAL DISTRIBUTION OF FORMER STUDENTS OF VOCATIONAL AGRICULTURE.



Percentages based upon total of known status—1923 (7,552 out of 8,340 former students).

a comparison is found from a nation-wide survey. It is based upon the number of farm boys who had had one or more years training in vocational agriculture. It showed that 59 per cent. were actually farming; 6 per cent. were in related occupations; 9 per cent. were in agricultural colleges, thus making a total of 74 per cent. efficiency from the occupational standpoint.¹

A more recent report made by Dr. C. H. Lane, chief of the Agricultural Education Service of the Federal Board for Vocational Education, is that from the Sycamore Illinois High School where the agricultural department had been in operation

six years. The survey shows the following: Total number of boys taking the course in agriculture, 99; boys graduating from high school, 49; boys who quit high school 27; boys still in high school, 23. Of the 49 graduates, 33 are on farms, 7 in other lines of work, 2 are teaching, and 7 are in college. Of the 27 non-graduates, 18 are on farms and 9 in other lines of work.¹ It will be observed that 70 per cent. of all boys graduating from this high school and who took vocational agricultural work were on the farm at the time the survey was made.

A resume of the Indiana Bulletin No. 61 issued by the Department of Public Instruction, Indianapolis, Indiana, shows that of all boys in Indiana who had taken one or more years of vocational agriculture in high school, 76 per cent. were engaged in farming.

Evidence such as this could be multiplied many times but it all proves that the system is functioning in the way that it was hoped would be true. From 60 to 75 per cent. efficiency does not seem to be a bad average.

PRESENT TREND OF AGRICULTURAL EDUCATION.

By referring to Chart II, it will be seen that the greatest amount of work for vocational agriculture has been done in the all day type of school which is largely in the agricultural department of the high schools. This means that the boys of high school age have received the most attention. In 1921 other types of schools were first introduced. These were designed to reach the boys who had dropped out of schools for various reasons as well as the adult farmers of the community. Part time schools were established for the adolescent boys where they could attend during the period of slack farming operations. The special schools of agriculture are being used for this work to a large extent. Short courses at the State college of agriculture during the winter months are also attracting large numbers of such boys as have gotten out of step with the regular school system. By these special means, the earlier grade school training is salvaged and put to productive usefulness. Many of such schools are the means of creating new visions for expanding the mental ability for such boys and is making them better rural citizens.

For the evening school work the local high school agricultural department is largely being used. The high school vocational teacher is more and more enlisting the adults in such unit courses during the winter months. Probably no efforts are more worth while and give such immediate results as can be attained in this field. Much constructive thought is being given to the development of this work. It can readily be seen how such a system places the instructor on his mettle. He has to have his feet on the ground and his head in the air to give these men something worth while. It works to the mutual advantage of all.

¹ Federal Board for Vocational Education Bulletin No. 82, May 1923.

¹ Vocational Training in Agriculture School & Society, Apr. 9, 1927, p. 423.

THE VALUE OF *ZIZYPHUS ROTUNDIFOLIA* AS A STOCK PLANT.

BY

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The choice varieties of *Zizyphus jujuba* Lam., commonly known as "Bor" or "Ber," are always budded on the wild varieties of the same species. According to the classification of Edgeworth,¹ all the choice varieties which are propagated by grafting are horticulturally grouped as *Hortensis* to distinguish them from other wild as well as cultivated types which are grouped as *Hysudraiacus*.

The botanical description of *Zizyphus jujuba* is as follows:—A small much branched tree or large shrub; young branches softly pubescent; leaves 1-2½" by ¾-1½"; bifarious ovate-elliptic, rounded at both ends, faintly denticulate, glabrous above, and pubescent beneath; 3 nerved; petioles, ¼-½" long; prickles solitary or in pairs; flowers greenish yellow in axillary clusters; calyx woolly outside; lobes triangular; petals rounded at the apex; stamens between the calyx lobes and enclosed in the petals but not exerted beyond them. The disk has 10 grooved lobes. Ovary is about half sunk in the disk; styles 2, drupes edible, ½-⅝" in diam., globose, fleshy and smooth, yellow or orange on maturity; stone 1-2 celled.

These wild varieties are often grown with the object of using them as stock plants to get a better quality of *bor*. Of course, they are also found growing wild. Under all circumstances, they are useful as stock-plants and are favoured by the growers as such.

Side by side with these wild varieties of *Zizyphus jujuba*, another wild bush of the same genus known as *Zizyphus rotundifolia* grows on extensive scale. Its botanical description is as follows:—A small shrub branched from near the root; branches slender and zigzag; leaves ½-¾", ovate or orbicular, spinous dentate; flowers axillary, calyx pubescent outside; petals cuneate, rounded or truncate at the apex and longer than the stamens; filaments deflexed together with the enclosing petals; disk 10-lobed, with a pit opposite to each lobe; ovary 2-celled; styles 2, united to above the middle; drupes globose, ⅓" in diameter, red when ripe.

It is seen growing very commonly in the Northern Division of Gujarat. In the District of Ahmedabad, it is a common bush in the wilds. It seems to flourish on all sandy slopes and is extremely xerophytic in character. It is more or less of a

¹ *Flora Mallica* (Multan Flora).

Fig. 1. *Zizyphus rotundifolia*.Fig. 2. Choice *jujuba* plants budded on *rotundifolia*.

straggling nature and rapidly grows by means of the root buds. It covers large circular patches and is often considered an obnoxious weed by the cultivators. Every year it is cut but it never dies. On the other hand it grows with a redoubled vigour. It has got small leaves and possesses sharp prickles in pairs on its twigs. Like many other wild bushes, it does not even make a good fuel. It bears very small fruits with little edible pulp, which is acidic in taste. It is the shepherd or the cowboy who might value this bush for its fruit in normal years. Of course, during the famine days, fruit is collected by villagers for *barchumi* purposes. Whatever the case may be, *Zizyphus rotundifolia* is a weed (Plate V, fig. 1).

During the last few years we have been testing its value as a stock plant for choice varieties of *Zizyphus jujuba*, a fruit the cultivation of which is much desired in the Gujarat Division. Our observations, which extend over many years now, lead us to the definite conclusion that this obnoxious weed, as it is considered, makes a very valuable stock plant for *Zizyphus jujuba* and its varieties. This wild shrub takes the bud very readily and the budded plants require no further care, except protection from strong winds, to grow and to fruit. The quality of fruit produced is very satisfactory and fetches as much value as the fruit of other choice types budded on the *Zizyphus jujuba* stock. In fact, these plants are easier to handle as they do not grow into big trees. Whether this dwarf habit of the tree is due to the influence of the stock or the environmental characters, remains to be worked out. But it is a fact that these plants have been budded in thousands and are known to fetch good income (Plate V, fig. 2).

The method that has been adopted successfully in budding this bush does not materially differ from the one used in top-working the *Zizyphus jujuba* plants. This bush is headed back right to the level of the ground in the month of February-March and several vigorously growing young shoots sprout up. Out of these two to three vigorous shoots are preserved and the rest cut down. In the month of April-May, these young shoots are budded at a height of about a foot or so. The "T" method of budding has proved successful. All shoots which might sprout from time to time near and below the bud from the stock, must be lopped off. After the bud grows into a 5-6 ft. long shoot, it is earthed up to give support to the plant. These budded bushes bear good fruit in the course of three years. Fruit is harvested from December to the middle of February. In April-May, after the fruit is harvested, the budded plants are pruned. All growth is cut to a few buds. New shoots develop vigorously and bear good fruit. Each bush fetches an income of one rupee a season.

This foregoing description shows how *Zizyphus rotundifolia* (it is also called *Zizyphus nimmularia*) can be profitably used. There is no doubt that this bush wherever it grows can be made to yield a fair income without much investment.

TEA IN NORTH-EAST INDIA, IV.

BY

P. H. CARPENTER, F.I.C., F.C.S.,
Chief Scientific Officer, Indian Tea Association.

(Concluded from Vol. XXIII, Pt. IV.)

CULTIVATION.

Practically all cultivation in tea is done by hand, for the closeness of the bushes makes the employment of mechanical cultivators as at present constructed, almost an impossibility. Recently small bullock-drawn cultivators have been used on gardens which are flat, and attempts are being made to introduce cultivators driven by internal combustion engines.

It was early recognized that the more a garden was cultivated the greater the crop, and from this came the idea that "tincture of steel" should be the first consideration in garden operations. A deep hoe to a depth of six or nine inches was put in during the cold weather, and a light hoe to a depth of three or four inches about once a month afterwards. With the rains the weeds grew quickly and often got ahead of the cultivation by August, and in some cases the garden disappeared beneath jungle before the hoeing men caught up on it when the rains ceased.

In Ceylon where there is no marked dry spell during which the weeds cease to grow, the soil is clean weeded and the weeds are either burnt on the spot or carried off and dried. All this is organic matter lost to the soil but this loss is evidently preferable to a garden over-run with weeds.

With the shortage of labour in North-East India, the possibility of a monthly round of hoeing on a garden became out of the question and the weeds, especially undesirable thatch and deep rooting grasses, spread through the tea areas.

In 1922 extensive cultivation experiments were started at the Tocklai Experimental Station and although this work is still in progress, all the results point to the fact that it is the harmful effect of the weeds rather than the beneficial effect of stirring the soil during cultivation, that influences the tea crop. Accordingly it is becoming the custom to leave the sides of the bushes so that they cover the soil and tend to keep down weed growth. It has been found that such a procedure not only reduces the need for hoeing but also keeps the soil in good tilth, approximating, as it does, to jungle conditions.

(48)

In addition to deep cultivation once a year and to light hoeing, it is usual to fork round the bushes once a year in order to remove ferns and grasses which collect there and escape the ordinary weeding.

Trenching is also largely practised. A trench up to 18 inches deep is cut between the bushes and prunings or green crops are buried. This process is a good one on a soil with a pan; the tendency now-a-days is to disturb the soil as little as possible, provided it is free from weeds.

MANURING.

The systematic manuring of tea in North-East India is a recent innovation. The first manuring was top dressings of peat soil obtained from *hullahs* and *bheels*. Later on cattle manure was used, although only within the last decade or so has this most valuable manure been carefully collected and stored in properly constructed covered pits. The use of oilcake followed and, later on, animal meal. There has always been shown a preference for organic manures and only recently has the free use of chemical manures become common. Now the use of these substances threatens to supersede entirely the use of the more expensive organic manures.

The use of imported manures is increasing rapidly as is shown by the following table which indicates annual quantities sent from Calcutta into North-East India during the eleven years from 1915 to 1925:—

Year	Tons
1915	7,700
1916	9,150
1917	3,300
1918	5,250
1919	8,750
1920	8,200
1921	3,870
1922	12,200
1923	15,600
1924	20,000
1925	20,000

During the war there were at times difficulties in obtaining manures. The falling off in manure purchases in 1921 was due to the slump in tea. The amount of manure sent up in 1926 shows a marked increase over 1925.

The price of manure per ton in 1925 is about the same as in 1915, the orders for which were delivered at pre-war prices. This is due to the fact that cheap chemical manures are now being purchased in place of expensive organic manures. In addition it must be remembered that the present purchases represent a much greater amount of organic manures.

The tea soils of North-East India require constant additions of nitrogenous manures and of organic matter. From extensive field experiments it has been observed that applications of potash or phosphoric acid alone generally give little or no crop increase. On sandy soils, nitrogen is best applied with potash and on clays with phosphoric acid.

Nitrogen increases leaf production and is for that reason the main constituent of all our manures. Potash, it has been found, tends to keep the bush free from fungus attack and to prolong the growing period so that the bush flushes later than it otherwise would. Phosphoric acid tends to steady up the flushing and in that manner makes for slower growth and better tea. It is the general opinion that much of this plant food, however, makes for stalky teas.

Organic matter is added to the soil as cattle manure, if it is available, or as green crops. The difficulty of collecting cattle manure is great so that its use is limited. During recent years however green crops have been freely grown. These are either six-week crops like *dhaincha* (*Sesbania aculeata*), cowpeas (*Vigna catjang*), *mati kalai* (*Phaseolus* spp.), sann-hemp (*Crotalaria juncea*), soy bean (*Glycine hispida*), which are planted in the spring and hoed in May or June before the heavy plucking months; or *rahar* (*Cajanus indicus*) which is sown in every second or third row and buried at the end of the season. In other cases *Boga medeloa* (*Tephrosia candida*) is used and left up two years or *Indigofera* which is left up three to five years.

Several other crops have been tried but those mentioned above are the ones usually employed.

Many gardens at present are manured in cycles such as the following :—

1. Rock phosphate and a six-week green crop or 5 tons cattle manure per acre.
2. Chemical mixture giving—
30 lb. nitrogen per acre.
30 lb. potash per acre.
3. *Rahar* or *Boga medeloa* and chemical mixture forked round bushes giving—
30 lb. nitrogen per acre.
20 lb. potash per acre.
20 lb. phosphoric acid per acre.
Cut down and bury *rahar* at the end of the season.
4. Chemical mixture as in 3.
Lop and bury top branches of *Boga medeloa* at the end of the season.
5. Chemical mixture as in 3.

The manures are added in the spring. *Rahar* and *Boga medeloa* are lopped and thinned out at intervals, for excessive foliage on the green crop not only makes plucking difficult but also depresses the tea crop.

The amount spent per acre in manures is steadily increasing and now-a-days the figure often reaches Rs. 20 and in some cases much more.

The manuring of seed gardens is a different problem since the crop here is seed, not leaf. Accordingly large doses of phosphoric acid and potash are given in August when the seed begins to fill. Nurseries are not often manured, because they are usually put out in virgin soils.

Lime is seldom used now-a-days on tea in North-East India. The history of the use and disuse of lime is an interesting one. The earliest scientific advice was against the use of lime but when the soil acidity was studied and bacteriologists had shown that nitrogen fixation took place best in neutral or faintly alkaline soils, the use of small doses of lime (about 800 lb. per acre every 5 years) was advised. In the meantime field experiments were carried out with doses of lime varying from a quarter of a ton to 10 tons per acre. In few cases was any benefit observed and in most cases a small but definite crop depression was recorded. The result is that now-a-days lime is only advised on extremely acid soils or because of its physical action.

Shade trees are grown amongst the tea on most gardens partly for the benefit of the shade and partly for the beneficial effect of the leaf droppings.

Shade trees are usually planted about 30 to 40 feet square but as the trees develop planting at this distance is often found to be too close. About 50 feet apart is recommended for most districts. Too dense shade lowers both quality and crop. Shade is needed mostly during the spring and autumn months. Shade is needed more in areas where the light leaved variety of tea is grown than where the Burma or dark leaved grows.

The most common shade tree is the *Sau* (*Albizia stipulata*), a quick-growing tree which however easily cankers. The Ceylon *Sau* (*Albizia moluccana*) is not popular because of its dense shade in the cold weather and its consequent heavy call on the soil moisture reserves. *Albizia lebbec*, *A. procera*, *Dalbergia assamica*, *D. Sissu* and *Derris robusta* are also in common use.

Many of the tea areas are now over fifty years old and the bushes have been heavily pruned many times with the result that the frames of the bushes are now represented by gnarled branches bearing the scars of past prunings. Such bushes suffer from fungus diseases and the older wood is covered with lichens. It is often desirable to rest such areas. To do this the bushes are pruned in the cold weather and then left unplucked during the season, although the soil is kept clean. At the end of the season the bushes are again pruned and where this is done it is usually noticed that not only is the new wood strong and thick but the old wood has thrown off much of its lichen growth. A year of resting does much more good to old tea than a dose of manure.

PESTS AND BLIGHTS.

A plant growing in the conditions under which the tea bushes thrive is naturally subject to attack by insect pests and fungus diseases, and the list of known pests and diseases is already formidable.

The most serious and at the same time widespread insect pest is undoubtedly the tea "Mosquito" Bug (*Helopeltis theivora*), whilst the Red Spider, though perhaps not so serious, is even more widespread than the former.

Amongst the Orthoptera, crickets (*Branchypterus portentosus*) often give considerable trouble, more particularly in nurseries and heavily pruned tea.

Of beetle pests of tea (*Coloptera*), the most important is the Orange or Peel's Beetle (*Diapromorpha melanopus*), which by eating partly through the succulent shoot of the flush, causes the upper portion to die off. Cockchafer grubs (*Lachnosterna* spp.) attack the roots of the plant, and may do considerable damage in nurseries.

The Shot-hole Borer (*Xyleborus fornicatus*), so obnoxious in Ceylon, is, fortunately, unknown in North-East India.

The list of caterpillar pests (*Lepidoptera*) of the tea plants is a long one, amongst which those of the Faggot and Bag Worms (*Clania* spp.), Bark-eaters (*Arbela* spp.), Red Slug (*Heterusia magnifica*), Red Borer (*Zeuzera coffeae*), Looper (*Biston suppressaria*), Bunch Caterpillar (*Andraca bipunctata*), Sandwich Caterpillar (*Agriophora rhombota*), Leaf Rollers (*Homonoma menciaana*, *Grecillaria theivora*) and Nettle Grubs (*Thoesia* spp.) are the most important. The caterpillar of one moth (*Blustobasis spermogena*) lives inside the tea seed. It is a fact worthy of note that all the caterpillar pests of tea turn into moths, and that up to the present no butterfly pest of tea is known.

No member of the order Hymenoptera is known to be an actual pest of the tea bush, though ants of various species, by protecting scale insects and tea aphids, contribute indirectly to the amount of damage done.

The order Hemiptera includes the insects which occasion most concern to the tea industry. The tea "Mosquito" Bug (*Helopeltis theivora*), the arch enemy of the tea plant, occurs in practically all districts, but is particularly dangerous in the Dooars, Terai and the Surma Valley. The pest, when severe, may cause the bushes to stop flushing entirely. Green-fly (*Empoasca flavescens*) is credited with producing a stunting effect on the shoots but at the same time improving quality. The tea aphid (*Toroptera theaeicola*), by curling and stunting the young growing shoots, may cause a considerable check to young plants in the nursery, and to bushes commencing to grow after pruning. Scale insects do a considerable amount of damage in the hill district of Darjeeling, though in the plains the more vigorous growth of the bushes reduces the damage done by these insects. *Chionaspis manni*, in particular, does much damage in Darjeeling by sucking the downward stream of sap from the branches and so causing the branch to be starved below the point of attack. Thus a branch half an inch in diameter above the point of attack may be only an eighth of an inch in diameter below, and the growth of the bush is seriously interfered with. The tea mealy bug (*Dactylopius theaeicola*), which attacks the roots of the plant, is also a noteworthy pest of tea in Darjeeling. The tea-seed bug (*Poecilocoris latus*), while scarcely affecting the plucking bush, is a serious pest in tea-seed

gardens, as by puncturing the seed it permits of the entrance of fungi to the interior, with ultimate destruction of the seed.

The order Thysanoptera, or Thrips, includes a pest of tea which causes much damage in Darjeeling, viz., the common Thrips of tea (*Physothrips setiventris*). This pest causes very severe stunting of the flush, thereby reducing quantity, and, by making the young leaf papery and brittle, undoubtedly affects quality also.

Amongst the Pseudo-neuroptera, Termites, or White Ants, are often troublesome, by swarming into the bush primarily in search of dead pruning snags, plucked shoots which have died back, etc., and ultimately extending their ravage to the entire frames of the bush. Of the varieties found, *Odontotermes*, which lives in the ground, is most wide-spread, but attack by varieties of *Calotermes* nesting in the bushes, so serious in Ceylon, is practically unknown though it has been found to occur in tea seed gardens in the Surma Valley.

Various mites (*Arachnidea*) attack the tea plant, the most important of which is Red Spider (*Tetranychus bioculatus*), which occurs in all districts, particularly upon old and weak tea. The Scarlet Mite (*Brevipalpus*), Pink Mite (*Phytoptus theae*), and Yellow Mite (*Tarsonymus translucens*) do damage occasionally.

In the case of the more serious pests, the tea mosquito bug, red spider and thrips, adequate control measures have yet to be devised. Insecticides play their part in reducing the amount of damage done, but research is pointing more and more to the fact of the condition of the plant as regards its resistance to the pests as the main controlling factor, and the modification of cultural operations to increase this resistance is receiving increased attention.

Damage by caterpillar pests, termites, etc., has been much reduced in late years by improved methods of cultivation, pruning, manuring, etc., and in many cases modifications of cultural operations, based on an increasing knowledge of the biology of the pests, are found to be entirely adequate as a means of control.

The fungus diseases which attack the tea plant may be divided into two categories. Those which are usually associated with lack of vigour in the host plant and those in which this association is not readily traceable. In the former group the commonest diseases are Brown Blight (*Glomerella cingulata* [Stonem] S. & V. S. = *Colletotrichum camelliae*, Mass.) and Grey Blight (*Pestalotzia theae*, Sawads). The Alga (*Cephaleuros mycoidea*, Kart.) which causes Red Rust C. V. is also very commonly found on debilitated bushes. *Sphaerostilbe repens* frequently attacks bushes growing on water-logged or badly aerated soil and *Thyridaria tarda*, Banc. (*Diplodia*) is often found on bushes growing on soils subject to drought. A considerable number of species attack individual branches rendered moribund by other causes such as unsatisfactory systems of pruning and plucking. By studying the life-histories of these fungi in their relationship to the tea plant it has been found possible to reduce the loss due to their action to a great extent by modifications in the manuring, plucking and pruning.

The diseases which so far it has not been found possible to connect definitely with the condition of the tea bush include Blister Blight (*Exobasidium vexans*, Massee) and Copper Blight (*Laestadia Theae*, Rac., *Laestadia camelliae*, Cke.) on the leaves, various species of *Corticium*, *Nectria cinnabarina* and Thread Blight on the stems, and *Fomes lamacensis*, *Ustilina zonata* and *Rosellinia arcuata* on the roots. Blister Blight is the most serious of the leaf diseases in this country. This disease has been known in Upper Assam from the early days of the tea industry. It was found in other districts for many years. In 1907 or 1908 it reached the Darjeeling district and at the same time was found in isolated gardens in the Bhutan hills as well as certain gardens in the Darrang district and the Dooars. In November and December 1926 the disease appeared simultaneously on a number of widely separated gardens in the Surma Valley. The spores of the fungus are distributed by the wind and it has only been found possible to eradicate it from well isolated gardens. The disease only attacks succulent growth, and it has been found possible to protect by spraying, tea on which the undue loss of such growth will cause severe damage. Copper Blight is rarely sufficiently severe to warrant special treatment.

Of the stem diseases the most severe is Black Rot (*Corticium invisum*), but this and other species of *Corticium* and Thread Blight are readily removed by spraying with fungicides, e.g., lime-sulphur solution. *Nectria cinnabarina*, however, requires to be cut out; fortunately this disease is comparatively rare.

The root diseases not associated with lack of vigour in the plant are generally found to originate in decaying wood such as tree stumps, fence posts, remains of wooden bridges, etc. The only satisfactory treatment is the removal of the dead bushes together with all dead wood from the soil in their vicinity.

It has been found by practical experiment that the application of lime-sulphur solution to the tea bushes often results in increase in crop and its use is becoming more and more general. Experience has shown that the spray fluid can be economically distributed by means of knapsack sprayers.

In general the tendency of the research work on fungus and other diseases of vegetable origin has been to emphasize the importance of rendering the tea plant resistant by cultural methods. The primary object of the work on disease treatment has been the improvement in the outturn of the tea bush and in many cases serious outbreaks of disease have indirectly led to a general improvement in the gardens concerned.

MANUFACTURE.

Most tea factories in Assam are lofty single storied buildings with one or more withering houses nearby. In Darjeeling and the Dooars the factories usually have two or three stories, the upper ones being used as withering lofts, in which case separate, outside withering space is either reduced or entirely dispensed with.

The power used in tea factories is still mainly steam, although new installations are practically always oil engines. A few suction gas engines have been installed.

In a few Dooars gardens and in many Darjeeling ones, water turbines are used. In one or two cases only, is hydro-electric power employed. Power is needed to turn the rollers, to work the trays and fans of the drying machines and the sorting apparatus.

The ground floor of the factory is divided into three or four compartments, the rolling room, the fermenting room, the firing room and the sorting room. In Assam many of the fermenting rooms are apart from the factory and placed sometimes under a leaf house, for coolness. In some factories the rolling and fermenting rooms are one. The firing room is generally in the middle of the factory and separated from the rolling room by a brick wall which serves to stop the heat from passing into the rolling room.

The manufacture of tea leaf consists in four processes, withering, rolling, fermenting and firing. The chemical and biological changes going on during manufacture are but incompletely understood. Since tea is drunk mainly on account of its tannin content, most of the chemical work on manufacture has been in connection with the changes undergone by this substance. During the rolling of the leaf, the cells are broken and the sap exposed to the air with the result that some of the tannin changes to a phlobaphene and some to a substance which may be called oxy-tannin. The former compound is red in colour and the latter reddish brown. During fermentation, the processes started in the rolling are continued. These reactions are stopped by firing the leaf.

The loss of tannin due to its change to other substances during manufacture is shown below. The figures represent one particular case but may be taken as indicative.

	Per cent. tannin
Fresh leaf contains	22.2
Withered leaf contains	22.2
Fermented leaf contains	12.9
Fired leaf contains	12.0

As the leaf is plucked in the garden it is put into a basket by the plucking women who carry it to the factory or to a weighing shed, at the end of the morning, and again at the end of the day's work. When the leaf is heaped up in the basket it tends to get hot and turn red. Red leaf makes poor tea and, in order to avoid this, pluckers are instructed to pack the leaf lightly and to turn it over in the basket from time to time.

When the leaf is weighed, it is taken to the withering house and spread. In Assam the leaf house or withering shed is usually of the "chung" type. This type consists in a series of floors about 3 feet apart. There may be as many as ten tiers of floors in a shed. The newer withering sheds are made of iron, are tin roofed and fitted with weather board. The floors themselves are made of strips of bamboo covered with hessian. This type of leaf house is the most expensive

but general experience shows that it is the best so far as getting a good wither on the leaf is concerned.

The other type of withering shed consists in a series of narrow racks of wire netting, each rack about 6 inches from the next and reaching a height of about 6 feet. This type of shed takes more leaf but the wither obtained is often an uneven one.

When the factory is fitted with a loft it is usual to have narrow wire racks. The loft is generally heated by the hot air coming from the firing machine below and this air flows through a duct into the centre of the loft and is drawn to either end by means of fans.

The leaf is spread thinly on the racks. With a wire rack about 9 square feet are allowed for one pound of green leaf but with a "chung" a greater area is usually given, sometimes as much as 15 square feet. The thickness of spreading is naturally controlled by the quantity of leaf brought in and the spreading space available, and on many days spreading is by no means ideal. It is however uneconomical to provide enough withering space to cope with the heaviest days.

It is necessary for the leaf to wither in order that it shall take on the twist in rolling which custom demands in tea. Of late years, broken teas have been in greater demand than leafy teas, since the quick infusion given by a flaky leaf is required rather than the slower infusion given by a well twisted leaf. On this account leaf is not so well physically withered as it was some years ago. Yet in order to make a full, mature tea the leaf must be well withered chemically. When the mid-rib of the leaf begins to change from a bright green colour to a reddish brown the leaf is considered to be chemically ready for rolling. Working at temperatures averaging 80°F. it has been found that in North-East India a good chemical wither is obtained in about 18 hours if 100 lb. leaf dry to about 75 lb. The fresh leaf contains about 75 per cent. moisture so that the above degree of drying signifies that the withered leaf contains about 66 per cent. moisture.

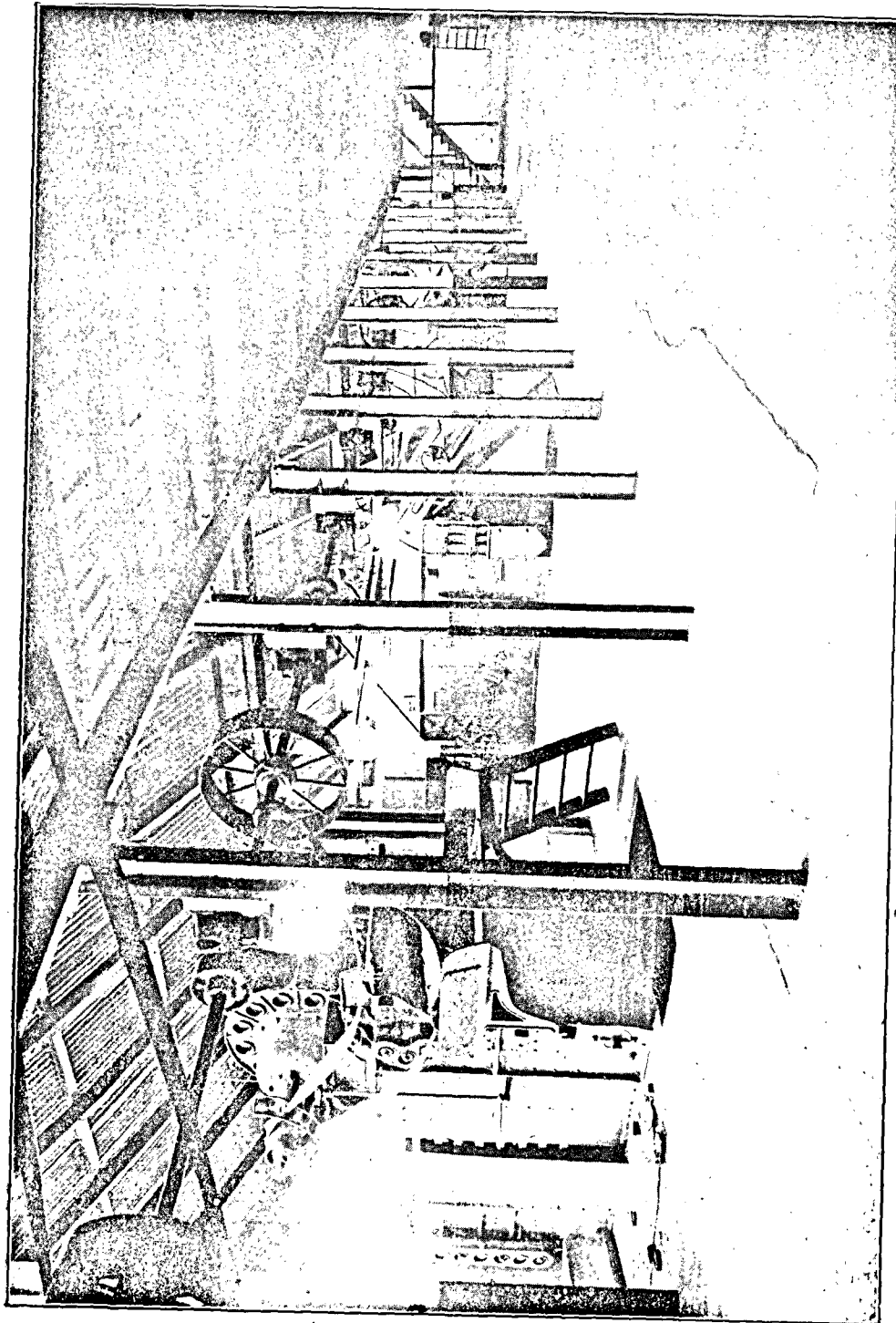
The withering process is the most important one in tea manufacture because if this is not completed then no alteration in the subsequent process can make the best out of the leaf.

In the monsoon it often rains for days on end with the result that a wither cannot be obtained unless a withering loft is used. Quite apart from the fact that leaf is continually arriving from the garden which must be spread on the withering racks, thus necessitating the removal of the earlier leaf, it is not possible to keep leaf indefinitely, since it goes sour after about 48 hours.

After withering, the leaf is rolled in rollers composed of brass which revolve in a rotary manner in imitation of the old hand process. The roller makes 60 to 70 revolutions per minute and takes as much as 500 lb. of leaf in each charge. Rollers are fitted with pressure caps which can be lowered so that the leaf is rolled under pressure.



A TEA FERMENTING ROOM, SHOWING HUMIDIFIERS IN USE.



A TEA DRYING ROOM, SHOWING FIRING MACHINES.

As soon as the rolling starts the leaf is broken and the fermentation process begins. On this account every attempt is made to keep the rolling room cool, for at high temperatures the control of fermentation is difficult.

The first roll is generally a light one lasting for about 30 minutes with little or no pressure. At the end of this time a trap door at the bottom of the roller is opened and the leaf drops into a trolley. During the rolling the leaf has formed into balls and has become warm. In order to cool it and break the balls to ensure even fermentation, the leaf is now put through a sieve either of the rotary or table type. This sieve is of a large mesh varying from 3 in some factories to 6 in others. The balls are broken and the finer leaves and the buds fall through the sieve and are taken to ferment separately. In this fine leaf the "tip" is found.

The coarse leaf is taken back to the rollers and is again rolled but this time hard, with pressure. Hard rolling makes strong tea but also exposes stalk.

The fermenting room must be kept cool, damp and clean. The cement floor on which the rolled leaf is spread is washed down with water from time to time. The leaf is spread about $2\frac{1}{2}$ inches thick and is left to ferment for periods varying from two to three hours. The time of fermentation varies according to the degree of wither, to the temperature of the room and to the thickness of the spreading. Experience has shown that as fermentation proceeds the tea gathers strength but tends to lose pungency and briskness. The art of tea making lies in taking up the tea for firing just at the right time, determined partly by the aroma or "nose" of the leaf and partly by its colour, which should be red.

Tea is dried or fired in machines which are actually endless perforated metal trays through which hot air is blown. The air is fan-drawn through tubes, heated in a furnace, and then forced into the bottom of the dryer where it first meets the nearly dry tea and then passes up to the moister tea till it finally meets the incoming tea fresh from the fermenting room. The hot air as it enters the dryer should be about $180-200^{\circ}\text{F}$. and as it leaves it should not be cooler than 120°F . This latter temperature can be obtained by altering the speed of the moving trays or the thickness of spread of the leaf. A temperature of 120°F . is insisted on because this ensures the stopping of the fermentation process.

Tea is dried in North-East India in two processes. The first fire is to "12 annas," i.e., three-quarter of the moisture is driven off and the leaf then contains about 30 per cent. moisture. The second fire is usually carried out in smaller machines at 180°F . and the tea dried to about 3 per cent. moisture.

When the tea comes from the dryer it is a mixture of long leaf and fine leaf. This mixture is now sorted. In factories where the grading of the tea is a special point, the leaf is first put through long rotary sieves which make about 25 revolutions per minute. The first sieve is usually of 13 or 14-mesh and the tea which falls is composed of the fine broken leaf and "tip." This mixture goes by the name of Broken Orange Pekoe or B. O. P. The spill from the first sieve then goes through a second one of 11 or 12 mesh and the leaf which falls is longer than that from

the first sifting and composed largely of the first leaf of the shoot. This is called Orange Pekoe or O. P. The spill is then put through a breaking machine and again sifted, this time probably through a mechanical sorter giving coarse grades resulting from the second and third leaves and the stalk. These coarser grades are known as Pekoe, Pekoe Souchong. The finest flakes are known as Fannings and the powdered tea as Dust. There are other grades such as Flowery Orange Pekoe, Fannings and so on, although only a few grades are very definitely demarcated. Throughout the grading process stalk is carefully picked out either by hand or by a stalk extracting machine.

It is usual to bulk the tea and then to pass it quickly through a dryer at about 150°F. before it is packed. During the sorting, tea picks up moisture and often by the time it is ready for packing contains 8-10 per cent. moisture. The drying before packing is designed to reduce the moisture content to 6 per cent. which is sufficient to allow for mellowing of the tea but not enough to allow the tea to go mouldy. The tea is packed mechanically in lead or aluminium lined chests generally of three ply wood. When sufficient tea to make an invoice or "break" has been made, it is sent to Calcutta or London for sale.

WORK OF THE SCIENTIFIC DEPARTMENT.

The laboratories of the Scientific Department are situated at Tocklai in the Jorhat district of Assam. A small laboratory is also in use at the Indian Museum, Calcutta. At Tocklai there are only 5 acres under tea but the main field work is carried on at Borbhetta about 1½ miles away, where 42 acres are out under tea for experiment.

The fundamental laboratory problems are chemical ones and the problems of the Mycological, Bacteriological and Entomological Departments in many cases eventually become chemical ones. This is more so since the possibility of disease treatment through the treatment of the bush has been recognized.

A detailed soil survey of the tea districts has been made and this is backed by field trials carried out in various districts and on all classes of soils. The result is that manurial suggestions can be made with great confidence. It is becoming increasingly a custom for a garden to obtain scientific advice before it embarks on a manurial programme.

The soil acidity problem is a major one and the limits of acidity and alkalinity tolerated by tea have been indefinitely fixed. Closely allied with this study is that of the work on soil bacteria.

The study of the changes going on during tea manufacture is now greatly assisted by a small, electrically driven experimental factory at Tocklai. Most of the study so far has been related to tea tannin and its changes. Experiments in factories are carried on throughout the season and the empirical side of tea manufacture is fairly well understood. The purely scientific side is however almost untouched.

In the Mycological and Entomological laboratories the life-histories of all the pests and blights common to tea have been studied and worked out. The control methods resemble those used in other branches of agriculture but continuous study is being devoted to the relationship of the disease to the condition of the bush.

At Borbhetta, pruning, plucking, manuring and cultivation experiments are made. All the tea at Borbhetta is young tea so that the problems of pruning old tea cannot be studied there. The plucking experiments which are in progress go to show that this operation is perhaps the most difficult on the garden in that it requires much discretion and experience. The incorrect plucking of an area may lose more crop than can be gained by liberal manuring.

The use of phosphatic manures has been extensively studied both in connection with their influence on green crops and on tea. The trial of nitrogenous manures on tea shows that the bush responds well year after year to chemical manures showing a much greater increase with this type of manure than with organic manures, but that with continued use of this manure the yields tend to even up. Potash and phosphoric acid used alone have been shown to give no appreciable increase in leaf.

So far as cultivation is concerned, all experiments go to show that the keeping of the soil clean rather than soil disturbance is what is needed.

Each cold weather, lecture courses are held for planters. These courses consist in lectures on chemistry, entomology, bacteriology and mycology as applied to practical tea problems and also in field demonstrations. The value of these courses is great, especially so far as field work is concerned. The oldest tea on the station was planted thirteen years ago and much of the tea is eight years old. The blocks, treated differently, have received consistently the same cultural or plucking treatment, during the period under experiment. The result of such treatment, as exemplified by the appearance of the bush and the cropping records, is invaluable to the practical planter and carries much more weight with him than does any amount of literature.

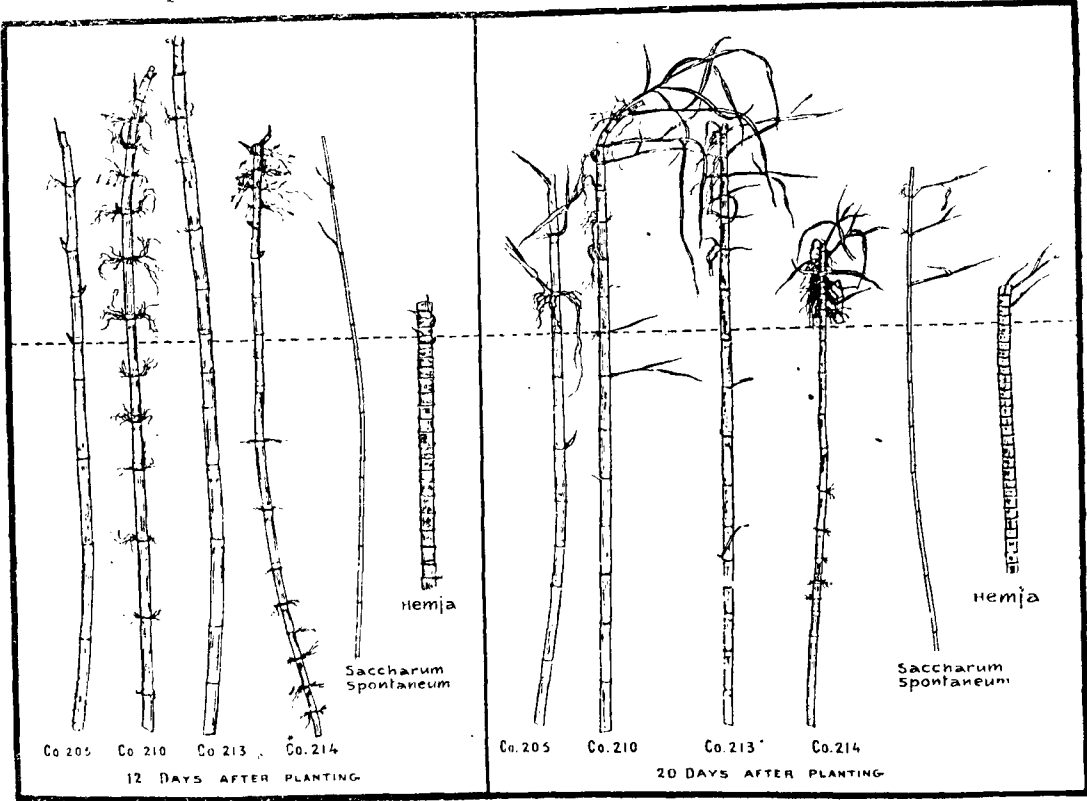
Apart from the small areas mentioned above, most of the tea is still very young. The value of the station is therefore increasing greatly annually.

WHAT PORTION OF THE SUGARCANE TO PLANT?

THAT immature canes and immature parts of canes generally germinate quicker than mature canes or mature parts of canes, would be well within the experience of most growers. The cane in the field ripens from below upwards, i.e., the bottom joints ripen first, then the joints above them, and so on till even the topmost joints are more or less ripe. It is at this stage that the cane crop in the field is considered ripe and is harvested.

The leaves on the sugarcane plant also cease to function and die from the bottom nodes upwards. In certain of the Indian canes the dead leaves remain attached to the canes, while in most tropical kinds they drop off. Portions of canes, which carry such dead leaves or have dropped them off, represent fairly ripe portions of the canes; and the rest of the canes—the portions above the dead leaves—are comparatively unripe.

In the illustration (drawn from photographs) which is of whole canes of certain varieties planted for germination, the dotted line passes below the highest dead



leaf in each of the canes. It thus divides each cane into (1) the upper unripe portion and (2) the lower riper portion. Four of the popular Coimbatore seedlings, a fairly important indigenous Indian cane, Hemja, and the wild grass *Saccharum spontaneum* were included in the experiment. The difference in germination between the ripe and unripe portions of the canes is fairly marked and has a lesson for the sugarcane grower.

A quick and vigorous germination is an asset of considerable importance in the growing of sugarcanes. In the event of an unsatisfactory germination, the filling up of gaps is not always possible and, where possible, not quite satisfactory. The plants used in the filling do not generally catch up to the rest of the crop. The desirability of planting unripe canes or unripe portions to ensure a good germination is obvious. [T. S. VENKATRAMAN.]



PRODUCTION OF SUGAR DIRECT FROM CANE IN INDIA DURING THE SEASON 1927-28.

As in the previous year, twenty-six factories making sugar direct from cane worked in India during the season 1927-28. Eleven of these are situated in the province of Bihar and Orissa, ten in the United Provinces, two in Bombay, Madras and one in Burma. I take this opportunity of expressing my thanks to the proprietors and the managing agents of these factories for supplying the statistics worked up in this note.

The table below shows the total quantity of cane crushed and sugar made by the factories in (1) Bihar and Orissa, (2) the United Provinces, and (3) Bombay and Madras Presidencies and Burma.

The production of sugar direct from cane by factories in India totalled 18,45,752 maunds or 67,684 tons during the season 1927-28, as compared with 17,16,426 maunds or 62,941 tons during the previous season.

There was thus an increase of 1,29,326 maunds or 4,743 tons in the output of sugar during the campaign of 1927-28 as against 1926-27.

	Bihar and Orissa		United Provinces		Bombay, Madras and Burma		GRAND TOTAL	
	1926-27	1927-28	1926-27	1927-28	1926-27	1927-28	1926-27	1927-28
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
Cane crushed	94,51,343	1,00,70,812	89,08,582	91,63,925	18,47,328	21,73,152	2,02,07,253	2,14,07,880
Sugar made	8,19,920	8,86,272	7,06,952	7,40,088	1,89,554	2,19,392	17,16,426	18,45,752
Molasses obtained	3,94,475	3,72,379	4,33,756	3,90,928	63,816	84,306	8,92,017	8,47,613
Recovery per cent.	8.67	8.80	7.93	8.07	10.26	10.09	8.49	8.62

It will be noticed from the above table that in the year 1927-28, the supplies of cane available for crushing were considerably larger in all the provinces than in 1926-27.

The average percentage recovery of sugar in India also shows an improvement, having risen from 8.49 in 1926-27 to 8.62 in 1927-28. The highest recovery is shown by a factory working thick cane, its average for the whole season being 11.1 per cent. In Northern India where thin or medium thick canes are crushed, a factory using the carbonatation process showed its average for the season as 9.92 per cent. sugar on cane. The highest recovery shown by a sulphitation factory is 9.4 per cent. on cane.

During the season 1927-28 India's production of molasses by modern factories making sugar direct from cane totalled 8,47,613 maunds as against 8,92,047 maunds in 1926-27, or a decrease of 44,434 maunds over the previous season. This is due to the increased recovery of sugar this year.

If we take a review of the last four seasons' average percentage recovery of sugar from cane as given in the table below, we find the factory side of the industry showing a satisfactory improvement. The most important subject now in connection with the factory industry is to develop the agricultural side of the industry so that the factories may get supplies of an early ripening cane in sufficient quantity to enable them to open the campaign early and that larger crops of well grown cane may be raised from the same area of land to compensate for the drop in the price of cane which has resulted from the low sugar prices now prevailing.

Provinces	RECOVERY PER CENT.			
	1924-25	1925-26	1926-27	1927-28
Bihar and Orissa	7.96	7.98	8.67	8.80
United Provinces	7.23	7.88	7.93	8.07
Bombay, Madras and Burma	8.14	8.98	10.26	10.09
Total for India	7.81	8.07	8.49	8.62

Statistics regarding the production of refined sugar by refineries in India during the season 1927-28 will be collected, collated and published in due course. [WYNNE SAYER.]

A BACTERIAL DISEASE OF COTTON.

The bacterial disease of cotton known as Angular Leaf Spot has recently assumed serious proportions in the Sudan. Hitherto, successful methods for its control have not been devised because the conditions for favouring or checking the disease were unknown. It could become prevalent under widely different climatic conditions, varying from desert to wet tropics, and further, its occurrence was in-

dependent of air temperature and soil acidity or alkalinity. R. E. Massey, however (*Annals of Botany*, 41, 497), has demonstrated a close correlation between soil temperature and the incidence of the disease. The experimental work was carried out on seedlings in boxes and also in the field, the temperature readings being taken at a uniform depth of 2 in., namely, that at which the seed is planted. Infection appears to be confined to a definite range of soil temperature. Whereas at 11°-20°C. it is slight, and not usually serious if conditions are favourable for the growth of the seedling, at 21°-26°C. infection is severe. At still higher temperatures, however, the intensity decreases, at 28°C. little or no infection being obtained, and at 30°C. the plant is generally immune. Preliminary experiments were also carried out with artificial inoculation, healthy seedlings being sprayed with water containing a suspension of the bacteria. If a cooling current of air was directed along the spray so that the soil and air temperatures were reduced from 34° to 22°C., marked infection was obtained. This furnished indirect support to Faulwetter's theory that splashing of raindrops was a means of transmission of the disease. [*Nature*, No. 3060, Vol. 121].



SOME EFFECTS OF LATE DEFOLIATION ON COTTON.

THE following is an abstract from *Bulletin 238, South Carolina Agricultural Experiment Station of Clemson Agricultural College*, by Mr. C. A. Ludwig :—

INTRODUCTION.

Occasionally a severe outbreak of leaf-eating insects in the autumn or late summer makes it necessary for the cotton farmer to decide whether or not to have recourse to any measures for combating them. The decision adopted depends of course upon the farmer's notion as to how heavy his loss is apt to be and whether or not any saving effected by such measures will more than pay the cost. But there is an idea, more or less common, that the loss of leaves late in the season is as much an advantage as a disadvantage and perhaps even more so. Some are even apt to welcome an attack by the cotton leaf worm at this time. This insect, *Alabama argillacea*, Hubn., migrates annually from Mexico, and by autumn often occurs in immense numbers. In such cases cotton plants are often stripped almost completely of their leaves. This defoliation permits the sunshine to reach the bolls more completely than when the leaves are still on the plant. The belief is that this causes the bolls to mature sooner and that the gain in maturity thus secured is more than enough to offset any reduction in yield.

It is understood by all that the effect of this worm on yield could hardly be other than a decrease. The effect on rapidity of maturity is more open to question, but there is at least room for suspicion that the impression mentioned above is mistaken. This situation led us, when a convenient opportunity was presented in 1925, to carry out some experiments to test the matter. We were interested in the amount

of reduction which might be produced in the yield but more particularly in the effect of defoliation on the rate of maturity.

It is realized in reporting on this work that there is considerable danger involved in drawing conclusions from a single season's results. However, the possibility of repeating the work at all soon seems to be remote; and it does not seem best, therefore, to withhold the data pending such a repetition. They are accordingly presented here, with such conclusions as seem to be justified from them.

METHOD OF TESTS.

In the exceedingly dry summer of 1925 we had three plots of upland cotton, all of which received the same treatment except for the amount of water which they received. One plot received no water except the rainfall, one received irrigation water to a moderate extent, and one received a great deal of water. Plot 1 was very dry and the crop suffered much from the dry weather, plot 2 suffered little or not at all, while plot 3 was so wet that the plants were smaller than those in plot 2 and were somewhat red in colour.

In each of these plots we selected three lots of forty plants each. One plant in the late defoliated lot in the moderately irrigated lot was lost, however, so that only 39 were concerned in the data recorded from it. The plants in each plot were numbered from 1 to 40 and were so arranged that the plants of the different lots alternated with one another throughout the plot; i.e., the No. 1 plants were grouped together, No. 2's together, and so on. The plants chosen were equal as nearly as possible in vigour and in severity of competition from neighbouring plants. The plants of the first lot were allowed to retain their leaves, those of the second lot had the leaves removed on August 20, and those of the third lot had the leaves removed three weeks later, on September 10. It was planned by this means to simulate a very severe attack by the cotton leaf worm at two different stages in the maturity of the bolls.

Records were made, with the exception of the check plants, which were used in another study also, by applying a numbered tag to each fruit on the day of blooming and then recording the date of shedding or maturity of the resulting boll. No effort was made to identify the bolls with the plants which bore them, but only to secure the history of each boll. In the case of the check plants each fruit on each plant was observed at regular intervals from the time it first became distinguishable as a square (bud) until it had shed or matured, and its entire life history was recorded. This method of observation entailed more handling of the plants, especially earlier in the season, than the other one mentioned. There is evidence that such treatment has a deleterious effect on the plants, and therefore the results from the check plants may not be strictly comparable with the others. The evidence from the data secured, however, as will be shown later, is such as to indicate that any errors thus introduced into the results do not invalidate the conclusions drawn but, rather, strengthen them.

At the first date of defoliation, boll opening was about to begin in the dry plot; and at the second date it was very far advanced, considerably over half of the bolls having opened. In the irrigated plots boll opening began a few days to a week after the early defoliation and many more than half the bolls opened after the second defoliation. A more detailed discussion of the relative conditions in the three plots is reserved for another paper. The present statement and any further data presented along this line in the following pages are merely for the purpose of giving the background for the present study.

SUMMARY AND CONCLUSIONS.

An investigation conducted during the summer of 1925 in two irrigated plots and one unirrigated plot of cotton to determine the effect of late defoliation on the rate of maturity, yield, and quality of the crop showed:

1. That the yield, both in size of bolls and in number of bolls, is reduced by defoliation if carried out long enough before maturity, the effect on size being the more easily observed.

2. * That the effect on the quality of the lint is not great unless the defoliation occurs a good while before the maturity of the bolls concerned, in which case the fibre is seriously weakened.

3. That late defoliation causes the death of most of the twigs and of many of the plants as a whole if the soil is moist, but that no such result follows if the soil is dry or if the defoliation occurs earlier.

4. That defoliation, contrary to a belief held in many places, delays maturity rather than hastens it.

5. That the effect on yield and rate of maturity is altered by the time at which the defoliation occurs. The earlier it occurs before the ripening of the crop the greater will the deleterious action be.

6. It follows from these considerations that an attack by the cotton leaf worm can never be anything but a piece of bad fortune, the seriousness of which will depend on the severity of the attack, the time when it occurs, and the weather following and immediately preceding the attack. Whether or not it will pay to combat the pest is of course another question in which the above conclusion is only one of several factors. But no farmer has cause to be congratulated because the pest has appeared.

TOBACCO CONSUMPTION OF THE EMPIRE.

WE have received the following for publication:—

The expansion of the world's consumption of tobacco, the decline in popularity of pipes relatively to cigarettes, the striking increase in the demand for Empire

* Lint quality was determined by the examination of the cotton of four different pickings for each treatment, by two expert classifiers who graded it for length and quality.

tobacco and the general recent improvements in its quality are among the main points discussed by the Imperial Economic Committee in their Tobacco Report (published by H. M. Stationery Office Cmd. 3168, price 9d. net). The problems facing those responsible for the future of the still small but important Empire tobacco trade receive detailed attention in this survey.

In 1921, states the Report, the Empire supplied 3.3 per cent. of the leaf tobacco imported into the United Kingdom and in 1927 the figure had risen to 18.4 per cent. It is estimated that 37 per cent. of the pipe tobacco consumed in the United Kingdom in 1927 consisted of Empire leaf, but only slightly over 1 per cent. of the cigarette tobacco. Over 250 brands of Empire tobacco and 40 to 50 brands of Empire cigarettes have been placed on the British market.

While in 1914 the annual average consumption in the United Kingdom was 2.4 lb. per caput of the population, in 1927, 3.4 lb. were consumed, "indicating a rapid increase due undoubtedly to the extension of the cigarette habit and to smoking on the part of women." Strictly comparable statistics for other countries were difficult to obtain, but it has been estimated that in 1926 Belgium's consumption was 6.6 lb. per caput, United States of America's 6.02 lb. and Germany's 4 lb.

TRIUMPH OF CIGARETTES.

A striking feature in the United Kingdom has been the change in recent years from pipes to cigarettes. In 1907 cigarettes accounted for 23.8 per cent. of the total, as against 71.1 per cent. pipe tobacco and 5.1 per cent. cigars; in 1924 cigarettes had risen to 58.5 per cent. and pipes and cigars fallen respectively to 40 per cent. and 1.5 per cent.

"The evidence we have received from trade sources," the Committee adds, "is to the effect that the trend to cigarette smoking has continued since 1924 and some witnesses considered that pipe tobaccos now account for only one quarter of the consumption in the United Kingdom. It is, we think, probable that pipe tobacco does not now form more than 35 per cent. of the total tobacco consumption of the United Kingdom."

The advance of the cigarette in popular favour in recent years is not confined to the United Kingdom. Throughout Europe consumption now inclines towards cigarettes and the milder varieties of pipe tobaccos.

Even in Germany where pipe tobacco still predominates, a marked increase in the consumption of cigarettes has taken place. In the United States, pipe and chewing tobacco still is the greater part of the consumption but the proportion of cigarettes is increasing. Even in India the annual consumption of cigarettes is now about 6,500 million as compared with an annual figure of somewhat under 1,000 million pre-war. The cigarette is thus at present advancing in world-wide favour but the consumption per head appears to be highest in the United Kingdom.

WORLD PRODUCTION.

The position of world supplies receives full analysis.

For the years 1909 to 1913 the average annual world production of leaf, excluding India and China, was estimated, states the Imperial Economic Committee, at 2,304 million lb. For the years 1920 to 1922 this average was placed at 2,673 million lb. and in 1926 it is computed that 3,415 million lb. of tobacco leaf were harvested. Unfortunately equivalent figures for the earlier years are not available for India and China, for which two countries the crop in 1926 was estimated at 1,485 million lb. If this quantity be included the estimate of the total production of tobacco in the world in 1926 was 4,900 million lb. The United States of America and the British Empire provided approximately half of this world total.

Empire countries contributing to this quota were, in the order of their output, India, Canada, Union of South Africa, Southern Rhodesia, Nyasaland, Northern Rhodesia, Australia and Cyprus.

In the international trade in tobacco the Empire does not, however, occupy such a prominent position as the quantity of its production would suggest, for some of the countries which are the largest producers of tobacco are also the largest consumers. This is especially true of India and China. Only somewhat over one-fourth of the world crop—1,240 millions out of 4,600 million lb. in 1925—entered international trade channels, the rest having been consumed in the countries of production. Over three-fourths of the total export surplus of the world in 1925 was provided by the United States (39 per cent. of the total), the Dutch East Indies and the Balkans (each 16 per cent.), and Brazil (6 per cent.). The contribution of the whole of the British Empire was only about 4 per cent.

"EMPIRE" CONSUMPTION.

Whereas the Empire only supplied $7\frac{1}{2}$ millions out of the 228 million lb. imported into the United Kingdom in 1921, it supplied 41 millions to the 1927 total of 222 million lb. Further, seven out of the seven and half million lb. of Empire tobacco imported in 1921 were drawn from Nyasaland, India and British North Borneo, whereas in 1927 although these three Empire countries had raised their contribution to 24 million lb. the imports from Rhodesia and Canada had grown from negligible quantities to 17 million lb.

Between 1920 and 1924 the consumption of Empire tobacco expanded at a rate of 1,650,000 lb. a year, and between 1924 and 1927 at a rate of 3,200,000 lb. a year. British manufacturers withdrew from bond 1,546,000 lb. of Empire grown tobacco in 1919 as against 22,793,000 lb. in 1927.

"We believe," the Committee continue, "that, given on the side of the producers increased experience in production, strict attention to the quality of the

crop and the requirements of the British market, and, given, on the side of the manufacturers, and British public, cordial support for Empire products, a still greater rate of increase could be established."

Already in certain of the newer countries of the Empire, such as Southern Rhodesia and Nyasaland, the cultivation of tobacco is becoming for the time being the mainstay of farming and, therefore, of settlement.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

HIS EXCELLENCY THE VICEROY, accompanied by Lady Irwin and the Hon'ble Anne Wood, paid a visit to Pusa on 4th January, 1929. His Excellency was shown over the various Sections of the Institute and evinced much interest in all that he saw.



MR. F. NOYCE, C.S.I., C.B.E., I.C.S., has been placed on special duty in the Department of Education, Health and Lands, Government of India, with effect from 14th December, 1928.



DR. W. H. HARRISON, Imperial Agricultural Chemist and Joint Director, Agricultural Research Institute, Pusa, has been granted combined leave for 7 months with effect from 9th March, 1929, or a subsequent date. During Dr. Harrison's absence, Dr. J. Sen will officiate as Imperial Agricultural Chemist in addition to his own duties of Plant Biological Chemist.



MR. Z. R. KOTHAVALA, B.A., B.Sc., N.D.D., has been confirmed in the post of Assistant to the Imperial Dairy Expert in the Imperial Department of Agriculture with effect from 30th November, 1928.



MR. R. S. FINLOW, B.Sc., Director of Agriculture, Bengal, has been granted combined leave for one year with effect from 15th January, 1929.



DR. G. P. HECTOR, M.A., D.Sc., Economic Botanist to Government, has been appointed to act as Director of Agriculture, Bengal, *vice* Mr. Finlow on leave.



MR. H. C. E. PETERSON has been appointed Agricultural Engineer, Bengal, which post, while held by Mr. Peterson, will carry the pay of Rs. 800—50—1,000.

Mr. E. S. FARBROTHER, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bombay, has been granted leave on average pay for 8 months with effect from 11th April, 1929.



KHAN SAHEB J. D. BUXY, G.B.V.C., has been appointed to act as Superintendent, Civil Veterinary Department, Bombay, *vice* Mr. Farbrother granted leave.



Dr. KIRPA RAM MOHINDRA, B.Sc. (Agri. Punjab), Ph. D. (Lond.), has been appointed Mycologist to Government, Punjab, Lyallpur, on probation for 2 years with effect from 28th August, 1928, against a special temporary gazetted post pending the formation of the Superior Provincial Agricultural Service.



U THET SU, B.Ag., who has been appointed Mycologist, Burma, reported himself for duty at Rangoon on 15th October, 1928.



Mr. R. G. ALLAN, M.A., Principal, Agricultural College, Nagpur, has been granted combined leave for 11 months.



Mr. J. C. McDougall, M.A., B.Sc., has been appointed to officiate as Principal, Agricultural College, Nagpur, *vice* Mr. Allan granted leave.



Mr. S. G. MURKAR, B.Ag., M.Sc., Deputy Director of Agriculture, Western Circle, Amraoti, has been placed on special duty in connection with the economic survey of the Itki village in Berar.



Mr. W. H. COSSAR, Second Agricultural Engineer to Government, United Provinces, has been granted leave in India for four months from 1st October, 1928.

REVIEWS

Farm Machinery.—By ARCHIE A. STONE. (New York: John Wiley & Sons; London: Chapman and Hall.) Price 15s. net.

This book is much more than a descriptive catalogue of the usual types of farm machinery. Besides a very comprehensive description of the leading types of American agricultural machines and implements, it gives a comparative study of practical repair work for each implement mentioned. This is a novel feature and is very useful for educational purposes. The range of American machinery being quite different from the ordinary English productions, many of the implements described are not likely to be found outside of America.

The book is divided into ten chapters dealing with horse-drawn implements and other five chapters dealing with tractors as follows:

PART I—Chapter I Plows, II Harrows, III Grain Drills and Seeders, IV Corn Planters, V Cultivators, VI Mowers, VII Grain Binders, VIII Manure Spreaders, IX Potato Planters and Potato Diggers, X Threshing Machines.

PART II—Chapter XI Tractors, XII Tractor Carburettors, XIII Magnetos and Ignition, XIV Repairing, XV Locating Tractor Troubles.

The chapters on the Fordson tractor are particularly clear.

The book is well printed on good paper and the illustrations and diagrams seem to be very well done. The use of this book, however, in India would be practically confined to reference work and it would not be suitable as a text-book [G. S. H.]



Manual of Dairy Farming.—By B. K. GHARE, L.Ag. (Bom.) MACMILLAN & Co., CALCUTTA. Price Rs. 3.

In this book the author attempts to put in print, for the benefit mainly of the students of the agricultural colleges, his knowledge and experience gained as a tutor in the subject of dairy farming. The book has been written in plain language to provide, for all interested in Indian dairying, information on the various branches of dairy farming, but particularly on the feeding of animals. The method of dealing with the subject is rather brief but the book as a whole should be instructive to all those who are in the line. To the dairy man, the book may be of academic rather than of practical interest though the author is not concerned to discuss the latest technical investigations into the dairy problem. It must, however, be re-

membered that dairy farming on scientific lines is still in its infancy in India, and whatever information the book provides on dairy farming, it should form a welcome addition to any library.

In part I of the book, on the rudiments of agriculture in chapters 1 to 3, the author deals in a suitable manner the subjects of soil, manure and cultivation. Part II, on cattle management, contains chapters 4 to 7 dealing with the housing, management and feeding of cattle. The information provided under these heads is very useful, while the embodying of results of experiments carried out at various centres in the country on animal feeding, brings the information on this subject most up-to-date. In part III, on milk and its products, in chapters 8 to 11, the author deals with the subject of milk, milk products, the various tests for these, and dairy bacteriology. The information provided on these subjects though not meagre could well have been supplemented by the knowledge gained in other countries and which could with advantage be applied to developing dairying in this country. In this part of the book, the author has done well to include the subject of dairy bacteriology. However elementary the information provided in this chapter, it is enough to give the reader an idea of the importance of cleanliness in dairy matters. Part IV, on cattle breeding, contains chapters 11-13, which deal with the principles of breeding and with the various breeds of cattle and their breeding. In the last portion of the book in part V, the author gives useful information in dairy economics.

The book is well printed and suitably illustrated. It deals with the dairy problem from an all-India point of view, and the fact that it is the only publication of its kind available on Indian dairying, makes it all the more valuable as a handbook to all interested in the dairy industry in this country [Z. R. K.]

CORRESPONDENCE

AGRICULTURAL IMPLEMENTS SUITABLE FOR INDIA.

To

The Editor, *The Agricultural Journal of India*.

Sir,

I have just read with interest the last of Mr. Cliff's very stimulating articles on agricultural implements suitable for the use of the Indian cultivator.¹ Mr. Cliff has so evidently devoted a considerable amount of time and thought to the necessary modifications he suggests in the plough, that it is surprising that he has not mentioned one obvious compensation for the difference between the furrow width and the draught width, namely, yoking the animals more closely together. It would seem easier to bore two or four extra holes in the yoke than to adapt a plough, as he suggests, and there is no reason that I know, why the animals should not work as close together as possible, that is, without actually touching. The difference of 11" which he mentions can in this way be reduced to an almost negligible amount, and I have found that ploughs like the Jat or the Monsoon, to name only two, can be worked easily. With almost everything else that Mr. Cliff writes I agree, and while I do not suggest that close yoking would solve all difficulties, it is such a simple remedy that it might have been mentioned.

Yours faithfully,

R. CECIL WOOD,

Professor of Agriculture,

Imperial College of Tropical Agriculture.

TRINIDAD :

21st August 1928.

¹ *The Agri. Jour. India*, Vol. XXII, Pts. 4, 5 and 6 ; Vol. XXIII, Pt. 2.

NEW BOOKS

On agriculture and allied subjects

1. Farm Cost Studies in the United States: Their Development, Applications and Limitations, by Merrill K. Bennett. Miscellaneous Publications No. 4, Food Research Institute, Stanford University, California. Pp. ix+289.
2. Comparative Morphology of Fungi, by Ernest A. Gäumann. Translated by C. W. Dodge. Pp. 701; 406 illus. (London: McGraw Hill Publishing Co.) Price, £1 17s. 6d.
3. Principles of Plant Pathology, by C. I. Owens. Pp. xii+629. (London: Chapman and Hall.) Price, 23s. 6d. net.
4. The Biology of Insects, by George H. Carpenter. Pp. xv+473; 16 plates. (London: Sidgwick and Jackson). Price, 16s. net.
5. The Evolution and Classification of Soils, by E. Ramann and C. L. Whittles. Pp. xii+128. (Cambridge: Heffer & Sons.) Price, 8s. 6d.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

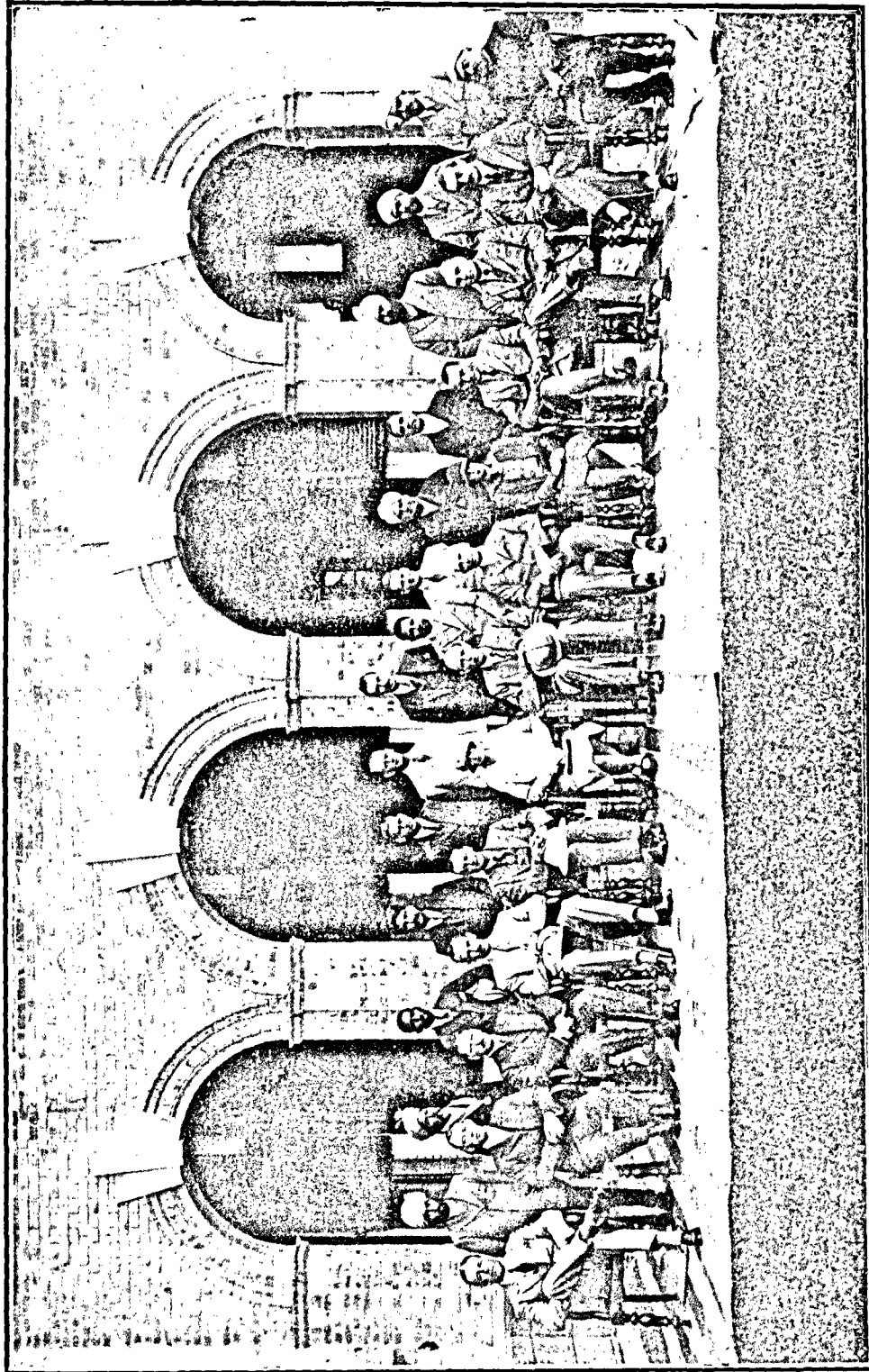
1. Foot-rot and wilt of Antirrhinums caused by *Phytophthora pini* var. *antirrhini* n. v. by S. Sundararaman, M.A., and T. S. Ramakrishnan M.A. (Botanical Series, Vol. XVI, No. 3.) Price, Re. 1 or 1s. 9d.
2. Non-dehiscence of anthers in Punjab-American Cottons, by Trevor Trought, M.A. (Botanical Series, Vol. XVII, No. 1.) Price, As. 4 or 5d.
3. Studies in the Wilt Diseases of Cotton in the Bombay Karnatak, Series I, by G. S. Kulkarni, M.Ag., and B. B. Mundkur, M.A. (Botanical Series, Vol. XVII, No. 2.) Price, As. 9 or 1s.
4. Nitrification of Calcium Cyanamide in some Indian Soils, by J. H. Walton, M.A., M.Sc. (Bacteriological Series, Vol. II, No. 3.) Price, As. 10 or 1s.
5. A Contribution to our Knowledge of the Thysanoptera of India, by T. V. Ramakrishna Ayyar, B.A., Ph.D., F.Z.S. (Entomological Series, Vol. X, No. 7.) Price, Re. 1-9 or 2s. 6d.

Bulletin.

6. A Preliminary Note on the Rice Crop in the United Provinces, by R. L. Sethi, M.Sc., B.Sc. (Agri. Edin.), M.R.A.S. (Lond.) (Bulletin No. 186.) Price, As. 7 or 9d.

Reports.

7. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, the Physiological Chemist, the Government Sugarcane Expert and the Secretary, Sugar Bureau), 1927-28. Price, Rs. 2-6 or 4s. 3d.
8. Annual Report of the Imperial Institute of Veterinary Research, Muktesar, for the year ending 31st March, 1928. Price, Rs. 1-6 or 2s. 3d.



HIS EXCELLENCY THE VICEROY, LADY IRWIN AND THE GAZETTED STAFF OF THE AGRICULTURAL RESEARCH INSTITUTE, PUSA.
(4th January, 1929.)

ORIGINAL ARTICLES

NOTE ON THE AMERICAN COTTON CROP FAILURE IN THE PUNJAB.

BY

W. ROBERTS, B.Sc.,

British Cotton Growing Association (Punjab), Ltd., Khanewal.

THE history of American cotton in the Punjab for the past 9 or 10 years has been one of occasional serious crop failures. In 1919 the crop failed generally in most of the colonies and again in 1921 there was a partial failure, though the 1920 crop was fairly good. The next big failure took place in 1926 and this was fairly general throughout the drier portion of the American cotton belt, which comprised at least $\frac{4}{5}$ ths of the American cotton area. In 1927, there was only a partial failure, mainly in the Khanewal Tehsil, and within a distance of perhaps 40 to 50 miles of the Khanewal Junction. In 1928, *i.e.*, in the present year, there has been a partial general failure again.

To realize the money value of what a poor crop in American cotton means—even assuming that the loss is only 3 maunds per acre (*i.e.*, half the Government estimate of 6 md. for a full crop)—on an area of one million acres, it would be equivalent to 3 million md. or 2 lakhs of bales, which at Rs. 200 per bale can be valued at rupees four crores. Losses on individual estates are comparatively much more serious than this. Thus at the B. C. G. A. Farm in 1927, the decrease in yield was over 9 maunds an acre on the average; in 1926, $7\frac{1}{2}$ md. an acre; and in the present year it is probably 6 md. an acre. In all cases, the decrease is estimated from 2 to 3 times the average decrease. It is very probable that in the case of general damage, the loss is in the region of 6 or 7 crores of rupees per annum.

It might be of interest to answer here the question which arises “Why grow American cotton.” The fact, however, is that the *desi* cotton in the present season, owing to untimely rains for one reason, has done even much more worse than the American, and those who sowed the larger portion of the crop in *desi* are bitterly regretting the same. The Punjab farmer has proved by experience that, in spite of bad years, American cotton on the whole gives him generally a better profit per acre.

THE CAUSE OF THE CALAMITY.

Various theories have been advanced. In a report issued after the 1919 disaster, Mr. Milne, who was then the Economic Botanist at Lyallpur and is now the

Director of Agriculture, came to the conclusion that it was mainly due to low humidity and lack of water in September and October, which the zemindars had been using for wheat sowing, instead of applying it to cotton. This theory held the field after the partial failure of 1921, and was again put forward as a result of an enquiry conducted by Mr. Milne's Assistants in 1926. The present writer had always strongly disagreed from this theory, especially since, with the experience of 1926 at the B. C. G. A. Farm and surrounding tracts, where, owing to the rivers running very full in that year, water was ample. It seemed very far fetched to assume that lack of water would be the cause. Similarly at the Iqbalnagar Farm where the water supply was under control and a known factor, it is obvious that lack of water could not be advanced as a cause. In the Indian Central Cotton Committee Meeting of January 1927, the writer, referring to the failure of the Punjab-American crop of that year, said "that he did not think the failure was a question of under watering. He could assign no particular time to the commencement of the factors underlying the crop failure, but he thought the trouble had begun in July. He was unable to give any definite reasons for this."

Mr. Trought, the Cotton Research Botanist of the Indian Central Cotton Committee, has also been studying this question since 1926. Mr. Trought had rightly an open mind, and advanced various theories, the one which he favours most being that the trouble was due to 'high soil temperature.'

In 1927 the writer sent specimens of cotton to Mr. Trought, which he thought at the time were being attacked by 'Jassids', and which Mr. Trought reported on as being attacked by the 'White Fly' of cotton (Aleyrodid) and not 'Jassids'. In the letter acknowledging this, Mr. Trought says that the Entomologist's report on this pest is that it is not regarded as a serious pest of cotton. The writer is not aware that Mr. Trought ever advanced the theory that the 'White Fly' or 'Jassids', which are seen in late September and early October in the crop, could be the main cause of the trouble.

In the winter of 1928, the B. C. G. A. (Punjab), Limited, secured the services of Mr. Roger Thomas, B. Sc., late Member of the I. A. S., with some experience in Iraq and who had made an extensive tour of the cotton-growing States of the U. S. A. Mr. Thomas noticed 'White Fly' attacking tomatoes and pumpkins in April and May in the garden. Later, after the cotton crop had started growing in May and June, he noticed fairly general attack by the 'White Fly'. He reported the matter to Lyallpur, and asked if the 'White Fly' attacking tomatoes and pumpkins was the same variety as that attacking cotton. No reply was received, but as the attack continued to increase in intensity, the B. C. G. A. took the matter up with the higher authorities in July. Mr. Thomas then advanced the theory for the first time that in his opinion 'White Fly' was probably the main cause of failures of American cottons. He also suggested that accurate observations should be kept by way of survey, of the extent of the existence of 'White Fly'

and its effect on subsequent yields. In consultation with the Agricultural Department in Simla, he made several suggestions as to how best to carry out this investigation, and it is very pleasing to be able to record that the department has taken up the matter with vigour, and has, I believe, at present 6 or 7 Assistants working on this problem.

The Entomologist at Lyallpur, Mr. Afzal Husian, has already collected very valuable information, but we believe both he and the Director of Agriculture still hold that the 'White Fly' is not the main cause of the trouble. Mr. Milne has recently changed his views somewhat, and thinks now that the trouble is due to a form of 'heat stroke' which is something similar to the views held by Mr. Trought except that the latter had the roots in mind, whereas Mr. Milne is probably thinking of the leaves and of the plant as a whole. If either of these theories is correct, then there seems to be very little hope of getting over the trouble, whereas if it is proved that the 'White Fly' and possibly 'Jassids' are the cause, the remedy may well prove to be fairly simple.

It is perhaps advisable here to note in what way the damage appears to the eye. The plants generally fruit copiously, but the colour of the plant is somewhat pale and growth stunted. However, up to the end of September (or the first week or 10 days in October when crop is late as in the present season) there is little apparent damage. Then all at once bolls begin to open prematurely, and unopened bolls will be found to be soft to the touch. It is not infrequent to see a plant with 15 or 20 bolls of which no more than 2 to 5 open normally and give fully developed lint and cotton seed. In these prematurely opened bolls there is often no seed at all, sometimes a half developed seed. The fibre has no strength whatever, and in practice the pickers will refuse to pick these bolls, and they are left on the field and are useless.

The attack is always worse on the 4F crop and is comparatively much less on a crop like 289F. Thus at the B. C. G. A. Farm this year, we are anticipating 8 or 9 md. per acre from 289F and only two md. per acre from the 4F. Our *desi* crops, both *Mollisoni* and *Sanguineum*, are expected to give 9 md. per acre. In a normal year, we would have expected about 18 md. of *desi* and about 15 or 16 md. of American. The 'White Fly' attacks both *desi* and American, the latter to a much more serious extent than the former.

Our belief that the 'White Fly' is the main cause of the bad opening and low yields, is based on the following:—

(1) The 'White Fly' attacks the plant by sucking the juice and as many as 250 insects per square inch of leaf may sometimes be counted. The life-cycle will take only 20 days in the summer, which would enable the insect to rear four or five broods from May till the end of September. Such weakening of the vitality of the plant as would be brought about by the attack of the insect would account for the failure of the plant to ripen its bolls.

(2) It was observed in 1926 in a general way, and more accurately in 1927, that late sown crops gave much better yields than early sown. The following table gives the results for the Khanewal Farm for 1927 :—

Date of sowing	289F		4F		MOLLISONI	
	No. of plots	Average yield per acre	No. of plots	Average yield per acre	No. of plots	Average yield per acre
		Md. Sr.		Md. Sr.		Md. Sr.
3rd week April . . .	11	3 0	..	..	..	..
4th week April . . .	25	3 3	..	..	..	..
1st week May . . .	31	3 2	..	..	2	5 1
2nd week May . . .	39	3 9	7	1 5	30	7 3
3rd week May . . .	18	4 2	10	2 4	35	8 7
4th week May . . .	10	6 8	10	1 9	18	9 6
1st week June . . .	..	..	32	2 2	28	11 4
2nd week June . . .	..	..	20	3 4	31	11 5

It will be seen from this that while there was evidence of damage in 1927 everywhere, the latest sown crops gave practically double the yields of the earliest sown, and this could be accounted for by the late sown escaping one or more cycles in the insect's life. This observation has been applied as far as feasible to the present year's crop, and the results promise to be equally if not more instructive than the 1927 results.

(3) In previous attacks, the Agricultural Department and the Mycological Experts from Pusa and Lyallpur examined the crop generally from November onwards. As soon as the cold weather starts, the 'White Fly' practically leaves the cotton crop, but is found to a lesser extent on other crops such as turnips, etc. Its absence during the period when investigations were in progress might easily result in the significance of the attack in July, August and September being missed. The Pusa experts inform us that apart from some reference to cotton in China in 1805, no mention of this insect has been made as a serious pest of cotton.

(4) Efforts were made this summer to spray the crop with insecticides, and while no conclusive results are forthcoming, it would appear that the spraying resulted in a distinctly better crop. We believe the Entomologist at Lyallpur has already some interesting results with regard to effectiveness of the various spraying material

(5) Mr. Trought during the summer suggested the application of sulphate of ammonia in September. This has been applied to the current crop, and appears to be giving encouraging results. The crop where the ammonium sulphate was applied is looking much greener and growth is more vigorous. Fifty pounds of ammonium sulphate was applied to half an acre at the B. C. G. A. Farm, and definite figures of yield will be available on a small scale at the close of the picking season. Altogether large areas received doses of ammonium sulphate at sowing time and in July, as previous results had been encouraging.

(6) Another very significant observation is that some of the selections made by Mr. Trought seem to have withstood the attack in a remarkable manner. One or two strains, grown at the Khanewal Farm by him, bore what appears to be a full crop of fully matured bolls, when surrounded by the ordinary crop showing the disease in an acute form. It has been generally observed that 289F, a few ounces of the seed of which the writer brought to Khanewal in 1921, and which is so far not officially recommended by the Agricultural Department, and is at present, as far as we know, only grown by the B. C. G. A. Punjab, Ltd., and to a small extent by Col. Cole of Coleyana Estate, has also shown a very much greater resistance to the disease than 4F has done. Individual plants in the 289F crop can be seen by any one, here and there, throughout the crop, showing remarkable resistance to the disease and developing fairly normally.

All these observations seem to us to point to 'White Fly' as being probably the main cause of the trouble, and they also indicate the lines along which we hope to overcome the trouble in the future. To summarize, these are briefly :—

- (1) Later sowing, i.e., June sowing instead of May. In this connection it is interesting to observe that while up to 1921, it was the practice to sow American cotton in early April, the writer found by experience that a crop sown in May gave better results at Khanewal. It was only in 1926-27, however, that June sowings were tried on a large scale, and proved to give still better results.
- (2) Selection of resistant varieties. This ultimately will be the main solution.
- (3) The application of nitrogenous artificial manures and more especially late in the season, say in September.
- (4) Spraying especially in May and June, to check the disease in its early stages.
- (5) Destruction of the pest during the cold weather period. 'White Fly' has a very large number of alternate host plants. These are being studied by an Entomologist deputed to Khanewal from Lyallpur this winter. It is of interest to note that during the cold weather, the insect seems to take a very long period to get through its life-cycle, and this may possibly be the best time to attack it, should it be found to be the main cause of our trouble.

THE LATE BERNARD COVENTRY, C.I.E.

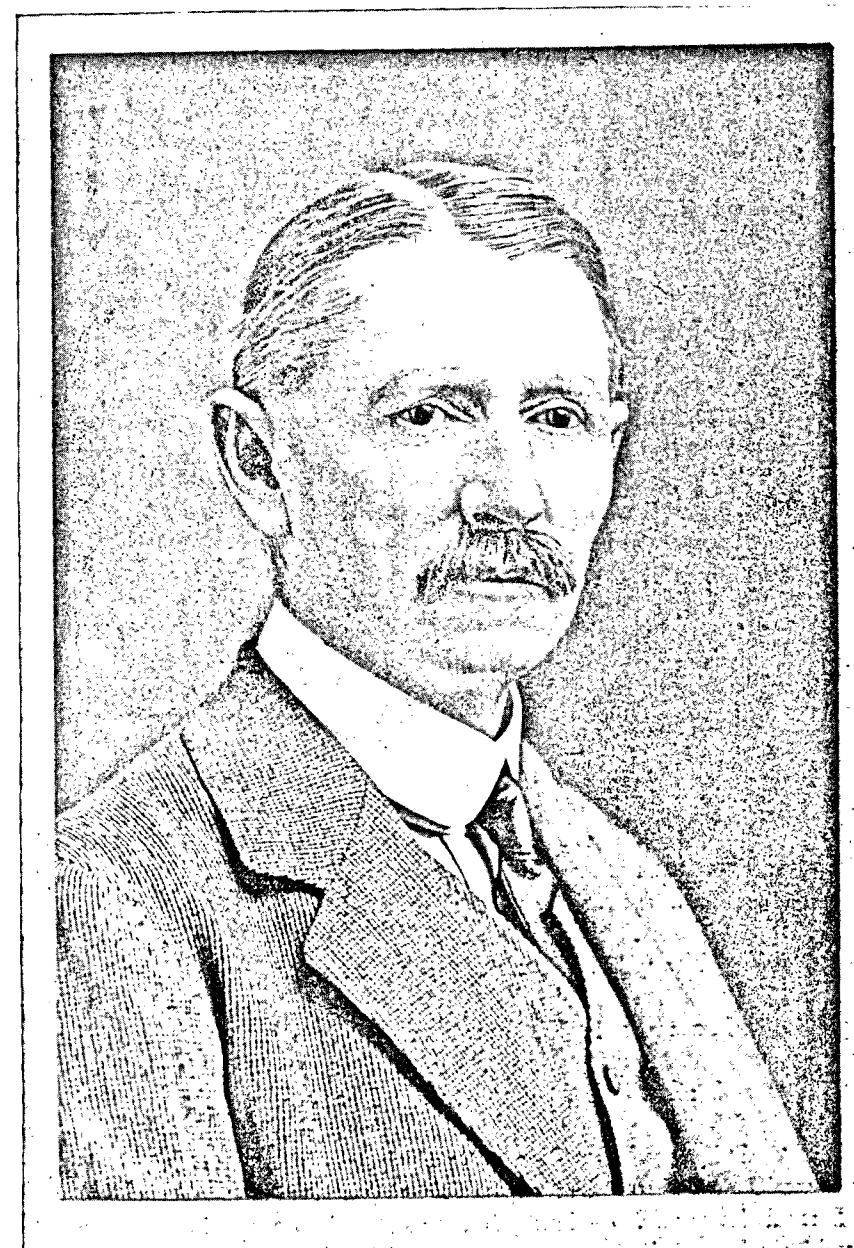
AN APPRECIATION.

Mr. Bernard Coventry, C.I.E., whose death is announced from England, was born on 10th December, 1859. After receiving a classical and scientific education at Beaumont College, Windsor, Mr. Coventry came out to India at the age of twenty-one as an indigo planter, in days when the indigo industry was in the heyday of its prosperity. He soon interested himself in scientific agriculture, and established in 1889, on his estate at Dalsing Sarai in the Darbhanga District of Bihar and Orissa, what it is not an exaggeration to describe as an agricultural research station on modern lines. The series of valuable experiments he initiated helped to raise the standard of farming on European estates in this part of the country and established his reputation as a skilled and practical agriculturist.

When the Government of Lord Curzon decided in 1904 to utilize a large part of Mr. Henry Phipps' munificent donation of £30,000 towards the establishment of an Imperial Agricultural Research Institute at Pusa, their choice for the post of Director fell upon Mr. Coventry. During the succeeding 12 years that Mr. Coventry was at the head of the Institute, he administered it with ability and contributed not a little towards its healthy development. For the last four years of his service, he held as well the post of Agricultural Adviser to the Government of India; his tenure of the combined appointment was a period of rapid and striking developments in the department. Considerable additions were made to the Imperial staff in almost all provinces, the Provincial and Subordinate services were reorganized out of knowledge and their pay and prospects were greatly improved. Extensive changes were made in the curricula of the Agricultural Colleges and the waning in their popularity that had set in was checked. Achievements of the utmost value were accomplished in regard to some of the most important of India's staple crops. The share Mr. Coventry had had in bringing about these developments was a very important one, and in appreciation of his meritorious services he was given a C.I.E.

On his retirement from the service of the Government of India in 1916, Mr. Coventry was invited by the Central Indian States to act as their Agricultural Adviser and he gave them the benefit of his ripe experience until 1919 when he left the country for good.

A man of great force of character, of sterling common sense and of high administrative ability, Mr. Coventry played a large part in the furtherance of the interests of agriculture in India. [D. C.]



THE LATE BERNARD COVENTRY, C.I.E.,
Director, Agricultural Research Institute, Pusa (1904—1916), and Agricultural Adviser to the Government of India (1912—1916).

COTTON SEEDS: THEIR ABSORPTION OF WATER, AND SPECIFIC GRAVITY.

BY

A. JAMES TURNER, M.A., B.Sc.,
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THE determination of the specific gravity of cotton seeds is not quite as simple a matter as might appear at first sight. There are two reasons for this: First, it is by no means easy to remove air bubbles which adhere to a cotton seed when it is immersed in a liquid; even in the case of naked-seeded varieties, the short remnants of the lint protruding from the seed surface provide an ideal means of entrapping air, while fuzzy-seeded varieties are of course even more powerfully armed for the same purpose; secondly, water is an unsuitable liquid, because it is rapidly absorbed by the mucilaginous seed-coats, thereby changing both the volume and specific gravity of the seed. The second objection may be removed by the use of some liquid hydrocarbon, provided it is first proved that the specific gravity of the seed remains unaltered in the liquid.

Some experiments on the subject were made by Leake* who states that he measured the weight of the seeds, and that the "volume and specific gravity of the seed are then determined by displacement in water". For the reasons already mentioned, the water-displacement method can hardly be regarded as satisfactory; it could only be so if the rate of water-absorption by the seed were so slow as not to affect appreciably the specific gravity of the seed during the period of the experiment after the addition of the water.

WATER-DISPLACEMENT EXPERIMENTS.

In order to test the method, therefore, some experiments were carried out with seed of Punjab-American 4F. This is a naked-seeded variety, so that in using it the difficulties from air-bubbles are reduced to a minimum. A number of seeds were carefully de-linted by hand; a small greenish tuft remained at the apex of each seed; in order to reduce still further the chances of formation of air bubbles, this small tuft and to some extent other adherent short hairs were removed by rapid-

* Leake, H. M. *Journal of Genetics*, IV, 1914, 44.

ly passing each seed through a small Bunsen flame. The seeds were placed in a previously weighed specific gravity bottle, and weighed. Distilled water was added to the specific gravity bottle, and the seeds were well shaken to release the air bubbles; the stopper was replaced in the bottle, and the bottle wiped dry: all this was done within one minute after adding the water to the seeds. The whole was then quickly weighed again. Even while weighing proceeded, water issued continuously from the orifice of the stopper, showing that the seeds were swelling through absorption of water. Fifteen minutes after the water had been added, the bottle was again wiped dry, and weighed. It was found that the apparent specific gravity had fallen by some 8 per cent. in this period. The experiment was therefore repeated and the first weighings made at much smaller intervals of time. A number of seeds were separated into two groups, according to their size, as small seeds and large seeds; the results obtained are shown graphically in Figs. 1 and 2 for the respective groups.

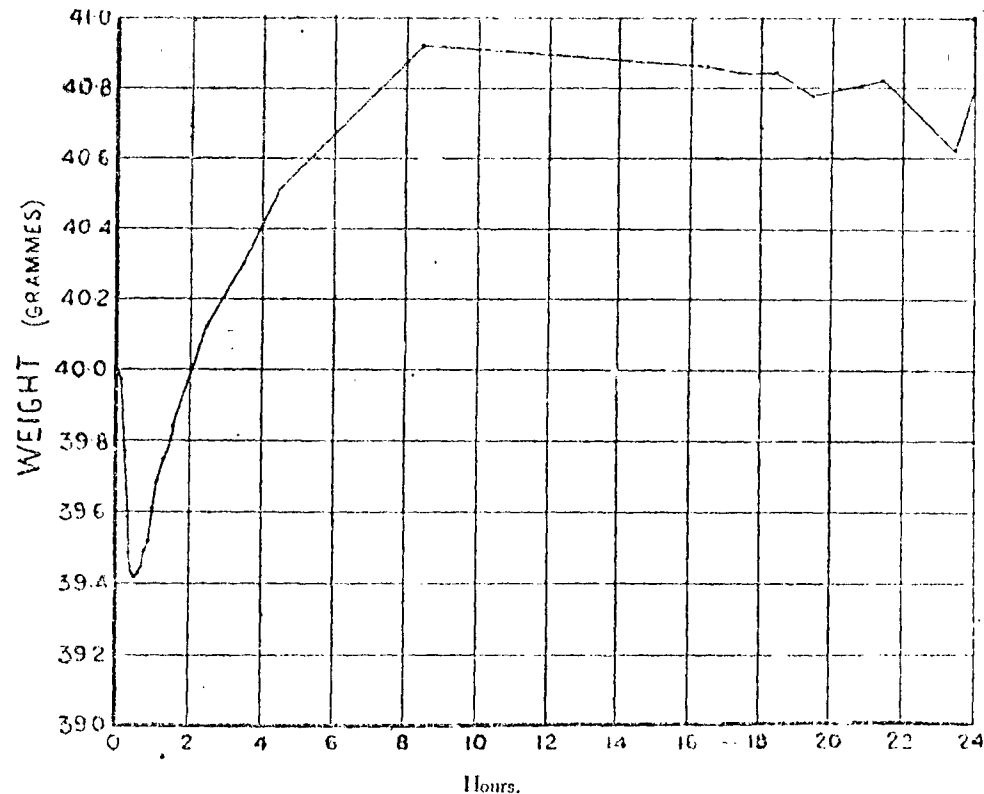


Fig. 1. Absorption of water by 100 small seeds of Punjab-American 4F cotton.

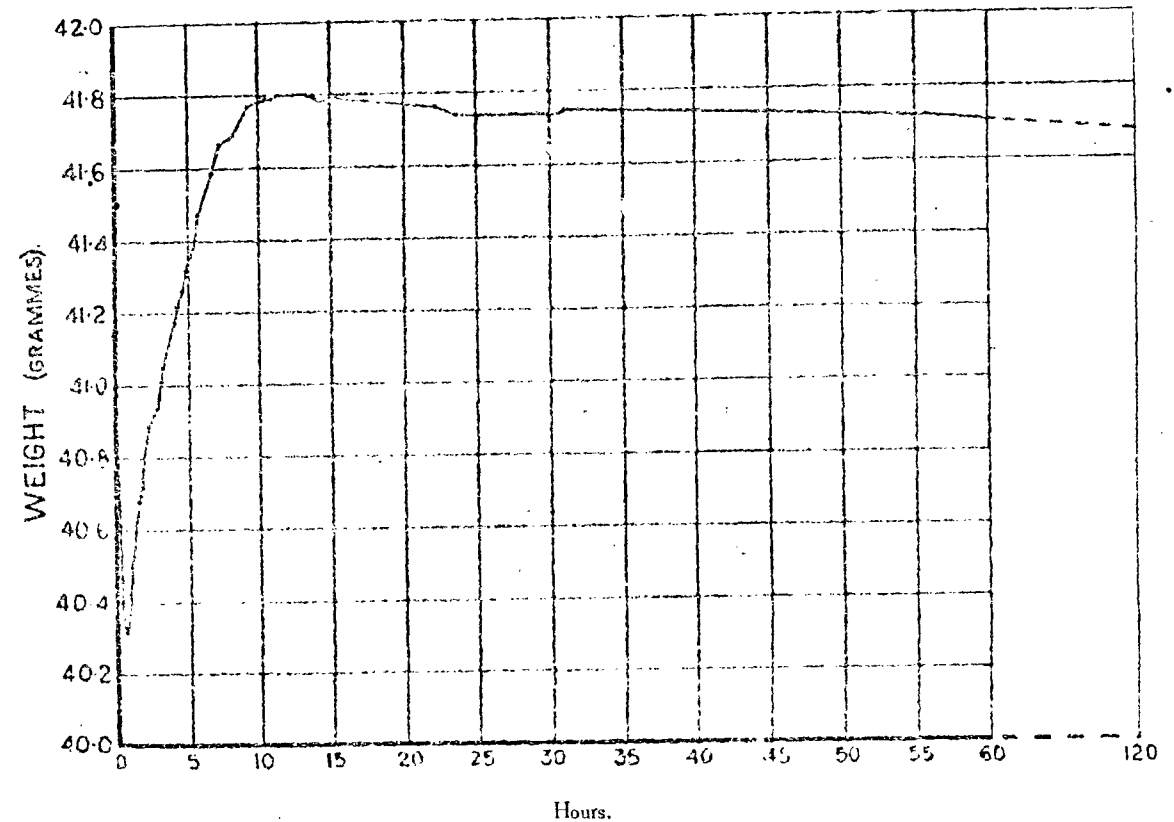


Fig. 2. Absorption of water by 75 large seeds of Punjab-American 4F cotton.

It will be observed that the change in weight follows the same curve in both diagrams. The observations in the case of the large seeds were continued for a much longer period than for the small seeds. The close resemblance of the curves throughout the first 24 hours (the whole of the period during which observations were made on the small seeds) shows that the sequence of events, as might be expected, was almost exactly the same in both cases. First, there is a period of rapid absorption by the seed-coats, which consequently swell greatly; this swelling is quite evident to the eye; the extent of the swelling is greater than the volume of the absorbed water, causing some water to be expelled from the specific gravity bottle, and the specific gravity of the seeds to be much reduced. The swelling continues for nearly half an hour, by which time the seed-coats have apparently attained their maximum distension, so that the volume occupied by the seeds can no longer increase by the absorption of water. But the absorption of water does not cease at this stage; as the seed-coats become permeated with water, the embryo within

naturally begins to absorb water too; now water absorbed by the embryo increases the mass of the seed without altering the volume, which is of course determined by the seed-coats; hence the water absorbed by the embryo tends to compensate for the water displaced by the expanding seed-coats. The absorption of water by the embryo appears to begin about 20 minutes after the addition of the water; during the next 10 minutes the change in weight is small, as water absorption by the embryo is increasing and the swelling of the seed-coats is nearly complete; at the end of this time water-absorption by the embryo gains the ascendancy, and the weight continues to increase for about the next 10 hours. Thereafter the weight remains fairly constant, even for the following 5 days (Fig. 2). It is, however, subject to small changes, because some of the seeds begin to burst their seed-coats; as the seed-coats burst, the volume increases and some water is therefore displaced from the bottle, and the specific gravity of the seed again falls. It appears from the curves that a slight fall in weight brought about in this way is sometimes followed by a rise in weight, doubtless due to the emerging growing-point absorbing water at a faster rate than its increase in volume.

From what has been stated above, it will be clear that the curves of Figs. 1 and 2 do not show the changes in *specific gravity* of the cotton seed, because in absorbing water the seeds undergo a change both in volume and in mass. The fall in weight during the first half hour shows the amount of water issuing from the bottle, and this is a measure only of the *difference* between the increase in volume of the seed and the volume of water absorbed by it; if these two volumes were equal, no water would issue from the bottle, but the specific gravity of the seeds would change, becoming more nearly equal to that of water. It is only if either the volume or the mass of the seeds alone changes that the curve can show the change in the specific gravity of the seeds. After the minimum weight has been reached, the volume remains constant and the mass increases, so that the rising portion of the curve during the next 10 hours shows the mass of water absorbed by the seeds at constant volume, and is a true indication of the increase in specific gravity. In order to determine approximately the actual specific gravity of the seeds at the conclusion of this experiment, they were removed from the specific gravity bottle, quickly dried on the outside, and weighed. During the course of the experiment, the water in the bottle grew dark in colour, and minute bubbles were given off by the seeds—possibly carbon dioxide as a product of respiration. Determinations were made of the specific gravity of the liquid after the experiment in each case; for the small seeds it was found to be 1.004 and for the large seeds 1.002 showing that the change in specific gravity of the water was negligible.

From the weight of the seeds after drying their surface, it was found that their specific gravity at the time of removal from the bottle was 1.09. Assuming that the volume of the seed at the minimum value of the curve was the same as when the seeds were removed from the bottle, the calculation of the specific gravity of the seed at this point showed it to be 0.97. The specific gravity, as determined within

90 seconds after adding the water, was found to be 1.029 for the small seeds and 1.036 for the large seeds, assuming the absorption of water and the change in volume to have been negligible in this period. These figures for specific gravity are, of course, only average figures for all the seeds; any diseased seeds would have a less specific gravity owing to the air-spaces enclosed within their seed-coats.

That the explanation which has been given above of the changes in weight is correct, is also indicated by some observations on the behaviour of the seeds within the bottle after the water had been added. In the case of the 100 small seeds, very soon after the water was added the seeds began to rise from the bottom of the bottle to the top, showing that their seed-coats had actually swollen so much by absorption of water as to make their specific gravity less than that of the surrounding water. After half an hour, however, 16 seeds still had a specific gravity greater than that of water. Thenceforth this number gradually increased, so that after three-quarters of an hour there were about 30 seeds heavier than water; after 1½ hours, 50 seeds; after 1½ hours, 60 seeds; while after 3½ hours, only 9 seeds were still floating; after 8½ hours, 4 seeds were floating. Similar results were obtained with the 75 large seeds. After 5 minutes there were only 5 seeds floating; other seeds then quickly rose, and after 7 minutes, 14 seeds were floating; after 15 minutes, only 12 seeds were left on the bottom, the other 63 floating; after 22 minutes there were 8 seeds still remaining on the bottom of the bottle; thereafter the number gradually increased, there being 10 seeds heavier than water after 36 minutes, 17 seeds after one hour, about 25 seeds after 1¼ hours, 54 seeds after 2¼ hours, and 61 seeds after 3 hours; after 4 hours, only 4 seeds were still floating; after 5 hours, 3 seeds and after 6 hours, only one seed—and this one seed remained floating for the rest of the experiment (*i.e.*, for 120 hours). The seed-splitting began after 14¼ hours.

DETERMINATION OF SPECIFIC GRAVITY USING LIQUID PARAFFIN.

As the water-displacement method of determining the specific gravity appeared to be unsatisfactory, two other methods were tried. One was the use of a volumometer, and the other the use of liquid paraffin instead of water as the displaced liquid. For the volumometer experiments, a type similar to Bremer's was used: this is described in Thorpe's "Dictionary of Applied Chemistry" (1926), Vol. VI, page 305, according to which this method "answers very well for porous bodies like cotton wool, the entangled air from which at once expands on the pressure being reduced." If therefore this method were satisfactory it would be as suitable for fuzzy seeds as for naked seeds. In all cases, however, the results obtained for the specific gravity of the cotton seeds were much higher than might have been expected from the water-displacement experiments, or from the subsequent liquid-paraffin experiments. It can easily be shown that too high results are bound to be obtained if the cotton seeds evolve moisture under reduced pressure; and it was eventually concluded that the cotton seeds were in fact evolving moisture, and that the method was therefore inapplicable.

From a consideration of its chemical and physical properties, liquid paraffin appeared to be a suitable liquid to use for the determination of the specific gravity of cotton seed. Experiments were therefore made in which liquid paraffin previously boiled to remove traces of water as far as possible was used instead of water, observations being made of the change in weight of the specific gravity bottle in exactly the same way as described in the case of the water-displacement experiments. The results obtained in different weighings are shown in Fig. 3. From this diagram it is clear that reliable results may be obtained by the use of liquid paraffin. From the reading of the weight made as soon as possible after the addition of the liquid paraffin, the specific gravity of the 100 small cotton seeds of average weight 71.8 mg. was found to be 1.063, compared with water at 83°F. A similar experiment with 75 large seeds of average weight 90.9 mg. gave 1.078 as their specific gravity compared with water at 81°F.

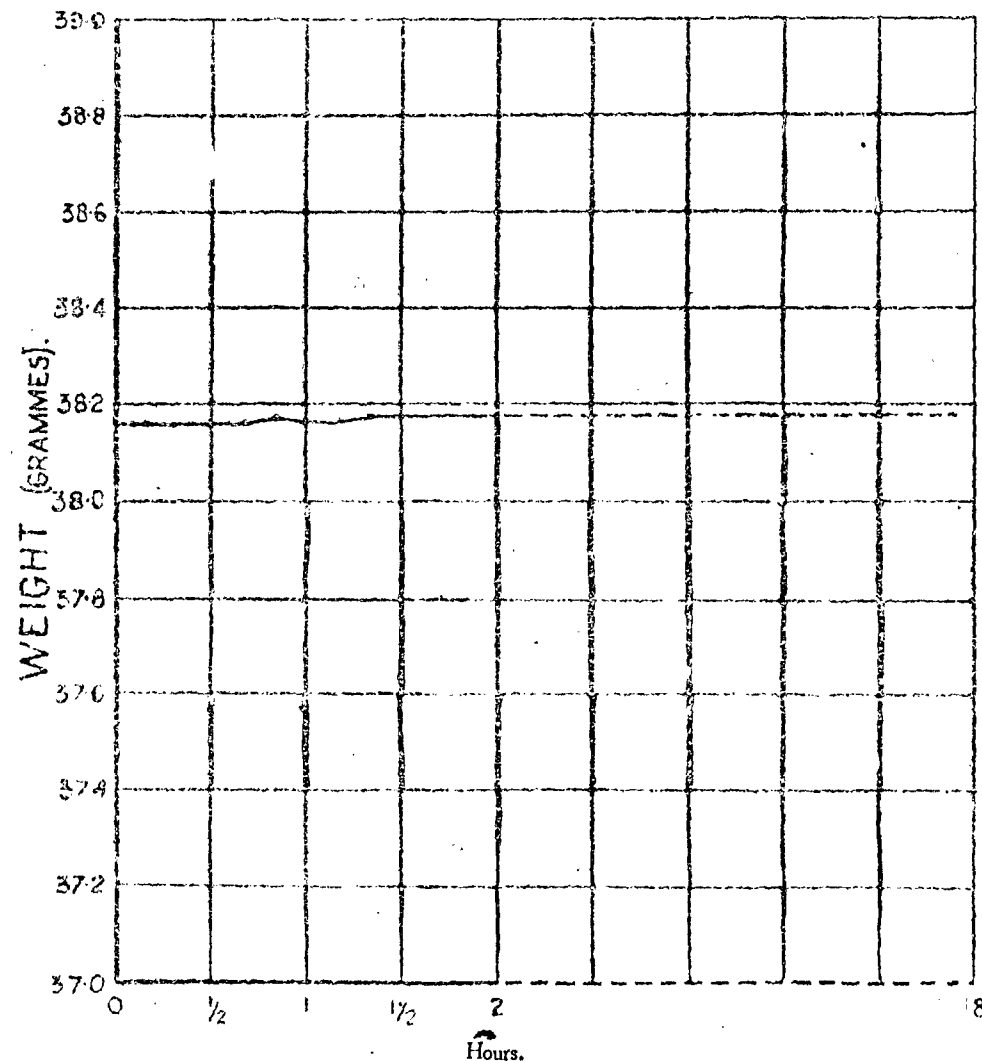


Fig. 3. Absorption of liquid paraffin by 75 large seeds of Punjab-American 4F cotton.

The following experiments were then carried out to determine whether there was any difference in specific gravity between seeds of different sizes of Punjab-American 4F cotton. The seeds were prepared as previously described, and were weighed individually. They were then classified into three groups—small seeds of individual weight less than 80 milligrammes, medium seeds of individual weight between 80 and 95 milligrammes, and large seeds of individual weight above 95 milligrammes. The average weights of the seeds in the three groups were 69.5, 80.1 and 103.4 mg. respectively. When some time later (1-2 months) the seeds were weighed in groups in the determination of their specific gravity, it was found that each weight was decidedly less than the aggregate of the individual seed-weights of that group. The reductions in weight were as follows:—7.3, 7.0, and 6.6 per cent. for the small, medium, and large seeds respectively. The first weighings were mostly made in the monsoon period, and the second weighings in the post-monsoon period, so it appears that the reduction in weight is due to a loss of moisture, and that this has been greatest for the small seeds and least for the large seeds; this is exactly what one would expect, because the amount of loss of moisture depends upon the area of the evaporating surface, and the ratio of the surface area to the weight becomes less as the size of seed increases.

The results obtained for the specific gravities of the different groups were as follows, compared with water at 78°F.:—

	Specific gravity
For 110 small seeds, of average weight 0.0644 gramme	1.064
For 112 medium seeds, of average weight 0.0801 gramme	1.078
For 81 large seeds, of average weight 0.0966 gramme	1.069

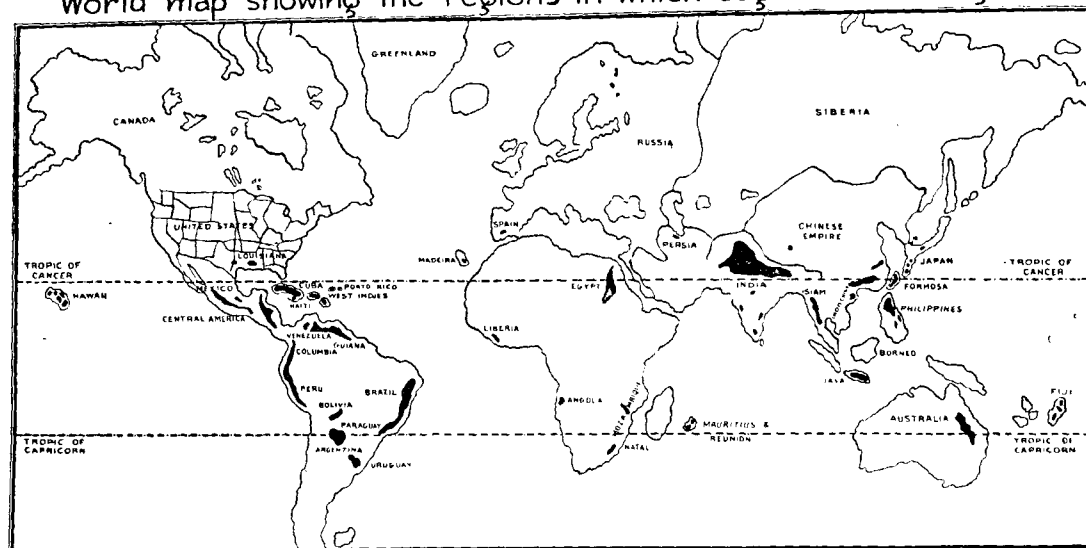
Seeing that in the first experiment the large seeds had a specific gravity 1.4 per cent. greater than that of the small seeds, and that in the second experiment the medium seeds had a specific gravity 1.3 per cent. greater than that of the small seeds, it appears that there is a slight tendency for the heavier seeds to be denser; but the large seeds in the second experiment had a specific gravity only 0.5 per cent. greater than that of the small seeds, and actually 0.8 per cent. less than that of the medium seeds. It appears possible, therefore, that these differences may be due in part, at any rate, merely to sampling errors in the selection of the seeds.

Another point of interest is that all the values obtained for the specific gravity of the cotton seeds with liquid paraffin as the displaced liquid are decidedly higher than those obtained with water, taking the readings obtained within 90 seconds of adding the water (pp. 86-87). It appears, therefore, that even in this short period of time, the seed-coats swell sufficiently to invalidate the water-displacement method; it is possible, however, that as the experiments were made at different times, the difference may be due to a difference in the moisture content of the seeds, for, as already pointed out, the cotton seeds lost weight when the atmosphere became drier,

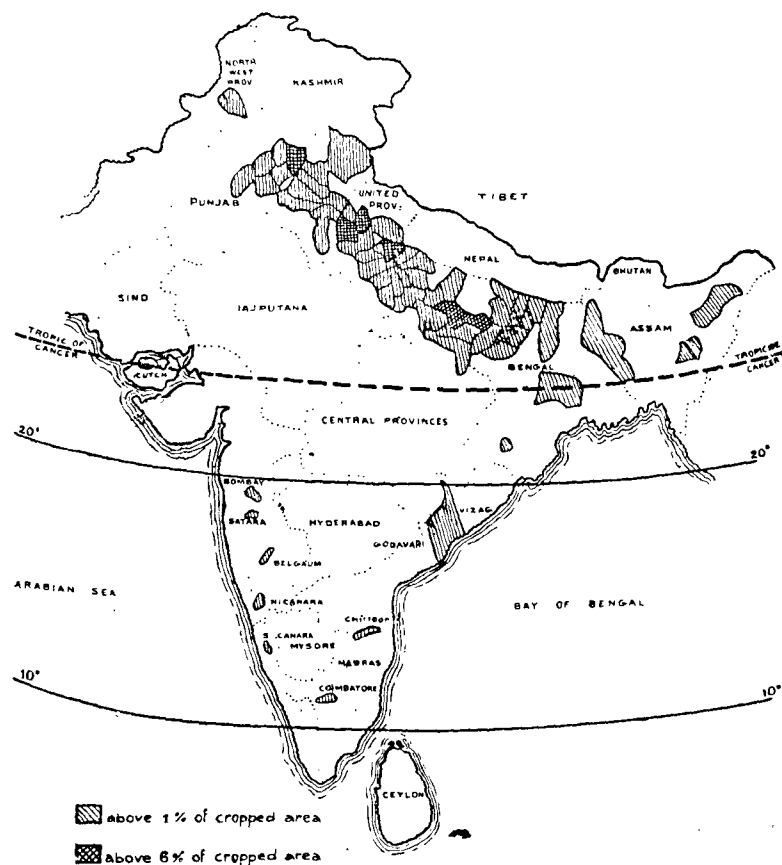
and it is of course quite likely that the loss in weight is accompanied by a change in specific gravity. However this may be, in view of the rapidity with which the cotton seeds absorb water and the difficulty of removing air-bubbles—especially in the case of fuzzy seeds—the water-displacement method of determining the specific gravity of cotton seeds must be regarded as untrustworthy.

The majority of the experimental readings for this paper have been taken by Mr. D. L. Sen, to whom accordingly I wish to express my thanks.

World map showing the regions in which Sugarcanes are grown



Map of India illustrating high concentration of Sugarcanes in subtropical regions.



FACTORS INFLUENCING THE GROWTH AND SUGAR CONTENTS OF CANE.*

BY

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. Assistant Sugarcane Expert, Imperial Sugarcane Station, Coimbatore.

INTRODUCTION.

THE total output of sugar in the world during the year 1925-26 was about twenty-four million tons. Of this, about sixteen million tons were from sugarcane and the rest from beet. Excluding Indian output—which as usual consisted mostly of *gur* or *jaggery* (unrefined sugar)—about thirteen million tons of sugar were produced from cane.

Sugarcane is a tropical plant. Its period of growth depends upon climatic conditions and is generally from twelve to eighteen months. It thrives best in places where high temperature, well-distributed rainfall and plenty of sunshine prevail during the growing period and cool dry weather during the ripening time.

From the world map showing the regions in which sugarcanes are grown (Pl. X), it will be seen that all the major sugarcane-growing countries—Cuba, Java, Hawaii, Brazil, Porto Rico, Philippines, Peru, Mauritius and the West Indies—are all situated within the tropics. Their combined output of sugar is about ninety per cent. of the world's total. The other cane-growing countries like Argentina, Natal, Louisiana, North Egypt, South Queensland, North Formosa and Spain are outside the tropics and are together responsible for only about ten per cent. In the case of India, however, the reverse is the case. As will be seen from a map of India (Pl. X), all the major sugarcane-growing provinces, viz., the Punjab, United Provinces, parts of Bihar and Bengal, are outside the tropics and produce nearly eighty per cent. of the raw sugar in India, while the provinces or tracts lying within the tropics are responsible for only about fifteen to twenty per cent.

TEMPERATURE AND WATER CONDITIONS FAVOURABLE TO CANE GROWTH.

(a) Temperature.

Stubbs¹ says that maximum activity is developed between 85° and 100°F. In another place, he² observes that a mean temperature of 77°F. is best for cane development.

* Paper read at the Indian Science Congress, Calcutta, January 1928.

¹ Stubbs, W. C. *Sugarcane*, Vol. I.

² *loc. cit.*

Alexander¹ notes that, with thirteen hours of sunshine and a mean temperature of 78°F., canes grew four and a half times as much as that observed with ten and a half hours of sunshine and about 69°F. mean temperature.

Experiments conducted at the Imperial Sugarcane Breeding Station, Coimbatore,² have shown that cane setts kept for four hours at a temperature of 105°F. (40 to 42°C.) germinated early and grew best.

Robertson Brown³ notes that during hot weather rains in August-September the mean temperature is 88° to 83° F., the air is steamy and oppressive and the growth of the cane extraordinarily rapid.

(b) Water conditions.

The quantity of water required for growing a good crop of cane obviously depends on (i) the growing period of the crop, (ii) the temperature conditions and the prevailing wind of the tract, (iii) the nature of the soil and sub-soil, and (iv) the varieties grown.

Mollison⁴ notes that including rainfall it would require about 110 inches of water to grow cane in the neighbourhood of Poona.

Round about Coimbatore, the quantity of water required has been computed at about 140 inches.

In Louisiana where the climate is humid, and the mean temperature not high and the cane-growing season short, a well distributed annual rainfall of sixty inches is found sufficient for the cane crop.

Alexander⁵ notes that in Hawaii an average of 19.03 feet of water is used during the whole irrigation period of 460 days.

As regards the moisture content of a soil best suited for cane growth, it is noted in "Cane Sugar" by Noel Deerr, that best results were obtained by Eckhart when the soil contained 31.38 per cent. of water. Alexander⁶ notes that, under Hawaiian conditions, about 26 per cent. of soil moisture content is the best and at this stage of soil moisture proper aeration is also possible.

It is a debatable point whether the water requirements of cane can be wholly met by artificial irrigation. In the crops at the station, consisting of a very wide range of varieties and seedlings, the writer has frequently noticed an appreciable increase in growth immediately after a rain, though the crop has been receiving frequent irrigations all the time. Mr. K. B. Bhagwat, B.Ag., landlord, Lonikalbhor, growing cane at Loni, eleven miles from Poona, has experienced that though he

¹ Alexander, W. P. *The Irrigation of Sugarcane in Hawaii*, 1923.

² Krishnamurthi Rao, K. Soil Temperature and Cane Germination. *Madras Agri. Students' Union Jour.*, Vol. XII, No. 1.

³ Robertson Brown, W. Windrowing Sugarcane in the North-West Frontier Province. *Mem. Dep. Agri. India*, Vol. V, No. 10, Pt. I.

⁴ Mollison, J. Text Book of Indian Agriculture, Vol. III.

⁵ loc. cit.

⁶ loc. cit.

could get ample supplies of canal water, the growth of his cane was stunted and outturn poor on account of dry hot atmospheric conditions of that cane tract which had only about ten inches of rainfall in that particular year.

Robertson Brown¹ mentions that during May, June and July—the hottest dry months of the year—the cane gets just established and that extraordinary growth takes place only when the air is steamy and oppressive though irrigation facilities exist during the hottest months also.

Barnes² also is of opinion that irrigation cannot adequately replace rainfall.

Though irrigation does supplement rainfall and play a very important part as a substitute for rain in certain parts of the world, e.g., Peru and Hawaii, yet its effects cannot be so beneficial as those of a good soaking rainfall under the dry hot conditions obtaining in Northern India before the summer monsoon. Rainfall, in addition to supplying moisture for cane growth, has the following other advantages over irrigation :—

- (i) It has got a moderating influence on temperature and increases the moisture content of the air ;
- (ii) It helps growth by washing the lower surface of leaves, thus promoting free transpiration ;
- (iii) It washes out plant toxins and any harmful salts accumulated on the surface soil, as also egg masses of injurious insects deposited on leaves ; and
- (iv) It brings small quantities of nitrogen from the atmosphere.

TEMPERATURE AND WATER CONDITIONS UNFAVOURABLE TO CANE GROWTH.

(a) Temperature.

Experiments conducted at the Sugarcane Breeding Station have indicated that localities where maximum temperatures are above 117°F. (47°C.) at the planting time are not suitable for cane as the buds germinate very poorly at 117°F. and are practically killed at about 122 to 131°F. (50 to 55°C.).

As regards the lower temperatures which adversely affect cane, Alexander³ notes that at a mean temperature of 69°F. there was practically very little growth. Robertson Brown⁴ states that cane is planted in the Peshawar valley about the middle of March and the mean temperature at that period may be taken as about 65°F. From a consideration of temperatures prevailing at the time of planting in other cane countries, it may be stated that when the minimum temperature goes below 50°F. or when the mean temperature is about 65°F., there is practically no growth. At still lower temperatures the bud itself is affected. On account of radiation in

¹ loc. cit.

² Barnes, J. H. Sugar and the Sugarcane in the Gurdaspur District. *Pusa Bull.* No. 69.

³ loc. cit.

⁴ loc. cit.

the open space on a calm, clear night, frost is experienced even though the recorded temperature is much higher than 32°F. Robertson Brown¹ states that cane buds are practically killed by frost in December-January when the average minimum temperature is about 52°F. In "Sugarcane" by Stubbs, it is stated that cane was killed by frost at 29°F. and that splitting frost which makes the cane unfit for sugar making occurs at temperatures below 26°F.

(b) *Water conditions.*

It is obvious that drought and water-logged conditions are both unfavourable for cane growth. The writer has observed that, if during the growing season watering is not done in due time, short joints are formed between two long joints. It has been recorded in Java that canes which owing to external conditions are unable to continue a regular growth and are thus retarded and then on the return of more favourable conditions make a rapid growth show cavities which are surrounded by spongy tissues. The cells of the spongy tissues are dead and filled with air and no sucrose collects in them². Continued drought makes the cane fibrous and pithy and dwarfs its growth. Alexander³ notes that when the soil moisture content was below twenty-one per cent. the wilting point of cane was reached in summer and that in winter the wilting point was below twenty per cent.

Inferences.

Other conditions being satisfactory,

- (i) cane growth starts at a mean temperature of about 68°F. and increases progressively with the gradual rise of temperature, reaching its maximum at somewhat about 88°F. mean temperature;
- (ii) growth is arrested when the mean temperature is about 65°F.; and
- (iii) bud is injured when the mean temperature is about 52°F.

Countries which enjoy a long humid and warm season during the period of growth with an average mean temperature of 78°F. (average of 68 and 88°F.) and a fairly dry cold season with an average mean temperature of 59°F. (average of 65 and 52°F.) appear best suited for cane cultivation.

APPLICATION OF THE ABOVE GENERAL CONSIDERATIONS TO PARTICULAR CANE-GROWING COUNTRIES.

Keeping the above in view, let us now examine the climatic conditions of some of the important sugarcane-growing countries of the world and compare the same with the conditions prevailing in the main sugarcane tracts in India.

¹ *loc. cit.*

² *South African Sug. Jour.*, Sep. 1918, p. 961.

³ *loc. cit.*

* (i) TEMPERATURE AND RAINFALL IN CUBA, JAVA AND OTHER CANE-GROWING COUNTRIES.

Cuba.

Temperature. The mean maximum is 82°F. and the mean minimum is 71°F. The mean average temperature of the island is about 77°F. There is no frost. The island enjoys high equable humidity.

Rainfall. During May to October (warm growing season) about 41 inches. During November to April (cool ripening season) about 14 inches. On limited areas irrigation is practised.

Java.

Temperature. Mean temperature during warm months about 80°F. Mean temperature during cool months about 78°F.

Rainfall. Wet or cane growing season (November to April) 53.0 inches. Dry season (May to October) 18.0 inches. Irrigation partly supplements rainfall.

Porto Rico.

Temperature. Uniformly warm. Maximum about 94°F. Minimum about 63°F.

Rainfall. Wet growing season (April till November). Dry harvest season (December—March). On limited areas irrigation is practised.

Mauritius.

Temperature. Maximum about 94.5°F. Minimum about 51.0°F.

Rainfall. Warm growing season (December to May) 53.0 inches. Cool fairly dry season (June to November) 20.0 inches. Irrigation supplements rainfall in some parts.

Hawaii.

Temperature. Decidedly cool for the tropics. Average 72 to 74°F.

Rainfall. Windward side plenty of rainfall. Leeward side only about 20.0 inches. Irrigation is being practised on a large scale in Oahu, Maui and Kawai of the Hawaiian islands. By withholding irrigation for about 60 days before harvest, cane is ripened. All the above important sugarcane-growing countries are, as a result of a long growing season, able to grow thick types of cane and give on an average not less than two tons of sugar per acre. In parts of Hawaii (Oahu, Maui and Kawai) which enjoy a long growing season with the help of artificial irrigation, yields as high as six tons of sugar per acre are obtained on an average.

* Data collected from "World's Sugar Industry" by Prinsep Geerligs and from the "The Planter and Sugar Manufacturer," Louisiana.

Of the countries which are outside the tropics, Tucuman in Argentine may be said to be the most important. It lies between the 25th and 26th degrees south latitude and its climate is distinctly sub-tropical. The summers are extremely warm and the winters are frosty. In these localities thick canes do not come to maturity and only thin or medium canes are grown. Hard-rinded, short and poor varieties which used to yield about fourteen tons of cane per acre and only about $\frac{1}{2}$ th of the weight of cane as sugar are now being replaced by Java varieties (P.O.J. 213, P.O.J. 36 and P.O.J. 234, etc.) which are of medium thickness and give nearly double the tonnage of the local cane.

The climate of the main sugarcane tract of India is somewhat similar to that of Argentine and the replacement of poor canes by medium hardy canes is obviously the most important means of raising the tonnage.

(ii) TEMPERATURE AND RAINFALL OF THE IMPORTANT CANE TRACTS OF INDIA.

(a) Peshawar valley.

Normal mean temperature (in degrees F).

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Decr.
51.3	54.1	63.3	72.9	84.0	91.6	90.9	88.6	83.1	73.1	61.7	53.1

Rainfall is about fourteen inches. Canes are planted about second-half of March, get established during the hot season (April to July) when there is scanty rainfall, and grow extraordinarily rapid during August-September-October when violent thunderstorms bring in rain. Growth practically ceases in November. In December and January frosts occur and injure the buds severely. Thus the growing season is only about seven and a half months.

(b) Other cane-growing tracts.

TABLE I.*

Showing normal mean temperature (in degrees F.) of some cane-growing tracts.

Province	MONTHS			
	January	May	July	November
<i>The Punjab.</i>				
Sialkot	54.4	88.7	188.8	65.8
Lahore	54.8	89.3	190.4	65.8

* Data collected from Imperial Gazetteers of India.

Showing normal mean temperature (in degrees F.) of some cane-growing tracts—concl'd.

Province	MONTHS			
	January	May	July	November
<i>* The United Provinces and Bihar.</i>				
Lucknow	60.2	91.3	86.1	68.4
Agra	60.8	94.1	87.4	70.7
Allahabad	61.1	93.2	85.9	69.4
Gorakhpur	61.0	89.1	85.4	70.4
Patna	61.5	88.9	85.1	71.4
<i>In the tropics.</i>				
Nagpur	69.6	95.5	81.7	72.7
Amraoti	71.3	93.8	80.7	74.2
Cuttack	70.7	90.7	84.4	75.8
Poona	70.4	85.6	76.7	73.0
Bijapur	72.8	87.6	78.8	73.8
Cocanada	73.8	91.4	85.4	77.0
Coimbatore	75.6	84.3	79.4	77.6
Calicut	78.7	84.2	78.2	80.4

TABLE II.*

Showing rainfall of some cane-growing tracts.

Province	MONTHS						
	Jan. and Feb.	March and April	May and June	July and Aug.	Sept. and Oct.	Nov. and Dec.	Total
<i>The Punjab.</i>							
Sialkot	4.38	2.12	3.81	17.03	3.04	0.98	31.46
Lahore	2.34	1.21	2.69	10.94	2.32	0.58	20.08

* Data collected from Imperial Gazetteers of India.

Showing rainfall of some cane-growing tracts—concl.

Province	MONTHS						
	Jan. and Feb.	March and April	May and June	July and Aug.	Sept. and Oct.	Nov. and Dec.	Total
<i>The United Provinces and Bihar.</i>							
Lucknow	1.63	0.39	6.13	22.11	6.81	0.54	37.61
Agra	0.84	0.42	3.19	17.50	5.02	0.51	27.48
Allahabad	1.58	0.43	6.06	23.18	7.68	0.54	39.47
Gorakhpur	1.53	0.76	9.67	25.86	12.27	0.34	50.43
Patna	1.42	0.66	10.03	24.39	9.82	0.33	46.65
<i>In the tropics.</i>							
Nagpur	0.99	1.08	8.91	25.99	11.06	1.20	49.23
Amroati	0.75	0.62	7.12	16.07	8.23	1.17	33.96
Cuttack	0.82	2.20	14.26	24.28	15.35	1.87	58.78
Poona	0.09	0.70	6.10	10.53	9.05	1.17	27.62
Bijapur	0.12	1.28	5.06	5.61	11.82	2.16	26.05
Cocanada	0.65	0.92	6.17	11.67	15.06	6.48	40.95
Coimbatore	0.81	2.22	3.96	2.27	7.82	4.61	21.69
Calicut	0.34	4.85	45.51	44.23	18.17	5.71	118.80

From the temperature and rainfall data, it will be seen that the Punjab enjoys a slightly milder climate than the Peshawar valley. Cane is planted about the same time as in the Peshawar valley and grows for about a fortnight longer. In December and January frosts occur, but are not so severe as in that valley. The total cane growing season may be put down as eight months.

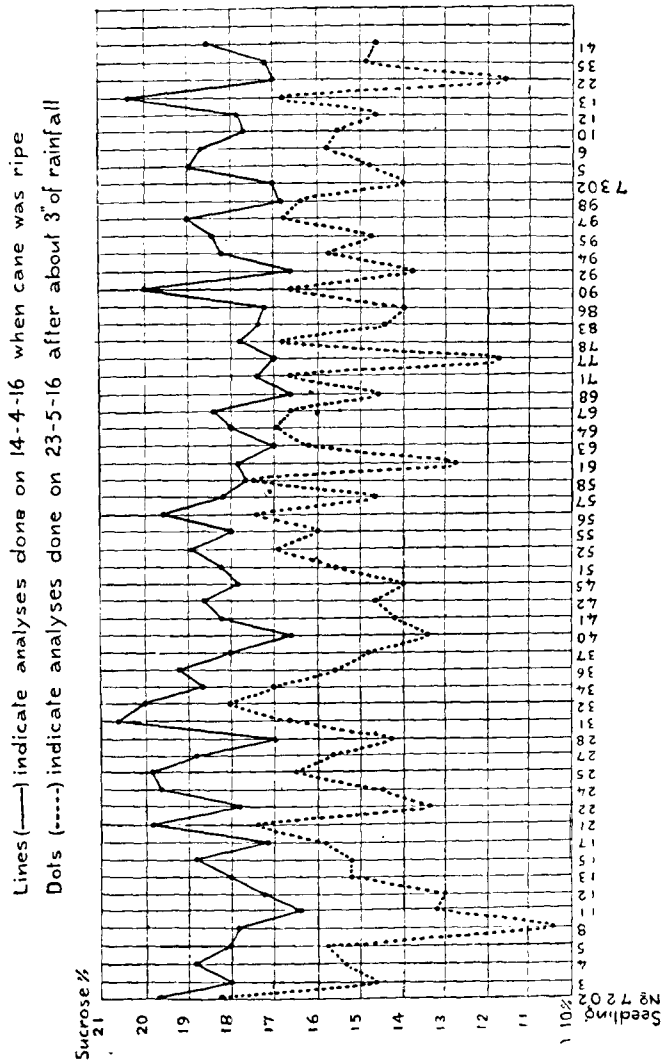
As we proceed southwards and eastwards into the United Provinces and Bihar, the temperature is more favourable and the growing season consequently longer. Canes could be planted in the last week of February or the first week of March and growth is not arrested till late in November or early in December. The period may be taken as eight and a half to nine and a half months.

In the above provinces thick canes, however, do not come to proper maturity and as such they are grown only for chewing purposes near towns.

From Nagpur downwards, the climatic conditions are suitable for thick canes. The cane has a fairly long growing season followed by a fairly cold dry weather which

PLATE XI.

Curve illustrating the adverse effects of rainfall on a ripe crop of Seedlings.



brings about proper ripening. In the Madras Presidency the growing conditions are better than in other parts of India, but the ripening conditions do not appear to be so favourable.

OTHER CONDITIONS INFLUENCING THE SUGAR CONTENTS OF CANE.

(a) Rainfall while canes are ripe.

Rainfall at the time when cane is ripe and fit to be harvested affects the sucrose contents of the cane adversely by inducing shooting. Plate XI illustrates the lowering of sucrose on the ripe seedling canes at the Coimbatore Station. A similar effect produced on beet mentioned in the *New Zealand Journal of Agriculture* is stated below. "The season 1918-19 at Maffara was exceptionally dry right throughout the growing period and the beets were stunted. At the usual time of maturity heavy autumn rains set in, and the stunted beets took on a second growth with a lowering of sugar content and purity to such an extent that the average sugar content for the whole of the season beets at Maffara was only 13.49 per cent."

TABLE III.

Showing how sugar content is influenced by climatic conditions.

Location	Topped beet. Tons per acre	Sugar per cent.	Purity per cent.	Sugar content per acre in tons	Remarks
Maffara	15	14.2	80.8	2.13	Average for several fields. Abnormal conditions. Unsteady growth.
Port Fairy and Warrnambool.	18	18.6	89.1	3.4	Average for several fields. Fairly normal climatic conditions. Steady growth.

(b) Continuous moist weather and absence of well defined ripening season.

Places which have a heavy and continuous rainfall over a long period without a pronounced ripening season, are also unsuitable for the development of sucrose in the cane. For example, Taliparamba, a Government Agricultural Station on the west coast of the Madras Presidency, receives about 140 inches of rainfall distributed as under :—

April and May	8.24 inches of rainfall.
June to September	113.20 " " "
September to November	18.62 " " "
December to March	1.22 " " " with over 75° F. mean temperature in the ripening season.
TOTAL	141.28

TABLE IV.

Showing fall in sucrose effected by continuous moist weather at Taliparamba.

Name of variety	AVERAGE SUCROSE PERCENTAGES AT		
	Taliparamba	Palur	Sa malkota
Red Mauritius	14.4	15.9	13.6
Striped Mauritius	16.9	18.6	18.9
B. 208	18.1	over 19.0	over 19.0
Pansahi	12.8	..	15.1
Chin	12.4	..	16.2

(c) Soil.

In calcareous soils which are generally well drained “not¹ only are the most robust canes grown, but these also afford juices richest in sugar and from which is easily extracted the desired product.” Saline² soils containing a good deal of chlorine render the juices of cane-growing on them highly saline and also lower the sucrose and glucose.

TABLE V.

Showing the variation introduced in the quality of the juice of canes grown on saline and non-saline lands.

Name of variety	GROWN UNDER SALINE CONDITIONS			GROWN UNDER NON-SALINE CONDITIONS		
	Sucrose per cent.	Glucose per cent.	Purity per cent.	Sucrose per cent.	Glucose per cent.	Purity per cent.
M. 1826	13.16	0.22	76.9	14.15	0.70	80.8
Hullukabba	10.64	0.15	74.3	14.83	0.27	82.6
M. 5459	9.65	0.15	67.6	10.44	0.77	70.4
Putlikhaje	9.23	0.45	67.8	9.40	0.97	77.8
M. 6621	9.84	0.17	72.5	13.60	0.97	77.8
Jagannathia	8.44	0.30	63.3	13.54	1.14	78.9

¹ Noel Deerr. Cane Sugar, p. 46.
² Krishnamurthi Rao, K. The effect of salinity on the growth and composition of sugarcane varieties. Agri. Jour. India, Spl. Sci. Congress No., 1919.

In light sandy soils though the tonnage is not high, the canes give richer juice. Ill-drained and water-logged soils not only inhibit the growth of cane but also lower the quality of juice.

(d) Quality of irrigation water.

It has already been noted above that from 70 to 140 inches of water are required for sugarcane, mostly depending upon the growing period of cane. Quality of irrigation water has some bearing on the nature of juice obtained from the canes grown. Sodium chloride in irrigation water is the most harmful for sugarcane cultivation.¹ Anything over 75 parts of it in 100,000 parts of water is not desirable.

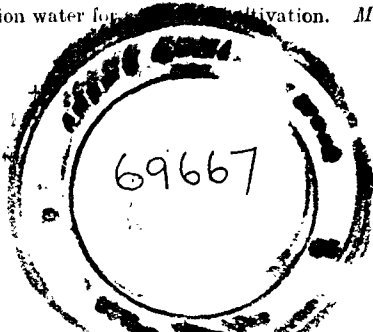
(e) Manures.

It is common knowledge that sugarcane like all other crops responds faithfully to the proper treatment of soil and to the application of manures. Heavy applications of bulky nitrogenous manures retard the maturation of canes. About two miles from the Coimbatore town, a ryot had applied to a portion of the land very large quantities of green leaf Dhaincha (*Sesbania aculeata*). In this portion, canes were much healthier and gave better tonnage, but the *jaggery* was darker than and not so well set as that from the other portions of the field to which castor cake was applied. The economic limit for the application of manures will naturally depend upon the growing period of the crop, the nature of soil, etc. An interesting experiment was conducted at the Manjri farm, Bombay Presidency, and some figures extracted from *Bombay Bulletin* No. 90 are given below :—

Total nitrogen applied	lb.	693	300	225
Total cost of production per acre	Rs.	883	563	498
Jaggery outturn	lb.	14,770	12,664	11,783
Value of outturn	Rs.	1,231	1,055	982
Profit	Rs.	348	492	484

It will be seen from the above that though an enormous outturn was obtained by the application of 693 lb. of nitrogen, the net profit was much less than that from the application of 225 lb. of nitrogen. Also, the *gur* (unrefined sugar) obtained from the heaviest manured plot was very poor in quality. It will, therefore, be no wonder if in North India where the cane-growing season is short and where the canes are not thick, excessive manuring only results in lengthening the growing period and producing an unripe cane at harvest time.

¹ Krishnamurthi Rao, K. Irrigation water for cultivation. Madras Year Book, 1920-21.



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THE RELATIONS BETWEEN THE DEPARTMENTS OF AGRICULTURE AND CO-OPERATION.

BY

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THE two Departments of the Development Branch of Government, the Agricultural and the Co-operative, while both exist mainly for the purpose of improving the condition of the masses of the people, are really very distinct and separate agencies; and unless this is realized and their definite spheres of activity clearly demarcated, recent experience has shown that there is very great danger of waste, not only of effort but also of material resources, from overlapping and confusion. To engage agricultural officers in collecting kist, and co-operative officers in giving technical advice on the use of seeds or manures, is not only largely to waste the time of both but also to risk serious loss, both in material and prestige. It is thought, therefore, that a clear definition of the functions of each, with particular notice of where they should supplement each other's activities, should result in increased efficiency in both departments by making each one separately and their combined efforts, of greater service to the community.

The Agricultural Department, the object of which is intensification of agricultural production, has certain very clear functions for which the training of its staff provides. First of these is to find and rigidly test improvements. Second is to demonstrate these improvements sufficiently to create a demand for them from the cultivators. Third is to maintain a reserve of certain improvements, such as pure seed of a special variety, to supply the demand that cannot be met from other sources.

The Co-operative Department, the object of which is the general uplift of the people, has on the other hand equally definite functions among which at present the provision of cheap credit to the masses is probably the most obvious, though the development of the spirit of self-help through the spread of the ideals of co-operation is even more important but lags behind on account of its infinitely greater difficulty. But a corollary of both is the obligation to assist the masses in obtaining and adopting means and methods of improving their condition, whether they be education for themselves, veterinary protection for their cattle, improvements in sanitation and general public health or agricultural improvements. A primary function of the Co-operative Department is to assist the masses, financially through the co-operative banks and mentally and morally through the organization of primary

societies and guarantee unions, to take advantage of the various possibilities of improvement in their lot from time to time brought to light.

The Agricultural Department is concerned with the discovery of improvements possible in one section of the people's life and the demonstration of these sufficiently to create a demand for them, and there, except for the maintenance of certain reserves, it should stop. Its men are not trained to banking or trading, and such functions are beyond their scope. At this stage the co-operative agency should come into the work, and once the demand for an improvement has been created, it should take on the task of fostering that demand, arranging supplies to meet it and financing those supplies. The Agricultural Department must take on itself the onus of making certain that the improvement is a sound one before demonstrating it. It cannot be too careful on this point. Great harm has been caused in the past by the premature demonstration of improvements either not rigidly tested or simply borrowed from other areas. But once the improvement is certain, the Agricultural Department should demonstrate it sufficiently thoroughly to convince the cultivator and create the demand; and it can then hand over that matter with a clear conscience to the co-operative agency.

If we discuss a few concrete cases, we shall perhaps be able to visualize clearly what is implied.

The Agricultural Department by selection work at Sabour has isolated and thoroughly tested a variety of paddy called Dahia, which, on poor paddy land, gives a bigger crop with less water than similar paddies tested against it. It must now demonstrate the value of this paddy by arranging through its district staff to grow it on numerous demonstration plots throughout the district round Sabour. That must be done by the agricultural officer, because he knows the paddy and knows what land it is suitable for. The demonstrations are successful and further show that that paddy is suitable for a wide range of soils and conditions. So for wider demonstration, the department distributes free to a very large number of growers sufficient seed to plant $\frac{1}{4}$ acre with this paddy. So many of these are successful that a demand springs up and all over the district people want seed of Dahia paddy. The wealthier cultivators can buy seed either from the department or from some one who grew it before, but the poor ones cannot, and this is the stage at which the co-operative bank comes in. It can buy seed from the Department and issue it to the members of its primary societies, and collect the price from them at harvest time.

The Imperial Sugarcane Expert at Coimbatore some years ago bred some new seedling canes certain of which, notably No. 213, have proved far heavier croppers and *gur* yielders wherever they have been tried, than the commonly grown local varieties. The Agricultural Department of Bihar has carefully tested these in most of its ranges and found them so successful that it has demonstrated them widely and in some places, to widen the scope of its demonstrations, distributed free to a large number of villages sufficient seed for $\frac{1}{4}$ acre. As a result of these two operations,

the testing and the demonstrations, an enormous demand for setts of this variety has sprung up among cane-growers of all classes. The wealthier growers can buy the setts either from the Government farms or from previous growers, the poorer ones cannot. They require financial assistance in the matter and also assistance in organizing their supplies, and here is the work the Co-operative Department can do for them, by buying setts in bulk for cash from the Government farms or large growers, and distributing them in detail on credit among the innumerable small growers who are members of primary societies.

Largely as a result of processes developed for the manufacture of explosives during the Great War, the prices of certain artificial fertilizers, notably sulphate of ammonia and certain combinations of nitrogen and phosphoric acid, have recently become so cheap that their use on a wide scale by the cultivators of India to supplement the far too small supplies of cattle dung is now a practical and economic proposition. A cultivator can now buy Rs. 10 worth of one of these with the certainty of getting back Rs. 15 to Rs. 20 worth of extra crop. The Agricultural Department has already carefully tested some of the cheapest ones in different localities, and, where the tests have shown a particular one to be really effective, have demonstrated its effect on the lands of neighbouring cultivators, and a demand has sprung up for certain artificial fertilizers in certain areas. Large cultivators can buy the manures from the local agents of the manure firms in fair quantity at reasonable rates, and can make fairly sure they get the right thing. But the small, poor cultivator depends entirely on his co-operative society, through its central co-operative bank, to supply him on credit, to buy in bulk from which his small detail supply can be made, and to protect him by ensuring he is sold the proper manure, unadulterated.

Recently the Agricultural Department in North Bihar has been investigating the possibility of bringing more efficient agricultural implements within the reach of even the poorest cultivators. As a result of its research and its testing, there are, now being produced by firms in North Bihar, ploughs, cultivators and ridging ploughs really suitable for the use of the ryots in North Bihar and costing only Rs. 10 each. These are being demonstrated all over Saran and Muzaffarpur and a demand is springing up. Well-to-do cultivators are buying them for cash from the Agricultural Department or from the makers. What is the poor man to do? He wants them, but Government simply has not the funds to consider giving every village a set. It can give every village a packet of seed valued at as. 2 or 3. But it cannot find Rs. 50 for every village. Here is the work of the co-operative society and the central co-operative bank. The latter can purchase implements from the makers and retail them on credit either to societies or to members of societies.

In each of the few instances given, it can be observed that there is a definite, clearly marked stage in the progress of the spread of an improvement, and this applies to all improvements not only to those in agriculture, when the work passes from demonstration to organised supply, with, in the case of the large bulk of ryots, the necessity of financing that supply. Such organizing and financing of supply

is essentially and entirely a business matter. It demands no technical knowledge but it does require business ability, banking facilities and methods, and a staff already covering the area to be worked.

The aim of the Agricultural Department being the intensification of agricultural production, its staff, high and low, must be trained to agricultural production, the growing of crops, the breeding and rearing of stock. All will agree that the agricultural producer is rarely a first class business man, and to try and train the agricultural staff to be such and to make him work as such, is simply to handicap and cripple his other work, that work for which he is fitted. Government has little money and, as far as can be judged, little prospect of obtaining much more. Surely it, and the people it serves, will get better value for what it spends on the Agricultural Department, if that department's activities are limited to agricultural work instead of being diverted to account keeping and debt collecting, buying and selling. Every man to his own trade is a sound maxim and most agricultural officers can be trusted to earn their day's pay at finding or testing or demonstrating improvements, while at accounting, or buying and selling, or recovering dues, few of them would earn their travelling allowances. So it seems entirely wise to limit the agricultural officer's work, as far as possible, to production either for test or demonstration, and keep him clear of supply work; while, where the disposal of his crops, etc., necessitates selling and buying, to keep them entirely on a cash basis and avoid the diversion of energy to book-keeping and kist hunting entailed by detailed credit supply.

The co-operative movement, on the other hand, rests largely on its banking business. All its uplift work rests on its ability to supply cheap credit and is judged eventually by the efficiency of its banking department. Its staff should be trained to that, and be employed on those lines; banking and business; arranging loans for desirable objects, financing improvements, supplying on credit and collecting its dues. To use them for technical propaganda is wasting them and their training. They should stand behind the propagandist saying "This man knows what he is preaching. If you like his seed and want it, we can lend you the money for it. If enough of you want it, we will order it for you and you shall pay us with interest at harvest. I have a small kist to collect from you then. This I can collect with it." The large grower can deal direct either with firms or, in special cases, with the Agricultural Department on a cash basis. The small one cannot but his society knows him, and his bank covers his area and already collects kists from him. It can take his order, lump it with others, save some thing on ordering in bulk, arrange distribution in detail, add the debt incurred to existing ones and collect it when due. But the co-operative bank should itself deal with firms and with the Agricultural Department at need, strictly on a cash basis. All credit costs money. The member of a society has already to pay for his credit with its bank and the latter has no right to saddle him also with the cost of its credit with trading firms. It should buy seeds, manures, implements strictly for cash whereby it can always get lower

terms, and regard the cash outlay as an advance to the society or member on whose behalf it has ordered, to be recouped in due course with appropriate interest. It is the poor man's banker, and it should most carefully resist the temptation to shift that duty on to supply firms or the Agricultural Department; as, if it fails, it is saddling its members with double interest charges.

Possibly, as seems to have been the case with many banks already, the business of supplying to its members the means of agricultural improvements becomes so large as to require extra staff. Government has shown its anxiety to help in this matter by paying certain banks the cost of extra clerical assistance required to deal with distribution and sales of large quantities of gypsum and sulphate of ammonia, and will doubtless help other banks as the need arises; though the need for such assistance should only be temporary as, with the growth of business, the interest on the advance, every sale by a bank on credit to a society or member should be regarded as an advance, will pay the costs of distribution and collection as well as actual interest on money involved. But it should be clearly realized that the bank does not require agricultural overseers for this work. The Agricultural Department has demonstrated a certain definite improvement and the demand has arisen from the cultivators, who know what they want and what to do with it when they get it. All the bank has to do is to supply a specific thing, arrange and record its distribution, and collect its price. For this the extra assistant requires no agricultural knowledge, but the better trained he is in the bank's ordinary business, the better he will do this particular work. The business of advocating and explaining the use of the seed or manure or implement is that of the agricultural officer, who is trained especially and entirely for that. The business of the bank's inspecting clerk should be most strictly confined to arranging to meet a demand already created, to recording the details of distribution properly, and to collecting the value in due course. For that he needs no agricultural training; but the better he is trained in his ordinary bank work, the more valuable he will be. Sound organisation, accurate and timely recording and posting of accounts, prompt collection of debts when due, in fact all the essentials to success in general business, these are the requirements of this supply work; and the incidental educational value to the ryots of out of the way areas, of sound business methods applied to his affairs, will be enormously valuable. Not only will the bank's business prosper largely in proportion to the extent it is carried on sound business lines, but such methods will rapidly lift the ryots from the morass of *kutchu* weights and measurements, interminable bargaining and indefinite indebtedness, in which he is to-day so largely submerged.

There is considerable opinion in favour of the use of the Sawaya system of advances of seed, because it is a system with which the ryot is already familiar; but it is doubtful if it is either profitable to the banks, or in the real interest of the ryot, to adopt it. While it is fairly simple for banks to arrange to distribute seed in small lots over an area, the collection of the Sawaya return is much more difficult and often impossible, and entails an amount of labour on the collecting officials out of

all proportion to the value of the interest. The cleaned grain is not all ready together, it has to be collected at centres, there is loss in transport and storage, and finally what has been collected has to be sold. If the crop is poor or fails, and it often does only because of the carelessness of the grower, payment is evaded. It is much simpler in every respect to treat all such advances as cash loans by entering the cash value of the supply made, adding interest at the usual rate and collecting that amount when due. An additional reason for treating the supply as an advance of cash is, that the cultivators will be more cautious in taking the advance and will only do so where demonstrations have convinced him of its value, and will be far more careful to make the best use he can of it.

In summarizing the foregoing, we can probably evolve some simple rules for the guidance of officers of both departments.

1. The work of the agricultural officer is to find improvements, test them carefully and rigidly, and if they justify it, demonstrate them. He should never attempt to demonstrate improvements in an area until they have been first properly tested in that area. Where his demonstrations are successful and a demand arises, he can, during his later inspections of his demonstration plots, advise cultivators as to how they can get supplies. Large cultivators he would direct to supplying firms or, if necessary, to the Agricultural Department, explaining that they must pay cash for supplies or, if ordering in advance, must pay a deposit at the time of ordering, and the balance in cash at the time of delivery. Small growers he will advise to obtain supplies through their co-operative society, and he will help the latter by collecting orders from individual members and forwarding these to the banks concerned. At that point his responsibility should cease. His main efforts should be directed to making his demonstrations so successful that a large demand for the improvement arises of its own accord.
2. The co-operative officer should not be asked to concern himself with agricultural propaganda, but should be trained entirely for the business and banking work of his department and in agriculture should be used entirely for the business side of the work of supplying improvements to the societies and members of societies who cannot obtain the improvements except with the business and financial assistance of the central bank. He will accept orders from members, verify orders passed to him by the agricultural officer to make sure that the member or society can repay the advance involved, order and pay cash for the bulk supplies, arrange with the societies to get the stuff distributed in good time for sowing or other use, record the transaction carefully and promptly and collect the advances when due. The bank should not only organize the receipt and distribution of supplies, but should finance its members by buying for cash and supplying in

detail on credit. Cash buying is most important with all firms as by it money can be saved. It is most important in dealings with the Agricultural Department also as, unless the cash system is adhered to, the time of the officers of that department is diverted from their proper work to account keeping and debt collecting, and every extra clerk that department has to employ means one less demonstrator in the villages.

The officers of both departments should co-operate to the greatest possible extent by advising each other as to the needs of the cultivators in the areas both serve. The agricultural officer will advise the banks of where and for what, successful demonstrations have created a demand, and will furnish them lists of societies or members who desire supplies of a certain improvement. He will advise the banks as to where supplies should be obtained, when orders should be placed and when distributions of seeds or manures must be made. In the last his advice should be especially valuable and should be freely offered to the co-operative officers and generally acted on by them. He knows when various crops should be sown, when manures should be applied, when cultivation operations should be done; and his advice will enable the banks to make supplies at the best and most useful time. For example, the cultivators want deep ploughing ploughs to prepare their lands for cane. They will buy them and pay cash for them far more readily in the months of December, January and February than during the rest of the year. If the banks arrange to receive supplies of these in October and November they will be sold and paid for by March. If supplies are not received till March, they will probably be on hand for 12 months. In all such matters, the advice of the agricultural officer should be of great assistance. On the other hand, the co-operative officer can advise the agricultural one as to areas where improvements are wanted, where there is trouble with certain crops, where the demonstration of a new variety of seed or a new manure is likely to interest and profit the ryot. He can advise as to what societies are progressive and anxious to help themselves and so most likely to take advantage of improvements demonstrated to them; which members are good cultivators and so likely to assist in the working of demonstration on their lands and which will not. I have seen too many demonstration plots unsuccessful, because the owners were too lazy or indifferent to cultivate the plot according to instructions, manure it, or even protect it from being grazed. By wise and timely advice the co-operative officer can save the agricultural one much waste of time, effort and money from such causes. In many ways such as these, the two departments can and should co-operate freely to the great advantage of the work of both. In the purely technical part of the great work of uplift, each should do its own work, that for which it is trained, the Agricultural Department that of cultivating and the Co-operative Department that of business and accounting; and the result will be more work better done, and the country will get better service from both these great nation-building departments.

EFFECTS OF HYDROGEN-ION CONCENTRATIONS ON RICE CULTURES.

BY

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INTRODUCTION.

EFFECTS of hydrogen-ion concentrations on plant cultures have been investigated by a number of workers during recent years. It has been found that there is a limit of resistance for plants to acidity on the one hand and alkalinity on the other, beyond which they cannot be successfully grown even in the best nutrient cultures. The limit of resistance varies with plants according to their different adaptabilities.¹ It should be noted that this factor has quite far-reaching effects on plant growth, in general, inasmuch as soil reactions play a very important part in crop production.

The present preliminary investigation was undertaken in order to gain some information about this limit of resistance or tolerance of the rice plant towards hydrogen-ion concentrations in culture media.

REVIEW OF LITERATURE.

Hoogland² found that a concentration of hydrogen-ion of approximately 0.7×10^{-5} ($5.15 \text{ p}^{\text{H}}$) was favourable to growth of barley and produced no injury, whereas a concentration of 0.3×10^{-3} ($3.50 \text{ p}^{\text{H}}$) was very toxic. On the contrary, he found that a concentration of hydroxyl-ion greater than 1.8×10^{-6} ($8.25 \text{ p}^{\text{H}}$) was distinctly injurious, while 2.5×10^{-5} ($9.40 \text{ p}^{\text{H}}$) was extremely toxic.

McCall and Haag³ found that hydrogen-ion concentrations exerted a very marked influence on the rate of growth of wheat seedlings, but their results were not quite conclusive.

¹ Mitra, S. K., and Phukan, L. N. Wood ashes as an ameliorant of soil acidity. *Agricultural Journal of India*, Vol. XXI, Part V, 357-365, September, 1926.

² Hoogland, D. R. The effect of H and Oh-ion concentrations on the growth of barley seedlings *Soil Science*, No. 3, 547-560, 1917.

³ McCall, A. G., and Haag, J. R. The relation of H-ion concentration of nutrient solutions to growth and chlorosis of wheat plants. *Soil Science*, No. 12, 69-77, 1921.

Hartwell and Pember¹ noticed acid toxicity with barley and rye both in water and in sand cultures.

Salter and McIlvaine² found that the optimum p^H values for seedlings of wheat, soy beans and lucerne were 5.94, whereas for seedlings of maize it was 5.16. In more strongly acid solutions soy beans and wheat suffered little until the value fell below 5.16, whereas lucerne suffered at once. They found, however, alkalinity to be more harmful than acidity, except in the case of corn seedlings where a slight increase was observed at p^H 7.71.

Joffe,³ working with lucerne at New Jersey, found that germination was practically unaffected between p^H 4.5 and 7.0. Below 4.5, however, it was much retarded. The yield showed a steady increase between p^H 3.8 and 6.5 with some irregularities between 6.5 and 8.0.

In connection with his work on aluminium toxicity, Magistad⁴ found that alfalfa, barley, rye, oats, soy beans, corn and red clover were all severely susceptible to acid toxicity at acidities greater than p^H 5.0. At reactions slightly less acidic than this, alfalfa and clover suffered strong acid toxicity, while rye, oats, barley and maize appreciable acid toxicity and soy beans no acid toxicity at all. At p^H exceeding 7.0, a considerable depression of growth was again noticed, but in that case only a few species of plants were experimented with.

Morris and Christ⁵ found that the range of survival for strawberry plants is p^H 4.0—8.0, for satisfactory growth p^H 5.0—7.0 and for optimal growth p^H 5.7 to 6.0.

EXPERIMENTAL.

Knop's solution was used as the nutrient medium throughout these experiments. To this solution was added hydrochloric acid in one set and sodium hydroxide in the other, in proportions from .001 to .01 per cent. and .001 to .05 per cent. respectively. Only 250 c.c. of the resulting solution was used in each case. A check with Knop's solution alone was also started.

The experiment was conducted in duplicates in 350 c.c. Erlenmeyer flasks in two series. The reactions of the flasks which were thoroughly cleansed with potassium dichromate in H_2SO_4 were very nearly neutral in all cases. The rice seedlings used were grown from the same variety of paddy. About one-month old seedlings were used and those which were fairly uniform and healthy were

¹ Hartwell, L., and Pember, F. R. The presence of aluminium as a reason for the difference in the effect of so-called acid soil on barley and rye. *Soil Science*, No. 6, 1918, 259-279.

² Salter, R. M., and McIlvaine, T. C. Effect of reaction of solution on germination of seeds and on growth of seedlings. *Journal of Agricultural Research*, No. 19, 1920, 73-95.

³ Joffe, J. S. The influence of soil reaction on the growth of Alfalfa. *Soil Science*, No. 10, 391-397, 1920.

⁴ Magistad, O. C. The aluminium content of the soil solution and its relation to soil reaction and to plant growth. *Soil Science*, No. 20, 181, 1925.

⁵ Morris, L. S. and Christ, J. W. Influence of reaction of culture medium on growth of strawberry plants. *Mich. Agric. Expt. Sta. Tech. Bulletin*, No. 77, 1-16, 1927.

picked up for experimental purpose. The roots were trimmed and were put in distilled water for a time before they were put in the culture solutions in the flasks. Each seedling was fixed in the medium by a cotton plug. The flasks were kept on a table in the verandah of the laboratory building. In all cases the chemicals used were pure salts obtained from Messrs. Baird, Tatlock & Co., London.

The experiment was continued for a fortnight and as the seedlings failed to produce sufficient vegetative growth during this period, the total length of the roots in millimetres was taken as the criterion of growth which, however, fairly agreed with the general development and appearance of the individual plants.

The total length of the roots in millimetres for the individual cultures are shown in the table below. The duplicate cultures agreed closely in all cases and are therefore not reported separately.

The p^H values of the culture solutions were also determined at the end of the experiment by the colorimetric method with La Motte colour standards and the results are shown in Table I. The p^H values of cultures No. 24 and No. 25 were a little above 8.4 and could not be accurately determined as the proper indicators and colour standards were not in hand at that time.

The general appearance of the plants during the course of the experiment was also noted carefully. In the cultures No. 7 to No. 11 with a concentration of 0.006 per cent. HCl and upwards, the stems and the leaves turned yellow soon after commencement and subsequently the plants died in no time. The cultures No. 5 and No. 6, with a concentration of 0.004 per cent. and 0.005 per cent. acid, gave only a slight root growth, but the general appearance of the plants was not at all satisfactory. To study the after effects, the cultures were preserved for another week, at the end of which all the plants died. The first three cultures containing the lowest concentrations of acid gave some root growth as shown in the Table. In the cultures No. 3 and No. 4, however, the plants died at the end of the third week, whereas in No. 2 they continued to grow till the end. The general appearance of this culture was very similar to that of No. 1 with Knop's solution alone.

TABLE I.

The length of roots and p^H values of the culture solutions.

SERIES I				SERIES II			
Culture No.	Concentration of acid	p^H value of solutions	Total length of roots in millimetres	Culture No.	Concentration of acid	p^H value of solutions	Total length of roots in millimetres
1	Per cent. nil	4.8	673	7	0.006	3.3	No root growth
2	0.001	4.5	512	8	0.007	3.3	Do.
3	0.002	3.9	355 } Average	9	0.008	3.3	Do.
4	0.003	3.9	167 } 262	10	0.009	3.2	Do.
5	0.004	3.8	Slight root growth.	11	0.01	3.0	Do.
6	0.005	3.8	Do.				

The length of roots and p^H values of the culture solutions—concl'd.

SERIES I.				SERIES II.			
Culture No.	Concentration of alkali	p^H value of solutions	Total length of roots in millimetres	Culture No.	Concentration of alkali	p^H value of solutions	Total length of roots in millimetres
	Per cent.				Per cent.		
12	0.001	5.4	537	20	0.009	0.5	1099
13	0.002	6.0	1095	21	0.01	6.5	1174
14	0.003	6.0	942	22	0.02	7.0	1326
15	0.004	6.0	951	23	0.03	7.9	1544
16	0.005	6.2	1352	24	0.04	Exceeds 8.4	1115
17	0.006	6.2	1305	25	0.05		1385
18	0.007	6.2	1168				
19	0.008	6.2	1397				

Cultures No. 12-25 continued to grow well till the end of the third week and all the plants therein presented, more or less, a healthy appearance.

DISCUSSION OF RESULTS.

The results as shown in the Table are further plotted in the curve in Fig. 1. The abscissa represents the percentage of acid and alkali in the culture solutions, whereas the ordinate represents the length of roots in millimetres. The O represents the check with Knop's solution alone. Concentrations of alkali higher than .01 per cent. NaOH have been omitted in the curve in Fig. 1 as they cannot be conveniently represented.

The relationship of p^H values and development of roots in rice seedlings is shown in a separate curve in Fig. 2. Here the abscissa represents p^H values from 3.0 to 8.4 and upwards, whereas the ordinate represents the root lengths of the culture solutions. For the same p^H value occurring more than once, the average of the total lengths of roots were taken, as shown in the Table.

The results clearly show that even such low concentrations of 0.002 per cent. acid is distinctly toxic, whereas higher concentrations than this are quite inhibitory to the development of roots in rice seedlings.

With the increase in percentage of acidity, as shown in Fig. 1, the curve shows a regular fall which is quite suggestive of a definite relationship between acidity and length of roots. On the other hand, both from the Table and Fig. 1, it is evident that the roots grow quite well with the higher concentrations of alkali which are far better in comparison to the equivalent proportions of acid. The best root growth is shown at a concentration of .03 per cent. NaOH.

Considering the results on the basis of p^H values of the culture solutions, as shown in the Table and Fig. 2, it becomes at once apparent that hydrogen-ion concentrations do exercise a considerable influence on the development of roots in rice seedlings.

The root lengths show a steady increase with higher p^H values with only a few irregularities which, however, falls within experimental error.

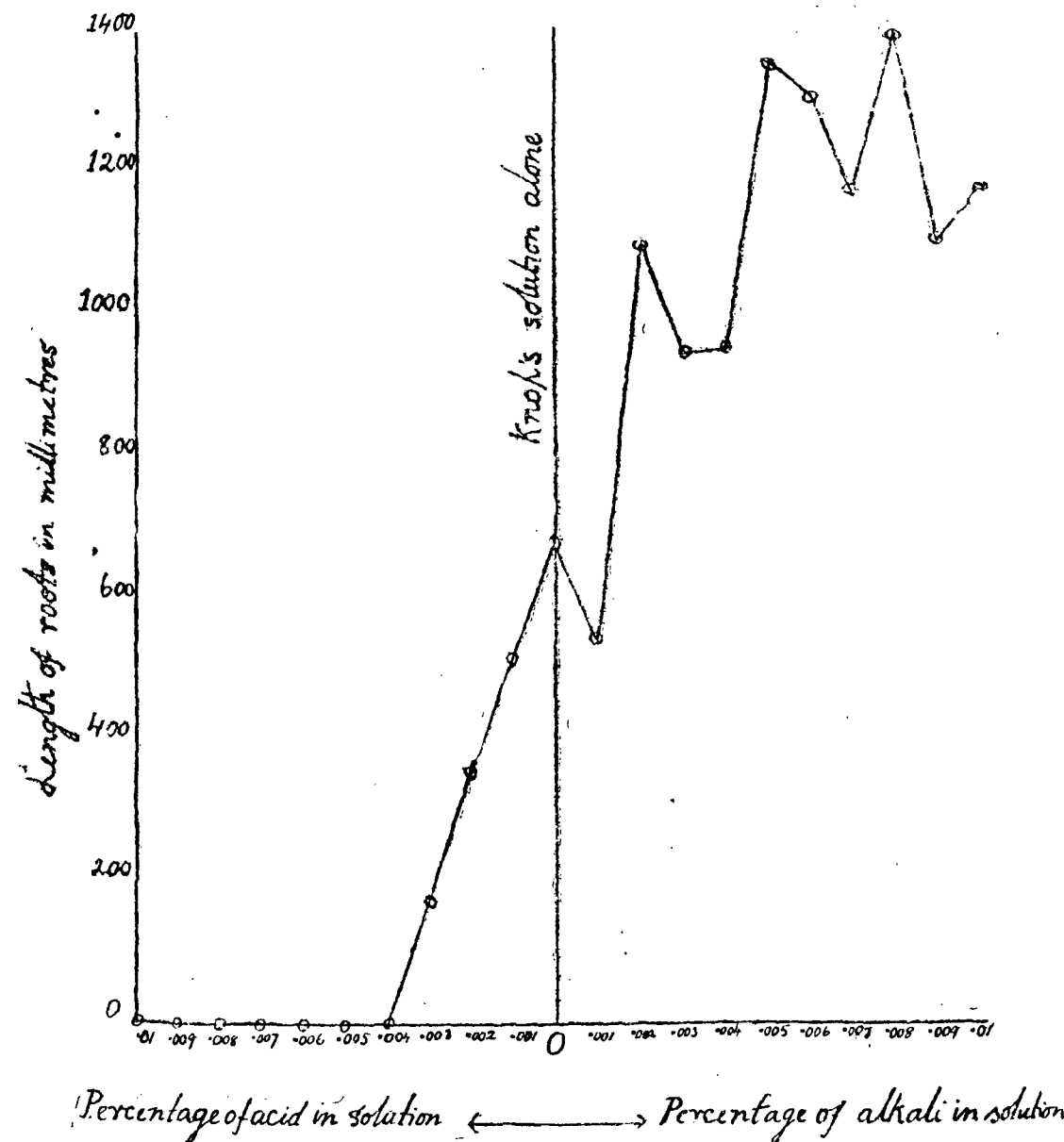


Fig. 1. The relative lengths of roots in millimetres of rice seedlings with varying concentrations of acid and alkali in nutrient solutions.

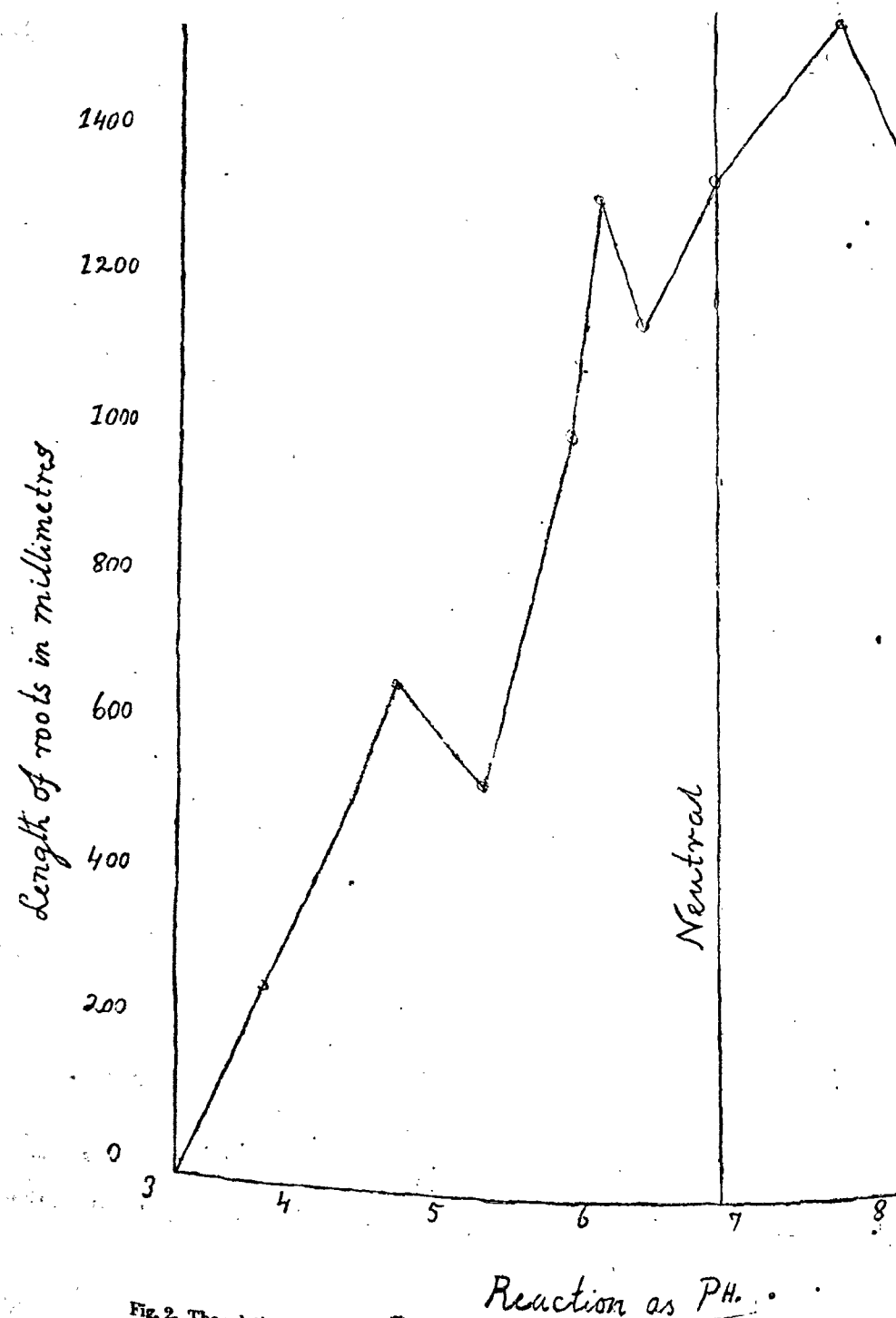


Fig. 2. The relative lengths of roots in millimetres of rice seedlings at various reactions.

On account of the buffer actions of the salts used, the p^H values of the culture solutions do not show any regular rise or fall as shown in the Table and in fact the same p^H value is maintained for two and even more cultures, although the total quantity of their titrable acidity or alkalinity varies a good deal. For such cultures, however, the total lengths of roots are very nearly the same. This apparent anomaly is quite significant and clearly explains that it is the hydrogen-ion concentrations and not the actual acidity or alkalinity which regulates the rate of growth of roots in rice seedlings.

Moreover, it is found that p^H 3.9 is distinctly toxic to the growth of rice seedlings, as quite unsatisfactory root growth is noticed at this point. Proceeding onward the toxicity of the culture solutions increases with the further decrease in p^H values, until it becomes quite inhibitory to the root growth of the rice plant. At p^H 3.3 and below, there was not the slightest root growth and the plants died within a very short time. p^H 3.3 may thus be taken to be extremely toxic to the growth of rice seedlings.

At acidities above p^H 3.9 and below p^H 6.0, the development of roots was not quite up to the mark, but beyond this limit, the growth of the plant was quite satisfactory.

Between p^H 6.2 and p^H 7.0, the root lengths, more or less, maintained a constant value and in each case the growth was optimum. Beyond the neutral point, the growth of the plants was again found to be quite vigorous. The highest root growth was shown at p^H 7.9, but proceeding onwards a drop is shown at about p^H 8.4 which is, however, of doubtful significance and cannot be fairly interpreted any further, unless some more cultures are started with higher alkaline reactions. However, it is fairly conclusive that, unlike most other plants, except corn, rice can grow quite well in an alkaline medium, which seems to be rather more favourable for the proper development of roots than an acidic one.* On the contrary, similar to all other plants, it is severely susceptible to acid toxicity and this agrees fairly well with other works as mentioned in the review of literature.

SUMMARY.

Effects of hydrogen-ion concentrations on rice cultures were studied with Knop's solution as the standard nutrient solution and with hydrochloric acid and caustic soda as the adjusting mediums, the concentrations of which varied from 0.001 to 0.01 per cent. and 0.001 to 0.05 per cent. respectively. The p^H values of the solutions ranged from 3.0 to about 8.4. The experiment was continued with one

* In fact rice grows generally in low-lying water-logged soils which are mostly less acid than the adjoining high lands, whereas the lowlands on the banks of rivers are invariably more or less alkaline. This closely corroborates the work of V. Subrahmanyam [Biochemistry of water-logged soils, Part I, *Journal of Agricultural Science*, Vol. XVII, Part 4; October, 1927] who has shown that water-logging results in an increase in alkalinity.

month-old seedlings for a fortnight and the total length of roots in millimetres was taken as the criterion of growth.

The results were as follows :—

1. The seedlings showed strong acid toxicity at a concentration of 0.002 per cent. HCl, whereas higher concentrations were distinctly inhibitory to root growth. With the addition of alkali, the roots developed far better and the highest root development was shown at a concentration of .03 per cent. NaOH.
2. A definite relationship was found between the hydrogen-ion concentrations of the culture solutions and their corresponding root lengths which showed a steady increase with the higher p^H values. p^H 3.9 was distinctly toxic, whereas p^H 3.3 was extremely toxic to root growth. At acidities less than p^H 6.0, the development of roots was below normal, but beyond this, it was quite satisfactory. The highest root growth was attained at p^H 7.9 but further on a drop was shown at p^H 8.4 which is, however, not quite confirmatory and requires further experimentation.

NEED OF CO-OPERATIVE MARKETING IN AGRICULTURE IN INDIA.

BY

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PRODUCTION alone, which has been stimulated by artificial and scientific means since the 18th century in different countries, is by no means the end of the story. Distribution (by which I mean physical distribution) is equally important and in the estimation of certain authorities perhaps more so. Of course, we cannot deny that the problem of distribution has arisen as a direct consequence of stimulated production after the limit was reached when a certain part of the product could not be easily consumed in the limited markets, yet as it stands now, the maladjustment between production and distribution threatens the civilized communities of the world. A well known agricultural authority in the United States said in one of his addresses that this surplus which is commonly attributed to over-production was a direct outcome of under-consumption and that the remedy therefore of the whole situation lied in adequate marketing facilities. But we shall at present confine ourselves to the co-operative side as applied to agricultural commodities.

With these few introductory remarks, let us analyse the term co-operative marketing itself. J. A. Hobson, a British economist, says that the word *co operation* is most confused in the terminology of economics, but still the legal and economic connotation of the word means "working together to an end or purpose." The term *marketing*, though equally difficult to define and commonly used to mean selling, has come to take a much wider significance and covers all the activities from the time the product leaves the producer to the time it reaches the consumer.

Thus far there is nothing in the meaning of the words to induce individual farmers to co-operate in order to merchandise their products. What he wants is a better price for his commodity and anything which will lead him to that end will be warmly welcomed by him. Various promoters in order to organize a co-operative association or certain other associations, in order to increase their membership, have offered golden opportunities and have approached the farmers with high sounding ideals which theoretically sound perfect, but practically lead us no further. Various lines of arguments brought forward by such promoters have been severely criticised. For instance, they always talk of shortening the channel between the producer and the consumer by eliminating the middlemen and thus saving quite a large slice of marketing expenditure. It is questionable how far this can be achieved, for if the organization manages to eliminate one or two middlemen, they at the same time add

quite an elaborate organization staff with its manager and number of clerks—in fact, the whole organization set-up is a large addition to the number of middlemen already existing. The experience of successful co-operatives have shown that though they can reduce a few middlemen they cannot eliminate them altogether. As the purpose of this article is not to criticise these shortcomings but to show wherein lies the immediate gain which one can foresee before an organization of this type is set up, we will approach the problem by assuming a co-operative association as a business organization whose motive is to increase the savings of the co-operators, eliminate waste and thus bring higher prices to its members, meanwhile not raising the price to consumers, perhaps even reducing it.

CO-OPERATIVE ASSOCIATION AND WASTE.

Various organizations have undertaken the study of waste and have revealed the fact that a large percentage of waste can be eliminated by efficient management. Dealing with the most important ones with which an Indian farmer has to face, they can be listed as follows :—

1. *Waste due to unnecessary number of middlemen handling the product.* The popular conception of eliminating the middlemen from the marketing channel and certain attempts to do so have met with considerable failure. As said above, the co-operative association cannot eliminate them entirely, but there is the possibility of reducing them to the minimum.

2. *Waste due to the glut in one market.* In case of fruits, a product grown by numerous producers scattered over a large territory, there is always likelihood of a glut in the central market and famine in the others. An adequate market news service prevents such waste and by switching a portion of the products to other markets, the producer may get a better price from both places. This could only be possible if there were some organization of the fruit producers which would keep adequate market news about the demands of these products in various markets and thus distribute the total supply according to that demand which ultimately would bring better returns. A farmer of to-day who has to be a specialist in his own field has neither the time nor the means to keep an up-to-date information service about the demands at various markets. Usually, he takes the risk by sending the crop to a central market, thus creating an over-supply, causing prices to drop and in some cases resulting even in an entirely unprofitable market.

3. *Waste due to transporting inferior products.* The quality of the goods demanded varies with the markets. An association can save a lot by not transporting inferior products to the markets where there is no demand for them. It often happens that when the inferior product is sold mixed with the superior, a lower price for the total results.

4. *Waste due to inadequate storage facilities.* Experience has taught our farmer that by storing his product at the time when the price is low, due to over-supply,

he can get a better price a little later when there is a shortage in the market. But he as an individual has neither the capital nor the resources to build for himself some sort of storage which will keep his product in perfect condition. The storage which he has at present is of a primitive kind where the product is exposed to all dangers of being spoiled. I have observed many cases where the poor farmer has suffered the entire loss of his product as a result of moth infestation and even has had to buy his seeds for the succeeding year. On the other hand, an association after pooling its resources has in hand either the capital or facilities of borrowing the capital for building such storage for the entire membership. This is particularly important in the case of grains and like commodities where an elevator can be built to store the entire surplus of the members at a minimum cost. This will not only take care of the surplus but will assure an even supply throughout the year. The need of such storage is more keenly felt in case of perishable commodities. Fruits worth hundreds of thousands of rupees perish either at the farm or in transit, or ultimately at the receiving end. If there were provided some sort of cold storage, preferably at both ends, and refrigeration cars for transportation, a tremendous loss could be prevented. It will take care of the surplus, assure a regular supply and will even out the prices. At the same time it is beyond doubt that the storage facilities will have a direct effect on production when the producer will be sure that his addition to the total supply will be taken care of and the prices will not drop.

5. *Waste due to inadequate transporting facilities.* It is very hard for a small farmer to deal with the railroad authorities for transporting his produce to the market. The only other alternative is to sell it to the local buyer and be contented with whatever price is offered. An association can very easily control the situation, for it can foresee its needs and can manage ahead.

CO-OPERATION AND THE BARGAINING POWER.

The commercial relations of an average farmer are limited to the local "Banya" (the country store-keeper), and the former is at the mercy of this usually hard-hearted individual whose motive is to get as much produce for as little money as possibly he can. He buys or engages to buy the product at a ridiculously lower figure than the prevailing market price of which he himself may be unaware. "Banya," being also the money-lender, is in position to dictate his terms to the farmer at the time the advance is made, and binds him by a verbal agreement (secured by the further promises to help him in need in the coming crop season) to sell the whole or a portion of his crop to him at whatever price he chooses to pay. The only other types of buyers with whom the farmers have to deal are what are known as "travelling buyers." They represent outside firms whose gains sometimes rest on pure speculation; being well informed of the prevailing and possible future prices they have considerable advantage over the farmer.

On the other hand, an association of farmers will keep itself well informed about the market situation, its future trend, and by pooling the bargaining power of

the farmers, will get better prices for their products. The bargaining power of such associations will depend on two things : the percentage control of the total output and the superior managerial ability. This, however, does not mean that the association should have the monopoly of the product and dictate its monopoly prices. Such control is not only a social menace but is detrimental to the interests of the association itself. Firstly, a monopoly control of some agricultural product is very difficult in these days of free competition. And, secondly, where an association has tried to dictate its own prices by getting a considerable control of some agricultural product, it has suffered terrific losses. For monopoly prices stimulate over-production on one hand, due to the farmers' greed of getting better price for each additional unit, and under-consumption on the other due to the resulting consumers' strike or boycott who will satisfy their demands by shifting to some other competitive commodity.

Co-OPERATION AND POOLING.

An individual who might send his product to the market at the time when there is a temporary glut, will get a very low price through no fault of his. To prevent this and to distribute the risk equally amongst all, there is this device of pooling. In other words, the purpose of pooling is to equalize the returns to the members in the pool for their product. Two different types of pools are possible, either to pool the returns or to pool the products of all members before selling. In the former class there will be a grave injustice done to the producer of the better quality, for he will be greatly discouraged to find that an inefficient producer is getting the same return. In the latter case, if there are separate pools for different grades of the same product, all the members producing the same grade or quality will get the same price for each unit. At the same time the length of the pool should not be very long so that the producer of an early crop, by having separate pool from the others, will get better price (since it is customary to pay higher price for the early crop). All this is only possible if the growers come together and form some sort of co-operative organization for marketing their products.

Co-OPERATION AND ADVERTISING.

Advertising agricultural commodities is almost unknown in India, but there is no doubt that it will play a great role in the near future and will be a very handy tool in educating the consumer. At the same time it must be borne in mind that this is an expensive weapon to be used by an individual. However, a co-operative effort in advertising and thus increasing the sales will be the cheapest, for the cost will be spread over the entire membership. In countries like the United States, advertising is generally recognized as one of the main activities of the co-operative marketing associations and will continue to be so. The following figures for the last nine years

showing the increasing importance attached to advertising by the Sun-Main Raisin Growers Association should be interesting :—

	\$	Rs.	
1914	120,803.74	3,62,411	} (approximately)
1915	240,335.83	7,21,007	
1916	219,592.29	6,58,776	
1917	287,000.00	8,61,000	
1918	291,756.44	8,75,269	
1919	347,147.11	10,41,441	
1920	1,261,342.72	37,84,028	
1921	2,139,567.57	64,18,702	
1922	2,520,000.00	76,60,000	

Evidently, this device has been profitable to this co-operative organization.

Co-OPERATION AND CREDIT.

The credit problems of the farmer are now taken care of by the co-operative banks, but if there were a co-operative marketing association of the farmers organized on a capital stock basis it can, by creating a loan fund, serve to supplement the above credit agency. At the same time it will improve the borrowing power of the members, for, possessing a better knowledge of the members' moral and financial standing, the organization will stand as a security for the loan at a lower rate of interest.

The association backed up by thousands of its members will itself have better credit and will be able to borrow at a low rate of interest whenever it needs money for its own improvements.

Co-OPERATION AND PROFITS.

A co-operative association works as a union of individuals rather than the aggregation of capital, or, in other words, any profit made by the association goes to the members themselves and not as dividend on the stock held by any group of outsiders. One of the most important features of a co-operative association is the method of dividing the profit. The association organized on non-stock basis works on a non-profit basis, *i.e.*, the proceeds are divided amongst members according to the business transacted by them through the association after all expenses have been deducted. In the other case where the organization has a capital stock, the profit is divided by means of a "patronage dividend," *i.e.*, after paying the dividend on the stock held by the members at the current rate of interest, the remainder is divided according to the business transacted. Whatever may be the method of dividing, the main point is that any profit made is a direct gain to the members.

Before bringing the general discussion to a close (for the above is neither an extensive study of the problem nor an adequate one because of lack of space and the object to bring forth only the high lights of the subject), we have still to sketch briefly the conditions necessary for successful co-operation.

The first pioneer co-operative society was started at Toadlane, Rochdale, England, by 28 flannel weavers in order to buy household articles at a cheaper price. The chief principles were democratic control, limitation of the numbers of shares held by each member, shares of low denomination and payable in instalments, sale of pure goods at market price, cash transactions, maximum interest 5 per cent. on the capital, a portion of profits set aside for social benefits and the rest divided according to the business transacted. The Rochdale pioneers were interested in consumers' co-operation, or co-operative buying, which is much simpler than co-operative selling, for in the latter case sellers compete with each other.

The essential features of a co-operative marketing or selling association, besides its aim of some tangible economic savings or improvement, are best described by Professor L. D. H. Weld in his book "Marketing of Farm Products" as "..... sufficient business to make it worth while ; sufficient capital to carry on its business efficiently ; sufficient loyalty on the part of the members to stick to the organization in the face of fierce competition to which it will be subjected ; and sufficient patience to build up the organization gradually and not expect it to be a whirlwind success from the start." To these can be added better understanding between the members ; democratic control ; and last but not least, efficient management and improved business methods.

So far we have not discussed the part played by the government in promoting such organizations and thus benefiting the community at large. The agricultural department in India has done considerable constructive work in a relatively short time, but there is a limit beyond which a government cannot help the people regardless of the efficiency of the former. The history of agriculture in various democratic countries reveals that even the most unselfish direct attempt by the public authorities towards the improvement of agriculture has met with opposition. Man's mind is suspicious by nature and this is even more true of the rural mind. The Agricultural Department in India in trying to introduce more scientific methods of production has faced the same difficulty but has wrongly attributed its failure solely to Indian rural traditions. Of course, we have to admit that in a static society like India it is difficult to change traditions, but this is by no means an impossible task. The crux of the whole problem lies in the use of various methods of mass suggestion. Attempts which may prove futile in educating in one direction may be shown to work most successfully when expertly handled and imparted in a more efficient manner. Self-suggestion is the most satisfactory method in educating one's own self, *i.e.*, if the suggestion comes from within the group, it will be more effective. To explain more fully, we have to consider the whole organization as a single individual ; with its directors and manager representing the head, and the entire membership the body. It is comparatively easy to educate the few enlightened people at the top (directors and other office holders of the organization) and when they in turn pass the suggestion on to the members after fully realizing its value, it will in general have a greater effect on them than if it were to come directly from an outside body like the govern-

ment. In other words, it will be the head suggesting the body to act in a certain way.

What the Department of Agriculture can do to help the farmer, through the co-operative organization, to solve the marketing problem, is to provide in an intelligible form, facts gathered through research and education, so that he can adjust his production according to the demands of the market. To-day's marketing problems are more or less international and in order to adjust supply and demand, a farmer must be guided by the probable need of the world and the activities in various parts of the world to meet those needs. He needs guidance not only regarding the present conditions of the world supply and demand but its future trends, so that he may get timely notice to adjust his farm operations to get in line with the rest and reap an equitable reward for his undertakings. He must also know not only the physical quantities of the world production but the comparative cost of production and marketing including transportation to the central market of the world. This is particularly important in cases of commodities like wheat and cotton which has a world-wide competition.

The way to effect this guidance of farmers is not through direct approach to producing farmers. The way is to effect commodity farmer co-operatives. With these organizations set up and functioning, the government can carry on effective education for producers through the heads of these units, who in turn can effectively transmit this educational matter to local membership.

PRESERVATION OF MANGOES BY COLD STORAGE.

BY

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AND

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It is a common observation that fruits and vegetables are in abundance only in certain seasons in India and these seasons are of short duration. During the time of plenty, the grower at present has no other alternative but to sell them in the local market as soon as possible, because both the fruits and vegetables are perishable. There are but few industrial organizations which make use of these articles by canning or bottling them or preserving them in some other way, such as drying. Preservation is hardly thought of, much less practised, by individual growers in any locality, with a view to placing on the market the articles in the preserved condition. The usual result is a glut in the market in times of plenty and a keen competition with a consequent lowering of the price.

Many good varieties of mangoes such as *Langra*, *Malda* and *Bombay* are abundant in Bihar in some years, but the season for these fruits lasts only for a short time. Ripe mangoes when plucked from the tree can be kept normally for 8—10 days, after which they get overripe and fungal and other attacks set in. This is probably due to the ripening enzyme being active on account of the high temperature (30—32° C.) prevailing in June and July, at the time when the fruits are ready for ripening. If the above assumption is correct, it follows that by lowering the activity of this enzyme, the fruits could be kept for a longer period without deterioration.

The problem is, therefore, to keep the mangoes in the raw condition for a month or over after they are fully mature without impairing the efficiency of the ripening enzyme and, naturally, storage at cold temperature suggests itself as one of the feasible methods. If this method is successful, fruits could not only be easily exported to foreign countries, but big cities like Bombay and Calcutta where cold storage is available would be enabled to keep them in sound condition for a long time. Even in small towns, where it has become the practice in modern days to instal cheaply "Frigidaire" or similar outfits by single individuals or co-operative organizations, for preservation of food and refrigeration purposes, the same could be utilized for the storage of quickly perishable fruits like mango for a pretty long period without

spoilage. We took the opportunity of carrying out certain experiments in this line with mango fruits, as there was an abundance of the same this year (1928) in Bihar. The present paper gives details of observations so far made by us.

Fifty *Malda* mangoes with stalk on were plucked from a tree by means of a netting basket tied at the end of a long pole, to prevent them from falling on any hard surface, and were brought to the laboratory within a few hours after their plucking on the 21st June, 1928. The rot starts, as usually observed, at the place where the stalk is attached to the fruit and then gradually extends over the whole fruit; hence it was thought that the organisms might be gaining entrance through the rupture of cells caused when the stalk is broken. To test this, stalks of half the number of mangoes were clipped very close by means of a pair of scissors and immediately the cut end of the fruit was dipped in melted paraffin. Thus we had 25 paraffined and 25 non-paraffined fruits. They were then divided into three series and kept at different temperatures as follows:—

- (a) at room temperature (30—32° C.) in a dealwood box.
- (b) at 25° C. incubator.
- (c) at 10° C. "Frigidaire."

Some of the mangoes were allowed to ripen to a half-ripe stage (*i.e.*, the green colour of the skin was allowed to be changed into light yellow) at the room temperature before they were transferred to 10° C. "Frigidaire," whilst others were allowed to ripen fully to acquire the yellow colour and softness to the touch and a fine flavour, and then transferred to 10° C., the object being to determine the different periods up to which they could be kept in the cold storage at the various stages of ripeness.

One point which emerged from these experiments was that paraffining the stalk end did not prevent rotting. Mangoes kept at 25° C. ripened almost in the same time as those at room temperature, *viz.*, in 6—8 days. On keeping them for a longer period at these temperatures, black patches appeared here and there on the skin and eventually the whole fruit got rotten. No difference could be made out between the paraffined mangoes and the control ones without paraffin.

It was also observed that if, by chance, during storage or in handling, mangoes came in contact with any hard surface or suffered any pressure by fingers, depressions with black spots appeared at these particular points, where later on rotting started. Hence particular care had to be taken in wrapping individual mangoes with a piece of tissue paper and storing them on a soft bed of cotton or other packing material.

Once the mango is completely ripe, death of the cells takes place and saprophytic fungi and bacteria gain access and attack the sugar, setting up fermentation and rot. This latter could be delayed to some extent by keeping them at 10° C., but it could not be completely stopped.

Fully ripened mangoes removed to 10° C. in the "Frigidaire" kept well for 3 weeks, after which time they lost their distinctive colour of ripeness and the skin gradually assumed a brownish black tinge; the flavour and taste were not, however,

affected in any way. When they were kept for another week more, they got over-ripe and lost in flavour also. On the other hand, those which had partially ripened at room temperature before being transferred to 10° C., kept well for over 6 weeks, both in appearance as well as in flavour, probably owing to the ripening process being retarded by the low temperature. A shrinkage of the skin took place slowly but no rot set in, unless some injury was caused to the cells by pressure or impact on any hard surface. Such half-ripe mangoes kept at 10° C. on the 23rd June, 1928 were quite good in appearance and flavour when cut open on the 10th August, *i.e.*, after a lapse of 7 weeks.

In the case of raw mangoes stored at 10° C., the ripening was uneven. Some of the mangoes normally ripened after a month, others did not, the ripening depending upon the state of maturity attained by the fruits when they were plucked from the tree. One cannot guarantee therefore uniform results if mangoes plucked green are stored directly in the cold storage chamber.

From these experiments it can be inferred that the enzyme or enzymes, to which the ripening of the mangoes is due, remain slowly active at 10° C., provided it is already present as is the case with partially ripened and fully ripe mangoes. One cannot be certain, however, of the presence of this enzyme if the mangoes are stored in the raw state.

In order to test further whether incubation at 10° C. is prejudicial to the proper functioning of the ripening enzyme and to see for how long a period the enzyme remains active at this temperature, it was considered desirable to keep the raw mangoes at 10° C. and then take them out at different periods, *viz.*, after 1, 2, 3 and 4 weeks, leave them at the room temperature and see whether they showed the usual signs of ripening. The result was that the enzyme remained active up to a period of 3 weeks, as was evident in the case of normal ripening of mangoes kept till that period at 10° C. and then taken out. By the 4th week, the ripening became uneven; some ripened normally, while others remained quite green and tasted somewhat sour even after several days' subsequent storage at room temperature.

The conclusions to be drawn from these experiments are —

- (1) that fully ripe mangoes could be kept for three weeks without rotting, while partially ripened ones could be kept for about six weeks, by storing them at 10° C. in the "Frigidaire";
- (2) that in order to secure the best results they should be plucked from the tree when they are fully mature, allowed to ripen partially at the room temperature which generally takes 2 to 3 days and then transferred to the cold storage at 10° C.; the period of storage can thus be lengthened to 7 weeks without deteriorating the quality of the fruits;
- (3) that any impact on hard surface or even rough handling of the fruits should be scrupulously avoided. They may be wrapped individually with a piece of tissue paper and stored on a soft bed of cotton, straw, or any other packing material.

ANNOTATED BIBLIOGRAPHY ON THE STORAGE OF COTTON-SEED AND OF SEED COTTON.

BY

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THE storage of cottonseed and seed cotton involves problems of considerable importance to the production, transportation, and manufacturing elements in the cotton industry. Studies relating to the subject have been made by the State experiment stations, the U. S. Department of Agriculture, and by other investigators. This bibliography, not claimed to be exhaustive, was prepared to present in summary form the results of official and other investigations concerned with the storage of cottonseed and seed cotton, and to call attention to bulletins and articles giving general information on the problem.

COTTONSEED.

Ayres, W. E. The cottonseed products industry with special reference to storing and marketing seed. (*Cotton Oil Press*, 3 (1919), No. 1, pp. 34-36.)

The risks in storing cottonseed are described briefly with precautions to be observed. The results of Rather (*Arkansas Sta. Bull.* 125) are cited.

Barr, J. E. Marketing cottonseed for planting purposes. (*U. S. Dept. Agr. Bull.* 1056 (1922).)

Information (pp. 16-18) is given on storage of cottonseed in bulk and sacked, warehousing and stacking.

Cornwall, H. F. Cotton oil mill construction and fire insurance. (*Cotton Oil Press*, 2 (1918), No. 2, pp. 22, 23.)

Different types of cottonseed warehouses are compared as to their storage hazards and operating hazards.

Creswell, C. F. and Bidwell, G. L. Composition of cottonseed. (*U. S. Dept. Agr. Bull.* 948 (1921).)

The authors indicate the factors affecting the composition of cottonseed and the effect of damage on cottonseed and of damaged cottonseed in warehouses (pp. 1, 5).

Eliot, W. M. Pressure of cottonseed. (*Engineering News*, 74 (1915), No. 21, pp. 991, 992, fig. 1.)

Results of tests to determine the horizontal pressure of cottonseed in warehouse bins are graphically reported, the equation of the curve being $P = \frac{5}{2} H$, in which P = the horizontal pressure in pounds per square inch and H = the head in feet.

The weight of loose seed was taken at 22.4 lb. per cubic foot and of packed seed as 33.6 lb. per cubic foot, and the angle of repose of the seed as 38° 40'.

Fraps, G. S. The composition of cottonseed meal and cotton seed. (*Texas Sta. Bull.* 189 (1916), pp. 5-79.)

Brief information (p. 16) is presented on storage of cottonseed intended for milling.

Knapp, B. The effects of methods of harvesting and storing on cottonseed. (*Arkansas Sta. Bull.* 181 (1922), p. 23.)

Seed cotton harvested in good condition, ginned, and the seed stored in bulks of 2 or 3 tons or less did not deteriorate, whereas cottonseed, even when harvested in fairly good condition, stored in large bulk tended to heat to the point of injuring the vitality. Gathering seed cotton when wet or damp led to great deterioration of the cottonseed, which heated rapidly after storing, with serious injury to germination.

Locket, C. L. Intensive seed cleaning. (*Cotton Oil Press*, 10 (1926), No. 3, pp. 29, 30.)

Calling attention to inefficient methods of cleaning cottonseed, the author indicates that foreign matter in cottonseed, such as sand, pieces of boll, bits of shell, and dirt take up storage space, and that the moisture in the bolls may be a cause of accelerating the process of heating during storage.

Ludwig, C. A. Studies with anthracnose infection in cottonseed. (*South Carolina Sta. Bull.* 222 (1925), p. 52, fig. 14.)

Cottonseed infected with the fungus *Colletotrichum gossypii* was found to become free of infection in storage. Under laboratory conditions this action appeared to proceed very slowly until the cottonseed are about a year old, when it becomes rapid, and by the second spring after harvest the infection has practically disappeared. No ordinary method of heating or drying the seed before storage appeared of much value in destroying the infection. Delinting with sulphuric acid and sterilizing with corrosive sublimate reduced infection, and that infection remaining in the seed appeared to be eliminated a few months sooner than in untreated seed. Storing cottonseed in a very moist atmosphere produced the most rapid reduction in anthracnose infection of the means tried, but the seed quickly became musty and failed to germinate. Storage in a very dry atmosphere prolonged the life of the fungus whatever the preceding seed treatment. Storage in alternating very dry and very moist conditions induced a more rapid reduction of infection at first than where cottonseed was stored under ordinary laboratory conditions. There was little damage from mustiness, but complete freedom from infection was little or no sooner than in untreated seed. Sunning the seed appeared to accelerate the death of the fungus, but results were so slow that the germination of the seed was seriously impaired before practical results were had. The best results were obtained where the cottonseed was delinted with strong sulphuric acid, placed in clean bags, and stored for two or three years in a dry building.

Malowan, J. Some observations on the heating of cottonseed. (*Cotton Oil Press*, 4 (1921), No. 11, pp. 47-49.)

Rather elaborate storage experiments with cottonseed by the author are reported on.

Ventilation. Cottonseed of different moisture contents were stored in air tight and ventilated bins, on certain of which weights equivalent to 200 lb. per square foot were placed. The results indicated that the weights employed or some natural ventilation does not affect the heating of cottonseed but does decidedly affect the rate of cooling. Compressing the seeds obstructs the passage of air and the seed will cool more slowly. Air passing through the seeds will also absorb moisture therefrom and dry as well as cool them. Forced ventilation of bins containing seed of different moisture contents demonstrated "that a blast of air will quickly cool hot seeds, but ventilation will not prevent heating of seeds unless the ventilation is continued until the moisture content has been sufficiently reduced. If the seeds have once reached the maximum temperature, they can be more easily kept cool than if they were never permitted to heat." Observation on bins filled with cottonseed, hulls and meats indicated "that even when the germinating power of the seeds had been destroyed, heating will still occur, and that not only oxidation processes, but also fermentation processes are taking place at the time of heating." When hulls were wetted, binned, and permitted to heat and cool undisturbed and the procedure repeated several times, it was observed that after the hulls ceased heating an addition of water caused them to heat again. They lost considerable substance during the test, the final volume being only about half of the original. About 35 per cent. of the pentosan content was lost.

Chemical control. When cottonseed were wetted, moistened with 0.1 per cent. of formaldehyde, and wetted and mixed with 10 per cent. of NaCl and binned, the results seemed to show that the amount of water added affected the heating more than did the moisture content, and that the heating is caused by some agent within the seeds and not from bacteria or moulds which most likely would have been killed by the formaldehyde solution. "That the addition of NaCl prevents heating has already been observed by E. R. Barrow who had taken out a patent for the prevention of heating by its addition to wet seed."

CO₂ evolution. The carbon dioxide (CO₂) evolution by cottonseed under different conditions was studied in considerable detail. The following deductions seemed warranted: "The CO₂ evolved corresponds to the amount of water added just as the degree of heating depended on the amount of moisture. Seeds to which no water had been added will also develop CO₂, although at a small rate The CO₂ generated depends more on the moisture content than on the temperature. After the maximum CO₂ generation has been reached, the evolution dropped rapidly, notwithstanding the rise in temperature A temperature of 140° F. prevents the generation of CO₂, and that if the seeds have been heated to 140° or even 130°, very little CO₂ will be generated, even when the temperature has later been reduced. The most favourable temperature for CO₂ generation seems to be 100° to 110°. If it does not exceed 100°, the seeds will generate CO₂ for a considerable time, while

at a higher temperature the amount of CO_2 generated will decrease rapidly Thus sterilization of the seeds prevents the evolution of CO_2 , but heating the seeds to 212° followed by a wetting of them will not stop the generation of CO_2 .

"Acids will prevent the generation of CO_2 , and alcohol acts like an acid, possibly by being quickly oxidized to acetic acid. Sodium chloride prevents the evolution of CO_2 as it did prevent the heating of seeds in the bins. A 10 per cent. solution of sodium chloride has no different action from water. Starch and sugar increase the CO_2 generation by being most likely oxidized themselves. That the mercuric chloride had no preventive action was surprising." Additional tests indicated that disinfecting solutions applied to lint-free seeds do not prevent the generation of CO_2 and that bacteria, moulds, or yeast cannot be the cause of it. Formalin was either oxidized to formic acid or could penetrate the meats complete, while copper sulphate and mercuric chloride possibly never penetrated beyond the hulls.

"Most of the CO_2 is a product of oxidation processes, and that the fermentation processes take a much smaller part. If air could be prevented from access to the seeds, no heating would take place. Although in a pile of seeds air occupies about 50 to 60 per cent. of the volume, the amount is so small that the temperature could rise only very little. But if the amount of moisture is large, deterioration of the seeds could not be prevented by the exclusion of air, because putrefaction would take the place of the heating of the seeds.

Spontaneous combustion. "No experiments were made to determine the maximum temperature to which seeds may heat. The highest temperature observed was 175° F. in a car of seeds received by us, and the temperature might even have been higher while in transit. I doubt if seeds will ever heat high enough for spontaneous combustion, and no case has come to my knowledge. Hulls will heat to a much higher temperature than seeds, and on several occasions have caught fire spontaneously."

Malowan, J. Chemical changes in cottonseed during heat and storage. (*Cotton Oil Press*, 5 (1921), No. 4, pp. 40-43.)

Cottonseed. Analyses of variously heated cottonseed showed "that when seeds are damaged through heating, the sugars and pentosans decrease, while the acidity increases, and the proteins become insoluble in salt solution. To prove these points, further tests were made by permitting seeds, meats, and hulls to heat while taking samples for analysis before, during and after heating. The tests were made as described in my former article by wetting prime seeds, meats, or hulls with a spray of water and placing them in bins." The results showed that during heating the sugars are used up, while the globulins become insoluble in sodium chloride solution. As long as the seeds did not heat, practically no change took place.

Meats and hulls. According to analyses of heated meats and hulls, there seemed no doubt that, when the hulls heat, the pentosans furnish the fuel and when the pentosan content had decreased, the intensity of heating dropped also. Toward the end of the test, the outside temperature had a marked influence on the rise and fall

of the temperature of the hulls. "Considerable heat must be developed to heat hulls containing 40 per cent. of water to a high temperature in two or three days. It is not surprising that hulls, when well insulated or in a large pile, will rise to a temperature high enough to ignite spontaneously. It is still an undecided question whether unsaturated compounds are formed which, by admission of air, become suddenly oxidized with a large generation of heat, or that, according to one theory, during heating free carbon in a state of very fine division is formed which will, when the conditions become right, suddenly burst into flame. When seeds or meats heat without an excess of air, the sugars are not oxidized completely and some alcohol and acetic acid are formed.

"The analysis of putrefied seeds does not show a large chemical change. It is remarkable that the seeds do not become black in appearance but only slightly off in color, while heated seeds soon become dark. The solubility of the proteins in the salt solution has not been changed much. The above analyses do not show a large increase in loosely bound ammonia or amines, most likely because some of the volatile nitrogen compounds were lost in drying or were extracted by the petroleic ether. Analysis of cottonseed cake showed that the heat during cooking does not coagulate the proteins completely. The high acidity of the oil left in the cake did not prove that the cake was made from damaged seeds. The oil left in the cake is invariably of higher acidity than the oil expressed. Analyses on sprouting cottonseeds indicated that the great difference between germinating seeds and heating seeds is that in sprouting seeds the oils rapidly decrease and that the pentosans increase."

Malowan, J. The deterioration of cottonseed by moisture. (*Cotton Oil Press*, 10 (1926), No. 1, p. 21.)

"The cause of deterioration of seed is usually rains at the time the bolls open in the field. The seed becomes then either field damaged or deteriorates further during storage by heating. Although there are no ways to prevent damage to the seed in the field, the seed can be stored in such a way that heating does not take place. A great aid to the industry would be better means of treating damp seed and a short method to determine the quality of the seed when bought."

Meloy, G. S. Grading cottonseed "as is." (*Cotton Oil Press*, 10 (1926), No. 3, pp. 17-22.)

Foreign matter and excessive moisture are described as factors influencing the deterioration of cotton seed.

Rather, J. B. Biochemical changes in cottonseed in storage. (*Arkansas Sta. Bull.* 125 (1916), pp. 3-18.)

Studies of the changes in stored cottonseed with reference to loss of vitality and the availability from the standpoint of the cotton-seed-oil mill and the livestock feeder are reported. In cottonseed from seed cotton gathered dry and stored for three weeks in a common farm cotton house and in a cotton-oil mill seed house in lots of 4,500 and 7,500 lb., respectively, no appreciable changes except a reduction in moisture content occurred. Dry cottonseed stored in a common farmhouse in a

3,000-lb. lot in a pile 12 by 12 by 4 ft. did not deteriorate during the period of oil-mill operation. A slight loss of moisture in the samples caused correspondingly small increases in the percentage of protein and fat. The free fatty acids in the fat and the total acidity of this seed did not increase significantly. Cottonseed stored in an oil-mill seed house in a 5,000-lb. lot in a pile 12 by 12 by 6 ft., dried out in storage and then heated. During heating the free fatty acids in the fat increased from 2.26 to 11.89 per cent. and the total acidity noticeably increased. The increase in the free fatty acids and in acidity seemed due to heating and not to aging of the seed. Cottonseed in lots of 1,000 lb. did not deteriorate in storage. It is concluded that unless cottonseed heats badly, the meal made from it will be as valuable for feeding as meal made from unheated seed, but that the oil from even slightly heated cottonseed is worth considerably less than oil from fresh seed.

Rocke, M. M. Cottonseed and hull houses. (*Cotton Seed Oil Magazine*, 52 (1925), No. 6, pp. 25, 26, fig. 3.)

The essentials of a new type of postless building which may be suitable for cottonseed and hull warehouses are described.

Taliaferro, T. C. Fire records of cottonseed oil mills. (*Cotton Oil Press*, 9 (1925), No. 5, pp. 26-28.)

This paper contains a description of fire hazards in cottonseed houses from electrical equipment, mechanical agencies, careless employees, etc., and indicates conditions for heating and spontaneous combustion of seed. Proper ventilation is suggested as a control measure.

Tempamy, H. A. Observations on the effects of storage on cotton seed. (*West Indian Bull.*, 10 (1909), No. 2, pp. 121-124.)

After a period of storage, crushed cottonseed gave a bright yellow color when mixed with water, due to rupture and chemical change in the resin cavities in the seed mass. Fresh seed had a germination percentage of 51 on February 24, 1908, 49 on June 3, but only 8 on April 24, 1909. Similar results were obtained when seed from the same lot was preserved in a desicator over strong sulphuric acid for the same length of time.

Tessier, E. L. The storage of cotton seed. (*Cotton Oil Press*, 3 (1920), No. 10, p. 22.)

A discussion of economy in cost of warehouse construction, and of handling, protection from fire loss, and protection of seed from damage by heating. The author states "even the seed need not be insured, as there is no spontaneous combustion hazard in seed, and all heating can be prevented by using the 'French' system of seed cooling."

..... Regulations for warehousemen storing cottonseed for commercial but not for seed stock purposes. (*U. S. Dept. Agr., Bur. Agr. Econ., Serv. and Regulat. Announc.*, 102 (1926).

The regulations under the United States Warehouse Act, approved August 11 1916, as amended, are concerned with warehouse licenses, bonds and receipts, duties

of licensed inspectors, graders and weighers, cottonseed grading and arbitration. The regulation on warehouse licenses (pp. 2-5) describes an acceptable building for storage of cottonseed, the extra bin required, conveyor system, air cooling system, tank storage, and bag storage.

SEED COTTON.

Brand, C. J. Improved methods of handling and marketing cotton. (*U. S. Dept. Agr. Yearbook* 1912, pp. 443-462, pl. 4.)

Farm storage of seed cotton (pp. 448-450) is recommended for strengthening fibre, improving luster, and economical usage of labour. "In some experiments conducted by the Office of Cotton Standardization in the Bureau of Plant Industry, an increase of several per cent. in strength was noted in the case of cotton stored in the seed as compared with the same growth of cotton ginned immediately. That the lustre of the fibre is improved by a sweating-out process is not surprising, and it is possible that both of these beneficial results may be due to the slight diffusion of the oil in the seed through the mass of the cotton In an experiment in South Carolina in the season of 1912, 40,000 lb. of thoroughly ripe seed cotton were stored in a single body for several weeks without 'heating' in the least. Early-season pickings are most likely to heat."

Brand, C. J. and Sherman, W. A. Behaviour of seed cotton in farm storage. (*U. S. Dept. Agr., Bur. Plant Indus. Circ.* 123 (1913), pp. 11-20, fig. 2).

In tests at Bennettsville, S. C., in which seed cotton was stored for several weeks in piles, loose and tramped, from 43.5 to 64 per cent. of the seed germinated when not affected by heating. When heating reached 111° F., from 5 to 13 per cent. of the seeds germinated, and when the temperature reached 127 and 133°, no seed germinated. Data as to temperature and moisture conditions in cotton stored in various ways are also tabulated.

Burns, A. C. The bacterial deterioration of cotton during damp storage. (*Jour. Textile Inst.*, 16 (1925), No. 6, pp. T185-T196, pl. 1, fig. 2.)

Seed cotton of the Sakellaridis variety was stored at Cairo, Egypt, in the open and in confined air and in bags, and ginned cotton in bags and in small pressed bales. The results of the study indicated that bacterial and fungoid infection, as a source of serious deterioration of cotton during damp storage, is to be sought and controlled in seed cotton rather than in ginned cotton. Cotton exposed to very damp storage prior to ginning resists bacterial or fungoid attack during subsequent normal storage much less than cotton stored under dry conditions from picking to ginning. Ventilation during storage in seed represses possible bacterial and fungoid deteriorative processes only where the damp material is able to dry out rapidly. Otherwise such ventilation may lead to slightly increased deterioration of the cotton. Sun drying of the cotton is advocated in addition to ventilation, particularly before storage in seed and before baling after ginning. Dampening cotton before or during baling is not advised.

Martin, J. G. and White, C. C. Handling and marketing Durango cotton in the Imperial Valley. (*U. S. Dept. Agr. Bull.* 458 (1917), p. 22, fig. 6.)

Information is given on the care of seed cotton (pp. 4, 5) before ginning.

Nixon, R. L. Weather damage to cotton. (*U. S. Dept. Agr. Bull.* 1438 (1926).

Moisture in seed cotton (pp. 2, 3) is described as a possible source of weather damage.

Orton, W. A. Sea Island cotton. (*U. S. Dept. Agr., Farmers' Bull.* 787 (1916), p. 40, fig. 13.)

The methods of drying and bulking seed cotton used on the Sea Islands to control moisture content and maintain the grade are outlined (pp. 30, 31), with precautions regarding heating.

NOTES

MOSAIC DISEASE OF SUGARCANE.

THE following communication has been received from the President of the International Institute of Agriculture, Rome :—

I have the honour to inform you that at the meeting of the Permanent Committee of the International Institute of Agriculture on 19th November last, M. Deoclecio de Campos, Delegate of Brazil, presented a highly interesting communication with reference to an international award offered by the " Instituto de Fomento e Economia Agricola do Estado de Rio de Janeiro " for the discovery of the cause of the " Mosaic Disease of the Sugarcane."

It is well known that most of the sugar-cane producing countries of the world suffer serious losses each year in consequence of the ravages of the so-called " Mosaic Disease," and the position is all the more serious, seeing that, up to the present at any rate, it has not been found possible to ascertain the true cause of the malady.

Hence the " Instituto de Fomento e Economia Agricola do Estado de Rio de Janeiro " was of opinion that the time was ripe for taking special steps to attain the solution of the problem and decided on 10th May to make a special award of the value of 100,000 milreis (equivalent to about L. 2,400 at the present rate of exchange) to the first scientist, whether of Brazilian or other nationality, to discover the cause of the disease and a practical and effective means of its control or prevention.

Priority of discovery will be settled by the date of the telegram sent by the person interested to the Office of the Director of the " Instituto de Fomento e Economia Agricola do Estado de Rio de Janeiro " and to the Bureau of Agricultural Science of the International Institute of Agriculture at Rome, in accordance with the terms of the resolution of the Instituto de Fomento, which contains all the conditions of the award and will be printed in full in the International Review of Agriculture published by this Institute.

I desire therefore to ask you be so good as to call the attention of the societies, institutions and individuals, which in your opinion are likely to be interested, to the present communication, with the object of securing their assistance in the solution of a problem which is of the highest importance for the agriculture of many countries.

I should be grateful also if you would kindly note that any person desiring to receive further information with regard to the award can apply to the Instituto de Fomento at Rio Janeiro or to this Institute.

ENVIRONMENT AND QUALITY.*

THERE seems to be a tendency in agricultural practice to lay more stress on yield than on quality. Two reasons may be given for this; first, that variations in yield, being strictly measurable, are more noticeable than variations in quality, which are generally matters of personal opinion, checked only by comparison with standards; second, producers disposing of their crops to merchants often find it difficult to obtain a premium for superior quality adequate to repay their extra outlay. This difficulty is a very great obstacle to the spread of cultivation of better quality cottons in India. The spread of the cultivation of "strong" wheats in England is delayed by the refusal of the millers to pay an adequate premium for the better quality.

Scientific study of crop plants has had a similar bias in favour of yield, and particularly in investigations on the influence of environment on crops has the study of quality been neglected. Recently, however, a certain amount of information on the effect of environment has been obtained by plant breeders in the course of investigations on the inheritance of quality.

The well-known phenomena of "degeneration," or "running out" of varieties of crop plants were formerly ascribed to the "instability of highly bred varieties" and consequent "reversion to type." Genetic investigation has shown that in a genetically pure line, no progressive deterioration will occur, so long as natural cross fertilization and mechanical mixing of seed are avoided. Commercial varieties of most crop plants are genetically mixed or are subjected to crossing and seed mixing during the ordinary routine of agricultural practice which constitutes their environment. Those components of the mixture yielding most seed under these conditions will be represented in greater proportion in each succeeding crop. A progressive change will take place in the constitution of the mixture, and if the quality of the produce of the highest seed-yielding component differs from the average quality of the produce of the original mixture, a progressive change in quality will result. This change may be either an improvement or a deterioration, but as deterioration is a great deal more frequently noticed than improvement, it is deterioration that has been studied.

An excellent example of swamping of superior strains in a mixture resulting from natural crossing is afforded by the "running out" of cotton varieties in Egypt. Strains giving a high seed yield and relatively poor lint arose as segregates from natural hybrids, and in a few years the desirable characteristics of the original strain were lost in a mass of mediocre mongrels. The effect of the environment is not on the quality of the lint, but on the seed producing capacity of strains possessing lint of varying value.

The quality of the produce of a variety may be radically changed with a change in environment. The genetic constitution of the plant is unaltered, but its reaction with a different environment produces a very different result. St. Vincent Sea

Island varieties grew excellently under irrigation conditions in the Sudan, but the lint hairs produced are said to have been "rod-like" and almost useless for spinning purposes.

The reaction of wheat to irrigation conditions varies in different closely allied strains. A number of strains of macaroni wheat first isolated at State Experiment Stations in the American wheat belt, and yielding there a high quality of grain, were transferred to Arizona and there grown under irrigation. A large proportion of the strains introduced gave a soft, poor quality grain. A number of strains, however, yielded hard, high quality grain, under the same conditions. The new environment reacted differently on different strains revealing variations in genetic constitution not previously obvious. The belief so firmly held until recently, that "strong" wheats could not be grown in England arose from similar results obtained from experiments on imported "strong" American bread wheats. While Red Fife and a few others will produce "strong" wheat under English conditions, a number of the best quality American and Russian bread wheats give a soft wheat when grown in England.

Apart from very large changes in environment, the ordinary seasonal fluctuations of climatic factors, soil conditions and so on, exert a considerable effect on the quality of a crop, bringing about seasonal variations which may be similar over a large area. The number of factors concerned, and the complexity of their inter-relations have made scientific investigations laborious and very often inconclusive. The best and most successful attack on the causes of seasonal fluctuations in quality was made by Dr. Balls on cotton in Egypt.

Quality in cotton ultimately depends on the presence of those factors which make it possible to spin it to a strong fine yarn. In the absence of more complete knowledge of the factors concerned in the production of good yarns, Dr. Balls investigated the effect of various environmental factors on lint length and hair strength. By taking daily pickings from carefully controlled plots of pure line material, a series of samples was obtained, each of which had been subjected to a slightly different environment. By determining mean maximum length by combing out the lint on the seed, and measuring the breaking load of each sample, curves of lint length and lint strength were obtained for the series of samples. It was found that there was no correlation between the strength of lint and the length of lint in the same sample, but that there was a marked correlation between strength of lint in a given sample, and the length of lint in the sample picked from the same plot 21 days later. Anatomical studies showed that the lint is growing fastest at about 28 to 30 days from maturity, and that the cell wall is thickening most rapidly at about 8 days from maturity. Consequently any change in environment will exert its greatest effect upon the strength of the lint in bolls due to open 8 days later, whereas its effect upon lint length will be upon lint in bolls not due to open for a month. There will be thus a three week interval before a change in environment, which has shown its effect in a change in lint strength, will also show its effect upon lint length. Under

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Egyptian conditions the most marked changes in the plant's environment are those resulting from the periodic changes in the water content of the soil due to irrigation and it was found that the general rise and fall of the strength and length curves follow the rise and fall of water content in the soil fairly closely if the curves are shifted back 8 days and a month respectively.

Absolute control of water supply and relatively constant conditions of temperature, humidity, sunshine, etc., make Egypt particularly suited for such investigations. The greater complexity of environmental changes in rain grown cotton areas make it difficult to analyse the results of such experiments conducted on rain grown cotton, and so far no one has succeeded in getting such close agreement between theory and expectation as Dr. Balls obtained in his researches in Egypt.*

Control of environment to improve the quality of the crop is practised intensively in tobacco culture. Each of the many forms in which tobacco is put on the market requires a particular grade and quality of leaf for its manufacture. Many of the chief tobacco growing districts have a name for particular grades of leaf suitable for certain purposes. While the type of leaf produced depends largely on the variety and the method of curing, the climatic and soil conditions determine within a fairly narrow range the varieties and therefore the type of leaf which will be most profitable in any particular district.

In districts specialising in the production of cigar filler leaf, heavy manuring with cotton seed meal and artificials is practised to produce a rapidly growing luxuriant plant with large leaves. The plant is "topped" when it has produced 14 to 16 leaves, and all secondary shoots removed as they appear, so that the whole vigour of the plant is concentrated on leaf production. The main factor in quality in this type of leaf—besides good burning quality—is good aroma. The cigar wrapper trade, on the other hand, demands a thin leaf with small veins and little aroma, and in the cigar wrapper districts tobacco is extensively grown under cheese cloth shade and is allowed to run up and flower.

Good burning quality is, of course, of first importance in all types of leaf. It is recognized that burning quality depends very largely on the environment of the plant. Good burning quality is associated with freedom from gummy materials, a low protein content, a low chloride content, and a high ash content. Heavy organic or nitrogenous manuring tends towards the production of a leaf rich in proteins, and stimulation of yield with organic manures is liable to be at the expense of quality. Close spacing and heavy manuring with artificials is practised to promote free, but not rank growth, and to provide an abundant supply of the ash constituents of the leaves.

Except in tobacco, control of quality by control of environment factors is very rarely practised. Success has been achieved because the tobacco grower is catering for a luxury trade and quality is of more importance to him than yield, and because

* Compare Bard: "Cotton in St. Vincent," *Tropical Agriculture*, Vol. II, No. 4, p. 79.

tobacco gives a product of very high value in proportion to the area under crop. It is therefore economically possible to go in for the intensive culture which must accompany heavy dressings of fertilizers, or to erect such expensive things as cheese cloth shades. Control of quality through environment in other crops has been limited to the selection of the environment, as in the citrus industry, which has been built up in areas where ample sunshine and a dry atmosphere give optimum ripening conditions.

While useful beginnings have been made by empirical methods, it is probable that further advances will have to await detailed research into such problems as the physiology and biochemistry of the tobacco leaf. So long as we know little or nothing of what "quality" means, we cannot expect to improve it very greatly. [J. B. HUTCHINSON.]



LYGUS ELISUS : A PEST OF THE COTTON REGIONS IN ARIZONA AND CALIFORNIA.

THE following extract is taken from the *United States Dept. Agri. Tech. Bull.* No. 4 of July 1927, by Mr. A. E. McGregor, Associate Entomologist, Division of Tropical and Sub-tropical Plant Insect Investigations, Bureau of Entomology.

The tarnished bug (*Lygus elisus* Van Duzee) is probably a native of western America, and has been found in all cotton districts of the Pacific region. It readily goes to crop plants from its native host plants, of which *Chenopodium* is one of the commonest. Its activity as a cotton pest was detected very early in an investigation of cotton insects in the Imperial Valley, Calif., conducted in 1916, 1917, and 1918. W. D. Pierce stated in an unpublished report on the cotton insects of the Imperial Valley, based on data gathered on a two-day inspection trip made on August 15 and 16, 1913, that "the considerable shedding of squares in cotton fields at that date was principally due to a pale variety of *Lygus pratensis* L." He undoubtedly referred to the species now known as *L. elisus*. During the season of 1916 this insect did not appear as an especially injurious species on cotton, but by midsummer of 1917 it had acquired the status of a real cotton pest. With still greater intensity it launched its 1918 attack at an earlier time of the year.

LIFE-HISTORY.

Doctor Morrill states in correspondence that in Arizona "*Lygus* species do not breed to any noticeable extent in cotton fields." Further, regarding generations, he says: "From the fact that there is so little breeding in cotton fields, and considering the length of time that the adults remain, it seems probable that the pests are rather slow breeders."

Owing to extreme difficulty experienced in rearing *Lygus* under confinement, the data on its life history are disappointingly meagre. It is certain, however, that the

tarnished bug breeds freely on cotton in the Imperial Valley. Development there begins early in the spring, and *Lygus* in all stages may be found throughout the growing season on numerous succulent plants. The eggs are deposited most commonly on the squares, being either placed in folds of the floral parts, or at times inserted in ovipositional punctures. Hatching occurs in about four days, and the bugs become adult, under summer conditions, in about 20 days. Since the occurrence of *Lygus* on cotton continued for 12 weeks in the season of 1918, it is probable that four generations developed on this crop during that time. On alfalfa it is probable that a maximum of seven generations occur between the spring appearance and the cessation of activity early in October. Very little is known about the hibernation of *Lygus* in the Southwest, but it seems probable that the tarnished bug passes the winter chiefly, if not entirely, in the adult stage.

DESCRIPTION OF ADULT.

Length 5.07 to 6.25 mm., averaging 5.54 mm., or 0.22 inch. A decidedly polychromatic species. The head, chestnut yellow, usually free of the dark longitudinal lines seen in the common eastern form (*L. pratensis*). Eyes deep chocolate, with yellowish posterior border. Proboscis with black tip. Prothorax yellowish green, straw color, or pale fulvous, with two or four small, pitchy, distinct spots in an arched row one-third the distance from the front margin, very variable in size and position, the two on each side sometimes partly coalesced; posterior margin usually much darkened, often with a pair of blackish spots postero-medially and with a fulvous to blackish spot at each posterior angle. Scutellum in the main pale green, straw colored, or, as usually, lemon yellow, the posterior three-quarters often in shape of a perfect heart, the remaining portion from pale chocolate to black. Wings with ground color deep amber, cuneus and membrane straw colored, clavus smoky to pale reddish brown, paling posteriorly with crimson tips; posterior margin of corium usually with large pale fulvous to cardinal blotch. Antennae chiefly reddish brown; first segment more yellowish, second segment darker at each end, third and fourth segments blackish brown. Legs amber color to reddish yellow, the posterior femora usually (but not always) twice annulated near apices with reddish to deep chestnut; dark forms with coxae and femora blackish olive; tibiae with two reddish to chocolate marks near base and a band of similar color at tip; tibial spines and tips of tarsi brownish to blackish. Venter uniformly yellow-green to lemon yellow; sternum a shade darker; male with subterminal genital blotch of same shade as sternum.

SUMMARY.

The tarnished bug, *Lygus elisus* Van Duzee, has been known for some time as a pest of various plants, but it remained for the present investigation to develop

the fact that it is perhaps the most serious pest of cotton on the Pacific coast. In the Imperial Valley, where it was chiefly studied, growing alfalfa is more extensively attacked even than cotton. Injury to alfalfa is less serious than to cotton, owing to the fact that on the former crop the pest distributes its attack to all parts of the foliage, while on cotton the insects concentrate on the buds, blooms and bolls, the sole productive portion of the plant.

Injury to cotton by the tarnished bug is caused by the feeding punctures made in the square, bloom and boll by the piercing mouth parts. Practically all stung squares, blooms and very young bolls are very soon shed. Since the actual mechanical injury associated with the feeding of *Lygus* is slight, compared with the resulting damage, it seems reasonable to suspect that either a toxic material or an organism may be introduced into the plant tissue at the time of feeding. Other evidence supports this supposition.

The work of this pest is denoted by the presence near the scene of its attack of characteristic yellow daubs. This feature caused A. W. Morrill to suggest the name "cotton dauber."

Development begins early in the spring in the Imperial Valley. Under summer conditions hatching requires about 4 days, and the bugs become adult in about 20 days. The tarnished bug attacks alfalfa during the greater portion of its growing season, while the attack on cotton is limited to the period from early in June to early in September. As a result, there are about seven generations per year on alfalfa and about four generations on cotton.

Infested alfalfa, growing in the neighbourhood of cotton, is a common source of the acute attacks on the latter crop. These may arise in two ways—either from the drying of the alfalfa because of water shortage or from cutting the alfalfa for hay. In either case an exodus of the tarnished bugs to the cotton is almost sure to occur, provided, of course, that the cotton is kept growing.

An abrupt reduction in the numbers of the tarnished bug occurs annually about the end of August. An explanation of this decimation is not known, as the climate in the hotter portions of the Southwest continues much the same until about the end of September.

Finely divided sulphur dust has been found effective against the tarnished bug. Applied to growing alfalfa at the rate of 6 pounds per acre, a single application of this material brought about a reduction of *Lygus* individuals amounting to 75 per cent. of the original infestation. A similar application to infested cotton practically eliminated the pest and kept the infestation down to a minimum for more than three weeks. In another case, where 80 acres of cotton were treated with sulphur dust by the cruder pole-and-bag method, the number of *Lygus* individuals was reduced in an average interval of two days to the extent of 44.7 per cent. of the initial infestation. Although it seems to have been demonstrated that severe migrations of the tarnished bug to cotton may be prevented by dusting near-by alfalfa, these tests have shown that direct control may also be secured by the sulphuring of cotton.

The latter operation is dependent on the availability of adequate cotton-dusting machinery.

When, in the Imperial Valley, under laboratory conditions, tarnished bugs were confined in screen cages from 12 to 24 inches above the ground, over sulphur dust liberally applied to the surface of the soil, and at temperatures of from 102° to 116°F., death followed in not more than 30 minutes. Individuals similarly confined over areas free from sulphur suffered no mortality.

The adults and nymphs of *Lygus* were killed in from three to five minutes when exposed to a soil temperature of 125° to 128°F. in the absence of sulphur.



THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THE DEVELOPMENT OF THE ANGULAR LEAF-SPOT DISEASE OF COTTON.

THE following extract from the *Tropical Agriculture*, Vol. V, No. 11, November 1928, is a review by Mr. S. C. Harland of Mr. R. H. Stroughton's article on the above subject published in the *Annals of Applied Biology*, Vol. XV, No. 3, August 1928.

This paper emanates from the Department of Mycology of the Rothamsted Experimental Station, and describes experiments on the artificial inoculation of cotton plants with the organism, *Bacterium malvacearum*, which is responsible for serious loss of crop in many cotton growing countries. The disease is almost universally distributed throughout the cotton growing countries of the world, and is particularly virulent in its effects on Egyptian cottons in the Sudan, and also on the native cottons of Nigeria. The disease presents three distinct manifestations according to the part of the plant attacked, (1) water-soaked spots on the leaves which develop into angular lesions delimited by the veins—the "angular leaf-spot"; (2) stem lesions producing the so-called "black-arm" disease; and (3) water-soaked spots on the young bolls producing the typical "external boll-rot." The author obtained all three forms of the disease under glass house conditions in England by means of varied methods of artificial inoculation. At a humidity above 80 per cent. relative saturation, the limiting temperature for attack of *B. malvacearum* was 32°C., above which infection did not occur. At 70 per cent. relative humidity infection was slight at 25°C. At lower humidities no infection was obtained at a temperature of 28°C.

The author states that the disease occurs to some extent on all species of *Gossypium* though some degree of varietal resistance has been reported. Recent observations in Trinidad indicate that some of the wild species of *Gossypium* are completely immune. The disease has not been seen so far on *G. Stocksii*, *G. Davidsonii*, *G. Sturtii*, and *G. Tomentosum*. The hybrid of *Tomentosum* × Egyptian shows susceptibility as marked as Egyptian, while the cross of *Sturtii* × Upland is attacked

though not badly. It appears that susceptibility to the disease behaves as an almost complete dominant. The only cottons which are attacked at all badly in Trinidad are of the Egyptian type, and it has been found easy to isolate from crosses of Egyptian × Upland both relatively immune and susceptible strains. In Trinidad the genetic constitution of the plant appears to be far more important in limiting attack than environmental conditions.

Personal Notes, Appointments and Transfers, Meetings, Conferences, etc.

MR. M. WYNNE SAYER, B.A., Secretary, Sugar Bureau, has been appointed to officiate as Imperial Agriculturist, in addition to his own duties, *vice* Mr. G. S. Henderson granted leave for six months and two days from 4th April, 1929.



MR. W. J. JENKINS, M.A., B.Sc., has been appointed to officiate as Secretary, Indian Central Cotton Committee, *vice* Mr. J. H. Ritchie granted leave on average pay for eight months with effect from 14th March, 1929.



MR. B. S. PATEL, B.Ag., N.D.D., has been appointed Deputy Director of Agriculture, Gujarat, *vice* Rao Saheb Bhimbhai M. Desai retired.



MR. V. G. GOKHALE, L.Ag., has been appointed Professor of Agriculture, Agricultural College, Poona, *vice* Mr. B. S. Patel transferred.



MR. V. V. GADGIL has been appointed to act as Deputy Director of Agriculture, Konkan, *vice* Mr. V. G. Gokhale transferred.



MR. E. J. BRUEN, Live-stock Expert to the Government of Bombay, has been granted combined leave for 8 months and 13 days from 11th April, 1929.



The term of appointment of Mr. MUHAMMAD ISMAIL MALIK, B.Sc., M.R.C.V.S., Special Officer in the Civil Veterinary Department, Bihar and Orissa, has been further extended for one year more from 1st December, 1928.



MR. H. R. STEWART, A.R.C.Sc.I., has been appointed Assistant Director of Agriculture, Punjab, for a period of two years from 1st November, 1928.

MAJOR E. M. NICOLL, O.B.E., M.R.C.V.S., has been appointed Research Officer at the Punjab Veterinary College for five years with effect from 10th December, 1928.



MR. H. F. ROBERTSON, B.Sc., has been appointed to officiate as Principal, Agricultural College, Mandalay, *vice* Mr. J. Charlton granted leave for eight months from 15th February, 1929. Mr. Robertson will, in addition, hold charge of the current duties of the Agricultural Engineer and Professor of Agriculture, *vice* Mr. W. M. Clark transferred.



On relief by Mr. H. F. Robertson, Mr. W. M. CLARK, B.Sc., M.B.E., has been posted as Deputy Director of Agriculture, Northern Circle, Burma.



U PO SHIN has been appointed to officiate as Agricultural Chemist, Burma, *vice* Mr. Charlton granted leave.



MR. J. W. GRANT, M.A., B.Sc., Deputy Director of Agriculture, Burma, has been posted to the charge of the Southern Circle, *vice* Mr. D. Hendry on leave.



MR. R. C. WOODFORD has been appointed Live-stock and Dairy Expert, Assam, with effect from 1st January, 1929.

REVIEW

Leaf-Mining Insects.—BY J. G. NEEDHAM, S. W. FROST, AND B. H. TOTHILL.
Large 8vo, pp. viii+351; 91 figures+3 plates. (LONDON: BAILLIÈRE,
TINDALL AND COX: 1928.) Price, £1-7-0.

HAD this book been called "North American Leaf-mining Insects," its title would have expressed its scope more exactly than is the case, as practically all the species dealt with are found in the United States and almost no notice has been taken of the numerous Leaf-mining Insects recorded from other parts of the world. The only Indian species noticed seems to be *Phyllocnistis citrella* (misquoted as *citronella*, p. 105) and that only because it has been carried into the States on nursery stock. As a general introduction to a fascinating subject, however, this book will prove useful to the observer who cannot help noticing the numerous mines and blotches which are found on almost every kind of leaf which is examined at all closely. Many of these mines are caused by the caterpillars of small Moths but others are due to the grubs of Flies and Beetles. Several hundreds of leaf-miners are already known in India, where the fringe of the subject has hardly been touched as yet, and numerous new discoveries still await all observers in this line. Although our species may be different, we in India can offer parallels to practically every type of leaf-mining habit brought forward in this book and, indeed, "go one better" in many cases. Thus, amongst the Butterflies, the Lycænid, *Talica nyscus*, common in Southern India, has a caterpillar which mines in the fleshy leaves of *Bryophyllum calycinum*, from which it emerges only to pupate. In the Tipulidæ also, in which the authors state that "there is as yet but a single known leaf-mining species," recorded from the Hawaiian Islands, many leaf-miners occur in the Hills of Northern India.

The numerous misprints rather detract from the pleasure of reading this book; thus "*Parecopta*" (pp. 21, 130) for *Parectopa*, *Ypnomentidæ* (p. 79) for *Yponomeutidæ*, etc. A few errors of fact may also be indicated. Thus, Figure 2 does not represent *Lithocolletis hamadryadella*, which is correctly shown in Figure 43; what Figure 2 represents is not very evident, as the moth shown does not seem to agree with any species illustrated in Miss Braun's Revision of this genus (*Trans. Am. Ent. Soc.* XXXIV; 1908). *Melitara prodenialis* is not a *Phaloniad*, as stated (p. 26), but a Pyralid. The bulrush leaf-miner, *A. robusta*, Braun, discussed on p. 152, is an *Aristotelia* (Gelechiadæ) and not an *Elachista* (*Apheloseia*).

The statement (p. 124) that *Acrocercops* "is a small group of leaf-miners" requires qualification when applied to areas outside of North America. India is probably the Headquarters of this genus, of which over one hundred Indian species have already been described and at least an equal number await discovery. In such cases it is necessary to modify the information given here. Bearing these points in mind, this book may be commended to our readers as a good introduction to the subject with which it deals. [T. B. F.]

NEW BOOKS

On Agriculture and Allied Subjects

- Popular Hand Book of Indian Birds, by Hugh Whistler, F.L.S., F.Z.S. (Gurney and Jackson ; London : 22, Paternoster Row, E.C.) Price, Rs. 15 net.
- A Comprehensive Treatise on Inorganic and Theoretical Chemistry, Volume VIII, by J. W. Mellor, D.Sc., F.R.S. (Longmans, Green & Co. Ltd., 39, Paternoster Row, London, E.C. 4.)

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

- Studies in Indian Chillies, I: The Types of Capsium, by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., and Khan Sahib Abdur Rahman Khan. (Botanical Series, Vol. XVI, No. 2.) Price, Rs. 1-10 or 2s. 6d.
- Pythium aphanidermatum* (Fds.) Fitz on *Opuntia Dillenii*, Haw, by T. S. Ramakrishna Ayyar, M.A. (Botanical Series, Vol. XVI, No. 7.) Price, As. 8 or 10d.

Bulletins.

- Investigations in the Bacteriology of Silage (1926-27), by J. H. Walton, M.A., M.Sc. (Bulletin No. 182.) Price, As. 5 or 6d.
- A Milk Fermenting Yeast, by C. S. Ram Ayyar, B.A. (Bulletin No. 183.) Price, As. 5 or 6d.
- List of Publications on Indian Entomology, 1927, compiled by the Imperial Entomologist. (Bulletin No. 184.) Price, As. 6 or 9d.
- A Preliminary Note on the Rice Crop in the United Provinces, by R. L. Sethi, M.Sc., B.Sc. (Agri. Edin.), M.R.A.S. (Lond.). (Bulletin No. 186.) Price, As. 7 or 9d.
- The Production of Cigarette Tobacco by Flue Curing, by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., and Kashi Ram. (Bulletin No. 187.) Price, R. 1 or 1s. 9d.

ORIGINAL ARTICLES

THE IMPROVEMENT OF PLANTS.*

BY

GABRIELLE L. C. HOWARD, M.A.,
Institute of Plant Industry, Indore.

SOME years ago several members of the Agricultural Section of the Indian Science Congress came to me with the suggestion that there should be a special section of the Congress for Genetics. They pointed out that under the present organization there was no suitable place for papers on inheritance. The difficulty is a real one. Genetics is a border-line subject and has claims on agriculture, botany and zoology. The classical experiments of Mendel were carried out on peas, while insects have furnished much of the material by which the mechanism of inheritance has been demonstrated. The theories underlying the subject are of a very technical nature and pre-suppose a knowledge of botanical and zoological terms and conceptions. Papers on this aspect of the subject are suitable for the botanical and zoological sections. Most of the Indian work takes the form of economic plant-breeding and it is, therefore, chiefly of interest to agriculturists. Thus members interested in genetics are sometimes present in one section, sometimes in another and it is difficult to ensure a good discussion on any particular paper. I can find no sectional address which deals directly with genetics—the nearest approach is the interesting address on *Facts and hypothesis in the problem of evolution* by Father Blatter when President of the Botanical Section in 1925. It is clear that genetics has not been very prominent in this Congress. On the other hand, this branch of science is becoming an increasingly significant factor in the progress of the world. The importance of plant and animal breeding to the prosperity of a nation has long been known. A more recent development is the recognition that modern theories of inheritance are applicable to the study of criminology and to the improvement of the human race. From the scientific aspect also, the development of this science offers a most fascinating field of study. It would be a pity, therefore, if genetics were to remain the Cinderella of the Indian Science Congress. To afford an opportunity for the consideration of this question I have taken one aspect of

* Presidential address to the Agricultural Section of the Sixteenth Indian Science Congress, Madras, January 1929.

this branch of science as the subject of my address to-day. I suggest that, at the conclusion of this paper, we should discuss the best methods of making genetics a more prominent feature at the Indian Science Congress and of University teaching in India.

When I began to write this address I was faced with the same difficulty as that experienced in placing genetical papers in this Congress. Should the address deal with the practical side or with the modern theories of inheritance? As so much of the work in India is economic, I have first dealt with a few practical points in plant breeding. Afterwards, in the second part, I have tried to show how the periodic changes in our conceptions of heredity have influenced practical methods. Genetics is, at present, in a most interesting transition phase and offers a good illustration of the swing of the pendulum. Such oscillations are characteristic of the development of all sciences but research on genetics is of such recent origin that many of the phases are within the memory of the older investigators.

While the biological conceptions underlying plant-breeding have in recent years undergone several fundamental changes, the object of the economic plant-breeder has always remained the same. He desires to produce a variety which will bring an increased monetary return to growers of some particular crop. This increased profit may be obtained by an improvement in yield or in quality. Of the two, yield is the more important. An increased amount of produce per acre is an advantage which the most illiterate cultivator readily understands. It is easily converted into money and does not involve any discussion. It is immaterial whether the increased yield of the new variety is due to potential yielding power, to enhanced disease-resistance or to a more suitable root-system. The extra cash the grower receives is a definite advantage.

The sale of improved quality is a very different matter. It is often extremely difficult to obtain the real value of any improvement in quality. In the first place, no trade agency will pay for improved quality unless there is competition for the product and unless a large quantity of the produce is regularly forthcoming. Owing to the length of time required for the replacement of the original crop by a new variety, a long interval elapses during which the cultivator reaps no appreciable benefit. In the second place, the needs of the market may change very quickly, whereas the breeding of an improved type is a lengthy process. At least ten years are required to establish a new variety. The market demand may, however, be altered in a couple of years by the introduction of new machinery or of new methods of manufacture. Fashion, such as colour or taste in tobacco, may bring about a radical change which cannot be foreseen. In this country especially, where marketing facilities are still undeveloped, the tangible benefit of increased quantity will always conquer the almost intangible and often unmarketable advantages of improved quality. The rapid increase of the area under certain rough, short-stapled cottons in the black soil tracts, where less heavy-yielding but better cottons were once grown, is a case in point. The plant-breeder must, therefore, make yield

his first consideration. He will strive simultaneously to improve the quality and in most cases there is no reason why yield and quality should not be combined. Speaking generally, no new variety should be distributed in India on the basis of quality only. It is better to wait until this improved quality has been combined with a yield equal to or greater than that of the variety to be replaced.

In addition to yield and quality, an improved variety should possess a third characteristic. This is the power of adaptation to a wide range of agricultural conditions. We here touch one aspect of a very controversial question—centralised or local research. A certain school of thought in India has always considered that, as regards soil and climate, a large number of plant-breeding stations and of improved varieties are necessary for every crop. The practical difficulties in carrying out such a policy are obvious. It is impossible adequately to finance or to staff a large number of small experiment stations and seed stores. There is, however, a more fundamental objection to the multiplication of plant-breeding stations. Modern trade and manufacture demand a uniform product. To come into line with these requirements definite grades must be established at each large trade mart. As these centres draw their supplies from extensive tracts of country, the establishment of definite grades becomes impossible if each locality grows a different variety. The multiplication of varieties actually diminishes the market value of the produce of the tract. Thus from the financial, administrative and commercial standpoints the advantage lies in having a few good experiment stations and extending an improved variety over as large a tract of country as possible. This can only be done if the new type is elastic enough to respond to varying environmental conditions. Such varieties are more difficult to obtain than those suited to a small tract, but experience has shown that they can be produced. I will instance two cases of which I have practical experience. The cane known as S48 does equally well on the alluvial soils of Rohilkhand and on the black soil areas of Peninsular India. Pusa 4 wheat is being extensively grown in such diverse places as the North-West Frontier Province, Oudh and the well-irrigated areas of Central India. No plant-breeder should, therefore, be content with any variety which is not capable of being grown over large tracts of country.

I will only deal with one further practical point in connection with plant-improvement, namely—the necessity of self-denial in introducing new varieties. There is a very natural temptation to bring forward as a new variety anything which shows even a trifling improvement over that already in cultivation. This tendency is especially noticeable among young plant-breeders and is easy to understand. Each man wishes to show his employer that he is really accomplishing something. As the work of a plant-breeder is laborious and tedious a small success is hailed with delight. From the point of view of general strategy any such premature attempt to supersede an existing variety is, in the long run, disastrous and generally involves a waste of public funds. It also tends to lower the status of plant-breeding and to shake the confidence of the public. A small increase in yield or in quality is often

wiped out or even reversed in bad years. The cultivator knows this and feels that it is better to stick to his old varieties unless the anticipated profit is great enough to justify the risk of change. It used to be an axiom that the Indian cultivator would adopt nothing new. This is not true. If the profit is great enough, he will adopt anything but he will not change his seed or his methods unless the increased profit is large. Experiment station workers do not always realize the amount of trouble and expense involved in changing a variety in general cultivation. Members of the audience who have experience of extension work will bear me out when I say that varieties cannot be changed every two or three years without disturbing the confidence of the cultivators and causing very great expense and trouble. It is better for the plant-breeder to wait until he has a really substantial improvement to offer and then to strain every nerve to get it adopted as quickly as possible. The difference between improved varieties is as great as that between the pictures of great artists and those of art students. Only masterpieces should be imposed on the cultivator. There is, however, another side to the question. If plant-breeders are to exercise this self-denial and restraint, the necessity for it must be recognized by their employers. The prospects of a plant-breeder should not depend on the rapidity with which he produces an improved variety. The situation is difficult as popular opinion clamours for tangible results. It can only be met by increased knowledge among the general public and a keener appreciation of the special difficulties of investigators. It should be more generally realized that the essential act in the organization of research is the selection of the man to do the work. Such men when appointed must be given both the time and the means to work out their own salvation. I have dealt with this point at some length because I think it is a real danger at the present time when facilities for plant-breeding are being rapidly extended.

Improved varieties may be produced by two methods: selection and hybridization. An erroneous impression is current that selection is extremely easy and within the scope of untrained men whereas to obtain an improvement by hybridization a mysterious process needing great scientific knowledge and insight is required. This is not fair to those who use the method of selection. It is largely due to a confusion of thought in which the breeding of an improved variety is considered to be of the same order as an investigation into the laws governing inheritance. The wording of the section which deals with this point in the report of the Royal Commission on Agriculture in India¹ is unfortunate: "*Hybridization is a much slower process than selection and requires greater scientific experience and a higher level of scientific aptitude. We are however of opinion that the plant-breeder in India will be well advised to adhere to the selection method until its possibilities have been much more nearly exhausted than is at present the case and that hybridization should only be undertaken by officers, who, in addition to special training, have had the ex-*

¹ Abridged Report of the Royal Commission on Agriculture, Bombay, 1928, p. 79.

perience of Indian crops and conditions which is necessary for successful work." It is true that hybridization is a slower process than selection but the impression given that really valuable selection work can be carried out by untrained men is erroneous and if adopted is likely to lead to much waste of time and money. The ultimate success in obtaining an improved variety both by selection and by hybridization demands identical qualities in the investigator: (1) a detailed and first-hand knowledge of the botanical constitution of the crop and of its physiological requirements, (2) insight and judgment in correctly selecting the most promising plants. In both processes the investigator can apply the knowledge gained in studies of heredity. In both he will require a thorough acquaintance with the mechanism of pollination, the range of variation of his material and the response to the environment of the various characters. The difference between the methods of selection and hybridization lies in the nature of the material available. In improvement by selection the investigator is limited to what Nature has provided. Thus selection is of most value in countries where crops as ordinarily grown are a mixture of types or in species in which mutation and natural cross-fertilization occur. In improvement by hybridization the investigator attempts to combine desirable characters present in different individuals and thus provides for himself the material from which he later selects. Defining the laws of inheritance is work with an entirely different aim and, though in the early days it was possible to combine this with the production of improved varieties, that period has long been passed.* The complicated relationship shown to exist between various characters and the large number of plants involved necessitate for the investigator of the laws of inheritance absolute freedom from economic considerations. Even in the past the attempt to combine profit and the acquisition of new knowledge was unsatisfactory and often resulted in both objectives being missed. In every crop India requires a few first class varieties combining good quality and high yield, each suitable for a large tract of country. It is immaterial whether these improved types are produced by selection or by hybridization, but it must be realized that whichever method is adopted varieties of this class can only be evolved by men with a sound scientific training and great natural aptitude. In addition, they must be given sufficient time to produce something really worth distributing. Whichever method is used, success depends on the man and his training.

I do not propose to consider the various methods of selection but to pass on to a short survey of some of the changes in the theory of genetics which have influenced economic plant-breeding. Until the re-discovery of Mendel's laws, selection was the method most frequently employed in plant improvement. An empirical technique was developed in great detail especially in Germany. Recent research in genetics has swept away most of the old cumbersome methods and modern selection

* I am not speaking here of investigations which deal with the applicability of certain laws of inheritance to particular crops but to researches which attempt to discover the fundamental laws governing inheritance such as the work of Morgan and Baur.

is far more scientific and direct. But it is on the point of stability or the fixing of the variety, that present day plant-breeding diverges so markedly from the work of the last century. It is obvious that the degree of usefulness of an introduction is in direct relation to the length of time during which the improvement can be maintained. Before the re-discovery of Mendel's laws by Correns, plant-breeders were working in the dark with regard to this point. Many attempts were made to formulate principles of inheritance as a guide to breeders but these early efforts only seemed to make confusion worse confounded. Certain successful breeders were able to deduce empirical rules as the result of experience but these were generally applicable only to one particular crop. Plant improvement was dependent on the judgment and experience obtained during a laborious apprenticeship by a few men who were often unable to hand on their partly intuitive knowledge.

The nature and stability of hybrids was a particularly debateable point. Most persons held the view that the hybrid was a blend of both parents and attempts were made to determine the percentage inherited from each. The confusion of forms obtained in the later generations and the tendency of the parental forms to re-appear (reversion as it was called) were great stumbling blocks. In all the older investigations the complete individual was considered to be the unit. The re-discovery of Mendel's law of unit characters changed the whole aspect of the subject. As everyone knows, Mendel, while experimenting on peas in the monastery garden at Brünn, discovered certain principles underlying the inheritance of characters. He found that, if the individual attributes of the plant such as colour, height and so forth, were separately considered instead of the whole plant, the inheritance proceeded in an orderly and even mathematical fashion. Mendel's results made no impression at the time of publication and it was not until 1900 that their re-discovery by Correns brought them to the knowledge of the general public. Time has modified some of Mendel's conceptions and considerably amplified others, but his main conception of the individual as an aggregate of characters, the inheritance of each of which must be studied separately is still the basis on which investigation proceeds. The analysis of a plant into units of inheritance and the technique evolved by the early Mendelians has enabled plant-breeders to obtain stable varieties in a reasonable period of time. From the economic point of view this is the greatest benefit which Mendel has conferred.

I well remember the enthusiasm these early Mendelian researches inspired. If desirable characters could be transmitted unchanged and could be combined, the regeneration of the crops of the world was a simple matter. It was only necessary to find two varieties possessing between them all the desirable attributes and to cross them. The perfect individual containing these characters in homozygotic form could then be extracted from the second generation. It was admitted that there might be a little difficulty in distinguishing between heterozygotic and homozygotic forms in the case of dominant characters but this should only mean a short delay. The greatest scorn was meted out to those old-fashioned investigators who

still used selection methods. The millenium as regards crop improvement seemed to be in sight.

After twenty years, plant-breeders are sadder and wiser. It is true that modern plant-breeding has accomplished much. The monetary gain from improved varieties in India alone is estimated to be ten and a half crores a year. Nevertheless we are still a long way from the perfect variety in any crop and the way of improvement is long and arduous and not the simple matter formerly anticipated. The chief stumbling block has been the complex gametic constitution of what Mendel considered to be unit characters. Each character we see, such as flower colour, rust-resistance and so on, is not produced by one simple gene but is controlled by a large number of factors. Thus according to Tammes¹ no less than eight factors are involved in the flower colours of linseed yielding 32 genotypically different coloured forms. This means that the parental form will only re-appear once in a very large number of plants. As the perfect variety must possess many desirable characters each of which may be conditioned by several genes, the number of plants involved may be so great that in practice the required combination never appears. Moreover, characters which appear identical to the eye may be produced by separate genes. For example, the red chaff colour in two varieties of wheat, although similar in appearance, may really be produced by two quite different factors. These two red chaffed wheats, when crossed, produce, therefore, a certain number of white chaffed individuals. It is often quite impossible to determine the gametic difference of similar phenotypic characters by observation. This can only be done by breeding from individuals possessing these characters and then studying the offspring. Generally speaking, the greater the number of genes, the smaller the visible differences and the greater the tendency for them to be obscured by fluctuating variability and by environment.

The existence of what is known as linkage introduces a further complication. It is found that certain characters are inherited together, i.e., they are linked. Characters are often linked with sex, but linkage may also occur when sex is not involved. Moreover, linkage may not be absolute. In a certain percentage of the offspring the connection may be broken and the characters may be inherited separately. This is known as crossing over. Again certain genes do not affect one character only but produce an impression on several organs of the plant—that is, their effect is manifold.

Recent investigations have been able to explain these difficulties in a remarkable manner but it is quite obvious that the complications I have just described have made the direct application of the simple Mendelian rules impracticable.

Up to the beginning of this century, plant improvement depended almost entirely on the personal qualities of intuition and judgment in the individual. The really successful breeder either of plants or animals possesses a kind of flair or in-

¹ Tammes, T. *Bibliographia Genetica*, 4, 1928, p. 1.

stinct, probably a sub-conscious integration of various small observations, which are never definitely formulated. The laws of Mendel promised to substitute exact measurements for this intuition and to make successful plant-breeding mechanical. This promise has not been fulfilled. The laws of inheritance are more indirectly than directly useful to the plant improver, who, in the later stages of his work, is thrown back on the once despised selection methods and on his own judgment. The position may be reversed in the future when the detailed gametic constitution of crop plants has been determined. The brilliant work of Morgan and his school has not only shown that the genes or carriers of inheritance are located on the chromosomes but that to each gene can be assigned a definite position on an individual chromosome. Thus it should eventually be possible to obtain gametic maps showing the location of all the genes in any particular economic species. It should also be possible to state accurately the gametic differences between well-known varieties. When definite information of this nature is available for all common crops, the pendulum will swing again towards greater precision and a more mechanical technique.

In conclusion, I wish to draw attention to some recent investigations which are likely to affect profoundly our conceptions of heredity. As indicated above, the early period was a time of great confusion and controversy. Most of our conceptions were nebulous. The interminable discussions on the nature of variation, on pan-genesis, on continuity of the germplasm, on Lamarck's theory of the inheritance of acquired characters and so forth readily occur to all. Then came a period of clarification and definition. Clear distinctions were drawn between fluctuating variability, inherited variation and mutation. Weissman's classical researches showed that acquired characters were not transmitted. Mendel's laws were re-discovered. Johannsen enunciated the law that selection in pure lines is non-effective. Morgan's chromosome theory gave a definite location to the genes and an explanation of linkage and crossing over. Generally speaking, the germplasm was considered to be unalterable and its importance in heredity absolute. Effects produced by environmental changes were considered to be impermanent and confined to the generation in which they occurred. With each new discovery the subject became increasingly clear-cut and definite and the number of fixed tenets or principles became larger.

Investigations published during the last few years indicate that we may have to give up or modify some of our most cherished convictions. At first only a few papers were published more or less tentatively but at the present time it is almost impossible to pick up a journal in which there is not at least one communication of a revolutionary nature. I have no time to do more than briefly indicate some of the results obtained. The first paper to which I should like to draw attention is an investigation by Bond¹ on *The influence of pollen maturity and restricted pollination on a simple Mendelian ratio in the pea*. Bond found that the fertilization of ovules

¹ Bond, C. J. *Jour. of Genetics*, 17, 1927, p. 269.

by aged pollen grains produced an increased proportion of seeds with recessive characters. Fertilisation by a minimal number of pollen grains produced the same effect. Bond also obtained some evidence that there is a disproportionate increase in the number of recessive gametes during the declining stages of the growth of a plant. He points out that if differences arise in the gametes under varying growth conditions then the collection of seeds from different parts of the plant must affect the statistical data and Mendelian ratios.

Investigations concerned with the inheritance of acquired characters form another very interesting group. Most investigators will call to mind the work of Harrison¹ in which by administering manganese chloride to a strain of a certain insect—*Selenia bilunaria*—melanic individuals were produced. This melanism was then inherited as a Mendelian recessive. Lesage² was able to produce new characters in *Lepidium sativum* by the prolonged action of certain salts. These characters were stable and were inherited during a series of years. Here we have something like the inheritance of acquired characters although, as Harrison points out, the effect is not of the Lamarckian type but illustrates a new evolutionary principle that heritable variations may be induced by means of the food supplied.

Undoubtedly the most important modern researches are those dealing with the origin and nature of mutations. The occurrence of mutations has long been known but it has only recently been possible to attempt any real analysis of the various types. From the theoretical point of view the most interesting are the gene or factor mutations, that is, those in which a definite change is supposed to have taken place in the factor itself. At present the cause of such mutations is an open question. Many attempts have been made to induce them by external agencies such as X-rays, radium emanations and temperature changes. Certain investigators³ claim to have very greatly increased the rate of mutation by changes in temperature and by the application of X-rays. Some observers are inclined to deduce a complex constitution of the gene itself from these results. Others are more inclined to consider the change to be of the nature of a modification in a labile chemical compound. Factor mutations are rare. Even when the rate is increased the total number is small. Their present value in plant-breeding is undoubtedly less than that of the mutations produced by variations in the chromosome set or chromosome number. Geno-mutation or chromosomal variation may take the form of a multiplication of the ordinary chromosome number or of abnormality. Mutations of this type can be induced by the application of physiological stimuli—such as changes in temperature, X-ray treatment and so on to the sexual cells. A very large number of investigations on this subject have been published during the last few years.

¹ Harrison, J. W. H., and Garrett, F. C. *Proc. Roy. Soc.* B99, 1926, p. 241. Harrison, J. W. H. *Proc. Roy. Soc.* B102, 1928, p. 338.

² Lesage, P. *Compt. Rend. Acad. Sci.* (Paris) 180, 1925, and Richet-Bachrach-Cardot, *Compt. Rend. Acad. Sci.* (Paris) 180, 1925.

³ Blakeslee, A. F. Variations in *Datura* due to changes in chromosome numbers, *Amer. Nat.* 56, 1922.

Among the most interesting are those by de Mol^{1, 2} who showed that the horticultural practices in Holland, which have been so successful in producing new varieties of bulbs, are really methods of producing chromosomal variation. The possibility of inducing at will changes in the chromosome numbers opens out a new chapter in economic plant-breeding. The production of chromosomal variation by external stimuli also suggests an explanation of the origin of species³ and possibly of acclimatization. It may also furnish the solution of the much discussed problem of change of seed in crops like potatoes.

Exigencies of time prevent me from dealing with more of these most interesting investigations, but it will be obvious that genetics is entering a new phase in which the effect of environment on inheritance is the main theme. A most interesting field for research is open to investigators. Up to the present, India has taken little or no part in the investigations on which modern theories of heredity are founded and possesses no Institution where such fundamental work can be carried out. The time has come when this *lacuna* should be filled. In the improvement of plants India stands second to none. There is no country in which greater economic results in plant-breeding have been obtained nor which is better equipped with experiment stations for such investigations. The success of this part of the subject has, however, obscured the fact that little or none of the fundamental work on the theory of heredity has been carried out in India. No University has as yet a chair or even a readership in Genetics. For the theoretical conceptions underlying the practical aspects of the subject we have to depend on the work of Europe and America. As the years pass, it will be increasingly difficult to maintain the economic work at its present level unless it is stabilized by a school of pure research in the country itself. Such fundamental research cannot be carried out by the Agricultural Departments or in any Institute devoted to economic aims. The investigator in pure genetics must be untrammelled by the necessity of producing economic results and must not be limited to working only with cultivated plants. Twenty years ago vegetable physiology was an almost untouched subject in India. At the present time this aspect of botany is fully and worthily represented. We now require a living school of genetics from which economic workers and students can draw inspiration. Heredity is one of the great forces which moulds the human race. No more worthy object of endowment can be conceived than the establishment of a Chair of Genetics at one of the Universities. I hope that before the Congress meets again at Madras some wealthy corporation or public-spirited donor will have it made possible for us to have a Professor of Genetics among our members.

¹ Mol, W. E. de. Duplication of generative nuclei by means of physiological stimuli and its significance, *Genetica*, 5, 1923, p. 223.

² Mol, W. E. de. The originating of diploid and tetraploid pollen grains in *Duc van Thol* tulips dependent on the method of culture applied, *Genetica*, 11, 1923, p. 119.

³ Rosenberg, O. Speziesbildung mit Vervielfältigung von Chromosome, *Zitscher. f. ind. Abst. u. Vererbgsst.* Supp. 1, 1928, p. 332.

A VISIT TO THE SUDAN.

BY

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THE writer spent some part of his leave in April 1928 in visiting the Sudan and studying cotton-growing problems there, and it may interest the readers of the Journal to have a brief summary of some of the observations made.

GINNING AND PRESSING FACTORY AT PORT SUDAN.

This factory gins and presses 15,000 bales of 600 lb. each, or an equivalent of 22,500 bales of 400 lb. each. It works for two shifts of eight hours each. The *kupas* (seed-cotton) comes mainly from Kassala and also from Tokar. It is extremely easy to gin, the outturn per gin being from 2 to 2½ bales of 600 lb. per day, or at least 50 per cent. more than can be turned out with American cotton in the Punjab, and 100 per cent. more than is possible in ginning *desi* cotton. The gins appear to be of the single action type—Platt or Macarthy gin—as compared to the double action gin common in the Punjab.

The width of the factory is 75 ft. as compared to 30 to 32 ft. in the best equipped factories in India. In the Gezira, the Sudan Plantations Syndicate factories are 90 ft. wide. Tramway lines are constructed behind the feeding platforms and in the centre of the ginnery for carrying away the lint. The platforms behind the gins are on the level of the feet of the gins—not level with the feed as in India. Men (mostly) and women feed the gins standing. This would appear to be unnecessarily laborious and clumsy. In India factories work 12 hours, but the work is much easier owing to the different planning of the factory.

The cost of ginning at Port Sudan works out at 6s. per 100 lb. of lint, as compared to 3s. 6d. in the Punjab. At the latter figure we can gin and press easily 10,000 bales and upwards, with profit.

The journey from Port Sudan to Khartoum takes about 26 hours and is uneventful. The rolling stock and the general arrangements of the railways in the Sudan is far nearer the European standard than the Indian railways. Travelling is comfortable, and the trains are well equipped. At Khartoum, I visited the Shambat Experimental Farm with Mr. Davie, the Director of Agriculture. At this Research Station, Mr. Bailey, whose services have been lent by the Empire Cotton Growing Corporation, is doing splendid work in selecting and testing types of Sakel and

American cotton suitable for growing in the Sudan. So far, no new variety has been put out on a large scale, but important economic results will very shortly be available.

IRRIGATION.

The Agricultural Department in the Sudan is running nine different pumping stations. Mr. MacGregor, now Irrigation Adviser to the Sudan Government, and lately of the Punjab Irrigation Department, with whom I had several conferences, gave me valuable information, and the following points of contrast as regards Gezira irrigation will interest irrigators in India.

- (1) There is no apparent loss of water through seepage through the bed of the canals in the Gezira. Water let in at the head can be accounted for almost in full at outlet heads.
- (2) Water applied in the field does not penetrate beyond a metre or, in some cases, two metres, or say 6 ft. 6 in. in the soil. Owing to (1) and (2) there is no water-logging problem such as we have in the Punjab.
- (3) No field irrigation is done at night. The main canal takes water from the river regularly, day and night, but the canals must be big enough to hold the accumulation between sunset and sunrise. A system of weirs is used in the subsidiary canals for this purpose and works efficiently. In the Punjab, field irrigation proceeds day and night without intermission.
- (4) The soil in the Gezira is a black stiff soil similar to the black soil of Western India. It cracks in a similar manner to the black soil of India when dry and the surface is friable. Wind blows loose soil into the cracks, so that it more or less ploughs itself. This valuable quality should be preserved if possible in any scheme of cultivation finally adopted.

GENERAL FEATURES OF CULTIVATION IN GEZIRA.

The Sennar Dam controls now 300,000 acres and is expected to expand to 450,000 acres within two or three years. Two-thirds of the land is cultivated annually and one-third is fallow. The rotation is one-third cotton, followed by about one-sixth *dhura* millet (*Sorghum vulgare*) and one-sixth pulse *lubia* (*Dolichos Lablab*), and one-third fallow. A cultivator has thus 30 acres on which he grows 10 acres cotton, 10 acres of *lubia* and *dhura*, the remaining 10 being fallow.

The fallow land is cultivated by Maclaren crude oil windless ploughing sets worked by the Sudan Plantations Syndicate, and takes most of the time from October, after the harvesting of the *lubia* and *dhura* crop in the spring, till the next cotton sowing season. The land for cotton is ridged by the same tackle, the rows being about 30 inches apart and about 10 inches high. Irrigation is applied carefully, the plots being generally about one-tenth acre. In practice water appeared to

have gone over the tops of the ridges in most places, though applied in the furrows. Cotton gets 16 or even 17 waterings from 20th July to 10th April, and each irrigation is about 400 cubic metres—roughly 4 inches per acre. In the Punjab, from May till the last watering in November, American cotton gets from 6 to 8 waterings generally. On the B. C. G. A. farm in the Punjab, the average yield for three years ending 1927 was 400 lb. of lint per acre, this being the average of 2,400 acres of cotton grown. The Sudan Plantations Syndicate on the Gezira have obtained about 500 lb. of lint on the average of about 80,000 acres of cotton in 1926-27, and this year will get about 330 lb., the season not being a suitable cotton season. The writer was told that at Tokar the land gets one big flush from the river in July or August and no further irrigation except a small amount of rain. Yields at Tokar range about 300 lb. lint in good years, but the cotton plant is reported to grow more luxuriantly there than in the Gezira.

SUDAN PLANTATIONS SYNDICATE.

While at Barakat, the headquarters of the Sudan Plantations Syndicate, I received every assistance and information from Mr. Archdale, who was managing in the absence of Messrs. MacIntyre and Poyntz-Wright.

The four large ginning factories three miles from Barakat turn out 800 bales per day. The seed-cotton is classified into grades as soon as it arrives. From five to seven grades are used and the classification is strict, thus giving buyers confidence in the marks of the Syndicate, which are now becoming well known. The bales are of 425 lb., pressed to a density of about 30 lb. per cubic foot, as compared to 42 to 45 lb. per cubic foot in India. They are fully covered with hessian and neater and tidier than any bales I had seen before in any part of the world. Separate bands are used which are tied by a stud passing through two holes in the bands. Each bale has seven bands. From 1928 the bales will have eight bands. In India the bale is lashed with three bands, each of which goes round $3\frac{1}{2}$ times, the ends being slipped under the last turn. It tightens itself as pressure is released.

Mr. Maxwell took me to see the two pumping stations where the Syndicate developed 20,000 acres prior to the construction of the canal. It is a marvellous piece of work—the two Diesel engines being capable of raising altogether nine cubic metres per second, a height of over 75 feet.

The Syndicate's seed-growing block is in charge of Mr. Craig, and any satisfactory seed produced by the Agricultural Department is here multiplied, and ginned separately in a small factory situated on the block, and quite distinct from the main factories. The main stock is still sown with fine Sakelarides seed imported from Egypt. Some check plot experimental work was also in progress at this farm, but the main business is multiplication of reliable seed for the Agricultural Department. Seed from Kassala and Tokar is also multiplied here.

One morning was spent at the Research Farm at Wad Medani, which is in charge of Mr. Walley, with whom I had a very instructive discussion. Entomological problems were discussed with Mr. Johnson and his assistant, working at the Research Farm under the Wellcome Research Laboratory, whose head in the Entomological Section, Mr. King, I found refreshingly broad-minded and deeply interested in Sudan problems. It is only possible to touch generally in this report on some of the matters discussed with these experts, which I consider of special interest.

Ammonia sulphate.

At this early stage in the history of the Gezira cultivation, it is rather remarkable to find ammonium sulphate giving encouraging results. Quantities from 200 lb. to 600 lb. of sulphate per acre had been tried. In the Punjab we found best results came from much smaller dressings—60 lb. per acre being best. The results shown me by Mr. Walley seemed to indicate a greater relative profit from 200 lb. than from the heavier dressings. The Syndicate is trying about 1,000 tons this year. It would be well worth while, even for them to test lower dressings on a large scale.

Gypsum.

Applications of this chemical improve the physical condition of the soil and result in increased yields. Dressings of four tons and upwards are being tried. Possibly some organic manure or some change in the system of cropping would give equal and more economic results.

Water requirements.

Only one main line was being investigated, viz., applications of 5", 4½", 4", 3½" and 3" at a time (5" is equivalent to 500 metres per acre). Experience has indicated irrigation every 15 days is most practical under present conditions.

Economic factors.

The development of the Gezira depends on three main economic factors, viz.,

- (1) Land.
- (2) Labour.
- (3) Water.

(1) As regards land, I was told there were three million acres available and that the utmost expansion that can be clearly foreseen now is 500,000 acres, or about one-sixth of what is available, and only two-thirds of this will be cultivated in any one year as one-third is fallow. Land is, therefore, not a limiting factor.

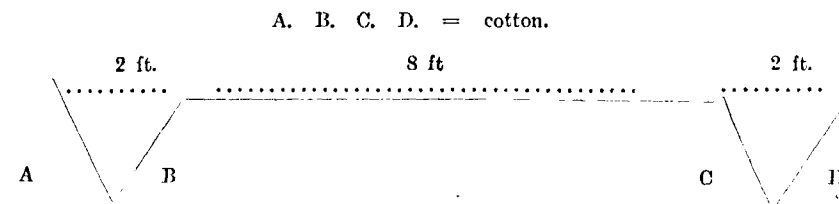
(2) Labour comes in from all over Africa, and I saw villagers from Nigeria who intended more or less settling on the land. This factor will, in the natural course of events, become less stringent as time goes on.

(3) Water is really the limiting factor. It would tend to a healthier outlook if, instead of *yield per acre*, one could visualize yield per unit of water—say, 7,500 cubic metres—the amount approximately used now over one acre.

The application of water to the stiff Gezira soil upsets its physical condition and tends to render it unhealthy from lack of aeration. In tropical conditions such as the Sudan, the activity of the soil flora should be a tremendous factor in maintaining fertility. The direction of research up to now has been with a view to adding artificial nitrogen manures and improving the texture with heavy dressings of gypsum.

It is quite possible that a much heavier intensity of cropping may be feasible. This might at any rate increase the organic matter in the soil and improve the physical condition, and possibly induce more activity of soil nitrogen organisms.

Again from first principles it is possible that better results could be obtained by growing cotton in double lines thus :—



the distance from the centre of one double line to another being 10 ft. or even more. In this case the furrow on both sides of which the cotton would be grown would be about 15" deep and, say, 2 ft. wide at the top. No water would be applied to the portion B-C in above sketch, and the soil might be cultivated occasionally to maintain a free aerated condition. Water could be applied copiously in A-B and C-D—possibly every 5 or 10 or 15 days as found most suitable. Even in the present small ridge system one of the chemists (Mr. Peto) informed me nitrogen accumulation is mainly on the tops of the ridges. In old British agriculture, farmers had a somewhat similar problem to the Sudan in that unless land was freely drained or aerated the cropping suffered. This led to land being ploughed so as to form a series of wide ridges and a furrow. These furrows would be from 15 to 45 feet apart, and the land would be ploughed away from them towards the centre, which gradually rose year after year. The configuration remains to this day in many thousands of acres of land in England and Wales. I cannot help a strong conviction that some similar solution may be found in the Sudan.

The conception of the main problems of the Gezira on the above lines and a realization of the economic relation of land, labour and water, lead to a few deductions which can only be briefly touched upon here.

(a) *Relation of water to lint production.* If the present depth of water is utilized, it is obvious that as only 20 per cent. of the land is watered, i.e., the 2 ft. furrow, the amount of water used will be theoretically 20 per cent. of what is used now.

Assuming it is 25 per cent., it is hard to imagine the acre yield falling much below 50 per cent. of present yields so that the total quantity of water used now might produce anything up to 200,000 bales of cotton.

(b) Any agreement between the user of water and the Government, if it fails to realize the real factors, is defective and may later be costly.

(c) The direction of research by the Agricultural Department would take a more constructive road and greater attention would be paid to natural recuperative factors in the soil. A fact constantly repeated to me was that the second or third crop of cotton on a given soil was never equal to cotton on similar original soil in the same season. In no case, even with unlimited manure and water, had the department been able, or apparently seriously attempted, to excel the original fertility. Investigation along this line might give valuable economic results even under the present system. It is in relation to "volume of water", however, that the optimum conditions have ultimately to be found. Questions of transport, cost of additional canals and watercourses, all have a bearing on the ultimate system adopted.

IV. One of the grave dangers visualized in the Gezira is excessive accumulation of salts. The system advocated above minimises the risk.

In discussing this matter with Dr. Clouston, he suggested that the groundnut crop, the cultivation of which has increased enormously in the black heavy soils in India in recent years, might also be a partial solution for the Sudan problems. The Agricultural Department in the Sudan is alive to the problem of trying new crops. Persistent efforts with such a valuable crop as groundnuts may, however, be of great value to them.

ABSENCE OF TREES.

Practically no trees are grown in the Gezira owing apparently to fear of their harbouring pests, and serving as shelters and resting places to the harvest birds which do great damage to *dhura* (sorghum).

The Nile is not many miles away and certain birds do come from that region when food is plentiful. The only bird I noticed in the Gezira was a reddish bee bird, which was fairly common in some cotton fields.

Timber is said to be expensive in the Gezira. It has been our experience in India that large scale pests are apt to get out of hand in a new colony where natural conditions are being altered on a gigantic scale. I would instance the bollworm epidemic of 1905 and 1911 in the Lower Chenab Canal Colony. Since 1911, however, there has been no large scale bollworm attack. It would appear reasonable to encourage the bird population in the Gezira in a more systematic manner. Probably the best way would be to have plots at the corner of, say, every 4 square miles, such plots to be from one to 100 acres as thought desirable. Such enclosures could be easily watched and if harbouring too many harmful birds could be easily dealt with. This policy would be better economically than single rows of trees and would cost less to maintain,

BOLLWORM.

Four kinds are known. All seed is treated by 'sunning' for $1\frac{1}{2}$ to $2\frac{1}{2}$ hours on a cloudless day in April to destroy pink bollworm, larva, etc. This method, which has been perfected by the Entomological Department, seems very practical and is being followed for all cotton seed used for sowing. The temperature of the seed while in the sun must reach 55° C. The seed is spread on mats in a layer $1\frac{1}{2}$ " to 2" thick. When testing the temperature, it is heaped up and the thermometer put inside. No harm results to germination if the seed gets up to 80° C.

BOLLWORM PARASITES.

Another very interesting bit of practical work is that done by Mr. Bedford on the breeding and control of parasites of bollworm. It has been found possible to keep the parasites in cold storage and multiply them at will. This is being worked on a practical scale and if there should be a sudden bollworm scare, the department is in a position to send almost unlimited parasites to any threatened region within a few days of the appearance of the bollworm epidemic. This is the first practical attempt of this nature I have come across; it is well worthy of adoption in India.

I wish to thank all the officers of the Agricultural Department, particularly Mr. Davie, and of the Entomological Service, who assisted me. The work of the Sudan Plantations Syndicate requires no commendation from me. I hope to adopt in India several features in their organization which I consider can be economically applied to the Punjab.

THE MADRAS AGRICULTURAL DEPARTMENT EXHIBITION MOTOR VANS.

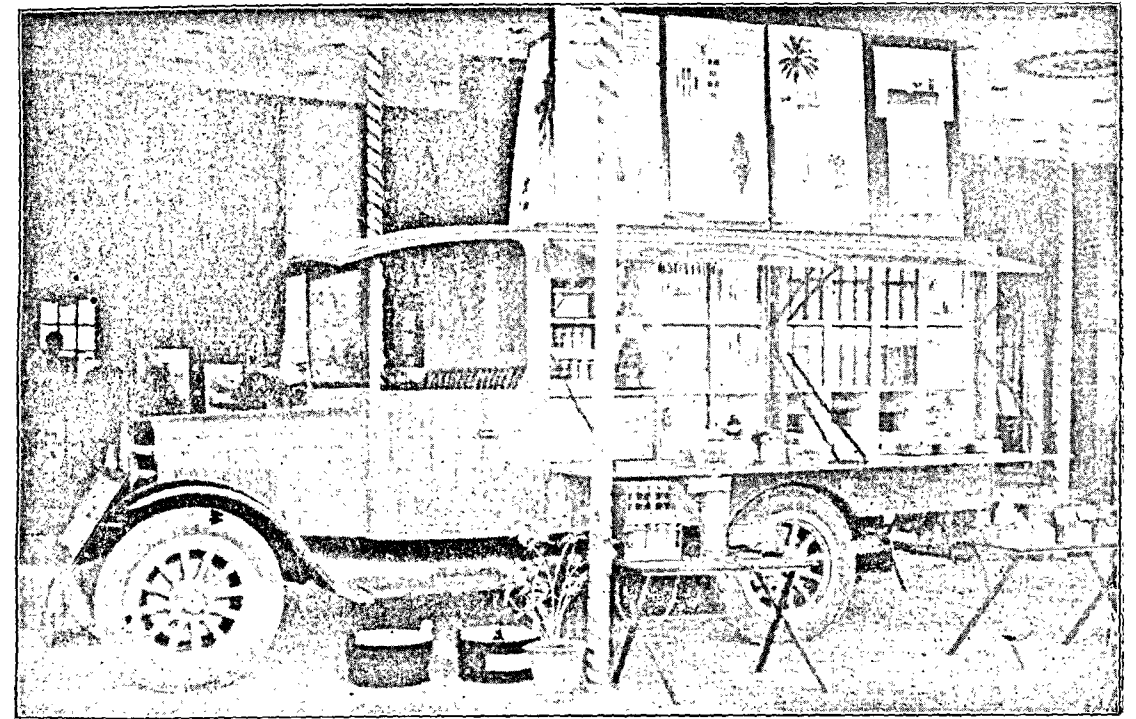
BY

R. D. ANSTEAD, C.I.E., M.A.,
Director of Agriculture, Madras.

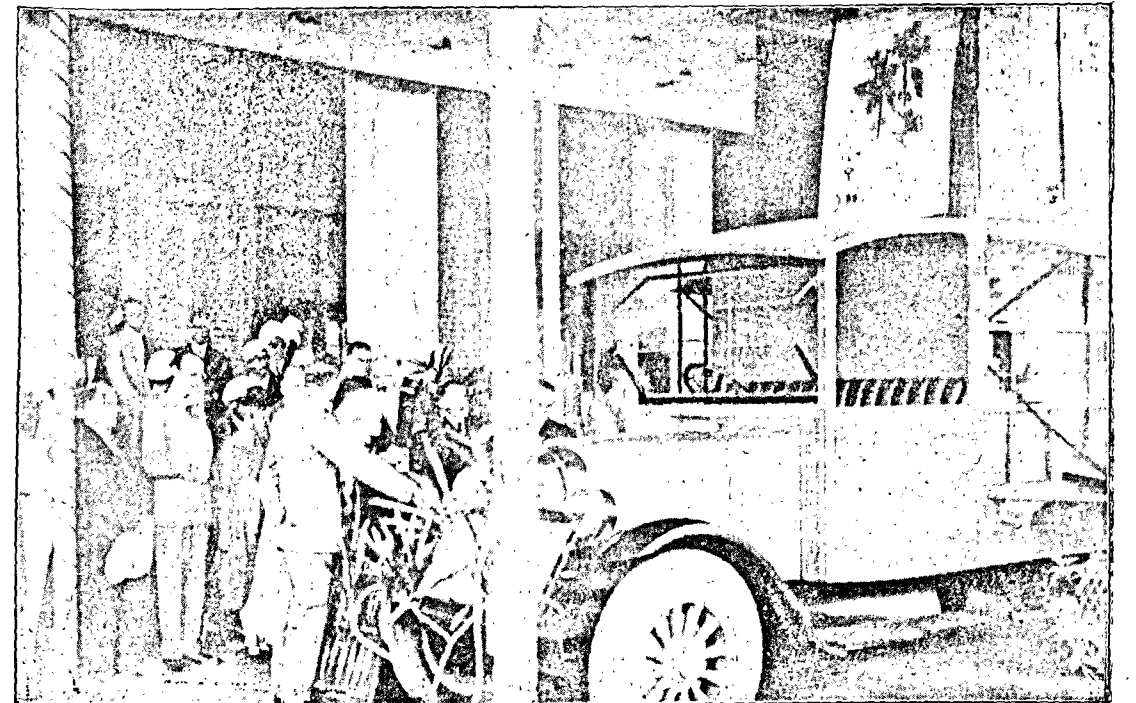
IN order to aid in their propaganda work, the Madras Agricultural Department has put on the road a travelling motor exhibition. This was considered likely to prove of more use than an exhibition train, such as that used in the Punjab, for the reason that in South India railways are comparatively few and they do not always pass through the densely populated districts. Moreover, it is only at big towns and centres that facilities exist for halting a big train in a siding without dislocating the traffic. It was, therefore, decided to try the experiment of a motor exhibition van which could be taken from village to village in the interior of the districts and brought to the very doors of the ryots.

The first unit, which is of an experimental nature, consists of a van with a Graham Bros. $1\frac{1}{2}$ ton chassis with a 137" wheel base and a 4 cylinder 24 H.P. engine. On this chassis is mounted a body divided into two main parts. The front portion consists of the driver's cab capable of carrying the driver and two passengers. The rear portion is a compartment divided into three sections. The central section is utilized for general storage and carries ploughs, implements, sprayers, and big samples. Moveable shelves can be fitted wherever required and these shelves can be converted into tables and benches when an exhibition is being given. The sides of the van are divided lengthways into two portions. The lower portion on either side folds down into a horizontal position to form a display counter. The upper portion folds up out of the way and forms a shelter to the counter. When these sides are opened up they expose on either side of the van a series of shelves for the display of exhibits. To protect these and keep them from shifting when the van is in motion light wood detachable panels are fitted in front of them. These panels fit into slots on the roof of the van and have hooked supports behind to hold them in place and here they serve as a screen on which posters, etc., can be displayed.

In addition to this there is a caravan in which the assistants in charge of the exhibition can travel and live. The chassis of this is a Graham Bros. model IC with a 137" wheel base and a 4 cylinder 24 H.P. engine, on which is mounted a body



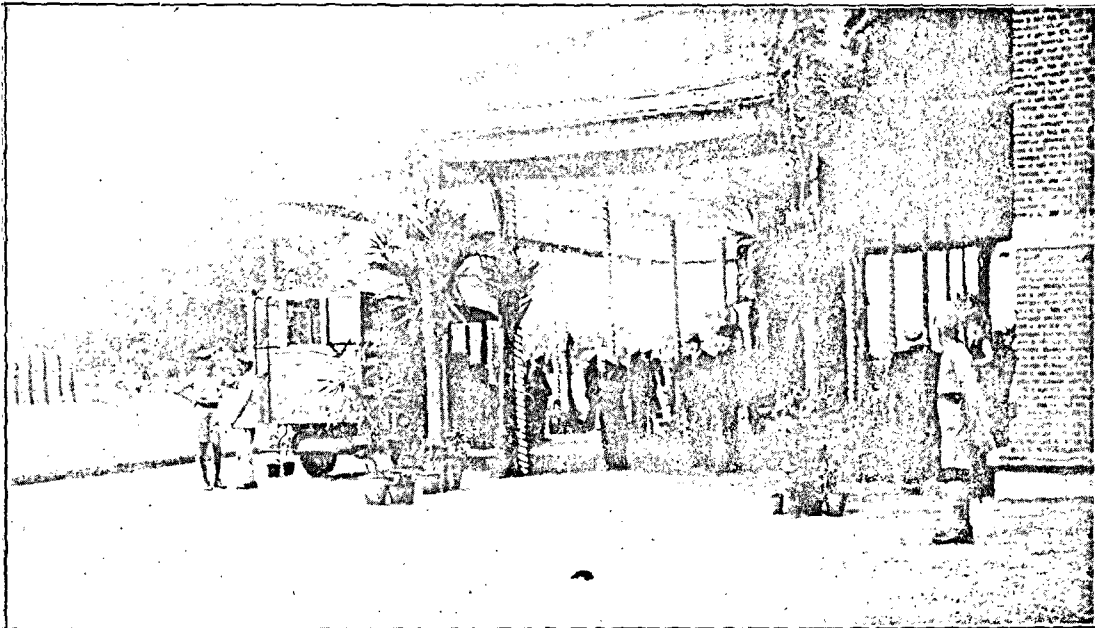
Exhibition van—fully displayed.



Exhibition van—front view.



Exhibition van—side view.



Caravan—back view.

divided into three sections. The front section consists of two parts, a driver's seat and, on the off side, a compartment to carry a magic lantern. This lantern can project through a hole to the left of the windscreen or sideways and it is operated from the driver's seat. It is worked from a special battery charged from the motor engine. The sheet is fixed to a small rail running round the rear end of the exhibition car.

The second compartment consists of a seat capable of carrying four persons in comfort with doors on either side. The rear portion consists on the rear side of two sleeping berths. The lower one is a permanent fixture underneath which are cupboards for clothing, etc. The upper can be folded out of the way. On the off side is a folding table and two chairs. Behind the forward chair is a large cupboard for books, etc. Three drop glass windows are provided on the off side and two at the rear and either side the door. A luggage rail runs the whole way along the roof on which tents, etc., can be stored.

The cost of these vans was approximately Rs. 8,000 and Rs. 6,500 respectively.

As regards the exhibits which the vans carry, these cover the whole range of the department's work. Each is fitted up in a small showcase with a glass front which fits into its own section and these can be changed at will depending upon the locality visited and the nature of the exhibition it is desired to give. A large number of posters are carried and these are displayed on boards on the roof and attached to the front of the counters. Tables and benches are formed of the shelves in the centre of the van and these are arranged round it to display other samples, etc. The whole, therefore, spreads out into an extensive display and it takes approximately an hour to get it ready or pack it all up ready to move on as the case may be.

Ploughing demonstrations, etc., are given at the same time and in the evening lectures are delivered with the aid of the lantern. The caravan goes ahead and chooses a suitable site and makes the necessary arrangements, advertises the coming of the exhibition, and so on, and in due course the big van arrives and the display is spread out. Halts of one to three or four days are made depending on the size of the place visited and the occasion. Local fairs and festivals are attended and the utmost use is made of all *shandais*, conferences, and gatherings of all sorts. Two assistants at least accompany the vans and of course there is a reliable driver for each.

The actual running cost including the pay of the driver is estimated at six annas a mile, and 15 per cent. depreciation has been allowed.

This unit is looked on as experimental and it will be improved on in future models as experience is gained. Future vans will probably be made lighter for instance, but on the whole the unit has proved very satisfactory indeed, and it has met with a great welcome and response from the cultivators and it is in constant demand.

It was due to the initiative and keenness of His Excellency Lord Goschen, the Governor of Madras, that this van was obtained, and at his suggestion it was ex-

hibited on the Government House lawns during the garden party. Their Excellencies gave to the members of the Indian Science Congress in December. There it was the centre of attraction during the course of the afternoon and His Excellency himself aided the Demonstrator in charge in explaining it and the exhibits which it contained, and showed himself a keen and well informed exponent of the art and science of agriculture in South India.

THE INDIAN OAT AND THE ERROR IN ITS IDENTIFICATION.

BY

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OATS are a crop of considerable importance in some parts of India, particularly in Bihar and the United Provinces of Agra and Oudh and in the vicinity of military stations.

According to Watt,¹ "It was first grown in Northern India, under English auspices, round cantonments and stud depôts, for the supply of horses. The cultivation of oats (*Avena sativa*) for the grain is confined mainly to the Delhi and Hissar Districts of the Punjab and the Meerut District of the United Provinces where it is grown as a *rabi* crop, but it is raised also to a limited extent in the Poona, Ahmednagar, Satara and Ahmedabad Districts of the Bombay Presidency. Elsewhere it is more frequently cut green for cattle fodder." No separate statistics of area or production are maintained and the foreign export trade is normally small in comparison with that of other grains produced in the country.²

De Candolle³ says "there is no Sanskrit name for oats, nor any in modern Indian languages and that the earliest mention of oats in China is in an historical work in the period 618 to 907 A.D. and refers to the variety known to botanists as *Avena sativa nuda*. The ancient Greeks knew the genus very well; they called it *bromos* as the Latins called it *avena*; but these names were commonly applied to species which are not cultivated, and which are weeds mixed with cereals. There is no proof that they cultivated the common oat. The English word oats comes, according to A. Pictet, from the Anglo-saxon word *ala* or *ate*."

The genus *Avena* belongs to the tribe *Aveneae*, of the natural order *Gramineae*, and contains a number of cultivated and wild forms. The oat plant as a member of the grass family naturally bears a strong likeness to the other members of this division, such as wheat and barley. It can, however, be distinguished even at a very early stage of its development by its habit of growth and the character of

¹ Watt. *Dic. Econ. Pro.*, I, 1889, p. 356.

² Cotton, C. W. F. *Handbook Commer. Infor. India*, 1919, p. 155.

³ De Candolle. *Origin of Cultivated Plants*, 1904, p. 373.

the ligule and auricles. These diagnostic characters are brought out in the following Table :—

Character	Oats	Wheat	Barley
1. Early habit . . .	Erect or semi-erect . . .	Semi-erect . . .	Erect with leaves usually curled on themselves.
2. Ligule . . .	Well developed and has a number of small teeth.	Developed, but more or less blunt.	Developed, but more or less blunt.
3. Auricles . . .	Absent . . .	Developed and hairy . . .	Well developed but glabrous.

There are clearly defined differences between the various species of oats, and those between the more important species *Avena sativa* Linn., *A. sterilis* Linn., and *A. fatua* Linn., are shown in the Table on page 174.

In the Indian oats which have been studied at Pusa, the young plant is generally sub-erect. The roots are shallow, fibrous and numerous. The culm or stem consists of a hollow cylinder about 0.5 cm. in diameter, intersected by a number of nodes from which the leaves arise and terminating in the inflorescence. The first node from the top is hairy. The ligule is well developed. The leaves are long and narrow (about 35.0 × 1.7 cm.) tapering gradually to the apex, with a drooping habit and yellowish green colour. There are a few fine short hairs on the margins. The panicle is erect, spreading and equilateral. The spikelets are generally 2 and rarely 3-grained, the third flower in the spikelet usually remaining abortive. Basal articulation is very marked leaving a 'sucker-mouth' scar when the spikelet is separated from the main axis. The upper grain, however, always breaks off with the rachilla. Glumes about 25 mm. long, pointed, having 9 coarse nerves. Awns numerous, fine and sometimes slightly twisted at the base, but never geniculate. Lower grain always awned but the upper grain may or may not be so. Basal pubescence prominent, having numerous brownish hairs. Grain yellowish, the lower one about 20 mm. long, 3 mm. wide and 2 mm. thick. Kernel hairy, about 10 mm. long. Stooling capacity medium to sparse. Maturity early.

The description given above conforms botanically to the species *Avena sterilis*, sub-species *culta*, and according to our observations the cultivated oat in India belongs to this species. In all important Indian floras and other publications, however, the Indian oat has been and is still identified as *Avena sativa* Linn. This mistake appears to be perpetuated from work to work and needs immediate rectification.

Duthie and Fuller¹ in 1882 refer to oats (*Avena sativa* Linn.) as having recently found their way into the agriculture of the N. W. F. Province and Oudh, through

¹ Duthie, J. F., and Fuller, J. B. *Field and Garden Crops of the N. W. F. Prov. and Oudh*, I, 1882, p. 13.

having been grown under English auspices round cantonments and stud depôts for the supply of horses.

Watt¹ in 1889 speaks of the cultivated oat in India as *Avena sativa* Linn., and although he refers to the wild oats, *A. fatua*, Linn., *A. pratensis* Linn., and *A. pubescens* Linn., he does not mention the true form *AVENA STERILIS* Linn.

Hooker² in 1897 considers *A. sativa* to be the form cultivated in Northern India from Bengal to the Indus, and the Himalaya up to 12,000 feet. He also mentions some wild forms such as *A. fatua* Linn., *A. barbata* Brot., *A. Cavanillesii* Koch., *A. pratensis* L., *A. aspera* Munro., *A. polyneura* Hook. f., *A. subspicata* Clairv., *A. Clarkei* Hook f., *A. micans* Hook. f., *A. flavescens* L., *A. acnea* Hook f., *A. Sikkimensis* Hook. f. and *A. flaccida* Hack. mss., but does not again mention the form *AVENA STERILIS* Linn.

Prain³ in 1903 says that the oat *A. sativa* Linn. is cultivated sparingly.

Cotton⁴ in 1919 acting perhaps on the information contained in the above floras mentions oats as *Avena sativa*.

Haines⁵ writing as late as in 1924 calls the cultivated oat *A. sativa* Linn., and says that the variety *orientalis* is frequently cultivated in the northern area in the cold season, chiefly by Europeans.

Acting on the information contained in these authenticated works of reference, important Government publications such as the *Agricultural Statistics of India*⁶ are continuing year after year to call the Indian oat *Avena sativa*.

Some work has been in progress in the Botanical Section at Pusa for a number of years on the selection of suitable types from Bihar oats. Working out the details of the oat plant, the writer observed in 1925 that the Bihar oats grown in Pusa do not fall under the species *A. sativa*, as has been suggested in the above quoted works, but belong to *A. sterilis*, sub-species *culta*. A thorough review of the literature available on the subject revealed that Marquand⁷ in 1922 had grouped a *desi* (= Indian) variety under *A. sterilis*, sub-species *culta*, and Archer⁸ also in 1922 classified a Calcutta variety under the same species.

To ascertain whether all the oats grown in different parts of India really come under this species, a number of samples were procured from the various provinces in India and grown and compared at Pusa. All of them without any exception proved to be *A. sterilis*. Touring round parts of Bengal, Bihar, the United Provinces of Agra and Oudh, and the Punjab, the writer found *A. sterilis* growing everywhere

¹ Watt. *Dic. Econ. Prod.*, I, 1889, p. 356.

² Hooker, J. D. *Flora of British India*, VII, 1897, p. .

³ Prain, D. A. *Bengal Plants*, II, 1903, p. 1217.

⁴ Cotton, C. W. E. *Handbook Comm. Infor. India*, 1919, p. 155.

⁵ Haines, H. H. *The Botany of Bihar and Orissa*, V, 1924, p. 954.

⁶ *Agricultural Statistics of India*, 1925-26, I, p. 73.

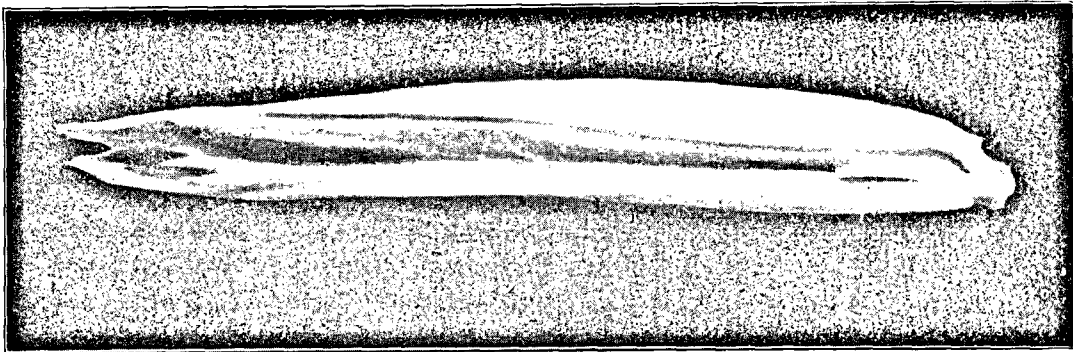
⁷ Marquand, C. V. B. *Varieties of Oats in Cultivation*. *Welsh Plant Breeding Stn. Ser. C.*, No. 1922, p. 37.

⁸ Archer, A. A classification and detailed Description of the Oats of Australia. *Commonwealth of Aust. Inst. Sc. & Indus. Bul.* 23, 1922, p. 26.

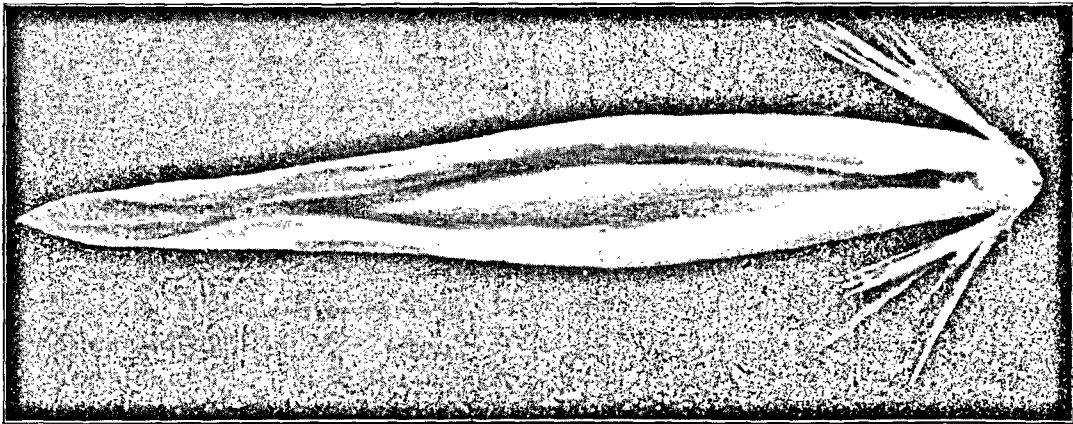
mixed here and there with some plants of the wild oat *A. fatua*. Some varieties of *A. sativa* imported from Europe or America were, of course, found in certain Government farms.

A number of panicles of the Pusa selections of Bihar oats together with some samples of imported varieties of *Avena sativa*, which had been grown at Pusa, and a few heads from the F₂ generation of a cross between Scotch Potato (*A. sativa*) and a Pusa selection (*A. sterilis*) were sent to the Royal Botanic Gardens at Sibpur (Bengal) and Kew for identification. The following table shows the results of the examination of the samples at Pusa, Kew and Sibpur :—

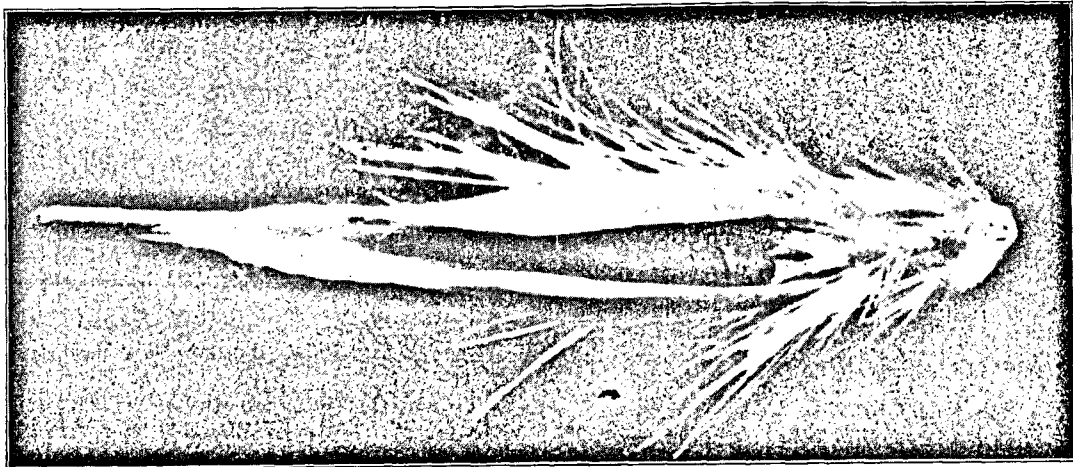
Sample No.	Variety (not mentioned in samples sent to Sibpur or Kew)	IDENTIFIED AT		
		Pusa	Kew	Sibpur
1	Pusa 19-1 (Type II)	<i>A. ster. L.</i>	<i>A. ster. L.</i>	<i>A. sativa</i> var. <i>orientalis</i> .
2	Pusa 14-2	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
3	Pusa 12-1 (Type I)	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
4	Pusa 10-4	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
5	Pusa 7-1	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
6	Pusa 1-1	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
7	Pusa Farm I	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
8	Kinwada	<i>A. ster. L.</i>	<i>A. ster. L.</i>	Do.
9	Iowa 103	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do. (white Tartarian awnless oat).
10	Gopher	<i>A. sat. L.</i>	Cult. var. of origin <i>A. sat. × A. ster.</i>	Do.
11	Kanola	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
12	New Harvester	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
13	Abundanco	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
14	Victory	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
15	Scotch Potato	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
16	Yielder	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
17	Iowa 670	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.
18	Iowa 105	<i>A. sat. L.</i>	<i>A. sat. L.</i>	Do.



A. sativa L.



A. sterilis L.



A. fatua L.

Sample No.	Variety (not mentioned in samples sent to Sibpur or Kew)	IDENTIFIED AT		
		Pusa	Kew	Sibpur
19	Orion	A. ster. L. . . .	Cult. var. of origin A. sat. x A. ster.	A. sativa var. orientalis (black Tartarian oat). Do.
20	White Cluster	A. sat. L. . . .	A. sat. L. . . .	Do.
21	Scotch Potato x 4-1 (F ₂) 1928 plant 10.	A. ster. L. . . .	A. ster. L. . . .	Do.
22	Scotch Potato x 4-1 (F ₂) 1928 plant 14.	A. ster. L. . . .	Cult. var. of origin A. sat. x A. ster.	Do.
23	Scotch Potato x 4-1 (F ₂) 1928 plant 22.	A. sat. L. . . .	A. sat. L. . . .	Do.
24	Scotch Potato x 4-1 (F ₂) 1928 plant 7.	A. sat. L. . . .	A. sat. L. . . .	Do.

The identification at Kew confirmed those which had been made at Pusa with the exception of sample No. 10 which was stated at Kew to be “a cross between *A. sativa* and *A. sterilis*.” At Sibpur, however, all the samples were identified as *A. sativa* var. *orientalis*, and it was stated that none of the samples forwarded belonged to *A. sterilis*, this form being considered there to be a synonym for *A. fatua*.

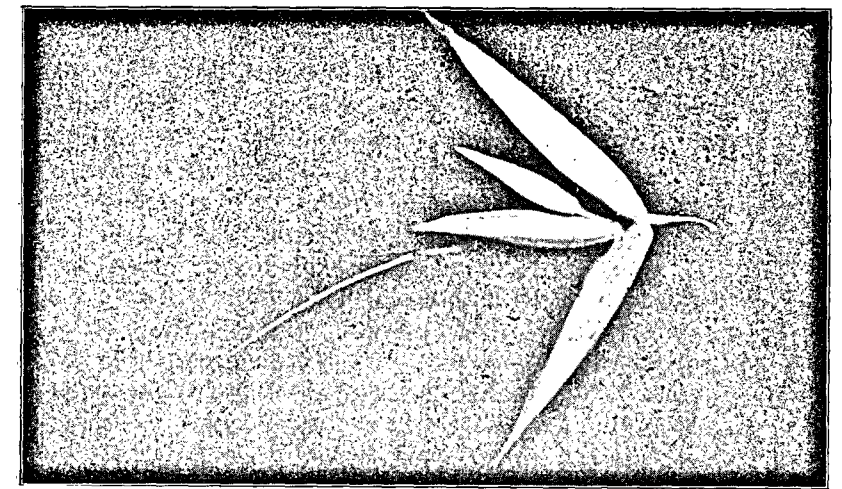
The mistake committed at Sibpur in diagnosing the specimens has perhaps been made by following too closely the Index Kewensis¹ which refers to *A. sterilis* as being a synonym of *A. fatua*. There is, however, a good deal of difference between these two species (Pls. XIV and XV). In *A. sterilis* the lower grain has a marked articulation with the main axis and is readily detached leaving a cup-like or ‘sucker-mouth’ scar, slightly to one side and running obliquely to the length of the grain. The upper grain, on the other hand, has no articulation and when detached from the rest of the spikelet it carries away from the lower grain the greater part of the rachilla which breaks, leaving only a small stump with a jagged edge to the lower grain. The awns are neither geniculate nor very much twisted at the base but are practically straight and thin. Basal hairs are usually present and are generally brownish in colour. In *A. fatua* the lower grain is articulated with the main axis as in the other species but the upper grain also articulates with the rachilla. The awns are long, coarse and geniculate. The lemma and rachillæ are covered with a thick felt of hairs, a character which is not found in the cultivated oats *A. sativa* or *A. sterilis*.

¹ Index Kewensis, Tommes, 1, p. 254 :—“Avena sterilis, Delile, en. Boiss. Fl. Orient. V, 543 = fatua.”

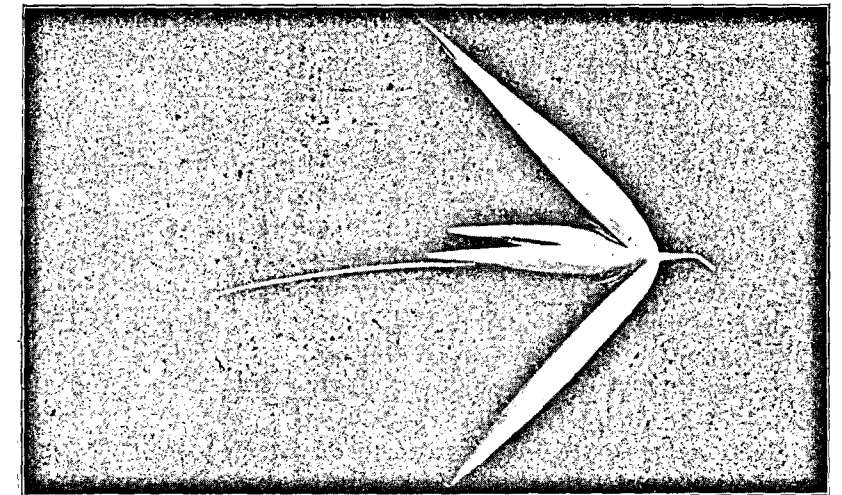
The chief characteristic differences by which these three important species of *Avena* can be distinguished are tabulated below and may be recognized on Plates XIV and XV :—

Character	<i>Avena fatua</i>	<i>Avena sterilis</i>	<i>Avena sativa</i>
1. Form of attachment of the lower grain with the main axis.	Articulated . . .	Articulated . . .	No articulation.
2. Form of attachment of the upper grain or grains.	Articulated . . .	No articulation . . .	Articulated.
3. Awns	Long, coarse and geniculate.	Thin and practically straight.	Long, coarse and frequently geniculate and twisted at the base.
4. Basal hairs	Dense tuft of hairs surrounding the 'sucker-mouth' in both grains.	Coarse and prominent at the base of the lower grain only.	Nil or very few fine hairs at the base of the lower grain.

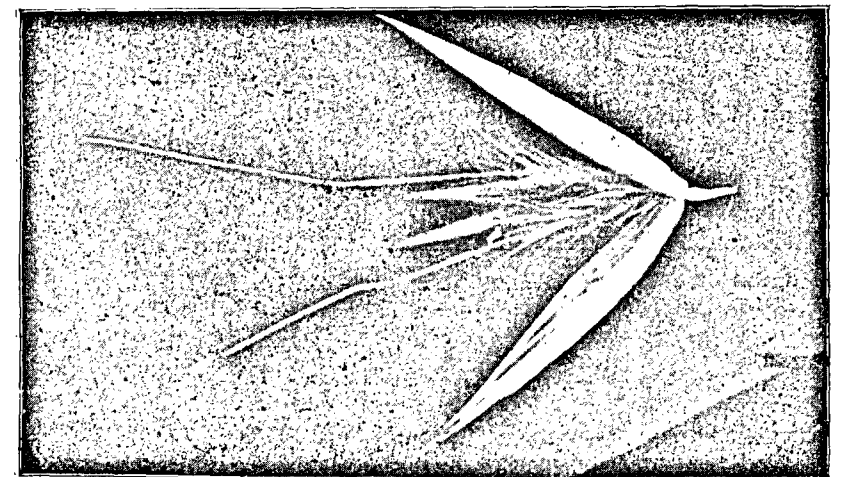
The cultivated forms of *A. sterilis* are widely distributed and extensively cultivated in the countries bordering the Mediterranean and this appears to be a form which is more suited to dry hot regions with a short season than any varieties of *Avena sativa*. It is only natural, therefore, that this species should be the oat best adapted to the soil and climatic conditions of India. The identification of the Indian oat as *A. sterilis* affords another instance of the similarity between the floras of India and the warm countries of Southern Europe, and should be remembered in all work which is in progress in India on this crop.



A. sativa L.



A. sterilis L.



A. fatua L.

WOOLLY-MITES (*ERIOPHYES GOSSYPHII*) ON COTTON.

ITS STATUS AND ECONOMIC IMPORTANCE IN GUJARAT.

BY

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WOOLLY-mites may reasonably be considered as being one of the most important amongst the numerous pests that infest cotton in this part of India. If a field of cotton during the growing season is observed, one will come across a large number of plants having fuzzy white material on the leaves. This is the principal symptom by which this pest is recognized and this gives the pest its vernacular denomination “Chhasio” (white as butter-milk) in Gujarat and “Badi Rog” (white disease) in the Karnatak.

This pest has been found occurring almost every year. It was in the year 1900 that the first attack was recorded on the agricultural station at Surat, and the annual report of that station for the year 1909 states that the damage caused by the pest was as much as 50 per cent. The pest is not confined to Surat but has been reported from many other places as shown below :—

Name of place	Year	Month
1. Kirkeo	1909	January.
2. Nadiad	1907	December.
3. Baroda	1907	March.
4. Sibpur	1905	July.
5. Cuttack	1906	November.
6. Pusa	1912-15 ¹	

¹ *Proceedings of the Third Entomological Meeting, Pusa, Vol. II, page 562.*

Our knowledge of this pest has been confined to the Gujarat tract only. The pest has been noted to have assumed a very virulent form in the Surat and Broach Districts, whereas in the other parts of Gujarat it occurs as a sporadic pest. Accurate estimates of the infestation of this pest at different places of the province are not available, but several reports of serious infestations have been received. During 1927-28, most of the talukas of the Surat District reported heavy infestations.

Specimens of woolly-mites on cotton leaves from Surat were sent for identification in the year 1906 to Mr. Nathan Banks who reported that the mites agreed with the specimen of *Eriophyes gossypii* from the West Indies. The description of *Eriophyes gossypii*, as given by H. A. Ballou, M.Sc., Entomologist, Imperial Department of Agriculture, West Indies, is as follows:—"Body elongate, cylindrical and tapering, about six times as long as broad, abdomen with about seventy rings, two pairs of bristles on lower side, one at about middle of length and the other half way from this to tip. At the tip there is a truncate plate, from each outer corner of which rises a long curved bristle. Dorsum of cephalothorax sub-triangular, the sides slightly undulate and in front truncate, above which three irregular sub-parallel ridges each side, the inner one the longest. Legs short, the femora slightly thickened near base, a long bristle near the tip of tarsus."

On account of the fuzzy material on the cotton plant and the microscopic size of the pest, it is by no means easy to observe these mites with an ordinary hand-lens. For scientific observations, the affected leaves were taken to the laboratory and were exposed to the sun. The mites escaping from these leaves were collected in the water that surrounded the dish in which the leaves were exposed and then examined under the microscope.

The outward indication of the attack of this pest is a slightly distorted or crumpled appearance of the affected leaves which have a dense growth of white hair. Later on, these mites develop on vegetative buds, lateral shoots, branches, flower-buds, flower-bracts, flowers and small bolls. On account of the blisters caused by the mite, the leaves and other affected parts of the plant show tiny silvery spots which develop the growth of a large number of adventitious epidermal hairs. This growth of hair is evidently caused by the irritation set up by these mites and it is under the protection of these hairs that the mite lives.

The pest begins to appear in August when the plants are about two months old and the attack increases as the season advances. The infestation is visible up to the harvest time to a varying extent. The severity of attack reaches its height in the months of November and December when the leaves of all the plants in the affected areas present an ashy white appearance.

LOSS IN YIELD DUE TO WOOLLY-MITES.

It is necessary to have some idea regarding the economic loss due to the reduction of the final yield of the crop, caused by this pest. Our knowledge of the life-



Fig. 1. Cotton plant badly infected by Woolly Mites and a non-affected normal plant.

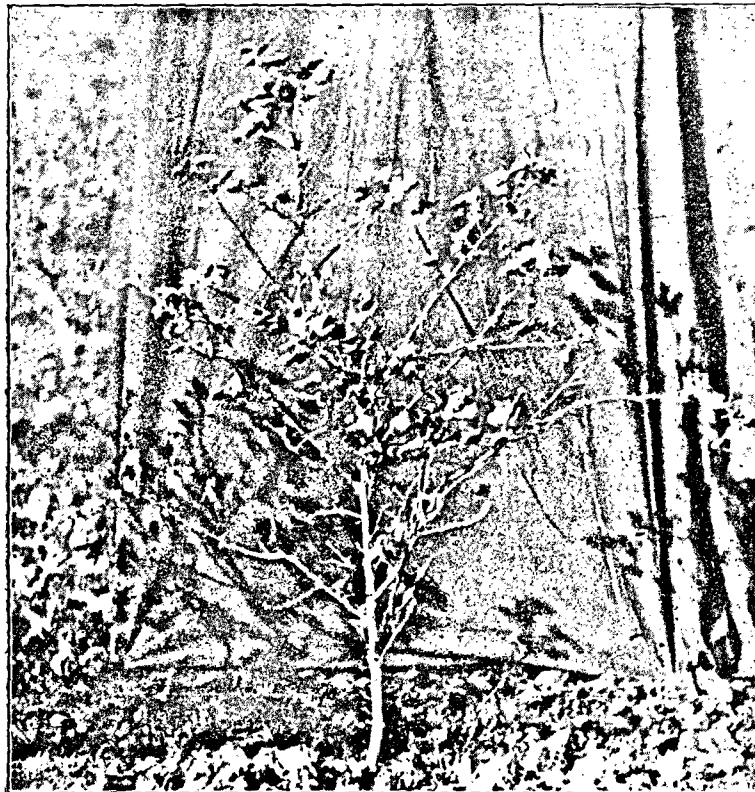


Fig. 2. A cotton plant dusted with sulphur.

history of the pest does not provide us with any clue to the complete protection of plants from woolly-mites. In order to compare the produce of these plants with that of the fully infested ones for calculating the loss caused by the pest, observations as mentioned below were therefore resorted to.

Two sets of fifty plants were kept under observation. One group consisted of plants that appeared to have escaped the attack and the other group was made up of completely affected plants (Plate XVI, fig. 1). The following statement shows the yield of the affected and non-affected cotton plants in two different seasons :—

Year	No. of plants	YIELD OF SEED-COTTON IN TOLAS		Percentage loss	REMARKS
		Affected	Non-affected		
1925-26	50	154	228	32.5	Cotton on ridges 3' x 3'.
1927-28	50	291	462	36.9	Cotton on ridges 5' x 3'.

From the above figures, it will be seen that when the plant is affected by woolly-mites, it yields on an average 34.7 per cent. less *kapas* than a normal average non-affected plant. This indicates the proportion of loss if all the plants are fully affected, but as infestation is very uneven and different plants are affected to different degrees, it is extremely difficult to calculate the loss of *kapas* from an infested area. The quality of lint, the weight of seed-cotton per boll and the ginning percentage of lint were not affected on account of the infestation of this pest on the cotton plant, as will be seen from the following statement —

No.	No. of bolls examined	Weight of seed-cotton per boll in grm.	Ginning percentage	REMARKS
1	31	2.18	35.5	Affected plants.
2	369	2.10	32.2	Unaffected plants.

PARTS OF THE COTTON PLANT AFFECTED BY WOOLLY-MITES.

As mentioned above, the infestation commences on the leaves. The flower-buds, flowers and young bolls, as they begin to arise, also show this damage, and critical observations have shown that almost every plant has a certain amount of infestation though it is only the badly affected ones which come to the notice of a

casual observer. The proportion of flower-buds which showed this damage was noted on 25 plants examined every week during the 1927-28 season.

It will be seen from the accompanying graph that throughout the whole season a certain proportion of the flower-buds was affected and the maximum number of the damaged buds was recorded in the first week of January. The attack on buds is also found more in the latter part of the season. By this time the leaf growth almost comes to a stand-still and flower-buds are the most suitable organs that can supply succulent food to the mites.

It is often seen that the flower-buds which are severely affected do not open out into normal flowers, and thus generally the period of opening of flowers is delayed by about three weeks. Cases are noticed where the petals are so tightly bound together (by overgrowth) that they cannot separate from one another and hence failure to open into normal flowers results.

Young bolls do exhibit some symptoms of mite-attack, but grown-up bolls are invariably free from any such trouble. The influence of mite attack in causing the shedding of flower-buds and young bolls cannot be definitely stated at the present stage. At the time of picking of *kapas*, a few bolls were collected from the severely affected plants. The *kapas* was ginned and the seeds were divided into two parts. Each seed from one of these two parts was cut into two. The cut and the whole seeds were exposed to the heat of the sun in two petri-dishes surrounded with water to catch the escaping mites if any. No presence of mite could be traced when examined. And hence it appears that the seeds do not carry any mites with them.

CARRY-OVER OF THE PEST.

This pest has been found on cotton plants only and no other alternative host plants have been recorded so far. The method of carry-over of this pest is only a matter of speculation at present. The presence of woolly-mite infestation on the leaves of cotton stalks of the last year was noticed upto the end of July 1928. This indicates the possibility of carry-over of this pest on the cotton plant itself and suggests that there may be no hibernation period of the pest in the off season.

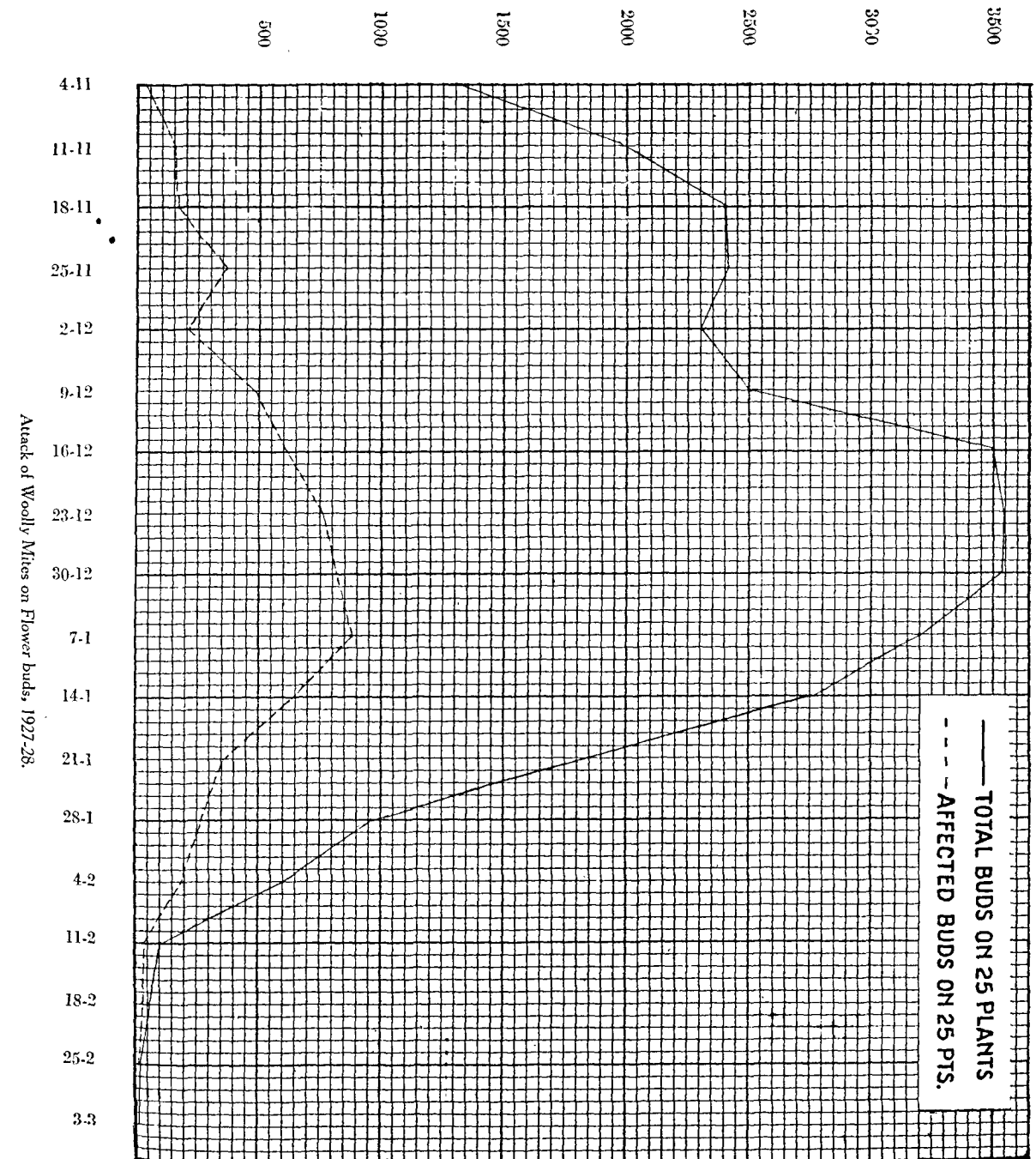
REMEDIAL MEASURES.

The following remedial measures have been tried till now :—

- (1) Irrigating the cotton crop.
- (2) Pruning of affected parts and removal of affected leaves.
- (3) Disinfection of cotton seeds.
- (4) Application of sulphur in different forms and study of its toxic effect.
- (5) Flour-paste spraying.

(1) Irrigation.

It is seen from the records that a few trials were made at Dhulia during 1917 and some plots of cotton were irrigated as a remedial measure.¹ The irrigated



¹ Proceedings of the Fourth Entomological Meeting, Pusa, 1921, page 96.

plots remained free from woolly-mites, whereas the neighbouring unirrigated plots were considerably affected. Further trials with regard to this point were not repeated, probably because irrigation facilities for cotton are not available in Gujarat and besides in some places the soil is not suitable for irrigation.

(2) *Pruning of affected parts and removal of affected leaves.*

The appearance of this pest is first visible on the leaves of the plants, and it was therefore thought that the picking and removal of affected leaves might successfully check the further spread of this pest. With this object in view, the operation was carried out on the Government Agricultural Station, Surat, during the seasons of 1919, 1920 and 1921.¹

The process was again repeated in 1925, but the results of all the seasons showed that the treatment was not effective.

(3) *Disinfection of cotton seeds.*

The appearance of mites was found on almost all parts of cotton plants, and hence it was thought that the infection of the pest might be through the cotton seeds. This led to the idea of disinfecting the seed before being sown.² For the purpose of disinfection, the seed was steeped in 0.2 per cent. solution of mercury perchloride before sowing. The trials of this treatment were conducted during three seasons. The results showed that the infestation appeared as early in treated plots as in the untreated ones and total infestation was about the same in both the cases.

Table showing infestation during 1925-26.

Area (Acre-Gunthas)	Treatment	PERCENTAGE ATTACK		REMARKS
		Partial	Complete	
0-30.	Treated . . .	19.6	5.2	All the figures show only the maximum attack noted in November.
0-30.	Check . . .	17.0	3.4	
1-5 . . .	Treated . . .	15.4	1.8	
1-5 . . .	Check . . .	13.3	2.1	

(4) *Application of sulphur in different forms and its toxic effect.*

The use of sulphur against mites is well known, and hence it was tried against woolly-mites on cotton in the forms of dust and spray with various diluents. But,

¹ Department of Agriculture, Bombay Presidency, Annual Reports 1919-20, 1920-21, 1921-22,

² Tropical Agriculturist, Vol. XXXIII, September 1909, page 209.

to the great surprise of the workers, the application of sulphur in any of the above forms led to the shedding of leaves, buds, flowers and small bolls of the cotton plants (Plate XVI, fig. 2). The tender vegetative shoots are the least affected. The shedding commences after about 72 hours from the time of dusting and the plants after a certain interval put up a fresh growth which gives the final yields of *kapas*. Naturally the time of picking is considerably delayed. The probable cause of shedding of leaves, etc., is attributed to the formation of penta-thionic acid which is an oxidation compound of sulphur and is formed at ordinary temperatures in the presence of water and oxygen.

The following statement presents the yield of *kapas* from treated and untreated plants. It will be seen that the yields are considerably reduced by the damage caused to the plant due to the injurious effect of sulphur :—

Serial number	Plants treated	Month and year	Nature of treatment	Yield per treated plant in tolas	Yield per untreated plant in tolas
1	50	Nov. 1924	Spray of sulphur 1 lb. : 2 galls. water	2.8	5.6
2	50	Do.	Spray of sulphur 1 lb. : 4 galls. water	2.8	5.6
3	100	Do.	Lime and sulphur dusting 4 : 1	3.1	5.8
4	100	Do.	Ditto 2 : 1	2.4	4.8
5	100	Do.	Lime sulphur wash	1.6	3.6
6	100	Do.	Flour paste with sulphur	0.56	0.64
7	10	Dec. 1927	Ditto	4.74	6.56
8	10	Do.	Potassium sulphide	6.92	7.81

One tola in the above statement = 11.3398 grammes.

With the object of determining the variation of the effect of sulphur dusting at different times of the season, the dusting was done on different sets of ten plants from September 1927 to February 1928 on affected as well as un-affected plants, and the results are tabulated below :—

Month of dusting	Unaffected treated plants		Unaffected controls		Affected treated		Affected controls		REMARKS
	B	Y	B	Y	B	Y	B	Y	
September	160	25	362	54	The attack had not begun sufficiently.				Dusting seems to have had a bad effect.
October	368	56	298	51	112	16	277	41	
November	316	41	507	80	202	24	285	48	
December	273	19	640	108	133	8	362	59	
January	138	14	640	108	142	19	362	59	
February	315	48	640	108	322	42	362	59	

B denotes number of successful bolls.
Y denotes yield of seed-cotton in tolas,

It was not known if the sulphur dusting was particularly injurious to the strain under observation (*viz.*, 1027 A. L. F.) or if the other strains were also equally susceptible. Sulphur dustings were therefore tried on the following strains of *herbaceum* cotton.

- (1) Surat Broach B¹, (2) I. A. C. B., (3) Selection I, (4) 1027 Cross 5¹, (5) I. A. Cross¹, (6) White-flowered Broach selection, (7) Goghari, (8) D₁ × Rosea Cross, (9) Wagad (Viramgam).

The first eight of these were dusted at Surat, while the last one was dusted at Viramgam during the same season. The observations showed that these strains were quite as badly affected by the dusting, (in the same way) as the strain of which we had written so far.

The suggestion of using polysulphides for controlling woolly-mites is due to Mr. Richards, Entomologist, U. P., and the following trials were made. Sodium polysulphide was prepared in the laboratory. The stock solution was diluted to 30 times and necessary precautions for removing alkaline material were taken. The spraying was done on 29th February, 1928, on two sets of 5 badly infested plants; one set of the above plants was sprayed with the above solution and in the case of the other set the solution No. 1 was further reduced in strength, having been diluted with an equal quantity of water (solution No. 2). A set of similar plants was kept as control. Infested leaves and buds of the sprayed and control plants were examined in the laboratory on 3rd March, and the mites were found present in all cases.

(5) *Flour-paste spraying.*

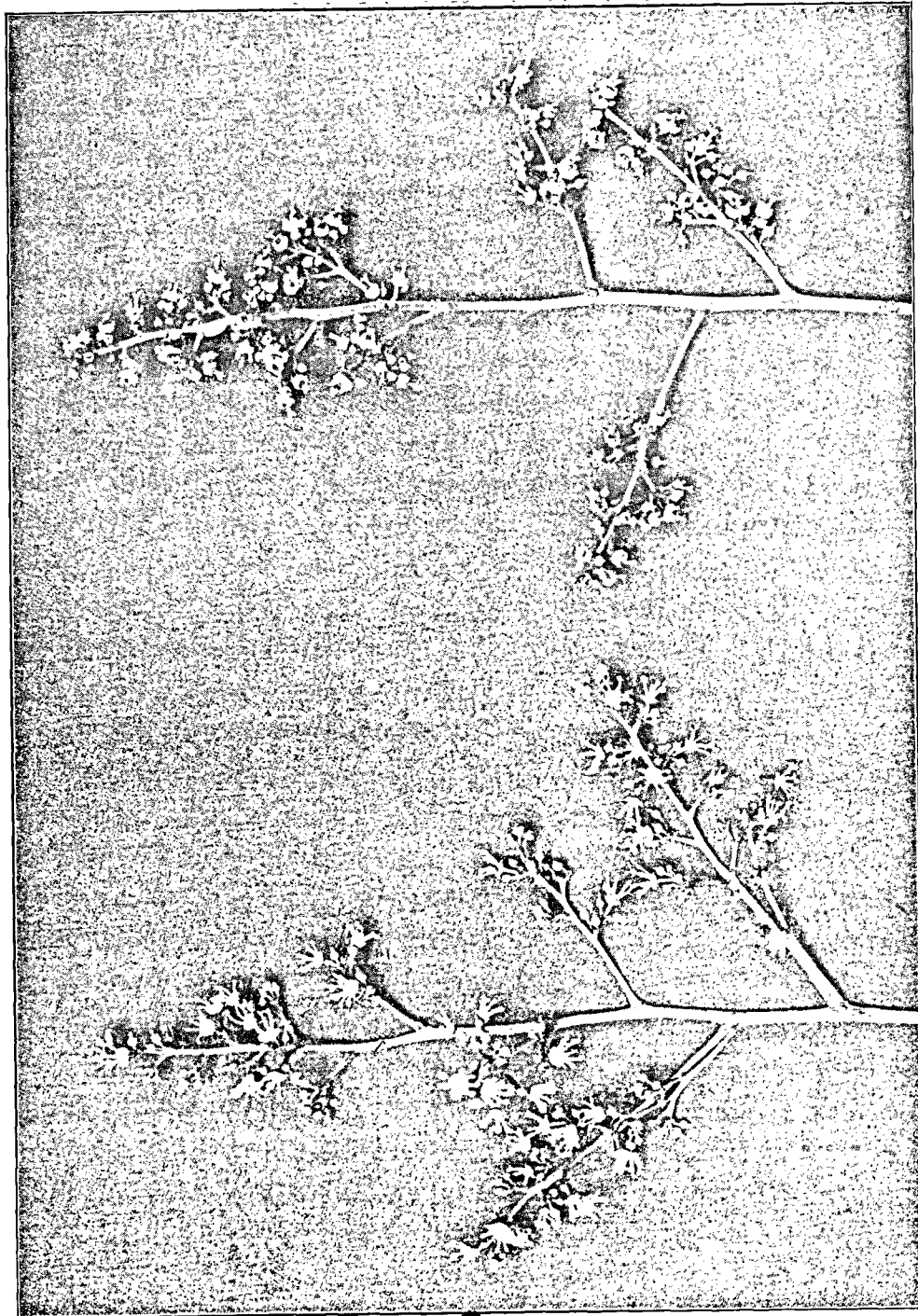
The trial of this spray was undertaken at the instance of Mr. T. Bainbrigge Fletcher, Imperial Entomologist, Pusa, during the season 1927-28. Gram flour was used for the preparation of paste as it is very sticky. Ten grammes of the flour was taken and it was turned into a paste with water. It was diluted to 500 c.c. of water. This dilution of paste was thoroughly sprayed on a set of 5 badly infested plants on 8th March, 1928. The plants were examined very minutely two days after spraying, but mites were found living on the affected parts. Another trial with flour-paste was made during the same season in the month of December 1927. Paste of wheat flour was prepared according to the standard method. Ten plants affected with woolly-mites were sprayed with the paste and another set of 10 plants was kept as control. The spraying was repeated after a week to kill any eggs that might have survived. The yield of these sets is noted below.

Treatment	YIELD OF SEED-COTTON IN TOLAS	
	Affected treated	Affected control
Flour-paste spraying	61.4	65.6

A similar trial of sodium polysulphide (no. 2) mixed with flour paste was taken which gave similar results. It may be pointed out here that no shedding of leaves was to be noticed as a result of the sprayings, viz., (1) polysulphide, (2) flour-paste, (3) polysulphide with flour-paste. These observations clearly indicate that even strong solutions of each of these sprays are not effective in killing the woolly-mites, and it is quite possible that these insecticides may not be effective in destroying the woolly-mites as their mode of living and feeding on cotton is quite different from other species of mites. Therefore the problem of finding out a suitable acaricide for the pest yet remains unsolved.

SUMMARY.

Woolly-mites are a serious and widespread pest of cotton. The pest is reported from Bombay and from various other provinces of India, and it is found to be very virulent in the Surat and Broach Districts of Gujarat. Plants completely affected by this pest give 30 per cent. below the normal yield of seed cotton. Various control measures that have been tried are discussed in detail and none is found to be effective. Application of sulphur, which is generally the best remedy against mites, causes specific damage by causing shedding of leaves, buds and young bolls. The susceptibility to sulphur dusting of various strains of *herbaceum* cotton in Gujarat has been established from the observations made. Sulphur in the form of polysulphide does not prove to be toxic to the cotton plant but has no effect in killing woolly-mites, which may be due to the peculiar habit of the pest.



Female branch of litchi.

Male branch of litchi.

POLLINATION AND FRUIT FORMATION IN LITCHI (*NEPHELIUM LITCHI*, CAMB.)

BY

KHAN SAHIB ABDUR RAHMAN KHAN,
First Assistant to the Imperial Economic Botanist, Pusa.

LITCHI is a small evergreen fruit tree commonly grown in Bihar and highly esteemed both by Indians and Europeans for its delicious fruit ; Muzaffarpur litchis are famous in Northern India for their excellent flavour. The observations which are recorded in this paper were made on litchi plants in the Botanical Area at Pusa in 1921, 1926, and 1928.

In most flowering plants the complete flower consists of a central axis in continuation of the flower stalk, on which a number of lateral appendages, which have four distinct forms, are arranged in four successive whorls. The outer or lower whorl is called the calyx and the whorl within or above the calyx is termed the corolla. These structures are not essential for seed production, they merely protect the other two inner whorls which are the essential organs of propagation. In the litchi flower the calyx is dentate and cup-shaped, the number of teeth being generally 4 or 5. The corolla is entirely absent. The whorl within or above the corolla is the andrœcium, the parts of which are called stamens. Each stamen has a bag called an anther which contains a powdery substance known as pollen. The anther when mature bursts and the pollen falling on the central organ of the flower stimulates the formation of seed. The anther is often carried on a stalk which is called the filament. The stamens are the male organs of the flower. In the litchi flower the stamens vary in number from 5 to 8 and are inserted within a fleshy disc which secretes nectar and forms 5 to 8 teeth according to the spaces left by the stamens. The whorl within or above the andrœcium is called the pistil. This is the last whorl of the flower and is composed of one or more parts termed carpels. The lower portion of a carpel is called an ovary and contains small bodies termed ovules. These ovules when fertilized by pollen grow into seeds. The prolongation of the ovary upwards into a longer or shorter neck is called the style. On the top of the style there is an organ of variable form, spongy and viscous, termed the stigma. The stigma receives the pollen which adheres to its surface. In the litchi flower there is only one carpel. The stigma is usually two-lobed (Pl. XX, fig. 14) or very rarely three-lobed (Pl. XX, fig. 15). The ovary has 2 or 3 compartments, called loculi, according to the number of the lobes in the stigma. There is one ovule in each loculus. The carpels are the female parts of the flower.

A flower which contains the female parts in perfect condition and in which the male parts are either absent or do not form proper pollen is said to be a female flower. A branch or a plant which bears only female flowers may be called a female branch or a female plant. Similarly if a flower has the male parts in perfect order but the female parts are absent or functionless it is called a male flower and the branch or plant which bears only male flowers may be called a male branch or a male plant. As a rule in flowering plants the flowers contain both male and female organs, and are hermaphrodite, but in the litchi the flowers are unisexual, either male (Pl. XIX, figs. 1 to 7) or female (Pl. XIX & XX, figs. 8 to 15). In the male flowers the stamens are perfect, i.e., the filaments grow to their full size and the anthers form good pollen, but the carpel either remains very small (Fig. 6), or, if it grows bigger, the stigma lobes never open (Fig. 7). The work of the male flower is over after the anthers burst and liberate their pollen. A day or two after the dehiscence of the anthers the male flower falls down, but in calm weather when the air is still it may persist for 4 or 5 days. In the female flower the carpel grows to its full size and the stigma opens into two or three lobes. The lobes remain receptive for a day or two after which they dry away and become functionless. The stamens of the female flower are functionless. Though they have large anthers, these never open and the filaments do not grow or at least do not grow to their full size. The flowers are borne on terminal panicles. Each panicle or flowering branch bears either male or female flowers at one time,* the same branch becoming male and female alternately. All the small branches of a main thick branch behave similarly, i.e., all of them at a time have flowers of the same sex for a brief period, except when it is in the transition stage.

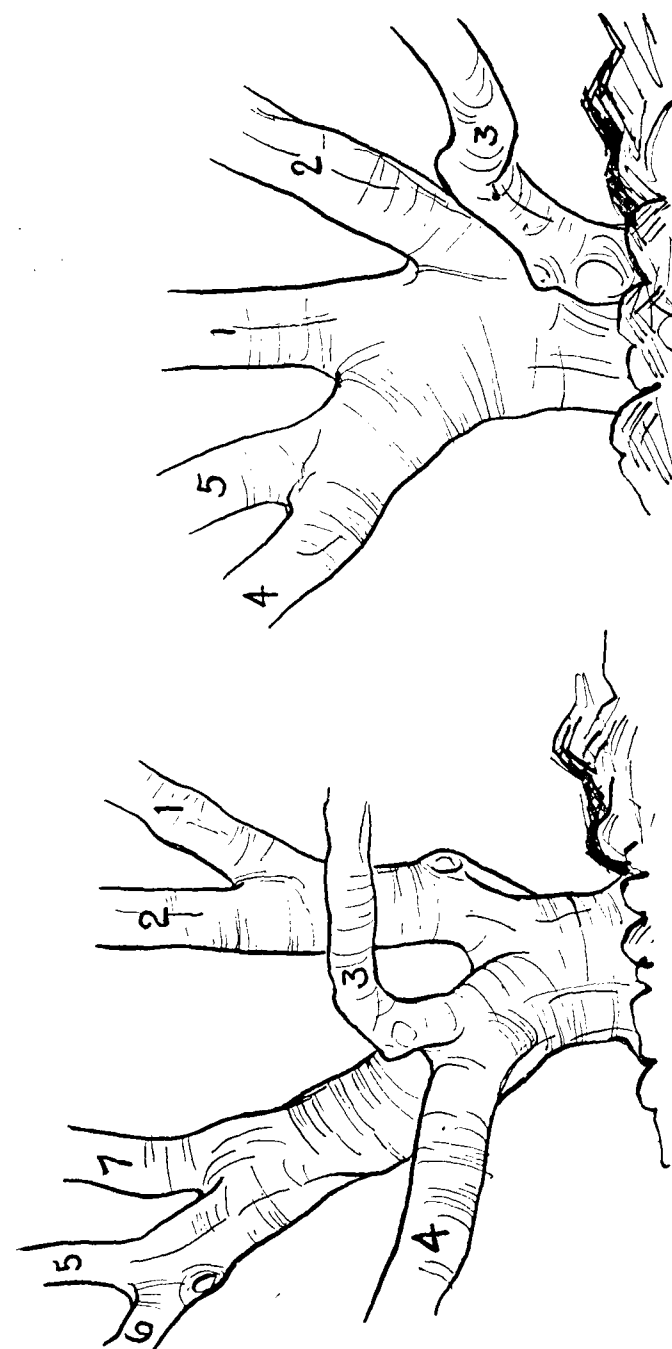
In 1928 two plants Nos. 5 and 6 were kept under observation (Pl. XVIII). Plant No. 5 had five main branches, while No. 6 had seven main branches. The flowering dates and sex of the flowers are shown in the following statement :—

Showing the dates of flowering and the sex of the flowers in two litchi plants

(F=female. M=male.)

Date	No. of branches	Plant No. 6							Plant No. 5				
		1	2	3	4	5	6	7	1	2	3	4	5
25th Feb. 1928						M							
26th "						M		M	M				
27th "			M			M		M	M				
28th "		M	M			M		M	M	M		M	M
29th "		M	M			M		M	M	M		M	M

* In the photo (Pl. XVII) the male branch is on the left and the female one on the right.

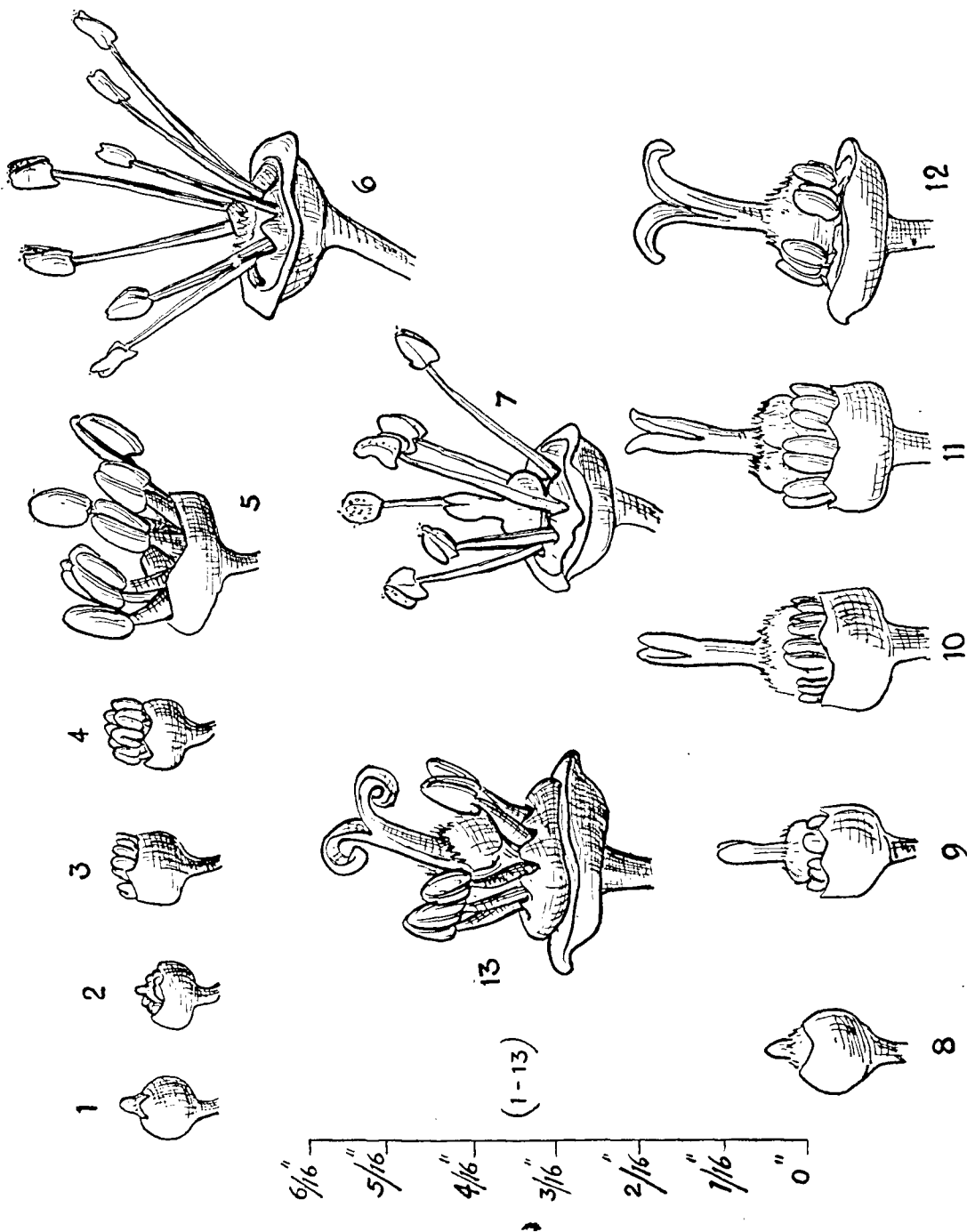


P.5.

P.6.

Two litchi plants showing their thick branches.

PLATE XIX.



Figs. 1-6, different stages of a male flower. 7, a male flower with fairly developed sterile pistil. 8-12, different stages of a female flower. 13, a female flower with fairly developed sterile stamens.

Showing the dates of flowering and the sex of the flowers in two litchi plants—contd.

(F=female. M=male.)

Date	No. of branches	Plant No. 6							Plant No. 5				
		1	2	3	4	5	6	7	1	2	3	4	5
1st March 1928	.	M	M		M	M	M	M	M	M		M	M
2nd "	.	M	M		M	M	M	M	M	M		M	M
3rd "	.	M	M		M	M	M	M	M	M		M	M
4th "	.	M	M		M	M	M	M	M	M		M	M
5th "	.	M	M	M	M	M	M	M	M	M	M	M	M
6th "	.	M	M	M	M	MF	MF	MF	M	M	M	M	M
7th "	.	M	MF	M	M	MF	MF	F	M	M	M	M	M
8th "	.	M	MF	M	M	F	F	F	M	M	M	M	M
9th "	.	M	MF	M	M	F	F	F	M	M	M	M	M
10th "	.	M	MF	MF	M	F	F	F	M	M	M	MF	MF
11th "	.	MF	MF	MF	F	FM	FM	FM	MF	MF	MF	MF	MF
12th "	.	F	F	F	F	FM	FM	FM	F	F	F	F	F
13th "	.	F	F	F	F	FM	FM	FM	F	F	F	F	F
14th "	.	F	F	F	F	M	M	M	F	FM	F	FM	FM
15th "	.	FM	M	FM	FM	M	M	M	FM	FM	FM	M	M
16th "	.	FM	M	M	FM	M	M	M	FM	FM	FM	M	M
17th "	.	M	M	M	M	M	M	M	M	M	M	M	M
18th "	.	M	M	M	M	M	M	M	M	M	M	M	M
19th "	.	M	M	M	M	M	M	M	M	M	M	M	M
20th "	.	M	M	M	M	M	M	M	M	M	M	M	M
21st "	.	M	M	M	M	M	M	M	M	M	M	M	M
22nd "	.	M	M	M	M	M	M	M	M	M	M	M	M
23rd "	.	M	M	M	M	M	M	M	M	M	M	M	M

From the above statement it is clear that, if we consider the plant as a whole, plant No. 6 began to flower on 25th February 1928, and produced only male flowers for 10 days and then female flowers began to appear and for 11 days it gave both kinds of flowers. The new female flowers ceased to appear on the 16th of March and the second cycle of entirely male flowers began from the 17th March and lasted till the 23rd of March when the flowering was practically over.

In plant No. 5 the first flower appeared on 26th February 1928. For 13 days all the flowers were male, and then for two days flowers of both sexes were present after which for two days the whole plant was female and then for three days again both male and female flowers were present, after that for seven days only male flowers opened and the flowering then ceased.

If we consider the main branches, including lateral daughter branches, separately we find that they all behave more or less in the same way. They have generally five stages :—

- (1) Male cycle when only male flowers are produced on all the daughter branches.
- (2) First transition stage, when some daughter branches change from male to female and some still continue to be male till at last all the daughter branches become female.
- (3) Female cycle when the flowers are female on all the daughter branches.
- (4) Second transition stage, when the daughter branches begin to turn from female to male. As all the daughter branches do not change into the opposite sex on the same day in the transition stage, some daughter branches are male and some are female. This stage remains till all the branches become male.
- (5) Second male cycle.

The two plants under observation in 1928 had 13 main branches and the number of days each branch remained in each stage is given below :—

Stages	Branches of plant No. 6							Branches of plant No. 5				
	1	2	3	4	5	6	7	1	2	3	4	5
	days	days	days	days	days	days	days	days	days	days	days	days
Male	12	9	5	10	10	5	9	14	12	6	11	11
1st transition	1	5	2	1	2	2	1	1	1	1	2	2
Female	3	3	3	3	3	3	4	3	2	3	2	2
2nd transition	2	0	1	2	3	3	3	2	3	2	1	1
Male	7	9	8	7	10	10	10	7	7	7	9	9
TOTAL	25	26	19	23	28	23	27	27	25	19	25	25

If we consider the daughter branches of a main branch, they generally behave alike, except that some branches start flowering earlier than others and at the time of the transition stages some may turn into the opposite sex a little earlier than others. It should be noted that a single lateral daughter branch having an inflorescence on its top has very seldom a transition stage having both kinds of flowers.

If we consider the ultimate branches of an inflorescence, they may be divided into five kinds according to their manner of flowering. The observations for these results were made in 1921 on 52 inflorescences on different plants. It was found that all the branches did not begin flowering at one time. Some were late or very late, but a branch whenever it began to flower always began from the stage which had been

PLATE XX.

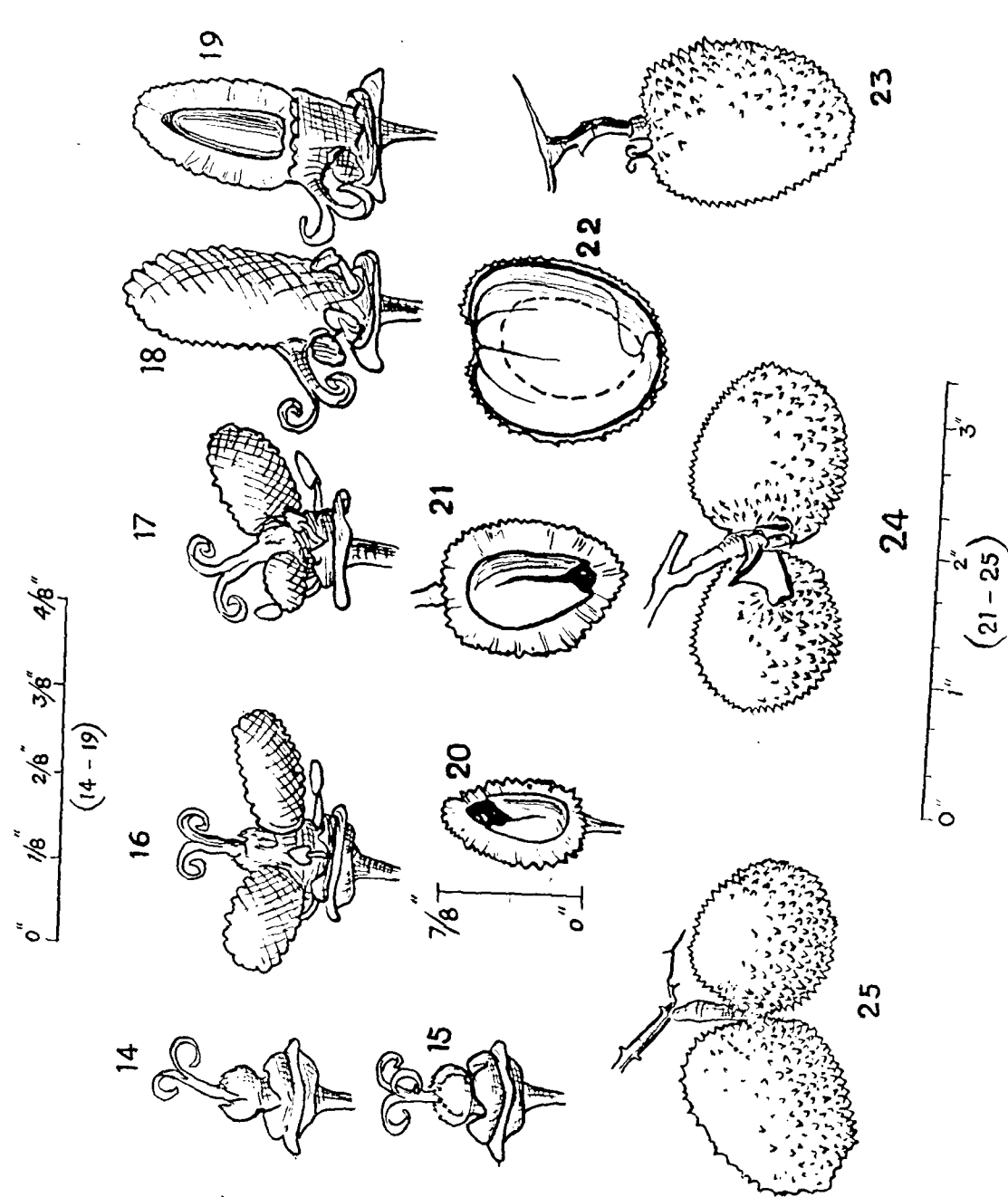


Fig. 14, a female flower with two lobed stigma. 15, a female flower with three lobed stigma. 16, 24 and 25, stages of double fruits. 17-19, stages of a fruit becoming erect. 19, a section of a young fruit. 20 and 21, fruits, skin removed; showing the growth of aril—not yet fully enclosing the seed. 22, aril covering the seed completely. 23, a normal fruit.

already reached by its sister branches in the same inflorescence. The five kinds are as follows:—

- (1) First male, then female, then male.
- (2) First male, then female.
- (3) Female only.
- (4) First female, then male.
- (5) Male only.

A branch begins flowering at the stage which has been already reached by the other branches of the same inflorescence and the differences are entirely due to late and early start in flowering.

From the above description it is clear that pollination from another flower, either of the same plant or of a different plant, is inevitable in the litchi plant. Although large numbers of many different insects have been observed in Pusa to visit litchi flowers, only a very small percentage of female flowers sets fruits. It is difficult to find out the exact percentage. According to observations made in 1928, out of 786 (466 males and 320 females) only 5 fruits were set, a proportion of 1 : 157; but in 1921 a similar observation showed that out of 549 male and female flowers only 7 fruits were set, a proportion of 1 : 78.

The setting in litchi is governed by many factors and the setting period is short, therefore it is not surprising that the setting varies in different years.

After fertilization a female flower begins to grow quickly. The ovary has generally two loculi but usually only one loculus grows to form a fruit. In the flower the style is in the same axis line as the flower stalk and the loculus is at right angles to this axis, but as growth proceeds the loculus gradually becomes straight in continuation of the stalk and consequently the style is bent sideways, and being persistent, can be seen at the bottom of the ripe fruit (Figs. 18 and 23). Very often the second loculus also grows to a certain extent but its growth is soon checked and it forms no seed or fruit. In such cases the loculus forming the fruit is much larger than the other (Fig. 17). In very rare cases both the loculi grow and form a double fruit (Figs. 24 and 25). In such cases both the loculi grow equally from the beginning (Fig. 16). In most cotyledonous seeds there are only two seed-coats, the second or outer seed-coat being called the testa. In the litchi seed the testa is hard and brown, but in addition a third seed-coat is also developed over it. This third seed-coat is called the aril or arrulus and is white and fleshy; this is the succulent flesh of the fruit which is eaten. In the early stage of growth the aril is not present. It begins to grow after fertilization from the base of the seed and gradually covers the whole seed. In Fig. 19 there is no aril, in Figs. 20 and 21 the aril is incomplete and an uncovered portion of the testa is still visible. In Fig. 22 it is fully developed and has surrounded the seed completely. In plant No. 6 the female flowers appeared from 6th to 16th March 1928 and the fruit picking continued from 18th. to 21st May 1928. This shows that after fertilization the fruit will take from 2 to 2½ months to mature.

SELECTED ARTICLES

APPLICATIONS OF SCIENCE IN AGRICULTURE*.

BY

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Director of Rothamsted Experimental Station.

It is widely recognized that science finds useful application in agriculture ; indeed, the degree of recognition is so great as to be sometimes almost embarrassing. At the present time there is a tendency to look to science as the best, if not the only, means to find a way out of the difficult situation in which agriculturists in all countries find themselves : not uncommonly the man of science is called in—late in the day, perhaps—to retrieve the errors and perchance to share the blame of mistakes by politicians, business men, and so-called practical experts, who have embarked on some enterprise and got themselves into a situation out of which extrication is difficult. All this is a new development : it is in striking contrast to the position of thirty years ago, when the scientific worker in agriculture was at best only tolerated and rarely taken seriously. The British Government would have nothing to do with him ; no grants were available—indeed, a distinguished Civil Servant, in response to a request for a research grant, declared that he could not conceive of circumstances in which any Government would be interested in scientific research for agriculture. It is a great change, and it has proceeded rapidly, mostly since the War, though it was not started by the War, but had, in fact, set in before that, and indeed was well on its way in 1914.

The actual progress of events, so far as Great Britain is concerned, is well known. In 1890 the Government of the day, having raised money by taxing whisky, spent it on Technical Education, including Agricultural Education : in consequence Agricultural Colleges and Departments of Universities were started and serious efforts made to educate young people for agricultural life : some bolder spirits even tried to educate farmers. The more progressive of the teachers soon discovered the need for learning something of the subject themselves, and they proceeded to make experiments with the purpose of gaining knowledge. These men prospered as they deserved. Farmers caught the spirit, and experimental farms and plots sprang up

all round the countryside. Much information of great value to the grower was obtained, and its value was widely recognized. The Government made a sharp distinction between education and research, however, and while they would make grants for educational purposes, they made none for research. The distinction always puzzled the laymen, and it was abolished in 1909-10, when Mr. Lloyd George secured the Act setting up the Development Fund, out of which increasing amounts have been voted for research each year. So profoundly has research impressed the farmers that when the £1,000,000 was allotted to agriculture in compensation for the repeal of the Corn Production Act, the farmers themselves asked that it should be used for "research and education," because, as the President of the National Farmers' Union truly said, "Without research there can be no agricultural education."

Now this position could not have been reached without very substantial reasons. English farmers are the last people to be dazzled by the glamour of pure scholarship or University prestige : they have no innate veneration for the professor as such. The fact that agricultural science has attained so high a position is substantial proof that it deserved success.

If one looks over the records of agricultural improvement for the past eighty years, it is easy to see why this position has been attained.

The first great triumph of science was in 1840, when fifty years of work by chemists and botanists had revealed the essential facts of plant nutrition, and Liebig, Lawes, and Gilbert put this discovery to practical use by the introduction of artificial fertilizers. The great improvement of crop yield, and, perhaps more important, the increased certainty of yield in bad seasons, dispelled the old fear of catastrophe and famine, and raised farm production to new levels. Some forty years later a new triumph was to come, for the terrible potato blight which had devastated Ireland and inflicted untold misery upon thousands of her peasants was finally brought under control, and has never since been a serious menace. This has been followed by the gradual control of many of the insect and fungus pests that had done so much damage on the farm.

Some twenty years later came the third triumph, when Bateson, studying the laws of heredity, rediscovered the work of Mendel, which had lain buried for over forty years, and attracted a group of enthusiastic workers to plant genetics, which has since greatly added to the resources of the farmer by providing him with new varieties of crops, but still more by providing the plant breeder with a set of principles that enable him within limits to build up new varieties almost to specification. Finally, there comes the latest achievement of fixing gaseous nitrogen from the air and converting it into fertilizers, thus securing indefinitely large amounts of those most important substances for the future.

Perhaps the simplest way of summing up the achievements of science in agriculture is to compare the prediction of Sir William Crookes in 1898 with the accomplishments of agriculture to-day. Speaking with a full knowledge of science as it was then, he predicted that the world in 1931 would require 90 million tons of wheat

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to feed its population, but that *unless science discovered new methods* this represented the utmost that the wheat growers of the world could do; afterwards the world would be faced with starvation. The accuracy of his forecast in regard to consumption shows how carefully he had made his calculation: the world does, as he predicted, require in 1928 about 90 to 100 million tons of wheat. But science has advanced so much as to upset altogether his calculations about the possible production. The 90 millions which he thought was the limit without new methods had been much exceeded even in 1911, and could be considerably exceeded to-day if it were needed. The fear of world starvation has gone, the achievements of science are only at their beginning, and there remains ample scope for patrons of science and for the patient efforts of the quiet scientific worker.

In spite of these brilliant successes, agriculture is not prosperous, and, as Mr. Hewison points out, it suffers even in those countries where science is most diligently applied to it. It would, however, be fallacious to attribute the suffering in agriculture directly to the progress of science. The application of science to agriculture is not an isolated phenomenon: science is being applied also to industry, and whenever this happens, production increases. Industries like the motor industry that have developed seductive selling agencies and played on the idea of "obsolescence" so successfully that the possessor of a perfectly good car feels bound to scrap it because a newer model has come out—these industries have remained prosperous. So also, but to a less extent, have those branches of agriculture that have followed the same methods: setting up good selling agencies and presenting goods in an attractive form to wheedle money out of a hesitating purchaser—such as some of the branches of market gardening, fruit and dairy production. But where salesmanship is less effective, the industry has languished: science has shown the way to greater production, but there has been no corresponding growth in demand; men have been thrown out of work and producers have been unable to sell their goods. It is difficult to see the remedy: there is always a tail-end in every body of men, whether workers or producers, and every advancement of science makes it less necessary to employ these people, so that they tend to be left unneeded. It is part of the cost of the inevitable forward march of science, and although some solution may some day be found, none is yet in sight.

Science, therefore, cannot cure all ills of agriculture or of modern civilization, particularly those arising out of its very success in increasing production per acre and per man, and in dispensing with the less efficient worker and producer: indeed, as science advances the efficiency line will be drawn higher and higher, and an increasing proportion of people will fall below it, unwanted and unemployable. What is to become of them is a social problem outside the scope of this paper.

So far as cotton is concerned, science can unquestionably increase the output per acre and per man, and also reduce the wastes and losses of the growing crop from diseases and pests: it can thus enable the crop to be sold more cheaply, or in the alternative it can give the grower a larger return. Within limits it can develop

new cottons, combining the desirable features of older sorts. These objects are still important, and so long as they remain so, there will be need for scientific work.

This work is of two kinds, roughly classified in simple language as gaining information, and using it: in official language as fundamental or pure science, and applied science, but the distinction is not sharp. The chemical and botanical work that revealed the food of plants was pure science—the gaining of information: the experiments made with the foods, which when manufactured were called artificial fertilizers, are applied science—the using of the information. Without the pure science there would be no applied science. Until the information is obtained, it cannot be used. If we are to make further advances corresponding with the great ones already described, it will only be after more advances in pure science.

Although the distinction between pure and applied science is not sharp so far as the subject-matter is concerned, there are clear-cut distinctions in practice. Pure science is concerned with general principles: applied science with solutions of particular problems. Pure science must be as exact as possible: applied science is satisfied if the figure is "near enough" or the method "generally works." From the practical point of view, the most important difference is that pure science can be studied anywhere, while the application must usually be made on the spot. This is important for two reasons: modern scientific work is very costly, requiring elaborate apparatus, a multiplicity of books and journals, and, most important of all, ready access to other scientific workers with whom the investigator may discuss his problems from day to day, and gain useful help and constructive criticism. An isolated research institute, however large and varied its staff, and however rich its library and equipments, is never large enough, and the workers always need access to larger libraries, meetings of scientific societies, demonstrations and exhibits of scientific apparatus or methods, and lectures by men of the highest rank in their respective subjects. These requirements make it easier to do fundamental work at home than in most parts of the Empire, for wherever in England the research worker happens to be, he usually has two or three Universities within 50 or 100 miles, and he can always attend lectures, meet fellow-workers, obtain books from libraries, or see and try new forms of apparatus at very little expenditure of time. This is not the only advantage of doing the fundamental work at home: Mr. Hewison has pointed out the great difference in length of working life of a man in the tropics and at home: indeed, he suggests—and in view of his experience no one will lightly quarrel with him—that the man at home should achieve at least four times as much as the man in the tropics.

In research work, however, the obviously advantageous course is not necessarily the best, for the research worker is apt to be an elusive person conforming to no rules whatsoever: and in point of fact, some very good fundamental work has been and no doubt will continue to be done in tropical conditions where everything seemed unfavourable. For purposes of organization, however, it remains generally

true that the home institution has the advantage when it comes to fundamental work.

In practice it is rarely possible to dissociate the pure from the applied science, there being, as already pointed out, no logical distinction between them. For many, if not most, of the problems by which the field expert is troubled, the underlying principles are not properly known, and until they are, the problem cannot be solved: a rough working solution may be found, but it will always be liable to break down. The logical course would be for the field expert himself to tackle the matter, fully, but as he has probably already got far more work than he can manage, he finds this impossible. It would be a great advantage if he could farm out the fundamental part of the investigation and himself do only what must be done on the spot, and yet remain in close touch with the fundamental investigator, so as to utilize fully all the information obtained.

The simplest way of discovering how far this kind of collaboration is possible is to try the experiment and see how it works. We are making the attempt at Rothamsted, but as we cannot afford wasted efforts, the work is being so arranged that it must still give valuable fundamental information, even if it does not link up as easily as we hope with the requirements of the man in the field.

Three attempts are being made. Agricultural investigators are well aware that field experiments, simple as they appear to non-experts, rarely give clear-cut results. So long as only single plots are used, a result may seem to emerge, but the figures are apt to be very confusing if the plots are duplicated or, better still, replicated several times. We periodically receive at Rothamsted a pile of data obtained in field experiments, obviously made with care, which seem to be wholly unintelligible. The trouble arises from several causes: from irregularities in the seed, the soil and watering, the cultivation, and the incidence of diseases and pests. Of these, irregularities in the seed can often be minimized by the use of a pure line; cultivation of experimental plots may be made more uniform than over whole fields, while the incidence of disease, if it cannot be regulated, can at least be recorded. There remain the irregularities of soil and water distribution, which may escape not only control but even recognition. These have recently been studied at Rothamsted by the Statistical Department, and methods have been devised for casting out their effects. The methods are not easily reduced to rule, and in the hands of inexperienced people may prove treacherous, but they can easily be applied by any mathematically trained person who knows something of statistical theory.

Fortunately this kind of work need not be done on the spot. If the worker can state in writing what field experiment he wishes to make, and can attach thereto some of the records of previous field experiments showing the kind of results usually obtained, the Rothamsted Statistical Department can draw up specimen plans of the field experiment from which the agriculturist can select the one best suited for field operations. Then when the results are to hand, the Rothamsted Department can inform the experimenter of their probable value and of the deductions that can

safely be drawn from them, as well as the indications or suggestions not fully significant but yet deserving of further examination.

This kind of service can already be rendered by the home institute to the tropical worker, and it has the advantage of securing the maximum value from the field experiments in the minimum of time without the necessity for setting up a costly statistical department on the spot, which would be justified only if there were sufficient work for a trained man, aided by skilled computers and efficient calculating machines.

A more difficult group of subjects is also being studied in the Physical and Chemical Departments at Rothamsted with considerable promise of a successful issue. It is well known that irrigation may cause considerable soil deterioration, and that schemes attractive from the political and engineering points of view may, after a time, break down in practice. The soil chemistry of the older textbooks had no explanation to offer; certain new conceptions of the nature of clay are, however, proving much more helpful. In a normal fertile soil the clay is a complex compound of which the basic part is mainly calcium, and the acid part is an aluminosilicic acid: clay can indeed be likened to a calcium salt. Under irrigation conditions the calcium may be displaced by sodium, giving a sodium clay altogether different from the calcium clay, not suited to the same crops nor amenable to the same or, indeed, any known treatment. The conditions determining the formation of the sodium clay, its properties, and its reaction to water and to salts, are being studied in the laboratory, in order to give full information to the man who is trying to solve the field problem. Further difficulties arise from the salts usually present in any dry area where irrigation is desirable: they act on the plant both directly and indirectly through their effects on the soil, influencing its growth, its reaction to parasitic organisms or diseases, and to seasonal factors. These problems can be disentangled from the local field problem and studied separately: the information when passed back to the field worker cannot fail to help him in finding some way round his difficulties.

The third direction in which attempts are being made to help the tropical worker is in the study of plant diseases. Of these there can be no end, because new crops and new conditions may change a hitherto blameless organism into a serious pest, and once a disease begins, it sooner or later spreads widely, thanks to our efficient modern transport. The Imperial Bureaux of Mycology and of Entomology have already rendered valuable service in the spreading of the news, telling the field experts what to look out for, locating the present situation of the disease, and reporting on control measures so far tried. They also examine and identify fungi and insects sent in to them. They do not, however, themselves conduct researches into the relationship of the parasite and the host plant, though the Bureau of Entomology has a laboratory for the breeding of parasites of insect pests.

Two attempts are now being made at Rothamsted to go further than this. Mr. R. H. Stoughton is working in conjunction with Major Archibald and Mr. R. E.

Massey in the Sudan on the angular leaf-spot type of the Black Arm Disease of cotton caused by *Bacterium malvacearum*. Mr. Stoughton has set up miniature glasshouses in which cotton is growing under any desired conditions of temperature, humidity and light. Everything is controlled electrically: a slight rise in temperature or humidity at once sets the correcting mechanism going to put things right once more: the electric sun is made to rise at six and to set at six automatically. Clean, strong cotton plants are grown right through to seed formation: indeed, seed free from any taint of disease has been raised here and sent out to the Sudan. Some of the plants are deliberately infected with the disease-producing organism, and its development in the tissues is studied, the relationships of soil and air temperature, water-supply in the soil, humidity of the atmosphere, and other factors to its progress are also fully investigated. The information thus obtained will, of course, be checked in the Sudan, but already it appears likely to save a lot of work there by discriminating between the paths which will probably lead somewhere, and those that will not. As all investigators know, much of the time spent in applied research is taken up in following the wrong track, and it is exceedingly helpful to be put on the probably right one straight away. Naturally the work has to be done cautiously, but Mr. Stoughton has had considerable tropical experience and is in frequent communication with the Sudan workers.

The other investigation to be made is into the nature of the virus diseases of plants: this is being done by Dr. J. Henderson Smith, who will be assisted by a cytologist, a plant physiologist, and an entomologist. These diseases are very serious already: they are spreading throughout the Empire, and the agent that causes them has not yet been discovered, so that they cannot be dealt with. If the agent is an organism it is so small that it passes through filters, and it cannot be grown on any medium yet tried. Two diseases can combine to produce a third different from either. Dr. Henderson Smith will first try to analyze the diseases and to obtain all information possible about the virus causing each. This work could hardly be done in the tropics: it will be costly and slow enough in England with men working all their time under favourable conditions, and with abundant equipment.

Up to the present our experience leads me to be hopeful about the future. With the speeding-up of communications between all parts of the Empire and England there is arising a spirit of co-operation between agricultural workers overseas and those at home: this has been fostered by the grants made by the Empire Cotton Growing Corporation to certain home institutions, Rothamsted among others, thereby securing centres where experts in cotton-growing can be sure of a welcome and a sympathetic discussion of their problems. Further, the development of scientific appliances enables the investigator to reproduce conditions for growth with an accuracy and certainty unattainable twenty years ago. The home institution can therefore go much further than has hitherto been possible towards lightening the task of the man in the field by providing him with precise information

obtained under temperature and moisture conditions identical with his own. It is impossible to say how far this co-operation may lead: for the present we cordially invite the field experts to visit Rothamsted whenever they are home, and to see how far any information obtained or obtainable here is likely to help them.

RECENT FERTILIZER EXPERIMENTS WITH COTTON.*

BY

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FERTILIZERS have long been recognized as an especially important factor in cotton production in the Southern States, and particularly since the Civil War (1861-1865). Before that period land and labour were both cheap and abundant, and cotton land was exploited and abandoned when no longer productive. The changed conditions following the war compelled the recultivation of lands once cast aside as unprofitable. In this postwar period, when chemical fertilizers were first assuming commercial importance, the real beginning of the use of fertilizers on cotton was taking place. After a time the cotton growers have begun to realize that for profitable returns fertilizers must be supplemented by crop rotations, improved cultural methods and better varieties, and other practices.

The present importance of fertilizers in the cotton industry may be measured by the quantities of fertilizer used on the crop in the cotton States. Of 48,890,000 acres reported in cotton in 1926, 18,256,000, or more than 37.3 per cent., received fertilizer. While fertilizers are used for cotton in all the cotton States, east of the Mississippi, the heaviest use is on the coastal plain in North Carolina, South Carolina, Georgia, and Alabama, and in the Piedmont regions of these States. In recent years the use of fertilizers has extended into the cotton States west of the Mississippi.

Investigations by the experiment stations in the Southern States have played a highly important part in furthering the use of fertilizers on the cotton crop. The earlier experiments were of necessity of such simple types as trials of sources of materials, comparisons of formulas, and tests of time, rates, and methods of application. In later years, however, a greater proportion of the experimental work has been directed toward the more fundamental aspects of the problem and has dealt with the chemical composition and nutrition of the cotton plant, its response to the different forms of the several nutrient elements, and the different plant-food requirements of the crop on the several soil types. Much of the earlier work on this problem has been reviewed in another publication of this office and in the recent books of Brown and of Collings.

The present paper aims to present a cross section of the investigations of the experiment stations with fertilizers for cotton reported during the years following

the end of the World War (1919-1927). Fertilizer mixtures, arranged from the results of experiments, are given, together with accounts of the relative merits of different sources of the nutrient elements, methods of application, and related practices. The paper has been necessarily limited to results and recommendations, although technique is discussed briefly in conclusion.

GENERAL FERTILIZER PRACTICE.

Fertilizer practices for cotton on the distinct soil divisions of Alabama have been recommended from the results obtained in 226 local cooperative fertilizer tests carried on by the Alabama station. The least returns from commercial fertilizers were obtained on the black-belt soils. Sodium nitrate was responsible for better profits than cottonseed meal in all sections of the State and is recommended in each of the formulas given. Early applications were found to pay better than late applications. The returns from all fertilizers, except sodium nitrate, were lower after the advent of the boll weevil.

The gray soils over yellow subsoils of southeastern Alabama were found to need considerable potassium and relatively little phosphorus. Somewhat less potassium seemed to be required by all red soils, the gray soils with red subsoils, and, in the southwest part of the lower coastal plain, by the gray soils with yellow subsoils, and the response to phosphorus on these soils was relatively low. The fertilizer needs of the upper coastal plain resembled those of the soils of southwestern Alabama, on which sodium nitrate produced especially good results.

Soils of the Piedmont and Appalachian Plateaus responded well to sodium nitrate and superphosphate (acid phosphate), although their needs for potassium were comparatively low. The gray or yellow chert-free soils with heavy yellow subsoils of the limestone-valley regions appeared to need much potassium and to give a good response to superphosphate and sodium nitrate. Sodium nitrate produced greater returns on the red lands of the limestone valleys than on any other soils of Alabama and a strong need for phosphorus and a low potassium requirement were indicated. Superphosphate was used to its best advantage on the high-land rim, and a moderate amount of potassium returned good profits in this area.

The average results of numerous experiments by the Alabama station demonstrated that a complete fertilizer gives best results on cotton on nearly all Alabama soils. Its recent tests on the rate and ratio of applying fertilizer to cotton conducted on Norfolk, Orangeburg, Dekalb, and Decatur soils indicated that the proper rates for combining materials for cotton is sodium nitrate 100 pounds, superphosphate (acid phosphate) 200 pounds, and potassium chloride 25 pounds.

Cooperative fertilizer experiments with cotton by the Arkansas station showed that, while nitrogen is the limiting element with the crop in the State as a whole, the best returns are rarely to be had from nitrogen unless it be used with phosphorus and potassium. Basic fertilizer recommendations have been made for cotton on the interior coastal plain soils, on the hill soils, and on the lowland soils of

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medium to low fertility. The station indicated that on the heavy soils of the lowland section from 100 to 150 pounds of sodium nitrate alone could be used. The favourable results which followed the use of manure called for its better preservation.

Fertilizer tests by the Georgia station, cooperating with the United States Department of Agriculture, showed that nitrogen and phosphorus were of importance in growing cotton on Piedmont soils and that the need for potassium was secondary. The Georgia Coastal Plain station has indicated a 9-3-5 (P-N-K) fertilizer formula for cotton on typical Tifton sandy loam, recommending a slight increase in the nitrogen and potassium on lighter soils. On good soils from 800 to 1,000 pounds per acre seemed desirable, and quickly available nitrogen sources were preferred. Liming was not economical, whereas green manure in combination with complete fertilizer gave good results with cotton.

The Holly Springs, Miss., substation advised for cotton from 400 to 600 pounds per acre of a complete fertilizer or of a mixture of superphosphate 200 pounds, sodium nitrate 100 pounds, and potassium sulphate or potassium chloride 25 pounds, or kainit 100 pounds. Experiments at the Raymond, Miss., substation indicated from 500 to 600 pounds per acre of a complete fertilizer, with modifications for certain conditions. Experiments at the South Mississippi substation demonstrated the importance of nitrogen and phosphorus for cotton, whereas marked reduction did not follow the omission of potassium. Potassium in the form of kainit appeared to have enabled the plants to retain their foliage throughout the season. Enhanced yields of seed cotton accrued from the use of lime. Considering experimental results and experience, the Mississippi Delta substation concluded that nitrogenous fertilizers used alone seemed most economical for the Delta, except along the foothills and on soil on which cotton either wilts or rusts badly. On such soils potassium usually pays, and both potassium and phosphorus are needed on some of the eastern border of the Delta. This substation also advised that superphosphate should be used on Delta soils derived from the hills.

Experiments in southeastern Missouri indicated that in general sodium nitrate should not be used alone, whereas superphosphate alone may be profitable with cotton on most soils in the region. A high-grade complete fertilizer or a combination of superphosphate and potassium chloride is indicated as generally giving good returns over a wide range of soil types and conditions.

Fertilizer tests by the New Mexico station indicated that on the heavier types of soil not too heavily cropped to cotton commercial fertilizer was unprofitable, especially when barnyard manure had been applied or the cotton followed alfalfa. On lighter soils 300 pounds of superphosphate per acre was more profitable than a complete fertilizer.

In fertilizer experiments made by the North Carolina station on Cecil sandy loam soil in the Piedmont and on Norfolk fine sandy loam in the coastal plain, as measured by the average percentage of cotton open at first picking, increases in the

phosphorus in the formula made for earliness, in the nitrogen caused little or no change, and in the potassium made the cotton later on both soils. Application of commercial fertilizer usually increased the percentage of cotton open at the first picking as compared with unfertilized cotton. Increasing the quantity of fertilizer per acre had a rather marked effect on maturity. From 600 to 800 pounds of complete fertilizer per acre was recommended for the more important soils of the Piedmont and of the coastal plain. The percentage of nitrogen at planting should be reduced to about half, if as much as 100 to 150 pounds of sodium nitrate or ammonium sulphate is used as a side dressing after chopping.

Applications of fertilizer carrying large quantities of nitrogen or phosphoric acid seemed to have a residual effect lasting for several years in tests on Cecil sandy loam by the South Carolina station. Phosphorus, closely followed by nitrogen, appeared to be the prime limiting factor on the soil, whereas potassium was considered of doubtful value. Lime reduced yields slightly when used with superphosphate alone and caused a slight increase when used with a complete fertilizer, but its application on this soil solely for cotton production did not seem profitable. Superphosphate with blood gave better results than any other combination of two elements. Manure (8 tons) with superphosphate (300 pounds) produced the highest yields of the several treatments used. It was found very difficult to maintain cotton yields on this soil by the use of commercial fertilizer alone.

Fertilizer tests on seven of the leading soil types in South Carolina showed that a properly balanced fertilizer produced the earliest crop and the highest yield, with applications of from 600 to 800 pounds per acre giving the most profitable returns. Nitrogen was the prime limiting factor in cotton production and phosphorus the next, both of which seemed to influence the earliness of the crop. Small amounts of potassium increased yield, while heavy applications tended to delay maturity and reduce the yield. From the results of all of its fertilizer experiments with cotton, the South Carolina station recommended for the coastal plain 600 to 800 pounds per acre of fertilizer containing 9 to 12 per cent. of phosphoric acid, 3 to 5 per cent. of ammonia, and 3 to 4 per cent. of potash, with 150 pounds of sodium nitrate or 110 pounds of ammonium sulphate as a side application, and for the Piedmont from 600 to 800 pounds containing from 10 to 12 per cent. of phosphoric acid, 3 to 5 per cent. of ammonia, and 2 to 3 per cent. of potash, with the same top-dressing as for the coastal-plain soils.

Fruiting studies made at the South Carolina Pee Dee substation showed that cotton on plats receiving nitrogen and potassium without phosphorus fruited slowly during the first part of the season and reached the peak late. Phosphorus and potassium without nitrogen resulted in early season fruiting. While the fourth week was the most productive, there were only two weeks of rapid fruiting. Although phosphorus and nitrogen used alone stimulated early season fruiting, the period of rapid fruiting appeared to be comparatively restricted through the omission of potassium.

Results of fertilizer experiments by the Tennessee station suggested the use of 200 pounds of superphosphate per acre for cotton, even on soils that were fairly well supplied with phosphorus, with a heavier application for the highland rim and eastern Tennessee soils. From 100 to 150 pounds of sodium nitrate or its equivalent in cottonseed meal should be applied where needed. A high-grade fertilizer mixture seemed excellent for cotton and preferable to low-grade mixtures. Although the differences were not large, liming was apparently profitable for cotton and for other crops grown in rotation with cotton.

Superphosphate produced a gain in 75 per cent. of the cotton tests, cottonseed meal in 68 per cent. and potassium in 53 per cent. in extensive fertilizer experiments by the Texas station. Superphosphate appeared to be the most certain and most profitable fertilizer for cotton, while a mixture of equal parts superphosphate and cottonseed meal at the rate of from 150 to 200 pounds per acre appeared to be the best mixed fertilizer for general use. The inclusion of potassium in mixed fertilizers appeared inadvisable, except where the soil is known to be deficient in potassium, in which case from 150 to 200 pounds of complete fertilizer is advised. Good immediate and residual effects were also obtained from barnyard manure. From a study of the chemical composition of the cotton plant this station estimated that the probable needs of cotton per 300 pounds of seed cotton or 100 pounds of lint are 7 pounds of phosphoric acid, 25 pounds of nitrogen and 15 pounds of potash. The draft on the soil was not in direct proportion to the size of the crop, being somewhat larger for small crops and somewhat less for large crops.

Fertilizer tests with cotton in Nansemond County by the Virginia station indicated for general use from 300 to 600 pounds per acre of a complete fertilizer, with the nitrogen reduced on soils adequately supplied with this element. Lime was not beneficial except when used with nitrogen and potassium, and even then the increase was hardly profitable.

NITROGEN SOURCES.

Considering the effect on cotton production by nitrogen in the form of sodium nitrate as 100, the Georgia station found that nitrogen in a mixture of sodium nitrate and cottonseed meal produced 114.7, ammonium sulphate 101, velvet-bean meal 100, cottonseed meal 100, sodium nitrate and ammonium sulphate 93.7, dried blood 86.8, and peanut meal 75.9. In later trials at this station sodium nitrate and ammonium sulphate produced about as much cotton as organic forms of nitrogen, and the differences in costs made the salts preferable. A combination of nitrogen from organic and inorganic sources appeared to give better cotton yields at the Georgia Coastal Plain station than nitrogen derived from a single source.

The average results during four years at the Mississippi station showed sodium nitrate and ammonium sulphate to be about equal as nitrogen sources for cotton, calcium cyanamide somewhat inferior, and cottonseed meal even less valuable.

The Mississippi Delta substation has found ammonium sulphate, and also sodium nitrate and cottonseed meal, alone or in combination, to surpass other commonly used nitrogen sources for cotton. Ammonium sulphate and sodium nitrate were similar in effectiveness per pound of nitrogen. Cottonseed meal, if as cheap per pound of nitrogen, seemed as economical as other nitrogen sources.

Sodium nitrate was found by the North Carolina station to be the most efficient nitrogen carrier for cotton, surpassing ammonium sulphate, dried blood, calcium cyanamide, and tankage in the order named. In comparison with sodium nitrate, dried blood and cottonseed meal were each relatively less effective on Norfolk sandy loam in the coastal plain than on Cecil sandy and clay loam in the Piedmont, and they averaged only about four-fifths as effective as sodium nitrate or ammonium sulphate. Sodium nitrate in two equal applications gave better yield increases with cotton on Piedmont soils than dried blood applied all at planting or half at planting and half after chopping. On the coastal plain soil the best results were had with half the nitrogen as dried blood with the phosphorus and potassium at the time of planting and the other half as sodium nitrate.

The South Carolina station, cooperating with the United States Department of Agriculture, found air-derived nitrogen salts to compare favourably with sodium nitrate and ammonium sulphate for cotton. Cyanamide in mixture with superphosphate and potassium reduced the yields when enough was applied to serve as the sole nitrogen source, whereas good results were had when it supplied only part of the nitrogen. Combinations with the nitrogen derived from more than one source generally gave better results than when the nitrogen came from either sodium nitrate or ammonium sulphate alone. Sodium nitrate produced slightly more cotton than ammonium sulphate in mixed fertilizers.

RATES AND TIME OF APPLYING SODIUM NITRATE.

Sodium nitrate made its best returns at the Georgia station when it was applied at the rate of 166 pounds per acre. Seed cotton yields rose at this station with the increase in the quantity of sodium nitrate applied. Tests at the Tennessee station suggested from 100 to 150 pounds of sodium nitrate, while the Georgia Coastal Plain station recommended from 100 to 125 pounds of sodium nitrate or its equivalent in ammonium sulphate applied at chopping.

Cotton receiving a complete fertilizer before planting at the Alabama station made its best average yield increases when the sodium nitrate (140 pounds) was applied at the first cultivation after chopping, i.e., 40 days after planting. In local experiments sodium nitrate (100 pounds) gave its best returns when it was applied at or before the formation of the first squares. The use of an additional 100 pounds about three weeks after the beginning of blooming was more effective and slightly more profitable than the single 100 pounds at about the time of the appearance of the first squares. The nitrate of sodium nitrate applied at the rate of 600

pounds per acre for cotton 14, 40 and 61 days after planting was absorbed in 36, 14, and 11 days, respectively, at the Alabama station, there being a close correlation between the rates of growth and of nitrate absorption. The results suggested that the loss of soluble nitrogenous fertilizer might be reduced by delaying the application until the crop is able to absorb it rapidly.

The Georgia station observed that nitrogen applied at the time of planting appeared to give the best results, and it found that top-dressings of sodium nitrate at planting or chopping were about equally effective, while application at squaring was followed by an acre loss of 150 pounds of seed cotton. Fifty pounds of sodium nitrate applied at planting and 50 pounds at the first squares showed greater profits than any other time of applications at the Mississippi Delta substation. The results indicated that application of sodium nitrate should start soon after chopping and be completed by the beginning of square formation. On deep sandy soil at the South Carolina Pee Dee substation sodium nitrate gave best results when applied as a side application soon after chopping, whereas yields did not vary much with different times of application on soil with clay subsoil. The greatest yield increase occurred in certain South Carolina tests, where 50 pounds of sodium nitrate was applied at chopping and 50 pounds at first squares, while 100 pounds at the first squares was also effective. In other trials yield increases were obtained with each addition to the sodium nitrate application up to the maximum 300 pounds.

PHOSPHORUS.

Different forms of phosphorus carriers were not found profitable on cotton on valley land at the Mississippi station. Raw rock phosphate and flowers of sulphur gave a considerable gain when used in combination, in spite of the fact that they seemed to have a depressing effect when used separately. The South Mississippi substation found superphosphate to be better than basic slag, raw phosphate, and soft phosphate rock as phosphorus sources for cotton. In the absence of the boll weevil, superphosphate gave earlier cotton than ground rock phosphate or Thomas phosphate at the South Carolina Pee Dee substation, although total yields were similar. Tests in Texas with cotton showed the phosphoric acid of rock phosphate to be about 22 per cent. as effective as that in superphosphate. The Georgia station has also conducted extensive tests with different sources of phosphorus for cotton.

POTASSIUM.

The Mississippi station observed that potassium in the form of sulphate or chloride seemed as efficient for cotton as the potassium in kainit. Experiments by the South Carolina Pee Dee substation showed that 2 per cent. of potash was enough for maximum cotton yields in a rotation and 4 per cent. for continuous cotton. Potassium chloride and kainit were equally valuable as sources of potassium. Heavy applications of potassium appeared to delay maturity.

MANURE.

Manure gave profitable gains with or without raw rock phosphate at the Mississippi station. Manure supplemented with commercial fertilizers gave 15 per cent. more cotton yields at the Louisiana station than manure used alone.

LIME.

Beneficial effects from the addition of limestone to cotton land were observed at the Georgia station. On the other hand, the use of hydrated lime resulted in an average decrease of about 6 per cent in the yield of cotton in 20 tests reported by the Texas station. At the South Carolina Pee Dee substation caustic lime and ground limestone were found of equal value as lime sources when used at rates of 1,000 and 2,000 pounds per acre, respectively, although lime was not profitable on the soil. Lime in a rotation of cotton, corn, oats, and a legume did not show a consistent gain at the Mississippi station for any form or quantity of lime used.

CROP ROTATIONS.

Crop rotations have an important bearing on the economical use of fertilizers. Decided increases were made by cotton following soy beans in tests by the Mississippi Delta substation. Seed cotton yields at the South Mississippi substation after legumes or corn with legumes were in excess of those after corn alone. For cotton production a rotation of cotton, corn, oats, and peas at the South Carolina Pee Dee substation, seemed to maintain the fertility as well as 1,000 pounds of a complete fertilizer applied to land continuously in cotton. However, a combination of systematic rotation and adequate fertilization appeared to be needed to produce cotton economically. Cooperative fertilizer tests on representative soil types in South Carolina indicated that applications of phosphorus and potash to corn and oats may be considerably reduced, if not entirely eliminated, when the crops are planted in a regular rotation after cotton liberally fertilized with complete fertilizer. Rotations have been responsible for enhanced cotton yields in northwestern Texas, and in the black-land region of Texas cotton yields in rotations were practically double those from continuous cotton.

SUMMARY OF RECENT EXPERIMENTS.

Appropriate applications of fertilizers for cotton are required in order to provide economically for the current needs of the crop and to compensate for the nutrients removed from the land in the seed and lint and lost through leaching, reversion, and denitrification. From the experiments and recommendations cited above, it appears that nitrogen and phosphorus are in greatest demand in cotton production. Potassium appears to be decidedly secondary in importance, except under certain conditions, although its functions are recognized and its omission from the formulas is not generally advised.

Nitrogen in such readily available forms as sodium nitrate seems to be most desirable, although organic sources, including cottonseed meal and other vegetable meals, dried blood, and tankage, have the longer residual effect. Most of the recommendations have been based on sodium nitrate, yet ammonium sulphate and combinations with the nitrogen from two or more sources have also given good results. Some of the newer sources of nitrogen, *e.g.*, ammonium nitrate, ammonium phosphate, and ammonium chloride, have compared favourably with sodium nitrate and ammonium sulphate for cotton. From 100 to 300 pounds of sodium nitrate per acre has been recommended but the greater margins of profits seemed to be had with the lower rates. Experimental results in general suggest applying half of the sodium nitrate at planting and half at the first squares or else making the whole application at some time between chopping and the appearance of the first squares.

Superphosphate has been preferred to other phosphorus carriers, and while the optimum application rates have varied with conditions, about 200 to 300 pounds per acre seems to be a practical quantity. Potassium chloride, potassium sulphate, and kainit were found similar as sources of potassium for cotton. The need for potassium also varies with local conditions. Manure has given good results, although the supply is quite limited and the nutrients contained in the manure alone may not be in proportions desirable for cotton on the particular soil. Lime in general has seemed of slight value for cotton. The crop rotation has proved to be an important factor in the economical use of fertilizers for cotton.

CONCLUSION.

Examples cited in this review show that the experiment stations have made progress in determining the proper use of fertilizers on cotton. However, much must still be done to obtain uniformity of methods and to correctly interpret the data obtained. The correct interpretation of the results of field trials with fertilizers is a difficult task, because of the many variables involved, besides the differences in crop response to the several fertilizer treatments, such as differences in soil type, soil heterogeneity (in depth, physical structure, and fertility), topography, season, the variety used, the availability of the fertilizer materials, methods of application, care in cultivation, and the methods of recording data. Experiments are frequently rendered valueless by excessive rainfall or drought, poor stands, or damage from insects or diseases. Some of the adverse factors may be minimized by judicious selection of the plat, with knowledge of its cropping history and requirements of the soil type, choice of a representative variety which is stable and uniform, rigid control of cultural operations, adequate replication permitting statistical treatment of the yield data, and repetition of the experiment during a period of average years.

The general type of the plat test may affect the reliability of the data. Permanent plats at an experiment station permit rigid control of treatment, cultural operation, and in recording data. They are useful in testing the interrelations of

the fertilizers and the particular soil and in comparing fertilizer sources, although the cumulative effect of continuous treatment of a plat may lead to erroneous conclusions, and prolonged fertilizer tests may render the soil unreliable for many subsequent comparative tests. This effect can be avoided by placing the series on different blocks in different years. Cooperative tests give information on the fertilizer needs on different soil types, residual effects are minimized, replication is easy, and the results, if not representative, can be discarded without great loss. On the other hand, control over cultural operations and accuracy in securing data are difficult. The experimenter can know little of the nature of the soil and variation within the plat. The separate tests are local in application, although the consolidated results may be indicative for a region. Cooperative fertilizer trials appear to be of particular value in testing under practical conditions the results obtained in pots or soil bins at the central station.

Concurrent with the general trend toward the more fundamental phases of research in fertilizer studies with cotton may be observed a refinement of experimental technic, endeavours to use a standard or uniform terminology, greater care in interpreting results, and more caution in making recommendations.

NOTES

SEEDLESSNESS IN PAPAYAS.

OBSERVATIONS made by the writers and by Mr. P. G. Joshi, Superintendent of the Ganeshkhind Botanical Gardens, Kirkee, show that perfectly formed papaya fruits containing no seeds are of not uncommon occurrence. During the months August 1923 to February 1924, these appeared in the Ganeshkhind Botanic Garden orchard on eleven female trees in the following numbers :—

Month	Number of fruits harvested	Number seedless
1923—		
August	14	0
September	40	0
October	26	4
November	21	8
December	9	7
1924—		
January	18	9
February	14	11

The question arose : “ Is this lack of seeds due to lack of pollination, or has there been pollination but no fertilization ? ” To settle this point, flowers on pure female trees were bagged with paper envelopes or cloth bags (Plate XXI, fig. 1). In every case of a bagged flower, a fruit was formed, containing no seeds and smaller in size than a fruit developing seeds in the usual way.

In the Montgomery District in the Punjab, there are no plants of papaya for a radius of 200 miles from the Government farm, and on this farm female papayas (there were no male ones retained) all developed fruits, and these were seedless.

It appears then that the fruit as apart from the seed of the papaya tree can develop without pollination. Daveis¹ confirms this, but Popenoe² and Higgins³

¹ Davies. *Bulletin No. 37 of the Department of Land Records and Agriculture, U. P.* Notes on the History uses and Cultivation of the Papaya, p. 3.
² Popenoe. *Manual of Tropical and Sub-tropical Fruits*, p. 235.
³ Higgins. *Annual Report of the Hawaii Agricultural Experimental Station for 1911*, p. 30.

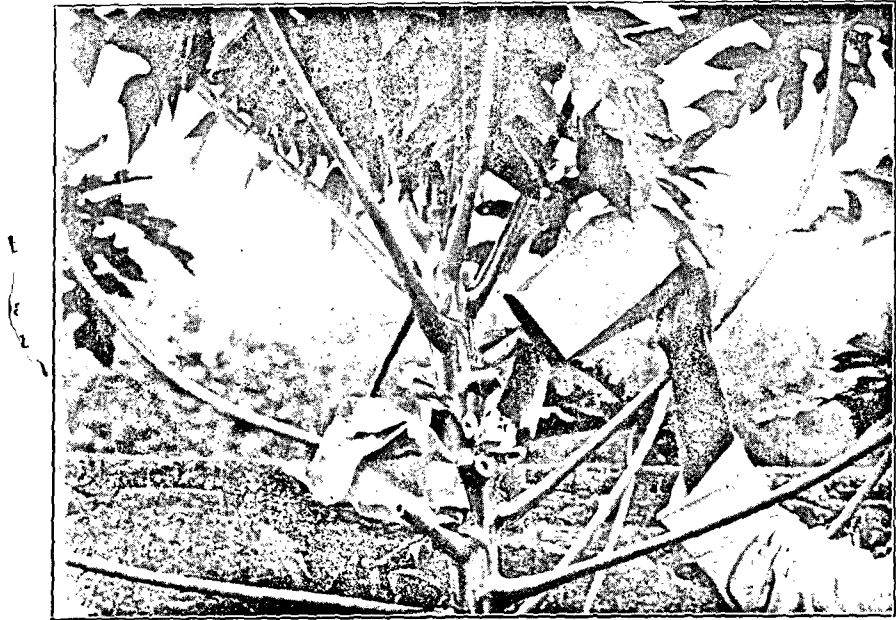


Fig. 1. Showing how unopened flowers are bagged.

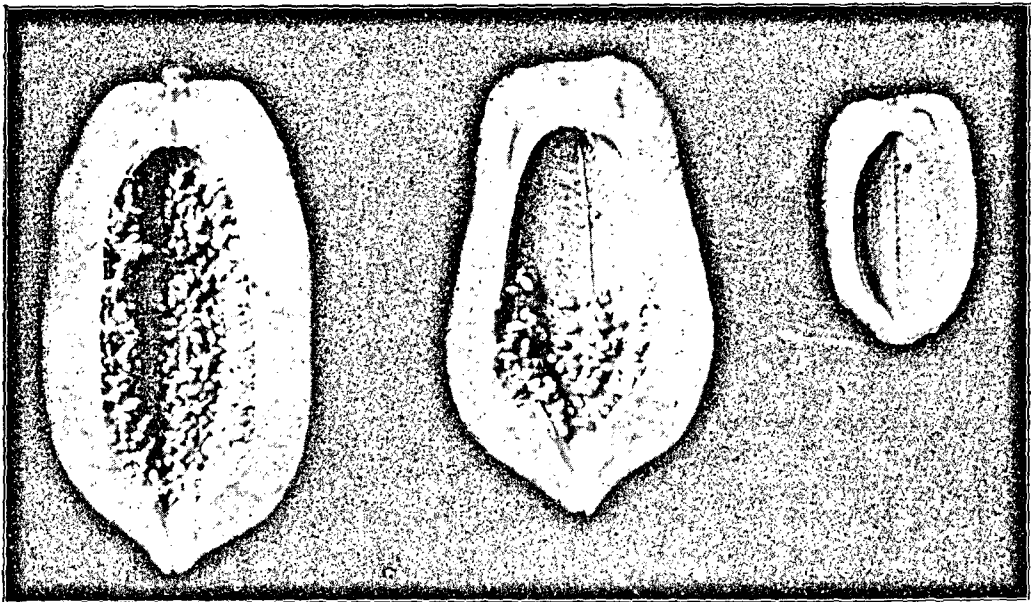


Fig. 2. Showing variation in seed contents of fruits on one and the same tree.
1, Fully seeded fruit ; 2, Intermediate type having fewer seeds (Note the bulging out of seeded portion) ; 3, Seedless fruit found without bagging.

state the contrary. It is just possible that as both these observers refer to conditions outside India, while Davies and ourselves refer to Indian conditions, that this may be the explanation of the disagreement.

We have also proved that partial pollination (*i.e.*, pollinating only certain branches of the stigma) results in partial fruit setting, the carpels corresponding to the pollinated stigma branches alone setting seeds. The weight of fruit is, as one would expect, more or less proportionate to the number of seeds developed (Plate XXI, fig. 2).

None of our observations bear out the contention of Higgins and Holt¹ that a parthenocarpic tendency is inherited. Moreover, on one and the same tree are found fruits (a) fully seeded, (b) with seeds at the stigmatic end, (c) without seeds.

We conclude therefore that for the trees which we have observed in India seedlessness is due to lack of pollination and to nothing else, and that the weight and size of the fruits is proportional to the number of seeds set. If it is desired to produce seedless papayas, all that it is necessary is to exclude pollen. [G. S. CHEEMA and P. G. DANI.]



POSSIBLE VALUE OF COIMBATORE SEEDLING CANES TO CUBAN CONDITIONS.

In the course of an article on "Sugarcane varieties in Cuba" in *The Planter and Sugar Manufacturer* (LXXXI, No. 19), Dr. F. S. Earle refers to the Coimbatore bred canes in the following terms:—

"Their principal characteristics are hardiness to cold, ability to grow on poor, exhausted soils, long ratooning, tolerance to mosaic and high sucrose and early maturity. When first introduced in Cuba, it was not supposed that they would ever be widely planted here. We are not interested in their ability to withstand cold, and their tolerance of mosaic was looked upon as a liability rather than an asset, since fields of these canes, even though scarcely injured by the disease themselves, serve as nurseries for the propagation of mosaic in adjoining fields. Quite apart from these considerations, however, their high tonnage on poor dry lands, and their high sucrose content and early maturity are bringing them more and more to the front as the best canes with which to replace Crystalina on lands where that is failing from soil exhaustion and lack of fertility. In diameter most of the kinds are fully as slender as Uba, but the trash falls from them so easily, and they clean themselves so completely, that their harvesting is not likely to prove a serious problem. In milling quality they are presumably midway between Uba and Crystalina although real comparative tests are lacking. The outstanding feature of the year's work with varieties seems to be the emphasis it places on some of these kinds for planting in the lower, dryer, more difficult soil situations."

¹Higgins and Holt. The papaya in Hawaii, *Bulletin No. 32 of Hawaii Experimental Station*, p. 41.

The *italics* are mine. The characteristics of early maturity, high sucrose and ease of stripping apply particularly to some of the latest Coimbatore productions. One of these, Co. 281, is attracting attention in Louisiana and Florida as well. [T. S. VENKATRAMAN.]



WOMEN'S INSTITUTES IN INDIA.

THE following from the London correspondent of *The Times of India* (dated 14th February, 1929) will be read with interest in continuation of Mrs. Mackie's paper on "Women and Rural Reconstruction (*Agri. Jour. of India*, XXIV, Pt. 1) :—

It will be recalled that the Royal Commission on Agriculture in India in emphasising the immense importance of the education of women in promoting the rural uplift the country so greatly needs, came to the conclusion that the establishment of a women's institute in a village would supply a centre for education and cooperative activities and might remove the present obstacles to the employment in the village school of women teachers. One of the most widely informed of the educationists in this country, Sir Michael Sadler, some time ago when asked for his advice by two British members of the I. E. S. in the Punjab who were setting out to investigate educational work in the English countryside with a view to considering its bearings on Punjab problems, said that women's institutes should form the most important part of their inquiry. They write that they were surprised to be told this, but they found as they went from county to county that these institutes are now widely regarded "as the greatest social and educational movement of the century in Great Britain".

In one part of India at least, Bengal, an Indian adaptation of this remarkable movement is being firmly established. The London Committee of the Saroj Nalini Dutt Memorial Association was at home at the Forum Club, on the occasion of the fourth anniversary of the founding of the Association, which has been instrumental in establishing some 250 *mahila samitis* (women's institutes) chiefly in Bengal on lines adapted from the English model. The London committee consists exclusively of Indian ladies, and is under the presidency of the Dowager Maharani Sunti Devi of Cooch Bihar, and its purpose is to enlist the goodwill and support of the women of England in the work started by the late Mrs. Dutt, wife of Mr. G. S. Dutt, I.C.S., after investigating at first hand the great value of the movement in this country.

The chair was taken by Mrs. Benjamin, and the purpose of the reception was indicated by Mrs. Hannah Sen, the honorary secretary. She said that the *samitis* were composed of and managed by women of all classes irrespective of caste, religion or political creed. Through the institutes social intercourse was stimulated and a spirit of helpfulness and social service was created. Public health work in most varied forms, the promotion of cottage industries, especially for widows and distressed families, primary and adult education, farms and kitchen gardens are among the activities fostered in the Bengal villages by the organization. Mrs. Sen justly

said that all who had any idea of the conditions of village life in India must recognize how great was the need for such a movement and the immensity of the possibilities it opened up. Its promoters desired to link it up with the work of women's institutes in this and other countries, so that there might be mutual help and co-operation.

Speeches of cordial encouragement were made by Miss Williams, president and founder of the Forum Club; Miss Grace Hadow, vice-chairman of the National Federation of Women's Institutes; Mrs. Murray Waller, who organized the movement in Australia, where it is known as the Country Women's Association; Miss Parr, secretary of the Forum Club; Mrs. Alfred Watt, founder of the movement in Canada; Mrs. Newton Harris, president of the Women's Institute section of the Forum Club, and Mrs. Cobb.

[The movement in Bengal, we understand, was actually initiated by the late Mrs. Saroj Nalini Dutt as far back as 1913—some three years before the first women's institute in England was established. It is true that the beginnings were small, and that it was not until after studying in England in 1920-21 the advantages of federating the institutes that Mrs. Dutt was instrumental in the provision of a similar central organization in Calcutta.—*Editor, A. J. I.*]



PRIZE FOR AN IMPROVED PERSIAN WHEEL.

WE have received the following for publication :—

The Punjab Government (Ministry of Agriculture) offers a prize of Rs. 2,000 for the design (detailed scale drawings) of an improved Persian wheel. Drawings must be sufficiently complete to enable any manufacturer to make up the wheel in all details. Competitors must observe the following conditions :—

1. The design must show a distinct advance on any Persian wheel known at the present time.
2. Durability, lightness, easy running and low costs will be specially considered.
3. Drawings must be submitted to the Agricultural Engineer to Government, Punjab, Lyallpur, not later than 15th February 1930.

Drawings will be examined by an expert of Government, and one or more designs may be chosen from which the actual Persian wheels are to be constructed for test purposes. The authors of selected drawings will be required to manufacture wheels or parts according to their drawings, and the cost of their manufacture will be borne by Government, but in no case a sum exceeding Rs. 400 be paid for the manufacture, the delivery and the erection of a complete Persian wheel at Lyallpur.

If in the opinion of Government no wheel complies with the above requirements the prize will be withheld, and if a wheel composed of improved parts from several designs sent in is approved, the prize will be suitably divided. The decision of Government will be final.

Any design winning a prize will become the property of Government,

LIQUID MANURE.

THE urine of farm animals is as valuable for manurial purposes as the dung. Unfortunately this fact is unknown or ignored by the majority of farmers in this country, writes R. S. M. in a British paper "Farm Feeding."

The urine of livestock contains extremely valuable fertilizing properties, but its collection and storage involve the construction of a special system of drains and tanks. Agriculturists in some European countries are far in advance of British farmers in this matter. In Germany huge cemented tanks are to be found on most large farms and the carts which spray the liquid over the land are a common sight. The evil of the great wastage in this country is mitigated to some degree by the provision of a plentiful supply of absorbent litter which is afterwards applied to the soil. Moreover, the more rigorous German climate makes it necessary for the cattle to be kept in sheds for several months of the year. Hence an outlay on tanks, etc., is repaid quicker than in milder climates where even in winter the cattle are allowed to graze for many hours each day.

The phosphatic and potassic salts present in the urine of cattle, unlike those present in the dung, require little or no change in their form before they are ready to stimulate plant life; in other words, liquid manure is much quicker than dung in its action. Sir Daniel Hall throws some interesting light on the properties of liquid manure in his volume on *Fertilizers and Manures*. "Roughly speaking," he says, "the richer the food the greater the proportion that is digestible," and it is the digestibility of the food which determines the proportion between the fertilizing salts contained in the slow-acting dung and those present in the quick-acting urine. It is shown in this work that in decorticated cotton cake there is 7 per cent. nitrogen of which 87 per cent. finds its way into the urine. In hay there is 1.5 per cent. nitrogen; 50-60 per cent. of this is present in the urine. These figures show that not only the fertilizing value of the urine is very high when the cattle are fed on rich food, but also that even when comparatively poor foods are used the urine is at least as rich in nitrogen as the dung. Thus, on a farm where the liquid manure is not collected and utilized and where rich concentrated cakes are fed, the loss to the farmer is very much greater than on a farm where the diet consists of roots and hay.

Notwithstanding all these facts the farmer should proceed with caution before he decides to involve the quite considerable outlay necessary for the installation of drains and tanks. In the opinion of the Ministry of Agriculture, however, this outlay would be recovered in a very few years, especially in the case of stalled cattle. Dilution by rain water increases the cost of handling and consequently reduces the profit. The Department publishes a leaflet (No. 382) on liquid manure tanks, describing in detail the construction of a suitable system.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE New Year's Honours List contains the following names which will be of interest to the Agricultural Department:—

K. C. I. E.—Sir Thomas Middleton, lately Member, Royal Commission on Agriculture in India.

C. I. E.—Dr. N. Gangulee, lately Member, Royal Commission on Agriculture in India.

Mr. J. A. Madan, I.C.S., lately Joint Secretary, Royal Commission on Agriculture in India.

Mr. F. W. H. Smith, lately Joint Secretary, Royal Commission on Agriculture in India.

Mr. R. S. Finlow, B.Sc., F.I.C., Director of Agriculture, Bengal.

Rao Bahadur.—Mr. B. Vishwanath, F.I.C., Government Agricultural Chemist, Madras.

Khan Sahib.—Sayid Mir Ali Sajjad, Retired Personal Assistant to the Director of Agriculture, United Provinces.

Rai Sahib.—Mr. Surendra Nath Basu, Superintendent of Sericulture, Bengal.
Mr. Nagendranath De, Senior Farm Manager, Cuttack.

Mr. Tej Bhan Bahl, Lately Assistant Superintendent, Royal Commission on Agriculture in India.



Dr. D. CLOUSTON, C.I.E., M.A., D.Sc., Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, has been granted leave on average pay for six months from 12th April, 1929, preparatory to retirement.



Dr. W. McRAE, M.A., D.Sc., Imperial Mycologist, Agricultural Research Institute, Pusa, has been appointed to officiate until further orders as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, with effect from 12th April, 1929.



Dr. F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S., Offg. Imperial Economic Botanist, has been appointed to officiate, until further orders, as Joint Director, Agricultural Research Institute, Pusa, in addition to his own duties, *vice* Dr. W. McRae on other duty.

Mr. H. COOPER, M.R.C.V.S., has been appointed to officiate as Director, Imperial Institute of Veterinary Research, Muktesar, with effect from 1st April, 1929, and until further orders, *vice* Dr. J. T. Edwards resigned.



Mr. NAND LALL DUTT, M.Sc., Second Cane-breeding Officer, Imperial Sugarcane Station, Coimbatore, has been confirmed in that appointment with effect from 3rd April, 1929.



Dr. A. E. PARR, Deputy Director of Agriculture, Western Circle, United Provinces, has been granted leave on average pay for six months from 20th March, 1929.



KHAN SAHIB M. ABDUL QAYUM has been appointed to hold charge of the duties of Deputy Director of Agriculture, Bundelkhand Circle, Jhansi, *vice* Rai Sahib Pandit NAND KISHORE SHARMA reverted.



Mr. J. F. DASTUR, M.Sc., D.I.C., Mycologist to the Government, Central Province, was on leave for one month and 15 days with effect from 14th March 1929.



Mr. R. H. HILL, B.A., Deputy Director of Agriculture, Southern Circle, Central Province, has been granted combined leave for 10 months from 2nd April, 1929.



We regret to record the death of Dr. G. S. Zaitzev, the Russian geneticist and plant-breeder, whose work on the botany and physiology of the cotton plant has achieved a very wide reputation. The sad event took place at Moscow on 17th January, 1929.

REVIEWS

Principles of Soil Microbiology.—By Selman A. Waksman. Pp. xxviii+897; 19 plates and 77 text-figures. (London, Baillière, Tindall and Cox.) Price £2-5-0

"THIS book is a collection of known facts concerning micro-organisms found in the soil and their activities; it is a study of the literature dealing with the science in question; it is an interpretation of the facts already presented; it indicates the various lines of investigation and notes where further investigation is especially wanted. Soil microbiology is a science which is at the very base of our understanding of agricultural processes and the practice of agriculture; it comprises a number of sciences. The book may, therefore, be looked upon more as an introduction to further research rather than as an ordinary text-book; as of help to those working in the allied sciences, who are desirous of obtaining some information concerning the soil population and its activities."

This paragraph from the author's preface gives an accurate statement of the character and object of the volume. The contents are divided into four parts. Part A is brief and consists of one chapter dealing with the numbers of different groups of micro-organisms found in the soil and the method of determination.

Part B describes the isolation, identification and cultivation of soil micro-organisms. The several groups of soil bacteria, soil algæ, soil fungi, soil actinomyces, soil protozoa, and the non-protozoan fauna of the soil are described.

Part C deals with the chemical activities of micro-organisms and Part D with soil microbiological processes and soil fertility and finishes with a short chapter on the history of soil microbiology and an enunciation of present outstanding problems. There are 19 plates, 77 text-figures and two portraits.

The author is to be congratulated on the production of a volume that no worker in any portion of the field of soil microbiology can afford to do without when any fresh line of work is being undertaken. It will prove specially valuable owing to the abundance of references to literature, especially that published in the last ten or fifteen years, that it contains. For example, in Chapter IV, on bacteria fixing atmospheric nitrogen, references, many of them to more than one work, number up to 187, in Chapter XVII, on the chemistry of decomposition of non-nitrogenous organic matter, to 133, and in the Index of Authors, 62 names appear under A.

The book cannot be recommended for use as a text-book by the beginner, and it is to be feared that the worker in an allied science, who wants only a general idea of the activities of the soil population, will also be repelled by the mass of facts that

is set before him ; on the other hand, the reader seeking for the available information on any topic on which this work touches is not likely to be disappointed. [J. H. W.]



The Evolution and Classification of Soils.—By the late DR. E. RAMANN. Translated by C. L. WHITTLES, Ph.D. Pp. 118. (Cambridge: W. Heffer & Sons, Ltd.) Price 7s. 6d.

The attitude of the author towards the subject of soil classification is clearly defined in the following paragraph which occurs in the preface :—"Whereas other branches of scientific investigation have been independent for a long time, Soil Science has still to fight for recognition. Its heaviest burden is its present dependence on Agricultural Chemistry, which, primarily an Applied Science, has to subserve practical purposes. Soil Science has other ideals. It is to be dedicated to the unfettered examination of the soil as an independent branch of knowledge." Consequently it is not surprising to find that this publication does not aim at the study of soils from the agricultural point of view but, is confined solely to the exposition of a system of soil classification based on climatic considerations.

The first three chapters deal with the formation of soils and cover very fully the subjects of weathering ; the action of circulating water ; and the action of organisms on the soil. These factors are dependent upon climate and in this book the interdependence of soil and climate is brought out clearly.

The remaining chapters deal with the author's system of soil classification wherein soils are divided into four groups, *viz.*, humid, semi-humid, semi-arid and arid, and these are in turn sub-divided into four divisions according to the climatic zones in which the soil occur, namely, cold, cool temperate, sub-tropical and tropical. This system of classification possesses novel features which will appeal to those workers who are in a position to take a broad survey of the main typical soil formations of the earth, but, on the other hand, it can make little appeal to that large body of workers whose interests are of necessity confined to the intimate study of the local variations occurring in one or two main soil types. It is a classification confined to the study of orders and sub-orders and which does not touch on genera and species, but nevertheless the book is of importance to all soil students and should find a place in the shelves of every library concerned with agriculture. [W. H. H.]



A Book on the Agriculture of Malwa "Fan-i-Zaraat-i-Mulk-i-Malwa".—By MAULVI MOHAMMAD ZIAUDDIN HYDER, Assistant Director of Agriculture, Bhopal State, formerly Superintendent, Government Experimental Farm, Cawnpore, and Overseer, Pusa Farm.

This book which is published in Urdu though written for the Malwa tract is equally useful for all Urdu knowing people who take interest in agriculture. It

explains in simple language the main principles underlying the improved agricultural methods with numerous points of practical importance. The cultivation of important crops has been dealt with in a very systematic manner. The last chapter dealing with the subject of cattle and cattle-breeding contains very useful information. As there are few books on agriculture in Urdu it will be a valuable addition to the Urdu literature. [A. R. K.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Minerals in Pastures and their Relation to Animal Nutrition, by J. B. Orr, M.D., D.Sc. Pp. xvi+150. Price, 10s. 6d.
2. Dairy Bacteriology, by Bernard W. Hammer. Pp. xii+470; 47 figs. (New York: John Wiley & Sons; London: Chapman and Hall.) Price, 25s. net.
3. Report on the Marketing of Wheat, Barley and Oats in England and Wales. Ministry of Agriculture, Economic Series, No. 18. (London: His Majesty's Stationery Office.) Pp. 206. Price, 6d. net.
4. Bharatiya Krishi Ka Vikas (Hindi Edition of The Development of Indian Agriculture), by A. Howard, C.I.E., M.A., and G. L. C. Howard, M.A. Pp. 152; 6 plates. (Bombay, Calcutta and Madras: Oxford University Press.) Price, Rs. 2-8-0.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Further Studies of Indian Grasses and Grasslands, by W. Burns, D. Sc., L.B. Kulkarni, M. Ag., and S. R. Godbole, B. Ag., B.Sc. (Botanical Series, Vol. XVI, No. 4.) Price, Rs. 1-4 or 2s. 3d.
2. Studies of Sugarcane Roots at different stages of growth, by Rao Bahadur T. S. Venkatraman, B.A., and R. Thomas. (Botanical Series, Vol. XVI, No. 5.) Price, As. 13 or 1s. 6d.
3. Studies in Indian Pulses. 1. Lentil (*Ervum lens*, Linn.), by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., and Rakhal Das Bosc, B.Sc. (Botanical Series, Vol. XVI, No. 6.) Price, Rs. 1-10 or 2s. 6d.
4. Soils of the Punjab, by P. E. Lander, M.A., D.Sc., A.I.C., Ramji Narain, D.Sc., and Mehta Mokand Lal, B.Sc., L. Ag. (Chemical Series, Vol. X, No. 2.) Price, Rs. 3-14 or 6s. 9d.
5. Nasal Granuloma of Cattle in Bihar and Orissa (Experiments regarding mode of infection and treatment), by Rai Sahab P. N. Das. (Veterinary Series, Vol. IV, No. 4.) Price, As. 3 or 4d.

Bulletin.

6. Design for Farm Buildings, by G. S. Henderson, N.D.A., N.D.D. (Bulletin No. 188.) Price, As. 6 or 8d.

List of Agricultural Publications in India from 1st August 1928 to 31st January 1929.

No.	Title	Author	Where published
GENERAL AGRICULTURE			
1	<i>The Agricultural Journal of India</i> , Vol. XXIII, Parts V and VI, and Vol. XXIV, Part I. Price Re. 1-8-0 or 2s. per part. Annual subscription, Rs. 6 or 9s. 6d.	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	<i>The Journal of the Central Bureau for Animal Husbandry and Dairying in India</i> , Vol. II, Parts III and IV. Price, As. 10 per part or Rs. 2-8 per annum.	Ditto.	Ditto.
3	Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert and Secretary, Sugar Bureau) for the year 1927-28. Price, Rs. 2-6 or 4s. 3d.	Issued by the Agricultural Research Institute, Pusa.	Ditto.
4	A Preliminary Note on the Rice crop in the United Provinces. Pusa Agricultural Research Institute Bulletin No. 186. Price, As. 7 or 9d.	R. L. Sethi, M.Sc.	Ditto.
5	The Production of Cigarette Tobacco by Flue-curing. Pusa Agricultural Research Institute Bulletin No. 187. Price, Re. 1 or 1s. 9d.	F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., and Kashi Ram.	Ditto.
6	Design for Farm Buildings. Pusa Agricultural Research Institute Bulletin No. 188. Price, As. 6 or 8d.	G. S. Henderson, N.D.A., N.D.D.	Ditto.
7	Villagers' Calendar 1929 (English).	Issued by the Madras Department of Agriculture.	Government Press, Madras.
8	Training of practical cultivators, maistries or field coolies (English). Madras Department of Agriculture Leaflet No. 53.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
9	Points to note in preparing dry seed beds for Paddy. Madras Department of Agriculture Leaflet No. 52.	Issued by the Madras Department of Agriculture.	Government Madras. Press,
10	A Soil Survey of the Malabar District. Madras Department of Agriculture Bulletin No. 91.	Ditto.	Ditto.
11	Cultivation of Plantains on wet lands in the Godavari Delta. Madras Department of Agriculture Bulletin No. 93.	Ditto.	Ditto.
12	Selection in the <i>Jowars</i> of the Bombay Karnatak. Bombay Department of Agriculture Bulletin No. 151. Price, As. 6.	G. L. Kottur and V. M. Chavan.	Government Press, Bombay. Central
13	Economic Value of Fruit Farming in Western India. Bombay Department of Agriculture Bulletin No. 153 of 1928. Price, As. 6.	Dr. G. S. Cheema and P. G. Dani.	Ditto.
14	Proceedings of the Bombay Provincial Board of Agriculture held at Poona on the 25th and 26th August 1925. Price, Rs. 1-3-0.	Issued by the Director of Agriculture, Bombay.	Ditto.
15	Proceedings of the Bombay Provincial Board of Agriculture held at Poona on the 26th and 27th September 1927. Price, As. 4.	Ditto.	Ditto.
16	Improvement of Cattle in Bengal (in Bengali). Bengal Department of Agriculture Leaflet No. 1 of 1928.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
17	Making Pit Silage with unchaffed Fodders (in Bengali). Bengal Department of Agriculture Leaflet No. 2 of 1928.	Ditto.	Ditto.
18	Cultivation of Tomato (in English and Bengali). Bengal Department of Agriculture Leaflet No. 4 of 1928 and No. 4 of 1924.	Ditto.	Ditto.
19	Cultivation of Potatoes (in Bengali). Bengal Department of Agriculture Leaflet No. 3 of 1927.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
20	Cultivation of Flax on Rungpur Demonstration Farm. Bengal Department of Agriculture Leaflet No. 5 of 1928.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
21	Cultivation of Strawberries. Punjab Department of Agriculture Leaflet No. 61.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.
22	How to make Orange Marmalade. Punjab Department of Agriculture Leaflet No. 64.	Ditto.	Ditto.
23	Dictionary of Poultry Terms. Punjab Department of Agriculture Leaflet No. 65.	Ditto.	Ditto.
24	Berseem as a new crop for the Province. Punjab Department of Agriculture Leaflet No. 66.	Ditto.	Ditto.
25	Ten Commandments from the Goddess of Agriculture. Punjab Department of Agriculture Leaflet No. 67.	Ditto.	Ditto.
26	Selection of Plants. Punjab Department of Agriculture Leaflet No. 68.	Ditto.	Ditto.
27	Windbreaks. Punjab Department of Agriculture Leaflet No. 69.	Ditto.	Ditto.
28	Planting of Fruit Trees. Punjab Department of Agriculture Leaflet No. 70.	Ditto.	Ditto.
29	Report on the Operations of the Department of Agriculture, Punjab, for 1926-27. Part II, Vol. I. Price, Rs. 4-8-0.	Ditto.	Ditto.
30	Report on the Operations of the Department of Agriculture, Punjab, for 1926-27. Part II, Vol. II. Price, Rs. 11-8-0.	Ditto.	Ditto.
31	Annual Report on the Lawrence Gardens, Lahore, for 1927-28. Price, As. 6.	Ditto.	Ditto.
32	Season and Crop Report of the Punjab Department of Agriculture for 1927-28.	Ditto.	Ditto.
33	Tables of Agricultural Statistics of the Punjab for 1927-28.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
34	Fourth Regular Wages Survey Report of the Punjab taken in December 1927.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.
35	Seasonal Notes for October 1928 of the Punjab Department of Agriculture.	Ditto.	Ditto.
36	Annual Report of Experimental Farm, Akola, and the Experimental Farm attached to the Agricultural College, Nagpur, for the year 1926-27. Price, Re. 1-11-0.	W. Youngman, Economic Botanist for Cotton and R. G. Allan, Principal, Agricultural College, Nagpur.	Government Press, Nagpur.
37	Annual Report on the Administration of the Department of Agriculture, United Provinces, for the year ending 30th June 1928.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
38	Report on the Agricultural Stations of Central Circle, Cawnpore, United Provinces, for the year ending 30th June 1928.	Ditto.	Ditto.
39	Report on the Agricultural Stations of Western Circle, Aligarh, United Provinces, for the year ending 30th June 1928.	Ditto.	Ditto.
40	Combined Report on the Experimental Stations in the Eastern Circle, Partabgarh, United Provinces, for the year ending 31st May 1928.	Ditto.	Ditto.
41	Report on the Agricultural Stations of North-Eastern Circle, Gorakhpur, United Provinces, for the year ending 30th June 1928.	Ditto.	Ditto.
42	Report on the Agricultural Stations in the Rohilkhand Circle, Shahjahanpur, United Provinces, for the year ending 31st May 1928.	Ditto.	Ditto.
43	Report on the Agricultural Stations in Bundelkhand Circle, Jhansi, United Provinces, for the year ending 30th June 1928.	Ditto.	Ditto.
44	Report on the Agricultural Stations in Hill Circle, Jeolikote, Naini Tal, United Provinces, for the year ending 30th June 1928.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
45	Report on the working and Administration of the United Provinces Gardens for the year 1927-28.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
46	Rudiments of Garden Designing	Ditto.	Ditto.
47	Influence of Parks, Gardens and Open Spaces in Civic Developments.	Ditto.	Ditto.
48	Cold Storage of Potatoes . . .	Ditto.	Ditto.
49	Annual Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
50	Annual Report of the Hmawbi Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
51	Annual Report on the Operations of the Mudon Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
52	Annual Report on the Operations of the Mahlaing Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
53	Annual Report of the Pwinbyu Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
54	Annual Report of the Pyinmana Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
55	Annual Report of the Yaungshwe (Southern Shan States) Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
56	Annual Report of the Akyab Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
57	Annual Report of the Myaungmya Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
58	Annual Report of the Padu Agricultural Station, Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
59	Annual Report of the Allannmyo Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
60	Annual Report of the Mandalay Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
61	Annual Report of the Tatkon Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
62	Annual Report of the Saing (Thayetmyo District) Agricultural Station, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
63	Annual Report of the Principal, Agricultural College, Mandalay, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
64	Annual Report of the Professor of Agriculture, Agricultural College, Mandalay, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
65	Annual Report of the Agricultural Engineer, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
66	The Marketing of Crops in Burma. Burma Department of Agricultural Survey No. 5.	Ditto.	Ditto.
67	Coconut Survey of the Coastal areas of the Arakan, Irrawaddy and Tenasserim Divisions, Burma, for the year ending 30th June 1928.	Ditto.	Ditto.
68	Manuring of Paddy lands for increased yields. Burma Department of Agriculture Leaflet No. 57.	Ditto.	Ditto.
69	Paddy Improvement in Arakan (English and Burmese). Burma Department of Agriculture Leaflet No. 58.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—contd.</i>			
70	Annual Report of the Department of Agriculture, Bihar and Orissa, for 1927-28.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbagh.
71	Cattle Improvement and Cultivation of Fodder crops in Orissa. Bihar and Orissa Department of Agriculture Bulletin No. 1 of 1928.	Ditto.	Ditto.
72	Maize. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
73	Groundnut. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
74	Simple Agricultural Implements, their use and care. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
75	The Bihar 5 tined Cultivator. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
76	The Mowing Machine and its use. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
77	Ammophos. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
78	Gypsum. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
79	Sugarcane in South Bihar Range. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
80	Ensilage. Leaflet of the Bihar and Orissa Department of Agriculture.	Ditto.	Ditto.
81	Annual Report on the working of the Department of Agriculture, Assam, for 1927-28.	Issued by the Department of Agriculture, Assam.	Government Press, Shilong.
82	A Note of Warning to the Potato cultivators in the plains district. (Assamese.) Assam Department of Agriculture Leaflet No. 5.	Ditto.	Ditto.

No.	Title	Author	Where published
<i>General Agriculture—concl.</i>			
83	<i>The Journal of the Mysore Agricultural and Experimental Union</i> (Quarterly). Annual subscription Rs. 3.	Mysore Agricultural and Experimental Union.	Bangalore Press, Bangalore.
84	<i>The Madras Agricultural Journal</i> , (Monthly). Annual subscription Rs. 4. Single copy As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
85	<i>The Planters' Chronicle</i> (Weekly).	United Planters' Association of South India.	Diocesan Press, P. B. 455, Madras.
86	<i>The Nagpur Agricultural College Magazine</i> (Quarterly). Annual subscription Rs. 3.	S. M. Ali and N. B. Chincholkar, Editors.	Udyama Desha Sevak, Press, Nagpur.
87	<i>Poona Agricultural College Magazine</i> (Quarterly). Annual subscription Rs. 2-8-0; Single copy As. 10.	V. G. Deshpande, M.Ag., and S. M. Rao, B.A., Editors.	Aryabhushan Press, Poona City.
88	<i>The Allahabad Farmer</i> (Quarterly). Single copy As. 8. Per year Rs. 2.	W. B. Hayes, E. W. Jeremy and J. N. Shivpur.	The Mission Press, Allahabad.
89	<i>Quarterly Journal of the Indian Tea Association</i> . Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
90	<i>Rural India</i> (Monthly). Single copy As. 6. Annual subscription Rs. 3.	A. Swaminatha Ayyar.	Magazine Press, Chingleput.
91	<i>Kisan</i> , Agricultural Monthly Magazine started at Indore. Annual subscription Rs. 3 or Re. 0-5-0 per copy.	Sukhsampattirai Bhandari, M.R.A.S., Editor.	Gajanana Printing Works, Indore.

AGRICULTURAL CHEMISTRY

92	Soils of the Punjab. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. X, No. 2. Price Rs. 3-14-0 or 6s. 9d.	P. E. Lander, M.A., D.Sc., A.I.C., and Ranji Narain, D.Sc., L.Ag.	Government of India Central Publication Branch, Calcutta.
93	Annual Report of the Agricultural Chemist, Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
94	Assimilation of nutrients by the rice plant. Bombay Department of Agriculture Bulletin No. 154 of 1928. Price As. 5.	Rao Bahadur D. L. Sahasrabudhe.	Government Central Press, Bombay.

No.	Title	Author	Where published
BOTANY			
95	Non-dehiscence of Anthers in Punjab American Cottons. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVII, No. 1. Price, As. 4 or 5d.	Trevor Trought, M.A.	Government of India Central Publication Branch, Calcutta.
96	Studies in Indian Chillies—I, The Types of Capsicum. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 2. Price Re. 1-8-0 or 2s. 6d.	F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.	Ditto.
97	Further Studies of Indian Grasses and Grasslands. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 4. Price, Re. 1-4-0 or 2s. 3d.	W. Burns, D.Sc., L. B. Kulkarni, M.Ag., and S. R. Codebole, B.Ag., B.Sc.	Ditto.
98	Studies of Sugarcane Roots at different stages of growth. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 5. Price, As. 13 or 1s. 6d.	Rao Bahadur T. S. Venkatraman, B.A., and R. Thomas.	Ditto.
99	Studies in Indian Pulses: 1. Lentil (<i>Ereum lens</i> , Linn). Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 6. Price, Re. 1-10-0 or 2s. 6d.	F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., and Rakhal Das Bose, B.Sc., F.L.S.	Ditto.
100	Annual Report of the Economic Botanist, Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
MYCOLOGY			
101	Foot-rot and Wilt of Antirrhinums caused by <i>Phytophthora pini</i> var. <i>antirrhini</i> , n. v. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 3. Price, Re. 1 or 1s. 9d.	S. Sundararaman, M.A., and T. S. Ramakrishnan, M.A.	Government of India Central Publication Branch, Calcutta.
102	<i>Pythium aphanidermatum</i> (Eds.) Fitz on <i>Opuntia Pillerii</i> , Haw. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 7. Price, As. 8 or 10d.	T. S. Ramakrishnan, M.A.	Ditto.

No.	Title	Author	Where published
<i>Mycology—contd.</i>			
103	Studies in the Wilt Disease of cotton in the Bombay Karnatak, Series I; with an Introduction by Dr. Harold H. Mann. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVII, No. 2. Price, As. 9 or 1s.	G. S. Kulkarni, M.Ag., and B. B. Mundkur, M.A.	Government of India Central Publication Branch, Calcutta.
104	A Leaf Spot and Blight Disease of Onions caused by <i>Alternaria palandui</i> , nov. sp. Pusa Agricultural Research Institute Bulletin No. 179.	C. Rangaswami Ayyangar	Ditto.
105	Coconut Stem-bleeding Disease (Revised). English and Tamil. Madras Department of Agriculture Leaflet No. 15.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
106	Red-rot Disease of Sugarcane (English and Tamil). Madras Department of Agriculture Leaflet No. 51.	Ditto.	Ditto.
107	Mosaic Disease of Sugarcane. Madras Department of Agriculture Bulletin No. 92.	Ditto.	Ditto.
108	A root parasite of Sugarcane and <i>Jowar</i> . Punjab Department of Agriculture Leaflet No. 63.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.
109	Annual Report of the Mycologist, Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
110	Betel Vine Disease (in Assamese). Assam Department of Agriculture Leaflet No. 4.	Issued by the Department of Agriculture, Assam.	Government Press, Shillong.
111	Remedy for the Areca palm disease. (Assamese and Khasi.) Assam Department of Agriculture Leaflet No. 6.	Ditto.	Ditto.

ENTOMOLOGY

112	A contribution to our knowledge of the Thysanoptera of India. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. X, No. 7. Price, Re. 1-9-0 or 2s. 6d.	T. V. Ramakrishna Ayyar, Ph.D., F.E.S., F.Z.S.	Government of India Central Publication Branch, Calcutta.
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No.	Title	Author	Where published
<i>Entomology—concl.</i>			
113	Rice Bug (Tamil, Telugu, Malayalam and Kanarese). Madras Department of Agriculture Leaflet No. 50.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
114	Annual Report of the Entomologist (including Sericulture), Burma, for the year ending 30th June 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
BACTERIOLOGY			
115	Nitrification of calcium cyanamide in some Indian soils. Memoirs of the Department of Agriculture in India, Bacteriological Series, Vol. II, No. 3. Price, As. 10 or 1s.	J. H. Walton, M.A., M.Sc.	Government of India Central Publication Branch, Calcutta.
VETERINARY			
116	Nasal Granuloma of Cattle in Bihar and Orissa (Experiments regarding mode of infection and treatment). Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. IV, No. 4. Price, As. 3 or 4d.	Rai Saheb P. N. Das	Ditto.
117	Report of the Imperial Institute of Veterinary Research, Muktesar, for the year ending 31st March 1928. Price Re. 1-6-0 or 2s. 3d.	J. T. Edwards, D.Sc. (London), M. R. C. V. S., Director, Imperial Institute of Veterinary Research, Muktesar.	Ditto.

ORIGINAL ARTICLES

IS BACTERIAL ASSOCIATION A FACTOR IN NITROGEN ASSIMILATION BY RICE PLANTS ?

BY

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THE investigation on the gases of swamp rice soils carried out by Harrison and Subramania Aiyer¹ throws light on the bio-chemical changes occurring in such soils and their relation to the growth of rice plants. It is not necessary to refer here in detail to all the important results obtained by these investigators, excepting their observations with respect to nitrogen gas which are of special interest in connection with the study which forms the subject of the present paper. They noticed that when green manure and soil organic matter decompose under the conditions prevailing in rice soils gaseous nitrogen is produced, a large amount of which ultimately escapes from the soil. In uncropped soils the nitrogen is evolved at a fairly uniform rate, whereas the presence of a crop prevents the escape of the gas during the early stages of its growth but brings about a very considerable evolution in the later stages. This phenomenon was found by them to be due to physical conditions, the surface development of the roots of the crop in conjunction with the fine-textured soil forming a layer which offers increased resistance to the passage of the gases. Escape of large amounts of nitrogen which takes place at the later stages was attributed to root decomposition.

The considerable evolution of nitrogen gas from the decomposition of green manure and soil organic matter which goes on in rice soils seems a surprising phenomenon in the economy of nature, especially as beneficial effects are often found to follow an application of green manure to these soils. Free nitrogen would generally be accepted as useless for the direct feeding of any crop (except a legume). The question therefore arises as to whether there is a provision of an agency whereby elementary nitrogen can be fixed and rendered available for use of the rice plant.

An examination of the contents of roots of rice plants conducted by Dr. Harrison at Coimbatore had yielded indications of the presence of bacteria apparently capable

¹ Harrison and Subramania Aiyer. The Gases of Swamp Rice Soils, Part I—Their Composition and Relationship to the Crop, *Mem. Dept. Agri. India, Chem. Ser.*, III, 3; Ditto, Part II—Their Utilization for the Aeration of the Roots of the Crop, *Ibid.*, IV, 1; Ditto, Part III—A Hydrogen-oxidizing Bacterium from these Soils, *Ibid.*, IV, 4; Ditto, Part IV—The Source of the Gaseous Soil Nitrogen, *Ibid.*, V, 1; Aiyer, Ditto, Part V—A Methane-oxidising Bacterium from Rice Soils, *Ibid.*, V, 7; Harrison, Ditto, Part VI—Carbon Dioxide and Hydrogen in Relation to Rice Soils, *Ibid.*, V, 8.

of assimilating free nitrogen. A transfer to Pusa and the pressure of other duties, however, stood in the way of his carrying out further work on this subject.

The fixation of elementary nitrogen is a phenomenon of great interest both from theoretical and practical points of view. Barring the utilization of free nitrogen by various bacteria, fungi and algæ in the soil, the most important among the known biological processes of nitrogen fixation is that brought about through the agency of bacteria living in the root nodules of legumes. Valuable work has already been done in the investigation of these organisms which live in symbiotic relation with the host plants and which can assimilate nitrogen from the air. Root nodules have occasionally been noted in other groups of higher plants besides leguminous plants but they are mostly found to be due to infection by disease organisms. Even in cases where they cannot be classed as definitely pathologic, it is doubtful whether the functions they discharge are similar to those performed by nodules regularly found in roots of legumes. It has been maintained by some that certain cruciferous plants contain nitrogen-fixing bacteria in their roots,¹ but the general opinion is that the subject requires further investigation. As a matter of fact, it can safely be asserted that the positive presence of nitrogen-fixing bacteria in the roots of plants other than those of legumes has not as yet been definitely proved.

It will not perhaps be out of place to draw attention to a very important point of difference between the cultural conditions prevailing in typical rice lands and those in fields growing leguminous crops. Except in the case of upland varieties, the rice cultivators' field practice is to try to maintain a stand of water on the ground, from the time of transplantation onwards. The rice roots have thus for the greater part of their life to develop under anaerobic conditions. With legumes, on the other hand, the growth of roots takes place under aerobic conditions. The phenomena of the growth and development of the nitrogen-fixing symbiotic bacteria, if any, present in rice roots are thus expected to be somewhat different to those of the organisms associated with roots of legumes.

It thus seemed to be of considerable importance to carry out further investigations on the possible occurrence of nitrogen-fixing organisms in the roots of the rice plant.

For this study several samples of rice plants were collected from the fields of cultivators from different areas outside Pusa. The plants were washed and cleaned in the laboratory, special attention being paid to the clumps of roots. These latter were carefully examined to single out normal sound unbroken roots. Suitable roots were individually snipped off and of these each cut end was looped over and securely tied up. This was done to prevent any possible contamination of the contents by the entry of foreign material from outside during the subsequent operations. The roots, with their ends tied up, were then subjected to a dipping in mercuric chloride solution in order to kill off any bacteria sticking outside. The

¹ Cauda, *Nuov. giorn. botan.*, Vol. 26, 1919, p. 169, quoted by Löhnis and Fred, *Textbook of Agric. Bacter.*, 1923, p. 113.

mercuric chloride was next removed by thoroughly washing the roots with sterile water, and the tied up ends were then cut off with sterile scissors.

The contents of these rice roots when examined under the microscope showed the presence of bacteria. Culture solutions containing a sugar and minerals but no nitrogen in any form were next inoculated with the contents of the rice roots. Slimy bacterial growths were noticed on incubation. Experiments showed that anaerobic conditions favoured their development. Microscopic examination of the growths revealed the presence of characteristic capsulated bacteria.

An opportunity was taken to visit Coimbatore. Through the courtesy of the authorities there, it was possible to collect and examine five strains of rice growing on the Agricultural College Farm. It may be noted that the paddy season in that part of the country was very abnormal this year. The rains had failed and it had not been possible to irrigate the fields in the usual way, so that the plots at times had been subject to conditions of drought. At Pusa (in North Bihar), on the other hand, there had been very heavy floods during the year.

Presence of organisms was noted in the roots of all the rices at Coimbatore and inoculations of four of the samples in liquid cultures were brought over to Pusa for further investigation. These also yielded positive results on incubation.

The development of bacterial growth in the solutions, which contained no nitrogen, clearly indicated an assimilation of nitrogen from the gaseous atmosphere. Actual analyses confirmed this deduction, as a definite, though small, fixation of nitrogen (1—2 milligrammes nitrogen in 250 c.c. culture solution*) was observed. It will be of interest to compare these figures with the results recorded in the case of nodule bacteria of legumes.¹ Although these latter organisms discharge their functions very efficiently when growing in their natural environments within the root nodules, their development and activity, when inoculated on substrates ordinarily used in the laboratory, are often very slight. Several investigators could not discover any nitrogen assimilation. Those who succeeded in getting positive results usually obtained low figures (2—3 milligrammes nitrogen per 100 c.c. solution).

This demonstration of an occurrence of symbiotic nitrogen fixing organisms within the roots of the rice plant throws new light on the problem of nitrogen nutrition of rice and opens out many interesting lines of study. Pure cultures are being isolated, the investigation of which as well as that of the crude cultures, and of their relationship to the plant, is being continued. The results will be published in fuller details in due course.

The author takes this opportunity of acknowledging with gratitude the help which he has received from Dr. W. H. Harrison, Imperial Agricultural Chemist, Pusa, during the course of this study.

* Some recent determinations have yielded higher figures, e.g., upto 5 mg.

¹ Löhnis and Fred, *loc. cit.*, p. 111.

SOIL ACTINOMYCES.

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ACTINOMYCES, also known as ray fungi and by a variety of other names, form an important group of soil micro-organisms. Their presence in the soil is generally recognizable by the characteristic "earthy" odour which they impart to the soil or other culture media.

Though much work has been done on actinomyces during recent years, our knowledge of their mode of occurrence, distribution and physiological activity in the soil remain comparatively obscure.

Recent investigations by the authors suggest that though the organisms occur vegetatively on rich, artificial media, they rarely do so in the normal soil. The mycelial threads when inoculated into the soil were found to perish in about a week. The conidia, also mentioned by some as spores, were, however, observed to be more resistant: examinations of over 50 specimens of soils from different parts of India showed that the actinomyces were present in them, almost exclusively, in that form. In one stray case in which they were noted to occur vegetatively, it was observed that they did so not on the soil itself, but on the undecomposed plant residues which happened to be present in the sample.

In the surface soil, they were observed to be generally slower in their response to treatment with nutrients, stimulants, toxic substances, etc., than were the bacteria and the fungi. This combined with the observations of Orskov, Conn and others, that they (1) shun light and (2) occur in comparatively greater abundance in the subsoil than in the surface soil would suggest that the actinomyces are mainly concerned in the transformations of slowly decomposing forms of organic matter, particularly in the dark. The characteristic musty odour noticed in dark and ill-ventilated places, or when digging up the soil or the inner portion of a partially rotted manure heap, is probably an indication of the active presence of the organisms under such conditions.

In view of the fact that there exists, at present, no standard method for the counting of actinomyces present in the soil, an attempt was made to evolve a plate

method which, in addition to being readily reproducible, would not only help to bring out the largest numbers of the different strains of actinomyces, but also discourage the abnormal development of the other forms of microflora.

After a large number of trials, it was found that a starch agar medium containing a minimum amount of nitrogen with the necessary minerals was best suited as the count medium. The composition of the medium with the technique adopted for the plating is briefly as follows:—

Soluble starch 2.0 gm.; dipotassium phosphate 0.5 gm.; hydrated magnesium sulphate 0.2 gm.; calcium chloride 0.05 gm.; ferric chloride, traces; sodium nitrate 0.05 gm.; asparagin 0.05 gm.; agar 20 gm.; distilled water 1000 c.c.; final pH. 7.4.

Air-dried specimens of soils were suspended in sterile tap-water and dilutions varying from 1 in 1000 to 1 in 100,000 used for plating. The plates were incubated at 25–30°C. for a fortnight, after which period the colonies of actinomyces, which always come out very prominently, were counted.

The counts of actinomyces thus obtained for specimens of soils from different parts of India and Ceylon varied from practically nil to about four millions per gramme of soil. They showed that the climatic conditions, rainfall and physical texture of the soil did not, by themselves, influence the numbers to any appreciable extent. Garden soils and, as also observed by Conn, sodden soils generally carried larger numbers than the more intensely cultivated, grain-crop bearing, arable lands. This combined with the observations of Waksman and others that the organisms can readily attack cellulosic materials would suggest that their growth and activities are greatly favoured by the presence of plant residues combined with surface shade.

The numbers did not suggest any relation to accredited soil fertility. Table I presents the counts obtained for certain representative types of soils:—

TABLE I.

No.	Locality and description of soil	Numbers of actinomyces per gramme of soil
1	Jacobabad, Punjab, Govt. wheat farm—Surface	3,050,000
2	Gujranwalla Dt., Punjab—Wheat Surface	2,560,000
3	Bundelkhand, U. P.—Surface	2,160,000
4	Ranchi, Bihar—Upland Soil—Surface	600,000
5	Gaya Farm—Waterlogged—Surface	480,000
6	Dacca, Bengal—Lowland—Paddy Surface	1,000,000

TABLE I—concl'd.

No.	Locality and description of soil	Numbers of acti- nomyces per gramme of soil
7	Sind—Kalar Soil—Surface	680,000
8	Indore, C. India—Institute of Plant Industry—Surface . . .	660,000
9	Nasik, Bombay—Surface	3,340,000
10	Sholapur, Bombay—Karl—Surface	950,000
11	Hyderabad, Deccan—Black Cotton—Surface	3,340,000
12	Chirakkal, Madras—Sandy Loam—Transplanted paddy—Surface .	3,820,000
13	Tellicherry, Malabar—Red Sandy Loam—Coconut—Surface . .	300,000
14	Tellicherry, Malabar, Red Sandy Loam—Coconut—Subsoil . .	40,000
15	Travancore, S. India—Peaty—Broadcast paddy—Surface . .	2,340,000
16	Jaffna, Ceylon—Sandy—Surface	1,220,000
17	„ „ „ Subsoil	360,000

The majority of actinomyces appearing on the plates were chromogenic and produced the characteristic musty odour. Certain soils contained only one or two varieties, while the others though carrying smaller total numbers had a more varied flora. Thus, the specimens from Gujranwalla and Chirakkal each contained almost exclusively only one strain, while those from Dacca and Nasik contained more than 15 each.

With our present knowledge it is not possible to define the exact role of actinomyces in relation to soil fertility and plant nutrition. Much work still remains to be done on the physiology of the more prominent varieties commonly occurring in the soil, particularly under conditions similar to those obtained in the depths of forest areas and the interior of manure heaps, before their importance can be properly assessed.

STUDIES IN SUGARCANE POLLEN WITH SPECIAL
REFERENCE TO LONGEVITY.

BY

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I. INTRODUCTION.

SUGARCANE pollen studies have a direct bearing on the problems connected with sugarcane breeding, and engaged the attention of Wilbrink and Ledebøer,¹ Barber,² Venkatraman,³ Calvino,⁴ Cottrell-Dormer,⁵ and more recently Weller⁶ and Mercado.⁷ Weller in his paper concludes that the “Methods for determining viability of sugarcane pollen have not been satisfactory because (1) they do not discriminate between viability and maturity, as, for example, the iodine method; (2) they are not adapted mechanically for securing counts in large numbers so that viability may be determined upon a quantitative basis, as, for example, the method of using the stigmatic surfaces of various plants such as *Hibiscus*, *Ipomea*, and *Datura*.”

The importance of pollen viability tests to sugarcane breeding and the failure or partial success of the previous workers to germinate sugarcane pollen artificially, suggested the retrial of various culture media in the arrowing season 1926, and after some experimentation 26 per cent. sugar and 0·7 per cent. agar was found to be the most suitable culture medium. With this medium the pollen of some of the Barbados, Coimbatore, Demerara, Java and Mauritius varieties was successfully cultured under artificial conditions.⁸ The data available from these viability

¹ Wilbrink, G., and Ledebøer, F. De Geslacht telijke Voortplanting Bij Het Suikerriet. *Archief Voor de Suikerindustrie*, Jaargang XIX, 1 Deel, 1911.
² Barber, C. A., Studies in Indian Sugarcanes, No. 2. *Mem. Dept. Agri. India, Bot. Series*, Vol. VIII, No. 3, p. 126, 1916.
³ Barber, C. A. A direct method of germinating sugarcane pollen grains. *International Sugar Journal*, Vol. XXVII, pp. 358-359, July 1924.
⁴ Venkatraman, T. S. Germination and preservation of sugarcane pollen. *Agri. Jour. India*, Vol. XVII, pp. 127-132, March 1922.
⁵ Calvino, E. M. Notas sobre la Fertilidad de las flores de la cana. *Chaparra Agricola*, Vol. I, No. 3, pp. 17-19, July 1924.
⁶ Cottrell-Dormer, W. Studies on fertility of sugarcane flowers. *Planter and Sugar Manufacturer*, Vol. LXXIII, No. 20, pp. 389-391, Nov. 15, 1924.
⁷ Weller, D. M. Progress Report of Sugarcane Pollen Studies. *Hawaiian Planters' Record*. Vol. XXX, No. 3, pp. 400-414, July 1926.
⁸ Mercado, T. Study of flowering habits and flower characteristics of three sugarcane varieties. *Philippine Agriculturist*, Vol. XV, No. 4, pp. 181-201, Sept. 1926.
⁸ Dutt, N. L., and Ayyar, G. Ganapathi. Germination of sugarcane pollen in artificial culture media. *Agri. Jour. India*, Vol. XXIII, Part III, pp. 190-202, 1928.

tests have been helpful in shaping the hybridization programme at the Thick Cane Section of the Imperial Sugarcane Station, Coimbatore.

With a view to corroborating the results obtained in the 1926 season, but chiefly with the object of prolonging the viability of sugarcane pollen, the studies were continued in the 1927 and 1928 arrowing seasons.

II. THE POLLEN GRAIN.

The sugarcane pollen is yellow in colour and ellipsoidal to spherical in shape (Plate XXII, fig. 1). In the fresh and dry condition it varies in size from $38.25\mu \times 42.75\mu$ to $67.5\mu \times 72.0\mu$. It contains about 48 to 51 per cent. moisture. Fig. 4 (Plate XXII) shows the smoothness of the grain, and the presence of the single pore.

Such characters as the number of folds and germinal apertures of the pollen grain, and the character and arrangement of the papillae on the surface, have been shown to be of classificatory value and indicative of phylogenetic relationship, by Gagnepain¹ for Geraniaceae, Kohler² for Gentianaceae, Urban³ for Bignoniaceae and Wodehouse⁴ for Vernoniaceae. These characters will not be helpful in the sugarcane, as in the pollen of all the varieties that were examined, the grains were smooth and with one germinal aperture.

Sugarcane varieties, however, differ in the amount of abortive pollen that they contain. This fact may be indicative of the hybrid origin of the variety or varieties containing abortive pollen, but is difficult to press into service for demarcating one variety from the other. Morphologically normal pollens range in dimension between 38 and 72μ when dry and fresh, and germination was noticed to take place irrespective of the size of the normal grain (Plate XXII, fig. 5). The aborted pollen is incapable of germination, and the percentage of such pollen in a variety will, to a certain extent, be a factor for its success or otherwise as a male parent.

III. THE CULTURE MEDIUM AND MOIST CHAMBER.

Tests made during the 1927 arrowing season showed that in the preparation of the culture medium, commercial white sugar could with advantage be substituted for chemically pure sucrose.⁵ In 1928 the constituents of the culture medium were varied rather elaborately to study their effect on germination. It will be seen from Table I that ordinary white sugar and shred agar suit the artificial culture of sugarcane pollen best. It was further found that filtered rain water could take

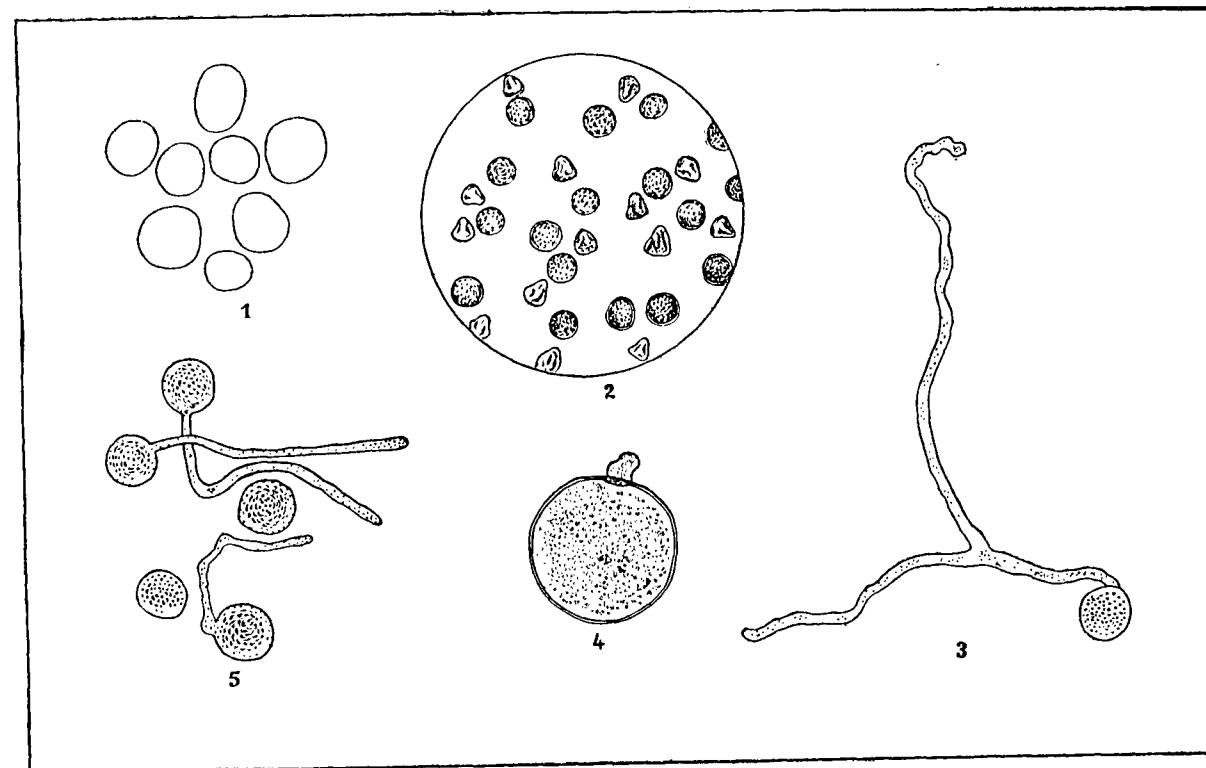


Fig. 1. P. O. J. 2696. Showing shape of fresh and dry pollen.

Fig. 2. Normal and aborted pollen in a mixture of pollen of some varieties.

Fig. 3. Co. 213. Bifurcation of the pollen tube.

Fig. 4. P. O. J. 2696 pollen enlarged showing the single pore.

Fig. 5. P. O. J. 2696. Germination takes place irrespective of the size of the pollen.

¹ Gagnepain, F. Contribution à l'étude du pollen des Geraniacees. *Bull. Soc. Hist. Nat. d'Autun*, XVI, 83, 1903.

² Kohler, A. Systematischer Wert der Pollenbeschaffenheit beider Gentianaceen. *Mitteilungen aus dem Bot. Mus. der Universität, Zürich*, XXV, 1905.

³ Urban, I. Ueber Ranken und Pollen der Bignoniaceen. *Ber. Deutsch. Bot. Ges.*, XXXIV, 9, pp. 728-58, 1916.

⁴ Wodehouse, R. P. The phylogenetic value of pollen grain characters. *Ann. Bot.*, Vol. XLII, pp. 891-934, 1928.

⁵ Dutt, N. L. Pollen studies (Culture Medium). *Sci. Rep. Agri. Res. Inst. Pusa*, 1927-28, p. 139.

the place of distilled water and that germinations did result on the use of 19 days old filtered rain water as solvent in the medium.

TABLE I.

Pollen germination as effected by varying certain constituents of the culture medium.

Date	Name of variety	Nature of the* culture medium	Percentage of germinations	Length of pollen tubes	REMARKS
12th October 1928	Co. 243	26 per cent. sugar and 0.7 per cent. shred agar in distilled water.	12.86	long . .	In the preparation of the culture medium filtered rain water may be substituted for distilled water.
Ditto	Ditto	26 per cent. sugar and 0.7 per cent. shred agar in filtered rain water.	11.94	medium . .	
Ditto	Ditto	Distilled water alone	1.23	short . .	
13th October 1928	Ditto	26 per cent. sugar and 0.7 per cent. shred agar in distilled water.	13.7	medium . .	The longest pollen tube was 1029 μ .
Ditto	Ditto	26 per cent. sucrose and 0.7 per cent. shred agar in distilled water.	12.17	short to medium.	
15th October 1928	Ditto	5 per cent. sugar and 0.7 per cent. shred agar in distilled water.	2.0	short . .	Commercial sugar can be substituted for sucrose.
Ditto	Ditto	10 per cent. sugar and 0.7 per cent. shred agar in distilled water.	2.6	short . .	
Ditto	Ditto	15 per cent. sugar and 0.7 per cent. shred agar in distilled water.	2.3	short . .	Sugarcane pollen germinates in quite a wide range of sugar concentrations.
Ditto	Ditto	20 per cent. sugar and 0.7 per cent. shred agar in distilled water.	13.4	medium . .	
Ditto	Ditto	26 per cent. sugar and 0.7 per cent. shred agar in distilled water.	12.0	long . .	
16th October 1928	Ditto	30 per cent. sugar and 0.7 per cent. shred agar in distilled water.	9.3	medium . .	
27th October 1928	P. O. J. 2696	35 per cent. sugar and 0.7 per cent. shred agar in distilled water.	only five germinations.	short . .	35 per cent. sugar and above do not suit artificial culture of sugarcane pollen.
Ditto	Ditto	40 per cent. sugar and 0.7 per cent. shred agar in distilled water.	only one germination.	short . .	

* Whatever the composition of the culture medium, 2 to 3 drops of it were placed at the bottom of the moist chamber and it was spread into a thin layer on the cover slip which after dusting the pollen was inverted at the top of the chamber.

TABLE I—concl'd.

Pollen germination as effected by varying certain constituents of the culture medium—concl'd.

Date	Name of variety	Nature of the * culture medium	Percentage of germinations	Length of p. llen tubes	REMARKS
27th October 1927	P. O. J. 2696	45 per cent. sugar and 0.7 per cent. shred agar in distilled water.	no germination.		35 per cent. sugar and above do not suit artificial culture of sugarcane pollen.
Ditto	Ditto	50 per cent. sugar and 0.7 per cent. shred agar in distilled water.	no germination.		
18th October 1928	Co. 243	26 per cent. sugar and 0.7 per cent. shred agar in distilled water.	13.7	short	Addition of fresh potato juice helps the sugarcane pollen tube growth.
Ditto	Ditto	26 per cent. sugar and 0.7 per cent. shred agar fresh potato juice.	14.2	medium	
19th October 1928	P. O. J. 2696	26 per cent. sugar and 0.7 per cent. shred agar fresh potato juice.	17.2	long	2 drops of fresh potato juice in 10 c.c. of distilled water. One drop of this solution added to 2 c.c of normal culture medium.
Ditto	Ditto	26 per cent. sugar and 0.7 per cent. shred agar in distilled water.	16.8	long	

* Whatever the composition of the culture medium, 2 to 3 drops of it were placed at the bottom of the moist chamber and it was spread into a thin layer on the cover slip which after dusting the pollen was inverted at the top of the chamber.

As to the most suitable concentration of sugar in the culture medium, it will be seen from Table I that the results are in substantial agreement with those obtained in 1926. 26 per cent. sugar plus 0.7 per cent. agar gave best results though germinations are obtained even when mere distilled water alone is used, or with 5, 10, 15, 20, and 30 per cent. sugar solution plus 0.7 per cent. shred agar. The results with 35, 40, 45, and 50 per cent. sugar solutions were either insignificant or negative.

As a result of the 1926¹ work, it was stated that in order successfully to culture sugarcane pollen artificially, it was a necessary pre-requisite to have a glass ring, 7.5 mm. high and 17 mm. in diameter, vaselined at top and bottom to ensure a fairly air-proof moist chamber. The results detailed in Table II point to the fact that any sized moist chamber ranging from 1.2 cm. to 15 cm. in diameter and 0.5 cm. to 1.5 cm. in height could be used, and though germinations are obtained if the moist chamber be not air-proof, it would be an advantage to have it so. As the 1926 work indicated, it was further found advantageous to have the sugar agar

¹ *ibid.*

solutions spread into a thin film at the top of the moist chamber, instead of having it as a large hemispherical drop presumably because, as pointed out by Adams,¹ oxygen is more readily obtained by the dusted pollen grains in this way.

TABLE II.

Pollen germination as effected by the size and the air-proof condition of the moist chamber.

Date	Variety	SIZE OF MOIST CHAMBER		Vasclined or not	Nature of pollen tubes	Per cent. germination
		Diameter	Height			
17th October 1928	P. O. J. 2696	12 mm.	5 mm.	vaselined	medium to long	12.1
Ditto	Co. 243	17 mm.	7.5 mm.	vaselined	medium	12.6
Ditto	Ditto	"	"	un-vaselined	medium	11.3
Ditto	P. O. J. 2696	"	"	vaselined	medium	10.8
Ditto	Ditto	"	"	un-vaselined	medium	9.6
12th October 1928	Co. 243	15 cm.	1.5 cm.	vaselined	long	12.00
Ditto	Ditto	Control. *		vaselined	long	12.86
13th October 1928	Ditto	15 cm.	1.5 cm.	un-vaselined	medium to long	13.08
Ditto	Ditto	Control.		vaselined	long	13.17

* In the control the diameter of the moist chamber was 17 mm. and the height 7.5 mm.

IV. POLLEN TUBE GROWTH.

The time that the pollen tube will take to reach the ovary naturally varies according to the distance and the nature of the path which it has to traverse. That greater distance does not always entail greater interval between pollination and fertilization is brought out by the classical instances given by Hofmeister² and Schleiden.³ In *Crocus* with a style 6 to 10 cm. long, the pollen tube covered the distance in one to three days and in *Arum* where the length of the style is only 2 to 3 mm. it took five days for the tube to do the distance ; while according to Schleiden in *Cereus grandiflorus* having a style 9 inches long, only a few hours are required for the descent of the tube.

Though very long tubes under artificial culture are not on record, Brink,⁴ Knight,⁵ and Bobilioff-Preisser⁶ working on *Scilla* and *Vinca minor* pollen, successfully

¹ Adams, J. On the germination of the pollen grains of apple and other fruit trees. *Bot. Gaz.*, Vol. LXI, pp. 131-147, 1916.

² Hofmeister, W. Neue Beitrage zur Kenntniss der Embryobildung der Phanerogamen. *Abhandl. Konigl. Sachs. Gesell. Wiss.*, 6, 533-672, 1859.

³ Schleiden, M. J. *Principles of Scientific Botany*, p. 407, 1849. (Gray's Botanical Text-book, by Goodale, Vol. II, p. 431, 1885.)

⁴ Brink, R. A. The Physiology of Pollen. III. Growth *in vitro* and *in vivo*. *Amer. Jour. Bot.*, Vol. XI, pp. 351-364, 1924.

⁵ Knight, L. J. Physiological aspects of self-sterility of the apple. *Proc. Amer. Soc. Hort. Sci.*, Vol. XIV, pp. 101-105, 1917.

⁶ Bobilioff-Preisser, W. Zur physiologie des pollens. *Beih. Bot. Centralbl.* I, Vol. 34, 459-492, 1917.

secured pollen tubes *in vitro* long enough to effect fertilization if they were growing in the style of the plant. Sugarcane pollen was found to show very irregular growth when cultured artificially. A difficulty that was experienced in this direction was that quite a large number of pollen tubes taken up for measurement either bursted or stopped growth after an hour or so. It was therefore decided to look up the cultures only after the first hour had elapsed and then pitch upon the particular pollen tubes for growth measurements. The curves in Text-fig. 1 represents the

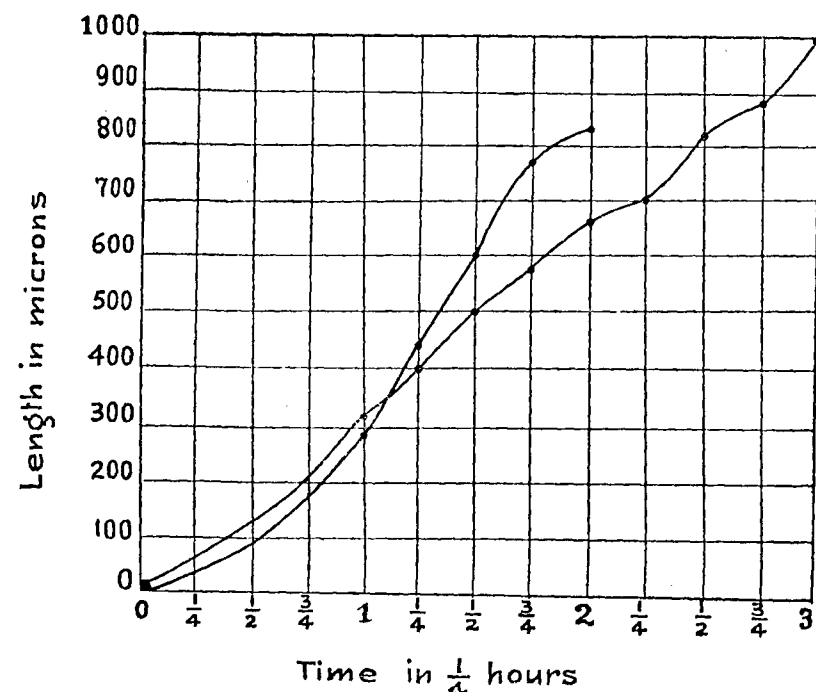


Fig. 1. Growth curves of pollen of P. O. J. 2696 cultured in 20% sugar + 0.7% shred agar.

growth of two such tubes. Though the longer of the two tubes attained a length of 1000 μ in 3 hours, it is not rare to find tubes measuring between 1500 μ and 2000 μ or more for the same period of time. The greatest length attained by a sugarcane pollen tube when grown artificially was by a pollen from P. O. J. 2696, which measured 2921 after 3 hours, and as pollen tubes have been met with, which attain that length or more after 3 hours growth in artificial culture, it might be said that the sugarcane pollen tube reaches the ovary in about 3 to 4 hours.

V. POLLEN STORAGE EXPERIMENTS.

The following experiments were conducted to ascertain the effect of exposing sugarcane pollen to various conditions, on its viability :—

- P. O. J. 2696 pollen, evenly spread in a watch glass and placed inside an oven, was subjected for 20 minutes to a series of temperatures ranging from 35°C. to 45°C. It gave no germinations when cultured in the normal way. Negative results were obtained when it was similarly treated at 50°C. and 60°C.
- P. O. J. 2696 pollen exposed to a temperature of 12°C. for 3 hours yielded 14.32 per cent. germinations, the maximum length of the pollen tubes being 1268 μ .
- P. O. J. 2696 pollen kept at 2°C. for 48 hours gave 0.4 per cent. germinations on culturing artificially.
- P. O. J. 2696 pollen when exposed to free atmosphere in the laboratory or to direct sunlight for more than an hour suffered in viability.
- Artificial cultures of P. O. J. 2696 pollen were subjected to temperatures ranging from 35°C. to 45°C. No germinations resulted. A second series was put at 12°C. and 14.32 per cent. germinations were obtained. On keeping another series at -2°C. the results were negative.

Weller's¹ attempts to germinate sugarcane pollen at atmospheric humidities controlled by sulphuric acid concentrations showed that, if exposed to relative humidities below 92 per cent., the sugarcane pollen grains shrivelled, evidently due to desiccation. This and the above experiments indicate that sugarcane pollen would keep best at moderately low temperatures (5° to 13° C.) and moderately high humidities. Knowlton² working with corn pollen also came to the same conclusion.

In 1927³ sugarcane pollen was stored alive for 96 and 168 hours in partial vacuum and corked and paraffined glass tubes respectively, at temperatures varying from 9° to 13° C. The pollen inside the glass tube was, however, found to have caked. It was thought that the caking might be due to incomplete sealing of the tube or to fungus growth. In 1928, glass ampoules were therefore substituted for the glass tubes. The ampoule tip was broken to allow the pollen in, after which the tip was sealed with the help of a blow pipe over a flame. For keeping the pollen at low temperatures varying from 5° to 13° C., galvanized iron box of a pattern used by Sandsten,⁴ was employed, the only difference being that a zinc rack to

¹ *loc. cit.*

² Knowlton, H. E. Studies in pollen, with special reference to longevity. *Cornell Univ. Agri. Expt. Sta. Mem.* 52, pp. 751-793, 1922.

³ Dutt, N. L. Longevity of sugarcane pollen. *Agri. Jour. India*, Vol. XXIII, Part VI, pp. 482-483, 1923.

⁴ Sandsten, E. P. Some conditions which influence the germination and fertility of pollen. *Wisconsin Univ. Agri. Expt. Sta. Res. Bull.*, No. 4, 1909.

accommodate ampoules was placed inside the inner box. The results were discouraging as the pollen inside the ampoules if allowed to remain in that condition for more than two days caked and subsequently turned into viscid liquid.

The idea in sealing pollen in ampoules was that the CO_2 content inside the ampoule would increase in course of time and with the lessening of metabolic processes by keeping the ampoules at low temperature, it was thought that these two conditions would be favourable for prolonging the viability of sugarcane pollen.

The negative results with the above arrangement led to the keeping of pollen over 85 per cent. relative humidity, in an atmosphere of CO_2 and at low temperatures varying from 5°C . to 13°C . This was done in the following manner. A watch glass containing pollen was placed on wire gauze inside a desiccator which had at the bottom a mixture of H_2SO_4 and water mixed in a proportion¹ to maintain the atmosphere at 85 per cent. relative humidity. The desiccator was connected to a CO_2 generating apparatus, the gas being passed through two wash-bottles, the first one containing water and the second $\text{Con. H}_2\text{SO}_4$, the object being to get dry CO_2 free from acid. After CO_2 had passed into the desiccator for about half an hour replacing the air inside the desiccator, both the tubings were tightly clamped and disconnected. The desiccator was then removed and placed inside a zinc box surrounded by ice and kept at temperatures varying from 5°C . to 13°C .

By the time the above method of pollen storage was decided upon, the flowering period of most of the varieties was nearly over. The pollen of Maur. 131, which was then available, was stored in the above manner. On the 13th day the pollen was removed and cultured artificially. The germinations worked out to 0.9 per cent. It has to be mentioned that in the fresh condition before putting up for storage, this pollen gave only a few germinations. Owing to the unavailability of pollen as the season was almost over, the experiment could not be continued.

VI. DISCUSSION OF RESULTS.

Earlier work on sugarcane pollen by the writer showed that for artificial germination, sugarcane pollen is very sensitive to moisture and that the concentration of sugar in the medium, the size and air-proof nature of the moist chamber had to be very exact. The experiments reported under Section III of the present paper indicate that sugarcane pollen would grow over a comparatively wide range of sugar concentrations, or in distilled or filtered rain water alone; and that to secure germinations an air-proof moist chamber consisting of a glass ring 17 mm. in diameter and 7.5 mm. high properly vaselined at top and bottom, is not an absolute prerequisite. This is at variance with the impression that for artificial germination the pollen of grasses requires exact sugar concentration.

¹ Wilson, R. E. Humidity Control by means of sulphuric acid solutions, with critical compilation of vapour pressure data. *Jour. Ind. and Eng. Chemistry*, pp. 326-331, 1921.

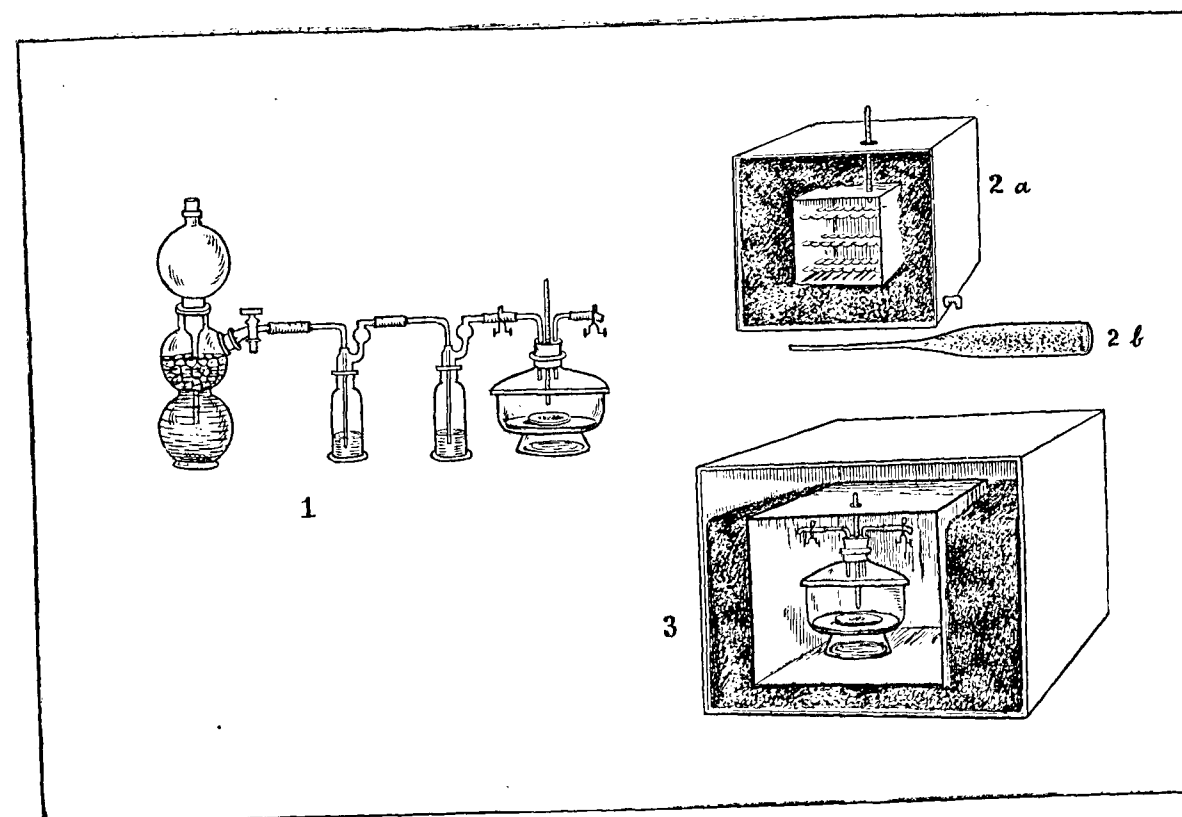


Fig. 1. Showing Kipp's apparatus for generating CO_2 and washbottles containing water and H_2SO_4 . The desiccator contains pollen over a mixture of water and H_2SO_4 (85% relative humidity).

Fig. 2a. Zinc box containing ice. The inner box contains rack for ampoules.

Fig. 2b. Glass ampoule.

Fig. 3. The desiccator in fig. 1 placed inside the box containing ice.

Best germinations were secured when 26 per cent. sugar plus 0·7 per cent. shred agar was employed, but even the pollen of varieties which usually gave good germinations when cultured artificially with this medium, sometimes yielded negative or very inconsistent results, and it was at one time felt whether artificial germination was at all any use as a pollen viability test and whether it would not be best to rely upon fertilization tests alone. It is true that conditions under artificial culture do not approximate those found on the stigma or inside the style, but as the physiology of pollen germination is the same in both the cases, and inasmuch as pollen tubes, comparable in length to the length of the sugarcane pistils, have been secured *in vitro* this method of attacking the physiology of pollen may not be entirely without use.

That pollen tubes about 1029 μ in length were secured by using distilled water indicates that, given the proper moisture in the stigma to start germination, there is enough reserve food material in the sugarcane pollen grain to carry the tube more than one-third way down the style.

The artificial culture of fresh Maur. 131 pollen yielded 5 per cent. germination in the 1926 season, 22 per cent. in 1927 and 2·1 per cent. in 1928. This once again brings out the fact that for artificial germination of sugarcane pollen it has not been possible to bring all the factors under control. Maur. 131 pollen, stored in an atmosphere of CO₂, over 85 per cent. relative humidity and at temperatures varying from 5°C. to 13°C. gave 0·9 per cent. germination when cultured artificially after 12 days' storage. Its fertilizing ability by dusting over a pollen sterile variety could not be tested as the flowering season was almost over. It is well known that the capacity to germinate under artificial conditions does not indicate that the same pollen will be capable of fertilizing the ovule, while, on the other hand, the pollen which failed to germinate artificially has been found to effect fertilization after a long time, suggesting that the fertilizing ability may outlast the power to germinate under artificial conditions.

VII. SUMMARY.

(1) In the fresh and dry condition sugarcane pollen varies in size from 38·25 μ × 42·75 μ to 67·5 μ × 72·0 μ . It contains about 48 to 51 per cent. moisture.

(2) Sugarcane pollen was found to germinate in quite a wide range of sugar concentrations or distilled or filtered rain water alone. Filtered rain water could without detriment be substituted for distilled water as solvent in the medium. A definite sized ring and air-proof condition of the moist chamber are not absolute pre-requisites. Best germinations were, however, obtained by using 26 per cent. commercial sugar plus 0·7 shred agar.

(3) The maximum length attained by a sugarcane pollen tube under artificial culture was by a P. O. J. 2696 pollen, when the tube measured 2921 μ after 3 hours, and as the sugarcane pistils measure less than this (between 1/12 and 1/10 of an

inch) it may be said that under favourable conditions the sugarcane pollen tube would reach the ovary in about 3 to 4 hours.

(4) Maur. 131 pollen was stored alive for 12 days over 85 per cent. relative humidity, in an atmosphere of CO₂, and at temperatures varying from 5°C. to 13°C.

The writer is indebted to Rao Bahadur T. S. Venkatraman B.A., I.A.S., Government Sugarcane Expert, for valuable suggestions. Sub-assistants K. Achuthan Nambiyar and T. R. Venkatraman helped in conducting the tests.

A SIMPLE METHOD OF STORING FOOD-GRAINS FOR HOUSEHOLD PURPOSES.

BY

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IN COLLABORATION WITH

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ON account of the very humid conditions during the monsoon months at Pusa, it is well nigh impossible to store and keep in sound condition food-grains of any kind. It is a serious problem which confronts every householder here. Wheat, rice and maize are badly attacked by the weevil *Sitophilus (Calandra) oryzae*, Linn. and the Bostrichid beetle, *Rhizopertha dominica*, Fb.; gram, *tur (Cajanus indicus)* and other pulse grains by Bruchids, chiefly *Bruchus chinensis*, Linn. As these insects are more or less cosmopolitan in their distribution, this trouble is also common to various countries. Several control methods have been tried in different localities, but everywhere workers agree that the best method is to fumigate the grains with a poisonous chemical fumigant, such as carbon bisulphide, and then store them in insect-proof receptacles. But the adoption of this method is not an easy matter in Indian households, firstly, because the handling of such a highly inflammable substance by unskilled people is fraught with serious danger, and secondly, the purchasing of insect-proof receptacles is beyond the means of many householders. There was consequently an urgent call to find out a simple and, at the same time, an efficient method for the storage of food-grains in Indian households.

Dr. Kunhi Kannan mentions (*Proc. Third Entom. Meeting, Pusa, 1919*) that in Mysore *raiya*s place a drop of mercury in an excavated soap-nut and put it in the receptacle used for storing pulses, but the practice seems to have died out practically. Later, the writer, while touring in North Gujarat, came to learn that the same practice was extant in those parts also to a certain degree. Knowing that local Indian agricultural practices are based on experience and observations of generations and centuries, it was decided to give trials to this method of storing grains. In place of an excavated soap-nut for holding the mercury ordinary cow-dung was substituted, which is decidedly a more porous material, and consequently allows mercury vapour to pass out much more easily. A small quantity of fresh dung was taken and rolled into a small ball about an inch in diameter. With the little finger pressing down a cavity or depression was formed and in it was poured

a very small quantity of mercury. An idea of the quantity of mercury used can be had from the fact that nearly two hundred cow-dung balls were filled with a pound of mercury.

The writer stores about twenty maunds of wheat every year for his use, and of this nearly one-fifth the quantity was badly damaged by weevils year after year. Empty kerosene oil tins were used for storage, and sun-dried wheat poured into them through a circular aperture on the top. The aperture was then closed with a piece of cloth and plastered over with wet clay, the tins being opened and contents removed, as required. In the storing season of the year 1925 (third week of May) wheat was stored in tins in exactly the same way as before, with the exception that in each tin were distributed six mercury-cow-dung balls. The greatest amount of damage by *Sitophilus* (*Calandra*) or *Rhizopertha* occurs at Pusa between the months of August and November-December, but the wheat in these tins remained perfectly sound during this period. A couple of tins, which remained unused till the following May, on opening showed that not a single grain in them was injured by insects. And these tins are lying to this day (February 1929) in the same good condition. Wheat was stored again by this method in the year 1926 by the writer and a couple of his friends whom he induced to follow his example, and results in all the cases were equally gratifying.

At this stage it became necessary to ascertain the action of mercury or to be exact, of mercury vapour, on insects which attack stored grains. Dr. Kunhi Kannan's experiments had proved that "the action was on the eggs of the beetles which are usually laid on the top surface of the pulses." The writer started a series of experiments to observe the effect of mercury vapour on eggs of various insects belonging to different families, irrespective of the consideration whether they were stored-grain pests or otherwise. The results obtained not only corroborate Dr. Kunhi Kannan's finding, but reveal two more facts. First, that the eggs in which the embryo is sufficiently developed and consequently are to hatch out in a day or so are not adversely affected; secondly, that mercury vapour is equally effective against eggs that are laid inside the grains, as against those that are laid exposed on the top. The eggs of *Sitophilus* (*Calandra*) are generally laid buried in the grain and when wheat, in which weevils were breeding freely, was placed under mercury vapour all further multiplication of the pest ceased. It was also observed that in one jar in which wheat was stored under mercury vapour and ten living weevils were liberated periodically, no breeding of the pest took place, while in the control jar breeding, when started, went on briskly. This experiment was repeated with gram and Bruchids; the result was similar.

In the course of experiments referred to above, it was noticed that whenever the mercury-cow-dung balls got jerked, at the time of examining wheat, small droplets of the heavy metal oozed through the porous dung and remained in the grains. Although the grains, whether they be of wheat, maize or gram, are thoroughly sun-dried and winnowed before they are ground, and thus all free mercury got

rid of, yet it was considered by some that the use of free mercury in grains, stored for consumption, was dangerous for the health of consumers. It was, therefore, thought necessary to use mercury in some other form, equally effective, yet free from danger. The question was referred to the Physical Chemist of the Institute in collaboration with whom all further work was done.

It is well known that mercury combines with several metals forming what are called amalgams. They are, in fact, solutions of metals in mercury and vary in consistency from semi-liquid to solid, depending upon the ratio of mercury to metal. In accordance with the law of solutions, an amalgam has got a lower vapour pressure than pure mercury; in other words, the former gives fewer particles of mercury to the air than the latter, in an enclosed space. In an amalgam, therefore, we have two important advantages over free mercury, for storing grains; first, its paste-like consistency which makes it easier to handle; and second, its reduced vapour pressure which renders it practically harmless.

Three different kinds of amalgams were prepared, viz., of zinc, copper and tin, and of these the last one was found to be the most suitable on account of the ease with which it is prepared and handled. Two parts of tin and three of mercury are rubbed together with a pestle and mortar, until the whole forms one homogeneous mass of a paste-like consistency. It is then squeezed in a piece of linen, removing any mercury droplets that may ooze out. The process of amalgam formation is quicker if the tin is in the form of thin strips, which can be prepared by melting tin in an earthenware crucible and then pouring and spreading it over a flat surface. The thin plate thus obtained can be cut into small pieces of convenient size.

In 1927 nearly sixteen maunds of wheat were stored in kerosene tins using tin amalgam instead of free mercury. The quantity of amalgam used per tin was roughly half an ounce, flattened into a disc with a diameter of three inches. The disc was enclosed in a filter paper envelope, and placed a little below the top layer of the grains. The tins were placed in a room, which could not be called free from *Sitophilus*, *Rhizopertha*, or *Tribolium*, as gunny bags of wheat stored there in the previous year, without any treatment, were heavily infested with these pests.

At the same time, experiments were started in the laboratory also, to see the effect of amalgam on the eggs of different insects, and a few typical cases are cited below :—

Pyrrilla sp. (Rhynchota, Fulgoridae).

Date	Under tin-amalgam vapour	Under mercury vapour	Without amalgam or free mercury, i.e., control
8th August 1927	46 eggs placed . .	46 eggs placed . .	46 eggs placed.
12th August 1927	not hatched	not hatched	Pinkish eyes of the nymphs noticeable within the egg shell.
14th August 1927	Ditto	Ditto	24 nymphs counted inside the jar.
15th August 1927	Ditto	Ditto	all hatched.
20th August 1927	Ditto	Ditto	

Scirpophaga nivella (Lepidoptera, Pyralidæ).

Date	Under tin-amalgam vapour	Under mercury vapour	Without amalgam or free mercury, i.e., control
10th August 1927	One egg mass placed	One egg mass placed	One egg mass placed.
12th August 1927	not hatched	not hatched	Several tiny larvæ are seen inside the jar.
15th August 1927	Ditto	Ditto	Numerous larvæ.
20th August 1927	Ditto	Ditto	.
24th August 1927	Ditto	Ditto.	

A Pentatomid bug (Rhynchota).

10th August 1927	8 eggs (pinkish coloured) placed.	8 eggs placed	8 eggs placed.
12th August 1927	Not hatched	Not hatched	Not hatched.
14th August 1927	Ditto	Ditto	} All hatched. 8 Pink coloured young nymphs are seen in the jar.
20th August 1927	Ditto	Ditto	

Thyrassia subcordata, Wlk. (Lepidoptera, Zygaenidæ).

8th August 1927	4 eggs placed	4 eggs placed	4 eggs placed.
10th August 1927	Not hatched	Not hatched	Not hatched.
11th August 1927	° Ditto	Ditto	All hatched.
13th August 1927	Ditto	Ditto.	
15th August 1927	Ditto	Ditto.	

The above experiments clearly showed that the amalgam was just as effective in killing eggs of insects as free mercury, and this was further confirmed when wheat, stored in tins with the amalgam, was found on examination free from insect attack.

It has been mentioned above that the tin amalgam was placed in filter paper envelopes, but the type of container to be used is largely a matter of choice and availability; the essential point about it is that it must be porous. Folds of filter paper, linen bags, and extraction thimbles have all been used with equal success. Another point about the amalgam which should be borne in mind is that, for the attainment of the best results, it is very necessary to spread out the amalgam, so that the surface available for giving out mercury vapour is as large as possible.

In 1928 wheat was stored in tins without either mercury-cow-dung balls or amalgam and although the tins were placed in a room where no wheat or cereals of any kind had ever been stored before, yet the wheat was badly attacked.

In order to see if mercury vapours are absorbed by wheat to any appreciable extent, a weighed quantity of pure mercury contained in a weighing bottle was kept with fourteen seers of wheat for five months in a sealed stoneware container. The loss of weight was 6.5 milligrams. Taking the average temperature as 20°C.

and the volume of air space as 5 litres, the amount of mercury vapour that would be required to saturate the total space would be equal to 35 milligrams roughly, (calculations based on the extrapolated values of vapour pressure of mercury at different temperatures). It would seem, therefore, that the amount of mercury lost is just sufficient to saturate only one-fifth of the total air space, and therefore there could not have been any appreciable amount of mercury absorbed by the wheat grains themselves.

In this connection the experiments of Coolidge on the absorption of mercury vapours by charcoal may be recalled (*J. A. C. S.* Vol. XLIX, p. 1949 (1927)). He found that at room temperature the absorption was negligible. If a substance like charcoal does not absorb any mercury vapour, it is extremely unlikely that wheat grains will do so.

There remained two more important points to investigate, namely, first, the residual effect of mercury vapour on stored grains—stored either for consumption or for seed purposes—and secondly, the range of sphere of action of mercury vapours. Experiments regarding the first point were started sometime ago, but the results are not yet conclusive. They have shown, however, that grains which remain under mercury vapour for one storing season, on exposure to air and sun for an hour or more, become so harmless for the beetles that they begin freely to breed in them, as if the grains had never been under the influence of mercury. As regards the effect on the health of consumers of such grains, it will be enough to mention that a very large quantity of wheat, about sixty maunds, stored under mercury vapour has been used in one family and about twenty-eight in others, during the past three years, without any untoward effect on the health of the consumers. Regarding the effect on the germinating power of wheat, the following tests were carried out. The grains used in the tests were out of lots which had remained under mercury vapours for previous seventeen months.

Date	With free mercury 100 grains	With tin amalgam 100 grains	Without mercury (control) 100 grains	REMARKS
Pusa Wheat No. 12, 7th November 1927 to 12th November 1927.	85	77	77	germinated.
Pusa wheat No. 4, 10th November 1927 to 14th November 1927.	92	92	75	germinated.
Pusa wheat No. 12 (Repeated), 19th November 1927 to 23rd November 1927.	79	73	73	germinated.

It will be seen from the above that mercury vapour had no deleterious effect on the germinating power of wheat grains. If anything, there was perhaps a slight

indication of stimulation. This was further corroborated when wheat (Pusa 4) stored, with and without amalgam, was sown in side by side plots, and the germination in both the plots was found equally good.

Experiments regarding the second point, i.e., range of sphere of action, have not yet been undertaken. It is hoped that work on this will be started during this year, and the results obtained will be of great use in solving the problem of bulk storage. For household purposes, food grains can be stored safely with a small quantity of tin amalgam, in empty kerosene tins or similar receptacles which can hold small quantities of grain, say seventeen or eighteen seers, and can be covered or closed on the top. The chief merit of the method lies in the facts (1) that it is not at all necessary to make the grains insect-free before storage, for, when adult insects from already infested material will emerge, pair and lay eggs, the eggs will never hatch, and thus all further breeding of the pest, or pests, will automatically cease; (2) that tin amalgam is not difficult to prepare or handle, and (3) that the amalgam can be used over and over again, year after year, as there is no appreciable wastage of the material due to either evaporation or usage.

STUDIES IN INDIAN CHILLIES.

(2) THE ROOT-SYSTEM.

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INTRODUCTION.

A thorough knowledge of the root habit is of very great value in the improvement of crops by selection. The work carried out by various investigators in recent years has shown that although the general form of the root is very responsive to environmental factors such as climate, soil, tillage and moisture, etc., yet it is also governed by heredity. The Howards and Abdur Rahman Khan^{1 2 3} have published a very interesting account of the root systems of many crops, e.g., gram, wheat, linseed, etc., grown at Pusa. Their investigations indicate that in the unit species of a crop growing under uniform conditions quite distinct kinds of root systems develop in different unit species or types. The present investigation into the root habits of various types of chillies grown in the Botanical Area at Pusa is intended to add further to our knowledge of this subject.

Root-systems of 50 out of the 52 types of chillies isolated by Shaw and Abdur Rahman Khan⁴ were examined. Two representative plants of each of these types, or even three in some cases if considered necessary, were examined for the purpose. The method followed was the same as hitherto employed in similar investigations carried out previously in the Botanical Section, viz., a trench was excavated at about

¹ Howards and Abdur Rahman Khan. *Mem. Dept. Agri. India, Bot. Series*, Vol. VII, No. 6, Dec. 1915.

² Howards. The economic significance of the root development of agricultural crops. *Agri. Jour. India*, Vol. XII (Indian Science Congress Number), 1917, p. 17.

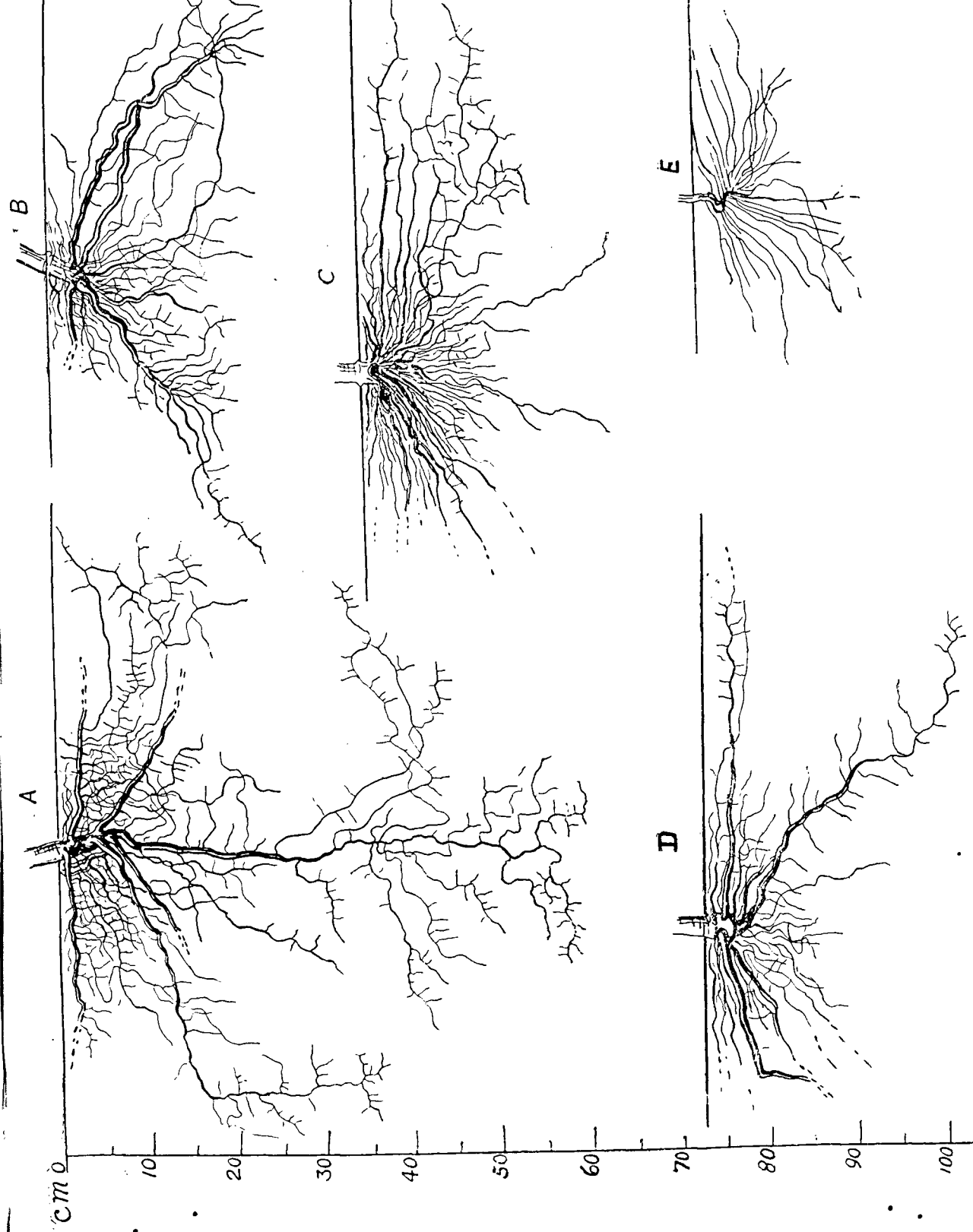
³ Howard, G. L. C., and A. R. Khan. *Mem. Dept. Agri. India, Bot. Series*, Vol. XII, No. 4, Jan. 1924.

⁴ Shaw, F. J. F., and A. R. Khan. *Mem. Dept. Agri. India, Bot. Series*, Vol. XVI, No. 2, Sept. 1928.

2 feet away from the plants and the position, extent, degree of branching and other root characters were observed by gently spraying away the soil to uncover the root-system by means of a Knapsack sprayer. The work was much facilitated by the friable and more or less open nature of the soil. Even the very delicate roots were exposed and traced without much difficulty. The soil is an alluvial calcareous loam of medium quality and was in a very good tilth and absolutely free from any weeds. It lay fallow since April 1928 after the removal of *rahar* (*Cajanus indicus* Spreng). During the "fallow" the soil had received thorough cultivation and was manured with superphosphate and rape cake, at the rate of 2 md. and 40 md. per acre respectively, before the crop was transplanted on 19th September 1928. After the transplanting of the chillies, the soil received no treatment other than being occasionally stirred with a view to keep off weeds and to preserve soil moisture. No artificial irrigation was given to the crop, but the plants did not seem to suffer from drought at any stage of their development. The amount of monthly rainfall recorded in the Botanical Area, from April 1928 since the land lay fallow till January 1929 when the crop of chillies was ready for harvest, is as follows :—

Month	Amount of rainfall in inches
April 1928	0.02
May 1928	0.96
June 1928	3.40
July 1928	14.05
August 1928	24.64
September 1928	2.81
October 1928	6.10
November 1928	0.00
December 1928	0.14
January 1929	1.27
TOTAL FOR 10 MONTHS	53.39

It can definitely be stated that the conditions on the whole were quite favourable for the normal development of the plants. The study of the root-systems was started early in January 1929, when the plants were full grown and were bearing fruits. Pencilled drawings were made in the field, and in these drawings (Plate XXIV) the extent, position and the branching of roots is represented to as nearly exact measurements as could be made. Many details were recorded with regard to the number of prominent branches and their thickness, etc. It was not found possible to depict exactly in the drawings, the condition of the root habit of certain types, on account of the difficulty afforded by the very fine enormous fibrous roots which formed a considerable part of their root-system. Effort has therefore been made to describe each kind of root-system in such details as may make the reading of the sketches easier and more instructive.



A GENERAL DESCRIPTION OF THE ROOT-SYSTEM IN CHILLIES.

Chillies are usually propagated by transplanting the seedlings. The primary root is apt to be more or less damaged during the process of transplanting. From the study of the root-systems of 50 types of chillies, it appears that the primary root does not grow sufficiently to form an important part of the root-system. Only in three, out of fifty types examined, did the primary root continue to grow to a sufficient depth to be called a tap-root; and even in these cases it was not as prominent as many of the secondary roots which generally arise from it at a point a few centimeters below the soil-surface. In all the remaining 47 types the primary root does not grow beyond 7 to 10 cm. below the soil-surface and a large number of more or less prominent secondary roots originate from the region of the main axis just below the soil-surface. These secondary roots spread in all directions forming a prominent fibrous root-system. Strictly speaking, however, the first three types above referred to have a tap root-system, and are described as such in the description of the five kinds of root-systems given below.

DESCRIPTION OF THE VARIOUS KINDS OF ROOT-SYSTEMS.

A. *Deep Tap Root-System.* (Sketch A.)

In this system the primary root continues to grow down for about 60 cm., giving off laterals all through its length. The prominent secondary roots, however, originate from the first few centimeters of the tap root below the soil surface. A few of these secondary roots are even more prominent than the primary root itself. These prominent secondary roots after extending more or less horizontally to a distance of about 30 cm. tend to grow downwards. The majority of these secondary roots are restricted to about the first 20 cm. below the soil surface, although some of them have been traced even up to a depth of about 40 cm. The less prominent roots, both secondary and tertiary, however, are much more numerous and spread within a radius of about 15 cm. and are generally confined to about the same distance below ground. The average number of secondary roots measuring between 0.15 to 0.60 cm. in diameter is from 10 to 15. This kind of root-system was observed only in two out of the fifty types of the chillies examined for this purpose.

B. *Shallow Tap Root-System.* (Sketch B.)

The tap root in this kind of root-system does not go as deep as the one in A above, but was found to confine itself within about 25 cm. below the soil surface. The number of secondary roots is much less than that in A. None of the secondary roots have been traced beyond a depth of about 30 cm., the majority remaining confined within a radius and depth of about 15 cm. or even less. The number, extent, and thickness of their roots is, on the whole, much less than that in A just des-

cribed. The number of secondary roots measuring from 0.15 to 0.25 cm. in diameter was found to be only from 5 to 10. Only one out of the fifty types of chillies formed this kind of root-system.

C. *Extremely Vigorous Fibrous Root-System.* (Sketch C.)

The tap root in this system does not grow more than a few centimeters in length and there are innumerable secondary roots shooting out profusely from it in all directions up to a radius of about 40 cm., but the majority of these confine themselves to a radius of about 25 cm. and are restricted to a depth of about 12 cm. The more prominent of these secondary roots, after continuing to grow more or less horizontally up to a distance of about 20 cm., tend to go down and some of these have been traced up to a depth of about 30 cm. The finer secondary roots, although relatively short, are numerous and well branched forming a very efficient absorbing system. The number of prominent secondary roots was found to be generally from 20 to 60. This kind of root-system has been met with in 28 out of the 50 types of chillies examined.

D. *Moderately Vigorous Fibrous Root-System.* (Sketch D.)

This root system more or less resembles the one just described but differs from it mainly in the amount of the finer secondary fibrous roots which are very much less, so that the roots cover on the whole much less area and the absorbing system is less efficient than that in C. Fourteen types fall into this kind of root-system.

E. *Shallow Fibrous Root-System.* (Sketch E.)

In this kind of root-system there is no tap root and the secondary roots are much less in number and thickness. The majority of these are confined only to the first 10 cm. or so below the soil surface and up to a radius of about 15 cm. A few of them, however, extend up to a length of about 20 cm. The number of prominent roots measuring from 0.15 to 0.30 cm. is only from 5 to 10. On the whole, this root-system is extremely poor and superficial, covering a very small area of the soil. Only 5 types come under this kind of root-system.

RELATION BETWEEN ROOT AND SHOOT DEVELOPMENT.

In order to establish whether any relation exists between the root and shoot development, the behaviour of roots of all the fifty types examined, has been compared with the following characters of their shoots :—

- (a) Height. The types have been grouped into two classes, viz., tall and short, according as the plants grow above or below 50 cm. in height.
- (b) General habit and branching. Certain types are well spreading at top and others are more or less erect; again some types are profusely branched, while some are sparsely so.

- (c) Time of maturity. The types have been classed as early, medium and late.
- (d) Bearing power. Three terms, viz., prolific, moderate and poor have been used for the different types in accordance with the relative amount of fruits borne by the plants, as could be judged from their inspection in the field.

The characters above referred to have already been described by Shaw and Abdur Rahman Khan and we have made use of their description as far as possible in the statement given below. Slight modifications, however, have been made with regard to certain points in view of the observations made in the field this year, for example, the height of plants in a few types was a little more or less than that published by them in the Memoir.

Statement showing the main shoot characters of the various types of chillies having different root-systems.

Kind of root-system	Type No.	General habit of plant above ground	Maturity	Bearing	REMARKS
A. Deep tap root-system .	1	Tall, profusely branched, spreading at top.	Late .	Prolific .	Perennial type.
	2	Ditto . . .	Do. .	Do. .	Do.
B. Shallow tap root-system .	14	Tall, sparsely branched more or less erect.	Late .	Poor .	Exceptionally big fruits.
C. Extremely vigorous fibrous root-system.	3	Tall, profusely branched, spreading at top.	Inter .	Moderate.	
	5	Ditto . . .	Do. .	Prolific.	
	9	Ditto . . .	Early .	Moderate.	
	10	Ditto . . .	Inter .	Do.	
	11	Ditto . . .	Do. .	Do.	
	12	Ditto . . .	Early .	Prolific.	
	18	Ditto . . .	Do. .	Do.	
	19	Ditto . . .	Inter .	Do.	
	20	Ditto . . .	Early .	Moderate.	
	22	Ditto . . .	Do. .	Prolific.	
	24	Ditto . . .	Do. .	Do.	
	25	Ditto . . .	Do. .	Do.	
	26	Ditto . . .	Do. .	Do.	
	27	Ditto . . .	Late .	Do.	
	29	Ditto . . .	Do. .	Do.	
	31	Ditto . . .	Early .	Moderate.	
	34	Ditto . . .	Do. .	Prolific.	
	35	Ditto . . .	Do. .	Do.	

Statement showing the main shoot characters of the various types of chillies having different root-system—concl'd.

Kind of root-system	Type No.	General habit of plant above ground	Maturity	Bearing	REMARKS
C. Extremely vigorous fibrous root-system.	38	Tall, profusely branched, spreading at top.	Late .	Prolific.	
	39	Ditto . . .	Do. .	Do.	
	41	Ditto . . .	Early .	Do.	
	42	Ditto . . .	Late .	Moderate.	
	44	Ditto . . .	Do. .	Do.	
	47	Ditto . . .	Inter .	Do.	
	48	Ditto . . .	Late .	Prolific.	
	49	Ditto . . .	Do. .	Moderate.	
	51	Ditto . . .	Early .	Prolific.	
	52	Ditto . . .	Late .	Do.	
D. Moderately vigorous fibrous root-system.	4	Tall, sparsely branched, more or less erect.	Inter .	Moderate.	
	6	Ditto . . .	Early .	Do.	
	7	Ditto . . .	Do. .	Do.	
	8	Tall, profusely branched, spreading at top.	Do. .	Do.	
	13	Ditto . . .	Do. .	Do.	
	21	Tall, sparsely branched, more or less erect.	Late .	Do.	
	28	Tall, profusely branched, more or less straggling.	Early .	Prolific.	
	32	Tall, profusely branched, spreading at top.	Do. .	Moderate.	
	33	Tall, sparsely branched, more or less erect.	Inter .	Prolific.	
	36	Tall, sparsely branched . .	Early .	Do.	
	40	Tall, rather profusely branched, spreading at top.	Inter .	Moderate.	
	45	Tall, profusely branched, spreading at top.	Do. .	Prolific.	
	46	Tall, sparsely branched, spreading at top.	Early .	Do.	
	50	Tall, profusely branched, spreading at top.	Late .	Moderate.	
E. Shallow fibrous root-system	15	Short, sparsely branched, straggling.	Inter .	Poor.	
	23	Short, sparsely branched, not spreading.	Early .	Do.	
	30	Short, sparsely branched, straggling.	Late .	Do.	
	37	Short, sparsely branched, more or less erect.	Do. .	Do.	
	43	Short, sparsely branched, straggling.	Inter .	Do.	

A close study of the above statement brings out the following facts regarding the relation of root to shoot in chillies :—

- (a) The deep tap root-system is only met with in two types which are known as perennial and belong to the species *Capsicum frutescens* Willd., which is quite different from the common species *Capsicum annuum* Willd. to which all the other types belong. The shallow tap root-system is found only in one type which has exceptionally big fruits. Comparing these two kinds of tap root-system, the deep-rooted one is decidedly the more vigorous (sketches A and B) and is associated with the tall profusely branched habit of the plants above ground and also with their prolific nature. The shallow tap root-system is, on the other hand, associated with a type sparsely branched and having a poor bearing capacity.
- (b) The extremely vigorous fibrous root-system has been met with in plants of 28 types, all of which are tall, profusely branched and spreading at top. The majority of these types are noted to be prolific and the others are moderate in bearing. This clearly shows that this type of root-system has a close correlation with the vigorous habit of shoot and the prolific nature of the plant. This kind of root-system (sketch C) appears to be an ideal one for the chilli crop under the conditions prevalent. It occupies the soil to a sufficient depth and throughout a sufficient radius to secure enough water and nutrients, to promote a good growth at all times and being associated with a vigorous development of the shoot maintains that proper balance between root and shoot which is very essential from the point of view of heavy crop production.
- (c) The moderately vigorous fibrous root-system includes 14 types of chillies. All these types are tall growing, but most of them are not profusely branched and spreading at top as were the characteristics of the types belonging to the previous root-system. There is no doubt, however, that a few types of chillies having their plants profusely branched and spreading at top are also met with in this kind of root-system, but the association of this root-system with the most vigorous type of shoot-growth cannot be closely established.
- (d) All the five types possessing the shallow fibrous root-system are short and sparsely branched or have a straggling habit. All of them are also poor in bearing. This kind of root-system (sketch E) is most undesirable and its association with the poor development of shoot is evident.
- (e) Several early, medium and late types of chillies have been found to belong to one and the same kind of root-system. The time of maturity is not, therefore, correlated with the root-habit.

SUMMARY.

1. Root-systems of 50 types of chillies have been studied.
2. Five kinds of root-system met with in chillies grown at Pusa have been described :—
 - (a) Deep tap root-system.
 - (b) Shallow tap root-system.
 - (c) Extremely vigorous fibrous root-system.
 - (d) Moderately vigorous fibrous root-system.
 - (e) Shallow fibrous root-system.
3. The relationship of the extremely vigorous fibrous root-system with the vigorous shoot-growth and the prolific nature of plants has been established.
4. The association of the shallow poorly branched root-system with the poor shoot-growth is made evident.
5. The earliness or lateness of a type shows no relation with the root-habit or the shoot-growth.

A PRELIMINARY STUDY OF THE POLLINATION OF THE ALPHONSO MANGO.*

BY

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THE subject of the pollination of the mango has attracted the attention of several workers in India, as well as abroad. The works of Burns and Prayag¹, and Wilson Popenoc² may be said to be the most important among these. The subject has been dealt with at length by these authors and the object of the present paper is only to supplement their observations with those made by the present writer on the famous Alphonso variety of Ratnagiri. The observations were made during the last three years as a part of a study of mango blight.

THE MANGO FLOWER.

The mango inflorescence, as described by the writer³ bears male or staminate and complete or hermaphrodite flowers, the male being much the more numerous. An individual flower has five sepals and five petals though occasionally flowers with four of each of these parts are found. The petals are inserted at the base of the fleshy, almost hemispherical, disc which is composed of five lobes. In the complete flower this disc is surmounted by a small round ovary with a slender, laterally inserted style. The andrœcium consists of from three to seven members, five being a common number. They are inserted upon the disc. They are all with the exception of the one opposite the style, small and rudimentary. The one fertile stamen has a filament a little shorter than the style and bearing a red anther. At times two of the stamens are fertile.

OPENING OF THE FLOWERS AND DEHISCENCE OF THE ANTHERS.

A number of flower-buds were kept under close observation to study their opening. Most of the flower-buds begin to open at night and are fully open by morning. A very few, however, are also found to open during the course of the day. In freshly opened flowers the discs are wet with honey secreted by them which serves to attract

* The author wishes to express his thanks to Dr. W. Burns, Principal, Agricultural College, Poona, for the help received from him in writing up the results.

¹ Burns, W., and Prayag, S. H. The Book of the Mango; *Bulletin* 103 (of 1920) of the *Bombay Department of Agriculture*.

² Popenoc, W. The Pollination of the Mango.—*Bulletin U. S. Department of Agriculture*, 1921.

³ Wagle, P. V. Studies in the Shedding of Mango Flowers and Fruits, Part I. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XV, No. 8 (1928).

insect visitors to the flowers. The dehiscence of the anthers begins at about 7 A.M. and is almost complete by 4 P. M. The bursting of the anther lobes takes place longitudinally. Just after dehiscence, the anther lobes turn blackish and the white pollen grains can be seen against the black surface under a hand-lens. The dehiscence took place as follows :—

TABLE I.
Dehiscence of anthers.

Date of observation	No. of flowers observed	7 A.M.	NUMBER OF ANTHERS DEHISCED UP TO				After 4 P.M.
			9 A.M.	11 A.M.	2 P.M.	4 P.M.	
4-2-28	37	2	19	31	36	37	..
10-2-28	39	2	22	28	31	37	39
11-2-28	84	4	62	77	84	..	..
13-2-28	82	7	56	71	82	..	..

It will be seen from these figures that the dehiscence mostly takes place between 8 A.M. and 11 A.M. A few anthers, however, burst before the flowers open.

POLLINATION.

With the bursting of the anthers, pollination begins. As described by Popenoe, from the well-developed adaptations in the flower to insect pollination, the mango appears to be mainly entomophilous. Wind also appears to play some part. To determine how far each is responsible for the pollination, we can compare the figures of fertilization in flowers which were open with the figures of those bagged to exclude all insects. Twenty inflorescences were taken for each experiment. Bags of two types were used, viz., (1) of fine muslin cloth which excluded all insects as well as movement of air and (2) of fine meshed mosquito curtain cloth which excluded only the insects. The following results were obtained.

TABLE II.

Effect on fertilisation of the exclusion of insects and movement of air by bagging.

Treatment	No. of complete flowers	PERCENTAGE OF	
		Flowers unfertilised	Flowers fertilised and set
Open inflorescences	2151	53.46	46.54
Bagged in muslin cloth	650	87.54	12.46
Bagged in mosquito netting	3383	78.51	21.49

These figures distinctly show the action of the movement of air and the part played by insects in pollination. In the absence of experiments to determine whether pollen travels in the air or can be blown through a mosquito net, it is, however, not possible to say what proportion of success to attribute to the better circulation of air within the mosquito netting. This point will be investigated in the next season. The insects are mostly bees, ants, and flies. The figures also emphasize the very large amount of unfertilised flowers even in spite of the presence of the pollinating agencies. The setting of fruits in the bags shows that self-pollination is possible in mangoes.

With a view to finding out the best time for pollination in the course of the day on which the flower opens, the stigmas of the flowers were examined from time to time under the microscope and the numbers of pollen grains deposited on them were counted. The following table gives details of the observations :—

TABLE III.

Pollen grains on the stigmas at different times on the day of the opening of the flower.

Time	Date	No. of stigmas examined	No. without pollen grains	No. OF STIGMAS WITH THE FOLLOWING NUMBER OF POLLEN GRAINS.										
				1	2	3	4	5	6	7	8	9	10	Above 10
7 to 8 A.M. .	28th January 1928	25	25	..	..	..	..	..	..	..	..	..	..	..
Do. .	31st January 1928	28	28	..	..	..	..	..	..	..	..	..	..	..
Do. .	4th February 1928	25	23	3	..	..	..	..	..	..	..	..	..	..
9.30 to 11 A.M.	28th January 1928	10	4	3	1	1	..	..	..	..	..	1	..	..
Do. .	4th February 1928	22	15	3	2	2	..	..	..	..	..	..	..	..
Do. .	7th February 1928	12	9	1	..	1	..	..	..	..	..	..	..	1
Do. .	10th February 1928.	13	9	4	..	..	..	..	..	..	..	..	..	..
Do. .	13th February 1928.	16	14	1	1	..	..	..	..	..	..	..	..	..
3.30 to 5 P.M.	24th January 1928	10	5	3	1	1	..	..	..	..	..	..	..	..
Do. .	13th March 1928 .	22	11	3	2	4	1	..	..	1	..	..	..	..

It can be seen from these figures that almost no pollination takes place before 8.0 A.M. By 11.0 A.M. nearly one-third of the flowers are pollinated and by 5 P.M. nearly half the number.

A few stigmas were also examined on the second and third day after the opening of the flower.

The following figures of pollination were obtained.

TABLE IV.

Pollen grains on the stigmas on the second and third day.

Time	Date	No. of stigmas examined	No. with-out pollen grains	NO. OF STIGMAS WITH THE FOLLOWING NUMBER OF POLLEN GRAINS										
				1	2	3	4	5	6	7	8	9	10	Above 10
Second day.	15th March 1928 .	30	18	10	..	1	1	..	..	..	..	..	..	..
Third day .	14th March 1928 .	23	14	2	4	3	..	..	..	..	..	..	..	..

The pollination has by no means increased on the second and third day of the opening of the flower. The pollination mostly takes place between 9 A.M. and 5 P.M. on the first day, as that is the time probably when there is lot of honey secretion in the flowers and a large number of insect visitors.

The number of pollinated flowers is nearly 50 per cent., which is almost in keeping with the figures of fertilised flowers found in nature, given in table II.

THE STIGMA.

The mango flowers are protogynous, i.e., the stigma comes into receptive condition even before the anther bursts. But how long it remains in that condition is not exactly known. In order to find this out, a few experiments were carried out. Several well-developed buds of hermaphrodite flowers were emasculated and enclosed in thin paper bags, the day previous to their opening, care being taken to see that the anthers had not already burst. The next day the bags were opened and some of them were pollinated with pollen collected on a glass slide from dehisced anthers by gently bringing the slide in contact with the stigma. The flowers were again bagged. Similar pollinations were tried on the second and third day after the opening of the flower, the flowers used being emasculated and bagged before operation and fresh pollen being used each time. After about a week, the bags were opened and the number of set fruits was noted. The results of several trials are given below.

TABLE V.

Effect of pollination on stigmas of different ages.

Age of stigma at pollination	Number tried	Number set	Percentage successful
First day, i.e., day of opening	31	24	77.4
Second day	31	13	41.9
Third day	30	8	26.6

Here it can be seen that the stigma was in receptive condition for all the three days, it however being in its best on the first day. It is not possible to say how much longer it remains receptive as no trials were made after the third day.

CROSS-POLLINATION.

It is not known how far crossing between varieties takes place in nature. In the gardens in this neighbourhood which mostly grow only the Alphonso variety of mangoes, pollination within the variety is naturally the rule. Popenoe¹ succeeded in getting a large number of fruits set by cross-pollination. A similar attempt was made by the author on a small scale. All the fresh flowers in a few inflorescences were pollinated with pollen collected on a glass slide from *Raival* or country mango trees, continuously for four or five days. The number of mature fruits obtained from them was also noted. The results as compared with the untreated inflorescences were found to be encouraging.

TABLE VI.

Effect of cross-pollination.

No. of flower heads under experiment	No. of flowers crossed	No. of mature fruits obtained
40	Nil.	15
9	318	9

No conclusions as to the value of cross-pollination can be drawn from these figures, but the fact that the Alphonso mango can be fertilised by *Raival* pollen is established.

SUMMARY OF CONCLUSIONS.

1. The dehiscence of the anthers of the Alphonso mango generally takes place between 8 A.M. and 11 A.M.
2. Insects play an important part in the pollination. Movement of air also helps pollination to some extent.
3. Nearly 50 per cent. of the complete flowers are unpollinated and unfertilized even in spite of the presence of these pollinating agencies.
4. Pollination mostly takes place between 9 A.M. and 5 P.M. on the day of the opening of the flower.
5. The stigma is in a receptive condition even for three days, but it is at its best on the first day only.
6. Pollination of the Alphonso mango with *Raival* pollen gives fruits.

¹ loc. cit.

SELECTED ARTICLES

THE MOISTURE REQUIREMENTS OF TROPICAL CROPS*.

BY

H. MARTIN LEAKE, Sc.D.

Of the requirements for plant growth under agricultural conditions only carbon dioxide, the source of starch and the sugars formed by the plant, is universally present in an abundance sufficient for unrestricted growth. Of other material requirements, soluble mineral salts and organic nitrogenous matter, the quantity present may be insufficient for vigorous growth, as the wide application of manures sufficiently indicates. But there are other, and as essential, requirements if free growth is to take place; of these the following are the more important.

The plant in growing incorporates into its structure the food material formed from the carbon dioxide of the air, as well as water and the salts dissolved therein which are taken up by the roots. The process is a chemical reaction which requires energy, and that energy is derived from light. Like most chemical reactions, too, it takes place only within definite limits of temperature, the optimum temperature varying with different species of plants, and the rate of formation of food material will, other conditions being favourable, vary with the temperature until that optimum is reached. The third essential is water or, better, humidity; for air humidity is as essential a factor as actual soil moisture. The plant is dependent on soil moisture not only as a medium to provide in solution the mineral requirements, but to maintain its tissues in a turgid, or unwilted, condition. It is dependent on air humidity not merely to limit the loss of water contained in the tissues, but to permit the access of carbon dioxide to those tissues in which that gas is converted into starch or sugar; for the mechanism by which the plant controls evaporation of the water contained in its tissues also controls the entry of carbon dioxide. When the evaporation of water is checked, the entry of carbon dioxide is likewise checked.

The essential difference between growth in the tropics and in temperate climates lies in the differences found in the incidence of these three factors, light, temperature, and humidity, under the two conditions. The seasonal variation in the length of day is less marked in the regions bordering on the tropics, and here light is not responsible for any marked seasonal variation in rate of growth, of which it is partly the cause in more northerly climes. Nor, as a rule, do the days of low light intensity,

so common in a country like England, occur in the tropics. Light may be said to be adequate within the range of the duration of the day, and it is removed from consideration as a factor limiting growth under tropical conditions.

Temperature, similarly, is adequate and rarely limits the growth of plants adapted to a tropical life. To discuss whether it ever exceeds the optimum, as it undoubtedly does in the case of a temperate plant transplanted into the tropics, would exceed the limits of the present subject, which deals with crops normally grown in the tropics. Such cases, if they occur, are sufficiently rare to be neglected here; moreover, where temperature appears to be excessive, further enquiry will probably disclose the fact that the real factor checking growth is air humidity; for really high temperatures, 110° F. and over, are associated with arid conditions.

Light and temperature thus being ruled out, humidity remains the main natural factor controlling plant growth in the tropics, and it is this essential simplification of the problem that lends importance to the study of the relation between the crop and humidity under tropical conditions. It is under these conditions that the study can be pursued freed from those complications which a deficiency of light or temperature superimposes.

Under natural conditions, humidity is dependent on local rainfall; and though exceptions occur in the case of floods, as in Lower Bengal, and under certain special and somewhat exceptional physiographical conditions to which reference will be made later, this may be considered the normal position. Rainfall is, however, a very variable factor, but it is a variability which takes more than one form. In the first place, there is the variability which exhibits itself as intermittence. In no country does rain fall continuously and steadily; it occurs in intermittent showers of greater or less duration and greater or less amount. In the second place, there is that variability which exists between the rainfall of different regions, and which exhibits a definite annual cycle. At one extreme no dry season is demarcated; periods of comparative drought only are to be distinguished from periods of comparative wet. Of such a nature are the regions with dense tropical forests characteristic of the equatorial belt. From these, with infinite gradations of an ever-increasing intensity of the dry season, are to be distinguished the regions with alterations of marked dry and wet, or monsoon seasons; and, ultimately, by a contraction in the duration of the wet season, the other extreme characterized by desert conditions.

It is this seasonal variability which determines the broad outlines of the agricultural practice of any particular region. In the wetter regions are grown such crops as rubber, cacao, and sugar, crops which take twelve months or more to arrive at maturity, and require continuous moisture; in the monsoon tracts are grown seasonal crops like cotton, maize, and simsim (sesamum), capable of arriving at maturity before the dry season sets in, and crops like coffee, tea, and sisal, perennial crops that is, but crops which are capable of withstanding a period of drought. The growth of crops like sugar may be extended into the monsoon area, where an artificial

* Reprinted from *Empire Cotton Growing Review*, V, No. 3.

supply of water is available for their maintenance throughout the rainless period. In this latter case the factor controlling growth may be air humidity. The main features of irrigation and its distinctive characteristics will be considered later.

It is not this seasonal variability, however, that is the main topic of this paper. The object is, rather, to consider that first class of variability which is illustrated by the intermittence of the rainfall. Everyone connected with agriculture is aware of the fact that the quantity of rain is not the only, or even the most important, feature. As important as quantity is distribution. Even in countries like England, where the rainfall is fairly evenly distributed and where individual falls are rarely heavy, the importance of distribution is obvious. In tropical countries, where the falls are commonly much heavier, the distribution becomes all-important. It is a common feature of the Indian monsoon to find that the best agricultural result is obtained from a definitely subnormal fall when this is well distributed. If, as is most desirable, it is attempted to measure the dependence of the crop on the rainfall—in other words, to determine the agricultural value of rain—clearly account must be taken of distribution as well as quantity. The figures of total annual rainfall are not only of little value, but may be actually misleading. At Cherrapunji, in the Assam hills, the annual rainfall averages over 400 inches, and sometimes exceeds 500 inches; yet it is a hill station with a five-month dry period when practically no rain falls. This may be compared with Rio with an average annual fall of some 40 inches. Yet the latter is a perennial garden in which all forms of tropical vegetation flourish. One of the heaviest falls in twenty-four hours, some 41 inches, is recorded in the dry area of Ceylon, while the heaviest fall in the writer's experience, some 21 inches in twenty-four hours, at Cawnpore, equals a somewhat low but totally adequate annual fall for the agriculture of the tract had it been well distributed.

Total annual rainfall was soon seen by those attempting to calculate the agricultural value of rain to offer no guide to the agricultural potentialities of a country, and efforts to arrive at that value have tended to place an increasing importance on distribution. The first serious effort in this direction is that of Rawson, a former Governor of Barbados and President of the Royal Statistical Society. In a report published in 1874 he analysed the rainfall data of that island, and calculated its influence on the sugar crop. He carried his analysis to the monthly aggregate falls without result, and reverted to the annual total. His very detailed analysis of the data, in a report occupying some 160 pages, may be summed up very briefly; he found that 1 inch of rain was responsible for 800 hogsheads of sugar in the crop yield of the following year. That he found such a relationship with the annual fall is due to the fact that the rainfall of Barbados is very equitably distributed. It is true a relatively dry period exists, but absolute drought is non-existent, while heavy rains—rains of more than 2 inches—are rare, and only associated with cyclonic disturbances which rarely touch the island. Rawson failed to identify a feature of

Barbados, to which reference will be made later, dependent on its geological formation and minimizing the effect of such drought as does occur.

Rawson's work antedates the more recent developments in statistical method which are the feature of the end of last and the current century, and further progress awaited that development. This method, the method of correlation, has formed the subject of an article in this journal by Yule and Engledow; it has been extensively employed to determine the dependence of crops on rainfall and, in temperate climates, on temperature. Detailed reference to this work is not possible here; summaries are to be found in papers by Melliash (*Quarterly Journal of Royal Meteorological Society*, 1910) and Hooker (*Journal of Royal Statistical Society*, 1907, and *Quarterly Journal of Royal Meteorological Society*, 1921). The basis of all these determinations is the division of the period of growth into a number of equal time intervals, varying from six days in some investigations to eight weeks in others. The aggregate fall for the corresponding period of successive years is taken and correlated with the yield, the process being repeated with each period into which the growth season has been divided. An outstanding example of work along these lines is that of Walter and also of Moore.

Walter applied the method to the sugar crop of Mauritius in 1910. His objective was primarily economic: an effort to work out a basis for the insurance of crops, more especially against the losses due to the cyclonic disturbances which visit that island so frequently. If the loss is to be gauged, some estimate must be made of the yield that would have resulted had the cyclone not struck the island. Though his results were striking, they were insufficient to convince the insurance companies concerned that they offered a basis for calculating risks, and the scheme fell through.

Moore, applying the same method to the rainfall and temperature data of the cotton belt of the Southern States of America, evolved in 1917 a system for estimating from those data the yield of cotton, for which he claimed an accuracy greater than that of the official estimate.

In spite of the considerable success which attended the application of the statistical method of correlation, it soon became apparent that the system was far from perfect, the greatest source of error being the undue value—undue, that is, in respect of its real effect—placed upon heavy rain. Much of the recent work, consequently, is found to consist of efforts to discount heavy rain by various systems of what is known as "weighting". Walter, for instance, recognized the desirability of such weighting, and adopted a system which took into account the number of days during which rain fell. His own example may be given as an illustration of the principle of weighting. The different value to be assigned to 5 inches of rain in a month of thirty days, according as it falls on one day or is distributed over twenty days, is given by the following:—

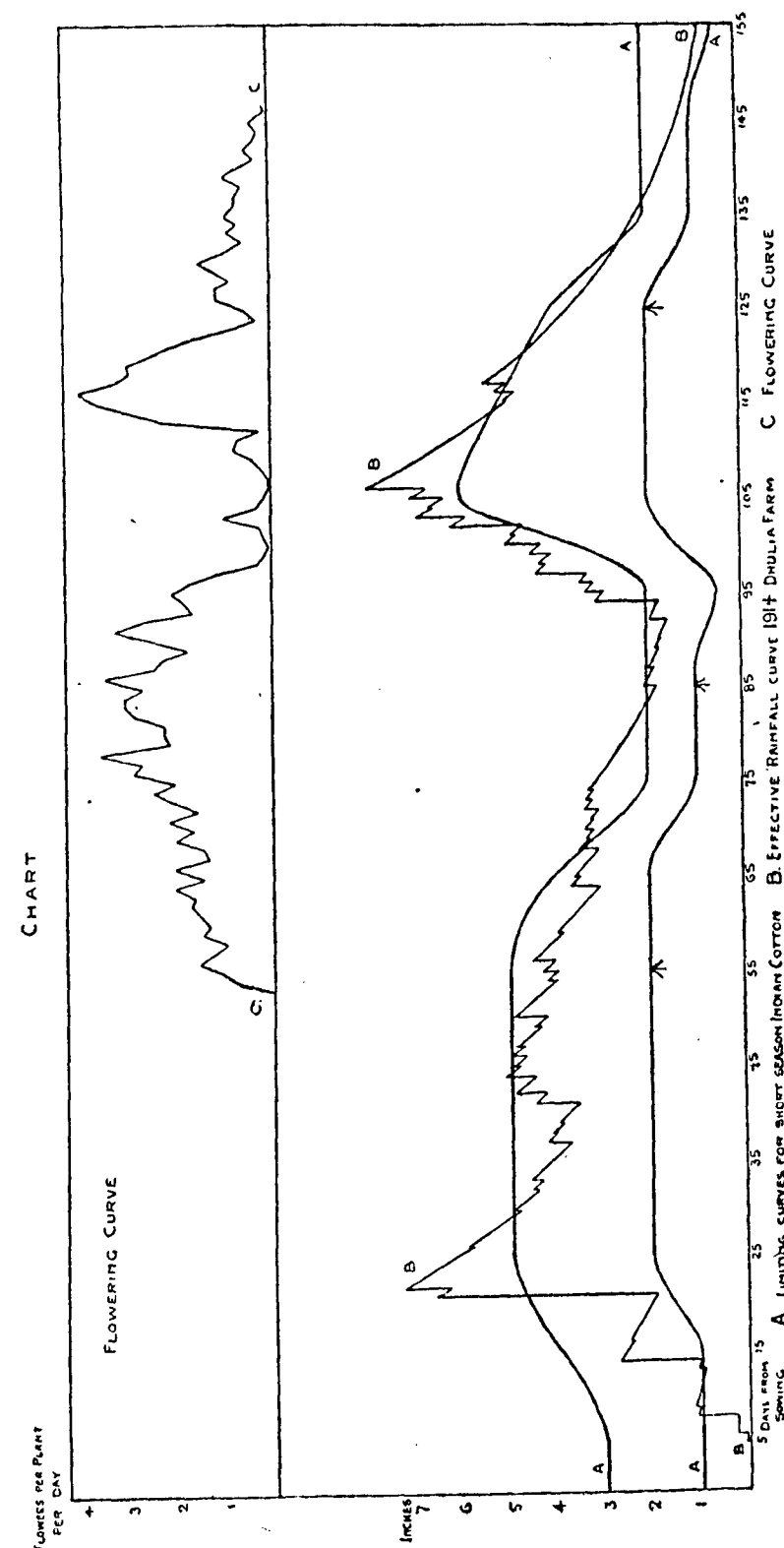
5 inches of rain on one day has a relative value of $5 \div 30 = 0.167$.

5 inches rain on twenty days has a relative value of $(5 \div 30) \times 20 = 3.333$.

More recently Fisher has evolved a newer method, and applied it to an analysis of the rainfall and wheat returns of Rothamsted. The method is intricate, involving polynomials up to the fifth degree, and is one which the writer is quite incompetent to interpret into the language of that large body of the uninitiated to higher mathematics of which he is one unit. His method, however, follows those already described in this, that it takes a six-day time unit of which the aggregate rainfall is employed.

Characteristic of all these applications of statistical method is the division of the crop period into greater or less intervals of time, varying from six days to eight weeks, of which the aggregate rainfall of the interval is taken to measure the effect of rain on the crop without any allowance for a carry-over from one period to the next. By Fisher's method alone is an allowance made. Yet it is clear that the effect of rainfall does not terminate thus abruptly at the end of a period which is, moreover, arbitrarily determined without reference to the developmental stage of the plant. This point was vividly brought home to the writer in the case of the fall of 21 inches already mentioned. This, though a continuous fall, occurred on August 31-September 1, approximately 10 inches falling in each twenty-four-hour recording period. In any system of division of time in which the end of the month is employed as separating the periods, an alteration of a few hours only in the incidence of the fall would have placed the whole 21 inches in an earlier, or a later, period, and materially affected numerical calculations based on the resulting figures. It would appear, therefore, that any system dependent on the use of aggregate falls for arbitrary units of time is open to the criticism that it takes no account of the fact that the effect of rain, while it only commences with the actual fall, continues for a period, indefinite but lengthy, when compared with the time intervals commonly adopted for statistical work.

To meet this criticism the writer has recently developed a method of evaluating the effect of rain which takes into account this essential characteristic. The name "effective rainfall" is applied to a daily figure obtained by adding to the actual rainfall of any day nineteen-twentieths of the figure similarly obtained for the preceding day. For explanatory purposes the method may be applied to the first rain of the monsoon when a dry period sufficiently prolonged to have reduced the carry over to an insignificant figure is followed by a rain of, say, 2 inches. Nineteen-twentieths of 2 inches is 1.90 inches, which amount is carried forward to the next day. If no rain falls on this day, 1.90 inches is the effective rainfall of the second day, and nineteen-twentieths of 1.90 inches, or 1.81 inches, is carried forward to the third day. But if rain, say, 0.50 inch, falls on the second day, the effective rainfall becomes $1.90 + 0.50 = 2.40$ inches, and the amount carried forward to the third day is nineteen-twentieths of 2.40 inches, or 2.28 inches. In this manner a continuous curve is obtained (*vide* chart) which represents in very graphic manner the moisture conditions of a tract.



The assumption here made is this : of the rainfall of any particular day one-twentieth is lost, or fails to become effective for plant growth, and, of the remaining nineteen-twentieth, a like fraction fails to become effective during the second day and so on. The successive fractions represent the loss due to run-off, percolation, direct evaporation from the soil and absorption by the plant. Clearly the loss is affected by such factors as temperature, and the same amount of rain is responsible for a more enduring effect in a temperate climate like England than in the tropics and in the cooler months of the year than in the summer. The fraction of one-twentieth is, therefore, only applicable to conditions of fairly high and uniform temperature such as occur in the tropics, and would require modification for the different conditions of temperate climates.

The effective rainfall of any particular day is, thus, a measure of the soil moisture, derived from rain, available for plant growth, and takes into account the cumulative effect of all previous rain. The average effective rainfall for any particular period of days, consequently, affords a better measure of the effect of rainfall on plant growth than the aggregate of the actual daily falls for the same period. Although the method is only a preliminary approximation, undoubtedly capable of improvement and on many points open to criticism, it has been found to be of considerable use in attacking economic problems, a few of which may be indicated.

The Governments of the various Provinces of India publish for trade purposes a series of "forecasts" of the principal crops. In Northern India, the Government of the United Provinces publishes early each year a preliminary forecast of the area under wheat, in which the estimates of the irrigated and unirrigated areas are recorded separately for each of the forty-eight districts. Wheat is sown early in November, and the unirrigated area is largely dependent on the moisture derived from the preceding monsoon which ceases in September or early October. The actual area of unirrigated wheat of the Cawnpore district has been compared for a series of twenty-seven years, first with the total monsoon rainfall, and, secondly, with the value of the effective rainfall on October 15. The former gives a correlation of +0.069, the latter a correlation of +0.82. Practically interpreted, this means that the unirrigated area of wheat can be forecasted some two or three weeks before it is sown, and with an accuracy which is greater than that given by the official system, the results of which, further, only appear some two or three months later. A similar calculation of the unirrigated cotton area of the Cawnpore district, a calculation which, for reasons which cannot be entered into here, is considerably more complex, gives a correlation figure of +0.77. An interesting economic point which has appeared in the course of this enquiry is that, while the irrigated cotton area is largely influenced by the relative price of wheat and cotton, the unirrigated area is not so influenced. Cotton is sown on irrigation prior to the break of the monsoon, and on land which, if not put down to cotton, would probably be left fallow and sown to wheat in the following October. There is here interesting proof of the foresight of the ordinary Indian cultivator, and an indication that he is quite alive to relative values. Further the dependence of area on price is more marked in the main cotton

tract of the province, in the Aligarh District, for instance, than is the case in the Cawnpore District, where cotton is a less important crop. When, however, the unirrigated area is considered, no such relation between area and price is found. The dominating factor here is the nature of the early rains. If these are favourable, the cultivator will sow cotton up to the limit of his ability, for is not a bird in the hand worth two in the bush? The later monsoon may be unfavourable for wheat, and at the worst, if the cotton crop fail, it will not be too late to plough and sow wheat or at least barley.

The preliminary results here given sufficiently indicate the value of the effective rainfall in forecasting areas, though much remains to be done before any wide application of the method will become possible. Investigations have, however, been attempted along similar lines in the case of yield, and the two analyses undertaken may be briefly described.

The Barbados cane crop is planted towards the end of the year and reaped in February to May; it occupies the ground, therefore, some fifteen months. There is no real dry period comparable to that of a monsoon tract, though the period June to December is definitely wetter than the period January to May. There are three seasons, the rainfall of which has been found to affect the crop yield; they are the wet season prior to planting, the dry season subsequent to planting, and the wet season preceding the harvest. The correlations of the average effective rainfalls of these periods with the yield are, respectively, +0.44, +0.42, and +0.76, all of which are significant figures and definitely higher than the corresponding figures for the total rainfall for the corresponding periods. An analysis of Rawson's figures is now being worked out, his report giving the necessary data including daily rainfall returns from 1847 to 1872; but the present results draw attention to a point, not recognized by Rawson, that the rainfall of the wet season prior to planting, and, therefore, two years prior to harvest, has a material effect on the yield. The explanation is probably to be found in the nature of the coral rock of which Barbados is built. By it, to a greater extent than in normal soils, the water is held as in a sponge to be returned to the surface during the succeeding dry weather when the young sets are establishing themselves. A somewhat similar phenomenon is met with in Bihar, where indigo used normally to be sown in March, although there might have been no rain later than early in the October previous, and none could be expected before mid-June. Here, however, the supply of water for germination and growth of the young indigo plant is due to the upward thrust imparted by the head of water in the Hills and derived from the previous monsoon.

One other analysis may be referred to, because it illustrates a further development of the use of the effective rainfall, and, dealing as it does with the cotton crop of the Dhulia farm in the Bombay Presidency, it will be of especial interest to readers of this journal. The general interest, however, arises from the fact that, in this case, there is direct evidence of the evil effect of excessive, as well as deficient, moisture.

The general habit of the cotton plant is too well known to require description here. The essential features are that a period of vegetative growth is followed

by a flowering period when, if the fruits set, the food materials formed by the plant are gradually diverted from vegetative growth to the developing bolls. The cessation of vegetative growth which results automatically reduces flower production; but, with the ripening of the first bolls, food material is released for further vegetative growth, and, with it, renewed flowering. The normal flowering curve of the cotton plant is, therefore, bimodal (see chart), and the crop is the sum of the produce of two flushes, though in practice, the product of the first flush only is collected and the crop cut out before the second flush develops. The moisture requirements of the cotton plant differ materially at the different stages of its development. Being sensitive to excessive moisture—it is a common Indian saying that a good cotton year is a half-famine year—it requires adequate, but not excessive, moisture during the first, or vegetative, period, and a relatively dry period during the first flowering period, for too much rain at this stage leads to excessive boll shedding. With the cessation of the first flowering period, the crop requires adequate rain to give renewed vegetative growth, and it is even able to withstand heavy rain if this is not too prolonged to damage the ripening fruit; while, with the development of the second flush, a diminution of the rainfall is necessary if the bolls are to mature.

Working from this basis, it has been found possible to draw two curves representing respectively the upper and lower limits of moisture requirement. Where the moisture, as measured by the effective rainfall, falls below the limit given by the lower curve, the plant suffers in yield, as is also the case when the moisture rises above the upper limit. As long as the effective rainfall curve lies between the limits of the two curves, the plant suffers no injury, and, hence, by adding the positive divergencies above the upper limit and the negative divergencies below the lower limit, a measure of the divergence of the season from the optimum is obtained. In the case of the Dhulia farm crop, a correlation of -0.70 has been obtained.

The possibility of calculating such a dual effective rainfall curve for a crop however, has wide implications. The above analysis refers to a plant of the "neglectum" type of cotton with a very short season. It is certain that a similar characteristic curve, and one readily distinguishable from the above, could be worked out for cotton of the American type. The dual curve appears, in fact to have a specific and even varietal significance. Such a result, if confirmed by further work, would be important. On the available information it is already possible, by working out in the above manner the rainfall data of a tract in which cotton has not hitherto been grown, to indicate broadly the type and with considerable accuracy the best season for sowing. Further work along these lines with the object of determining the curves characteristic of different varieties should render it possible to state on *a priori* grounds the varieties best suited to any particular tract for which the daily rainfall data are available.

Agricultural development, however, is not limited to tracts with adequate rainfall. There are large and important tracts where a deficient rainfall is reinforced by irrigation. Here an entirely new set of conditions arises. Irrigation, like rain, adds moisture to the soil, and provides adequate moisture to the roots,

but it has a relatively small effect on air humidity, which may now become the controlling factor of plant growth. The phenomenon is well known to all who have practical experience of agriculture in hot and dry countries. In Northern India the cane crop is planted in February and March, and is kept alive over the succeeding hot weather by irrigation. But, whatever the amount of water supplied, growth is negligible, for the hot dry air induces closure of the stomata, which, in its turn, checks the formation of food materials. Under these conditions no interpretation of irrigation water in terms of rainfall will enable an estimate of yield to be made, for the reason that it is not the available moisture in the soil, of which the effective rainfall is a measure, but the air humidity, which now controls growth.

A most interesting example of what appears to be an illustration of this condition is to be found in the Sudan. The report on the Anglo-Egyptian Sudan for 1926-27 (published by the Empire Cotton Growing Corporation) contains the following passage:—

One extremely interesting feature was noted, and that was the entirely different behaviour of the cotton on the Gezira Research Farm, compared with the previous year and with former experience in the Gezira.

The difference lay in the fact that the phenomenon of suppression of the lower fruiting branches was practically absent. Effective fruiting branches were commonly produced in the tenth or eleventh leaf axil of the stem, as against the twelfth or fourteenth axil in the previous season's crop. This effect was shared by *all* the cotton plots on the Gezira Research Farm, and by *all* varieties (in different degrees) in those plots. The change would not have been considered very remarkable, if it had not been noted that the plants at the adjoining Barakat Seed Farm did not show it. The behaviour there was that of the normal Gezira type noted in last year's report, fruiting branches being produced in the thirteenth to fifteenth axils, or even higher. An examination of the cotton in the neighbouring areas showed that it agreed with the normal Barakat type.

The improvement in appearance of the crop at the Research Farm was very striking, the usual "legginess" being practically absent. This improvement was accompanied by a very much improved yield, and by an entirely different manner of "arrival" of the crop as compared with Barakat.

There is here a very marked change in habit of the plant from abnormal to normal, a change which is, apparently, due to differences of environment so slight as not to be immediately apparent. On this aspect the report continues:—

The reasons for this difference in behaviour are being investigated, and it is hoped to publish the results at a later date, but it would seem probable that they are connected with the presumably higher moisture content of the soil at Wad Medani brought about by an extra watering given in the earlier stages and conserved by more frequent surface tillage

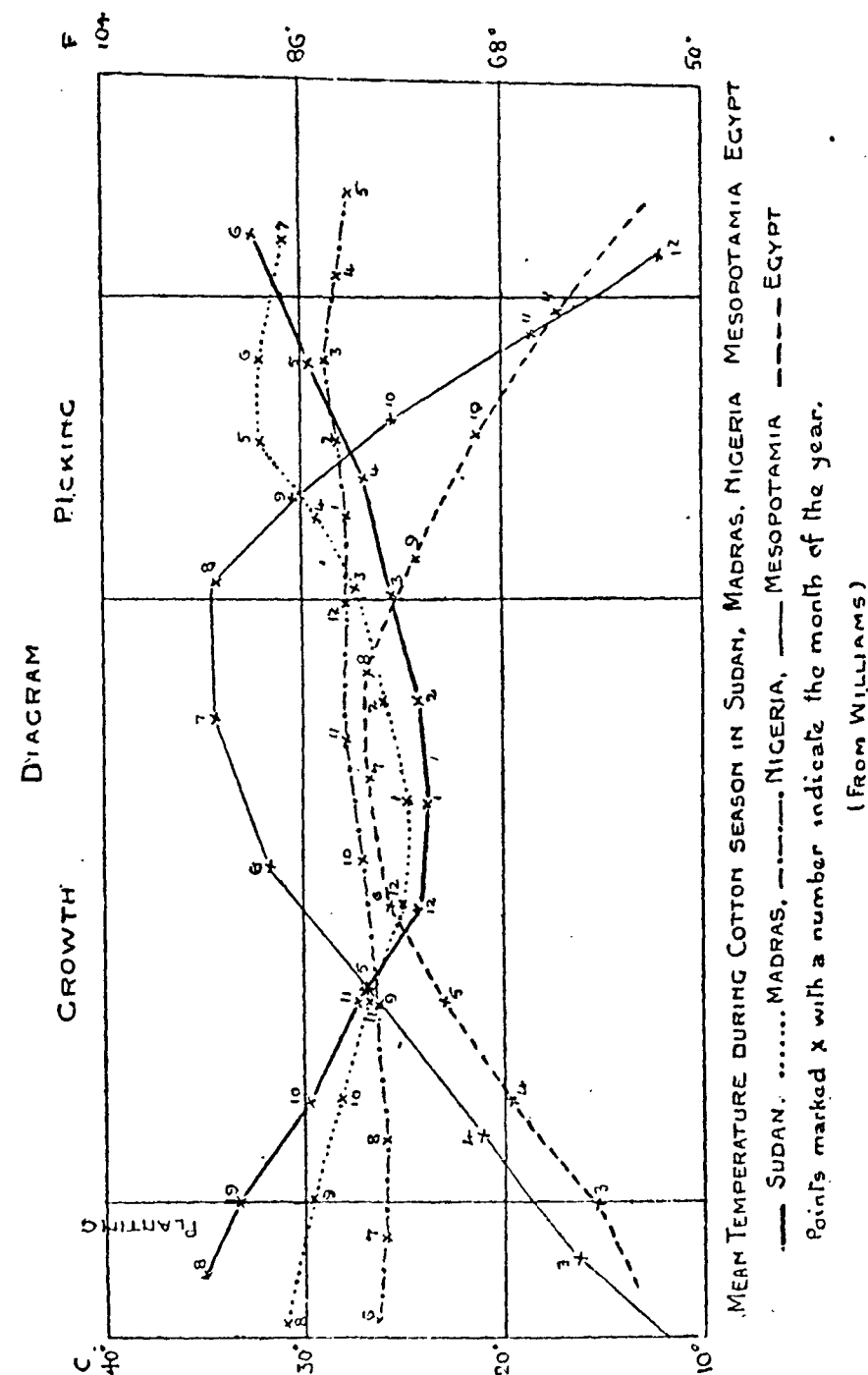
or possibly by a lower soil temperature or air temperature induced by these waterings.

The main present interest of the observations here recorded lies in the fact that the conditions under which the plant is growing at the time when the first fruiting branches are forming appear to be critical; a change, so small as to be far from obvious, being sufficient to produce a marked change of habit in the direction of increased health. The plant is evidently exposed to a water strain; but water strain may be induced either at the point of entry, the root hairs, or at the point of exit, the stomata. In the former it is not necessarily the absolute amount of water contained in the soil which regulates the supply to the plant; it may be the rate at which moisture moves through the soil to replace water taken up by the plant through the root hairs. A strain so induced would, in consequence, assert itself relatively early in heavy soils, such as are characteristic of the Gezira. In the latter case the strain is induced by external factors, air humidity or temperature, the effect of the former being emphasized by air motion—that is, by wind. Within limits, therefore, the water strain may be controlled from either side in a manner similar to that by which the draught to a furnace may be controlled by dampers set either in front of the fire box or in the flue. Temperature and air humidity are both variable factors showing a marked diurnal fluctuation, and it is conceivable that the plant is subjected to a limitation imposed alternately at the roots and at the shoot. It is possible, therefore, that a general increase of air humidity, or a fall in temperature, the effect of which would be to round off the peaks of the evaporation curve, would be effective even if that effect were the indirect one of reducing the plant's drain on the soil moisture. And where the adjustment is so fine as the observations indicate, a very slight change might be sufficient to produce a marked change of habit.

In following this line of thought, it is hardly possible to avoid associating the phenomena with another characteristic of the Gezira tract. There is here an area of 300,000 acres of cultivated land, of which some 100,000 acres are under crop, placed in the midst of an extended desert in which the only free water surface is the narrow strip of the Blue Nile. This area, moreover, has only recently been attained. Is it not conceivable that, with this increased area, a general rise of air humidity has resulted which, though too small to be readily detected among the large daily fluctuations, is adequate to produce the observed effect? Such an effect would not be uniformly apparent, and would be likely to occur locally where conditions favour the formation of pockets of relatively still air.

Certain observations of Williams (Bull. 32, Technical and Scientific Service, Ministry of Agriculture, Egypt, 1923) on the conditions under which cotton is grown in different countries would seem to point in the same direction. In this note he draws attention to the similarity of the temperature at the commencement of picking in all countries except Mesopotamia. But the phenomena in the Sudan concern the early stages of growth. If his diagrams be studied,* it will be noticed

* The diagram appended is taken from this paper.



that three countries exhibit an excessive temperature at this period : the Sudan, with an average mean temperature of 20°C. to 31°C.; Madras, with an average mean temperature of 28°C. to 29°C.; and Nigeria, with an average mean temperature of 27°C. to 28°C. The remaining countries have average mean temperatures ranging from 12°C. to 21°C. Of these three countries, the Sudan only has a markedly low air humidity, and it is an obvious temptation to look to these two abnormal conditions, high temperature and low humidity, for an explanation of the abnormal development of the plant.

The problem in the Sudan is here referred to, because it illustrates, better than any other known to the writer, the intricacy of all problems concerning the water balance of plants in the field. What the true explanation may be, and whether there be any basis for the speculations here outlined, for on the available information they cannot be other than speculations, will only be determined by the work now in hand in the Sudan.

It would appear, then, that in the tropics, while humidity is the major-factor controlling the growth of the plant, that control is exercised in two entirely distinct ways ; through the soil, as soil moisture, and through the air as air humidity. The former phenomenon is regularly exhibited, and, since the fluctuations in soil moisture are relatively slow, considerable progress has been made in the determination of their effect on the growth of the crop. Fluctuations in air humidity are much more erratic and rapid in their incidence. Not only is there frequently a large daily fluctuation, but those changes are intimately bound up with other conditions such as insolation and temperature, and the effect of air humidity as distinct from these others is not readily determined. The plant itself, too, possesses a greater capacity to adjust itself to these rapid fluctuations. The writer well remembers the first introduction of the Natal-Java indigo plant into Bihar early in the century. Seed was obtained from both countries, and though specifically the same plant, there was a marked varietal difference between the plants according to their source. Seed is harvested by cutting the plant and laying it out to dry, and, on drying, the pod is explosive and capable of throwing the seed some yards. In one case the plants of the two varieties had been cut and laid out to dry in close proximity, with the result that the seed became inextricably mixed and the subsequent crop was likewise mixed. It was possible, however, merely by standing beside a field during the hot part of the day, to pick out the two varieties with certainty ; for one (memory does not at this distance of time carry with any certainty which one) was distinctly more delicate, and in it the leaflets had closed on to each other and the whole leaves were folded round the stem, while the hardier variety did not require to make use of this adaptation against excessive insolation and low air humidity. The water balance of crops under arid conditions and irrigation thus offers problems of a complexity greater than is the case in a rains tract.

TERMITES OR WHITE ANTS.*

A LETTER from Mr. F. M. Kerr-Jarrett, of Montego Bay, Jamaica, has reached us, in which an interesting method is described of dealing with termites or white ants in the cane fields. The canes were D 1135 twelve months old and they were suffering from an attack. After various unsuccessful attempts to deal with them, an old cultivator advised strewing the ground with grated coconut, as this would entice the black, stinging ant which would quickly clear the patch of white ants. The result was a complete success. A further small infestation occurred at St. Catherine's Hill, but there the stinging ants were already in possession, and the outbreak came to nothing. Observations are further recorded on what appeared to be the normal procedure of these black ants. Apparently they patrolled in groups of three ; one acting as spy, another following as butcher, while a third acted as carrier and bore the carcass away.

This extremely interesting letter has called to mind the slumbering memories of past years. Having been located for 35 years in white ant countries, and always at heart a naturalist, the writer has noted many interesting things concerning them, but for the purpose of this article has fortified himself by glancing over two volumes on insect life in India, where termites abound both in numbers and in separate species.¹ In the following, information from these and other sources has been freely incorporated, and especially from the first named volume. Once interested, it has proved difficult rather to keep one-self within moderate bounds than to find material ; and there may thus be a tendency to record the more striking and interesting facts in place of a sober scientific discussion.

In the first place it may be allowed that the naturalist sometimes tends to be rather soft-hearted towards the objects of his study. An occasion is recalled where, after a sudden downpour of rain in India, the whole compound was found to be covered with an immense number of large centipedes crawling in every direction. With a lively remembrance of the intense burning pain caused by their bite—a lighted cigarette placed on the tender parts of the body, and pressed in, and yet further in—execution commenced at once. But after some thirty were accounted for, without appreciably reducing their numbers, sanity prevailed. Here was this enormous population, evidently living in close proximity to the house, of which no single member had ever been met with before or done any harm (it was a large form with alternate blue and yellow segments often seen in other parts). The

* Reprinted from *Int. Sugar Jour.*, XXXI, No. 362.

¹ "Some South Indian Insects", T. B. Fletcher, 1914 ; and "Indian Insect Life", H. M. Lefroy, 1909.

matter was left at that; all had vanished the next day, and no trace of this centipede was ever met with again. The cobra will not strike unless it is cornered or trodden upon and the dreaded scorpion will retreat, although with its tail lifted in menace; and the termites, as will be seen, take enormous pains to keep out of sight.

These latter generally have a bad character with folk returning from the tropics; but considering their countless numbers, over a large part of dry India and Africa at least, it is surprising how little damage they do. As is generally known, the termites feed pre-eminently on dead matter, but there are many different kinds (perhaps some hundreds, of which Fletcher states that there are forty to fifty species in Madras alone) and these vary in their food habits. Some will attack living plants including trees, others feed on deadwood and vegetable matter in general, some prefer the solid (half dead) wood of living trees, and yet others feed on grasses and lichens. In India, groundnuts, wheat and occasionally other cereals, safflower, and sugarcane are given as the principal crops which suffer from them. The attacks on sugarcane are not very common, but the writer once observed a fine clump of canes somewhat suddenly wilting; and on investigation found the lower cane joints filled with white ant earth, the water channels round the rind being naturally left untouched till the last. It was a case of extremely bad after-cultivation and entry was probably through borer holes. But the sets newly planted, with their half-dead tissues, are specially attractive to termites. Of course, the sets are not planted in dry ground, and reasonable irrigation usually keeps the termites at bay till the plant has gained sufficient size and strength to ignore them. Dipping the sets in preservative liquids is recommended, strong copper sulphate being specially efficacious. Where irrigation is available and they are still troublesome, placing a bag of crude oil emulsion in the stream is also commended. But in the writer's experience proper after-cultivation is the best remedy; the termites are a very intelligent folk, and hate to be disturbed, and moving the surface soil quickly drives them to lower levels.

The harm done to buildings and their contents is often very serious, and requires more attention; but even here, at least one person, brought up in an atmosphere of camphor wood and metal clothes boxes, has suffered very little loss. Termites will not effect an entrance without very easy detection, provided the house has been properly constructed. Cemented ground floors (and the cement layer may be surprisingly thin), and properly placed bricks with no gaps between and perhaps a cement course low down the walls, are all that is needed. But if the structural wood used in building is not well seasoned, with ends placed in preservative, of course there is danger. Here a remembrance occurs of an estate house in Antigua, where a large central room had a series of fine beams across the ceiling. These were coated at intervals with a good layer of paint, and were apparently very substantial. But when certain reconstruction became necessary, they turned out to be completely eaten out, and only held together by the accumulated layers of paint.

Summing up, to an observer in India, where sugarcane cannot usually be grown without irrigation, the termite is not a serious menace in the field, while with ordinary precautions houses and their contents can very easily be protected. But on occasion, for instance, when out in tents or living in a badly built house, destruction is sometimes very rapid. Such a case is mentioned by Lefroy, where the whole of the bedding was removed in a Bengal prison in a single night while the inmates were asleep on it. It is, however, quite conceivable that, in countries with a "well distributed" rainfall and cane grown without irrigation, the termites may sometimes be much more destructive and difficult to deal with.

But they have their uses also, although these are less dramatic and, moreover, less easy to define. It always appeared to the writer that the commination and movement of the earth, so obvious in certain parts, with the network of underground channels, was bound to have a marked effect on the physical condition of the soil. He was accustomed to point this out in lectures in India, and even to compare their action with those of earthworms in temperate regions. Subsequently he found, however, that this was no new idea, but had been eloquently discussed by Henry Drummond in his book on "Tropical Africa", as long ago as 1896. If this is a true reading, the balance would seem to be weighted heavily in favour of the termite! They are universal scavengers of any dried refuse, and wonderful cleaners up, though sometimes the dry stubble is wanted for incorporation in the soil. In places, they are an article of food valued by certain castes in India, and in Africa, being available in specially large numbers when swarming. White ant earth is also a valued commodity, for manuring the fields by the natives of South Africa, and for making tennis courts everywhere in dry countries. Termites are excellent for poultry, and especially valued for young turkeys where these are difficult to rear. But these are minor uses compared with their probable action in keeping up fertility in the soil as referred to above.

It is, however, in their social development that the greatest surprises are met with; for in the opinion of some they leave the ants, bees and wasps behind in this. They are *en masse* totally blind,* no misfortune in their tunnels in the earth but a great drawback when they seek their vegetable food. Hence they rarely emerge without carefully constructing an earth-covered pathway, by dividing the soil into minute particles and cementing these together with their saliva; thus all vegetation which they devour is covered by layers of fine earth, and their aerial pathways, so familiar to everyone, form closed-in tracks to the tops of high trees. On occasion, the earth excavated from their tunnels is built up into mounds (comparatively rare in south India), or peaks or miniature mountain ranges. And the surprising fact emerges that each species has its own architectural plan: they are wonderful architects, and the species is frequently easily determinable by the shape of its erections (as in the Bahr-el-Ghazal, according to Schweinfurt). Per-

* This is not strictly correct. The adult males and females have eyes, and eyes are also present in the workers and soldiers of the more primitive forms, such as *Nodotermes*—Ed., A. J. I.

haps the East African species have the largest aerial structures, and Drummond has some striking pictures of some of them. Quite recently the writer has seen a picture of a comfortable native hut, carved out of a "white ant hill".

Anyone in India wishing to see what termites are like has only to break a tunnel on a tree or building, when a vast commotion is seen among small, pale, ant-like insects, and almost immediately other larger forms appear flourishing a menacing pair of jaws, like small "earwig tails". These are the workers and the soldiers, both immature forms. The mature termites are best seen when swarming takes place. Out of a hole in the ground a constant stream of flying insects of a pale colour appear to be shot out. These alone are winged, and are the males and females designed to found a new colony when the parent nest is overcrowded. But deep in the heart of the settlement lies yet another form, the queen mother. No one would imagine that she was a termite: for she lies, an inert pale-coloured rather loathsome mass, sometimes as large as a man's finger, closely attended by a numerous body of workers with a sprinkling of soldiers acting as police, and also attended by a male as king. Her sole duty is egg-laying, and the ovaries may be seen in their convolutions under her semi-transparent, tightly stretched skin, with a constant stream of eggs passing along. She can rarely be found, for if she were, all problems of the white ant menace would be immediately solved: her removal would in all probability immediately dissolve the settlement.

Now, the workers, as their name implies, are the only ones who do any work, in the ordinary sense. And not the least of their duties is to obtain food for the development of the eggs. And the surprising thing is that it is very generally held that the workers, by appropriate feeding of the young, can alter the character of the form assumed when grown up.* But the other powers of these inconspicuous members of the crowd are still more astonishing. Like many of the leaf-cutting ants they are gardeners, and one species is often seen at Coimbatore, carrying bits of grass, leaves and stalks, as the ants do, presumably for this purpose. These do not use tunnels and are fully exposed to view. The method described in text books is as follows. By repeatedly passing through their bodies vegetable matter till all nutrient is extracted, they build up comb-like structures in excavated underground chambers, extremely light and porous, and sow (?) certain fungi on these, which at a certain stage of development produce small snow-white spheres wherewith they feed their charges, constantly stoking up the gravid female and dosing the young ones. It is even claimed that they keep pulling out any other fungi which may appear, and keep their gardens scrupulously "weeded". When a nest is deserted, the weed-fungi grow rapidly and ultimately appear above ground as mushrooms of sorts.

When a collection of white ants is disturbed, say, by moving a stone, the workers are thrown into violent confusion and soon soldiers make their appearance. An

* Fletcher records this fact for primitive races of termites, but did not find it to be the case with South Indian species.

interesting case was noted and sketched by the writer in India. A crater-like hole was made around the struggling workers to see what they would do. In a very few moments, the edges were occupied by a perfect ring of soldiers with their bayonet-like jaws equally spaced as a guard. Communication had been quickly and surely conveyed. Fletcher gives an interesting explanation of this. The contortions of the workers makes a distinct sound, sometimes audible at some distance, and he considers that this is their form of speech, and that definite forms of contortion with the resulting sounds convey very definite meanings. Based on this, a form of "termite finder" has been invented for locating the nest with the queen, consisting of a microphone attached to a sharp iron stake: the latter is driven into the ground, and if it reaches the nest, the microphone records the fact. But when tried in India, the machine was found to be a failure for all practical purposes, as the location of the nest is almost impossible.

When a surplus of males and females have been formed in the colony, migration takes place. Streams of flying white ants, all males and females, issue from some hole in the ground. These are taken advantage of not only by human beings, but by the whole creation of living things, the birds and insects in the air and the creeping insects and reptiles on the ground. For the unaccustomed flight is feeble and erratic and lasts but a short time. One more observation, made by the writer, is worth recording. He watched a cloud of dragonflies darting into the middle of the flight. But the moment a dragonfly had seized a termite, he appeared to drop it, and it went on crawling over the ground. Investigation showed that all the fallen termites were merely the forepart of the insects, head and wings and trunk, but without the long, white abdomen: the dragonflies were sufficiently sophisticated to know that this was the only part worth eating. When a termite finishes his or her feeble flight, it throws off its wings with a jerk and seeks a mate, regardless of enemies. Few survive, but here and there a pair finds safety in some crevice, and lays the foundation of a new colony. It is of course apparent that there is an appalling waste of life here, but what does that matter, with 30,000 eggs a day added to the numbers by one queen?

NOTES

DAIRY RESEARCH COMMITTEE OF THE EMPIRE MARKETING BOARD.

As recommended by the Imperial Agricultural Research Conference, the Empire Marketing Board has formed a Dairy Research Committee which includes representatives of Oversea Dominions and of British Departments of Agriculture and Research Institutes.

At its first meeting the Committee discussed the scope of its activities and, while leaving open for further discussion the formulation of a definite programme, agreed in general that its functions might be—

- (1) To discuss schemes of mutual assistance in the sphere of Empire dairy research ;
- (2) To explore the best means of securing systematic collection and dissemination of information ;
- (3) To consider the possibility of publishing a Journal or Bulletins of Dairy Research containing technical articles, high class reviews, and abstracts ;
- (4) To foster interchange and training of workers ;
- (5) To advise on the examination of such defects as are found in the condition and quality of imported Empire dairy products, and the possibility of effecting improvements in flavour, carrying quality, etc., and
- (6) To advise the Empire Marketing Board on applications submitted to it for grants for dairy research.

The Committee will not itself undertake responsibility for research but will act mainly as a clearing house of information and advice on technical matters. It contemplates an arrangement whereby dairy experts from overseas will be invited to spend a few months studying the United Kingdom markets in collaboration with the Boards' officers, Trade Commissioners and others interested.

The proposal to publish a Journal or Bulletins of Dairy Research is being explored by the Committee who will in due course be seeking the cooperation of overseas governments in regard to contributions. The Committee has invited Prof. R. Stenhouse-Williams of the National Institute for Research in Dairying, Reading, and Dr. H. H. Green, Director of the Scottish Dairy Research Institute, to act as Joint Editors of this publication.



STANDARDIZATION OF BALE COVERING FOR COTTON.

PROVISION for the use of net weights in inter-State and foreign transactions in cotton, and for the standardization of bale covering for cotton, is contemplated

in a bill (H. R. 14938) introduced in Congress by Representative Fulmer, of South Carolina. The bill would authorize the Secretary of Agriculture to investigate the handling, inspection, and transportation of cotton in inter-State and foreign commerce and to study the materials used for bale coverings. Also authority would be given the Secretary to establish standards for materials used for bale coverings, including specifications and tolerance as to sizes, weights, and patterns. Such standards would be known as the United States official cotton-tare standards. Minimum weights of bale covering used on cotton for shipment in inter-State or foreign commerce would be prescribed when such covering did not conform to the official standards. One year after the effective date of the official cotton-tare standards, all American cotton would be bought and sold for shipment in inter-State and foreign commerce on net weights, excluding in each instance the weight of bagging, ties, and patches. Violation would be a misdemeanor punishable by a fine not exceeding \$500. [Extracted from the *Official Record, United States Department of Agriculture*, Vol. 7, December 19, 1928, No. 51.]



MAYNARD GANGARAM PRIZE FOR AGRICULTURAL RESEARCH.

In 1925, the late Sir Ganga Ram, Kt., C.I.E., M.V.O., R.B., Lahore, with that generosity for which he is now so well known, handed over to the Punjab Government a sum of Rs. 25,000 for the endowment of a prize to be awarded for a discovery, or an invention, or a new practical method which will tend to increase agricultural production in the Punjab on a paying basis.

The prize is known as the Maynard Ganga Ram Prize and is to be awarded every three years provided a satisfactory achievement is reported to the Managing Committee. It will be of the value of Rs. 3,000 and the competition is open to all throughout the world. Government servants are also eligible to compete for it.

Wide publicity was given in 1926 and 1927 to the proposed award by advertisements in newspapers both in India and abroad, and by other means, and applications were invited by the 1st January, 1929. The response has, however, been extremely poor and consequently it has been decided to extend the time for submission of the applications to the Director of Agriculture, Punjab, upto 31st December 1929. The Managing Committee reserves the right of withholding or postponing the prize if no achievement of sufficient merit is submitted.

CHILEAN NITRATE INDUSTRY.

Discussions, which have been taking place in Chile during the past few months with a view to extending the Nitrate Producers Association for a lengthy period, terminated recently when, at an Extraordinary General Meeting of the Associates held in Valparaiso it was unanimously agreed to extend the life of the Association until 30th June 1939 ; to incorporate into the Association the Selling Corporation

formed in August, 1928, and to introduce into the Statutes a number of new provisions giving the directorate wiser powers of rapid action. The Anglo-Chilian Consolidated Nitrate Corporation becomes a member of the Nitrate Producers Association and its production will henceforward be sold under the rules of the Association except as regards the United States market. A subsequent announcement was made by the Superintendent of Nitrate on behalf of the President of Chile in which the Chilian Government expressed its satisfaction at the excellent results obtained in the year 1928 in the production and sale of Nitrate, and appreciation for the collaboration of the Producers in the sales organisation. The Government at the same time declared that it will spare no efforts to help the Nitrate industry to increase its production and to extend its markets still further and to contribute to this policy that it will make use for the benefit of the industry of the ample powers which the Nitrate Law gives it.

From the above far-reaching declaration it may be assumed that the help which is being accorded to the industry during the current year—estimated at about £2,000,000—will be on a rising scale in the future.

Under the Nitrate Law referred to, the Chilian Government have power to subsidize the Nitrate Industry with any surplus receipts from Nitrate and Iodine duties over £4,250,000 of which sum Iodine at present contributes £150,000, leaving a minimum to be obtained from nitrate of £4,100,000. On the basis of shipments in 1928, viz., 2,756,000 tons—duties received amounted to about £6,900,000 leaving a surplus of £2,800,000.



WORLD POULTRY CONGRESS, 1930.

The Fourth World Poultry Congress will be held at the Crystal Palace, London, England, from July 22nd to July 30th, 1930. The British Government cordially invites all persons interested in any aspect of poultry husbandry in any part of the world to be present.

The Congress is being organized by the British Government. It will be held under the distinguished patronage of His Majesty the King, Her Majesty the Queen, and His Royal Highness the Prince of Wales.

In connection with the Congress an Exhibition will be organized comprising—

- (1) national exhibits staged by participating countries;
- (2) exhibits of poultry, rabbits and pigeons entered by breeders from all parts of the world;
- (3) commercial exhibits of interest to the poultry industry.

Information regarding entry fees for exhibitors and membership charges for delegates, together with plans and all other particulars concerning the Congress, may be obtained free on application to the Secretary, World Poultry Congress, 10, Whitehall Place, London, S. W. 1, England.

Personal Notes, Appointments and Transfers, Meetings, and Coferences, etc.

His Majesty the King-Emperor's Birthday Honours List contained the following names which are of interest to the Agricultural Departments :—

- G.C.I.E.*—The Marquess of Linlithgow, D.L., lately Chairman, Royal Commission on Agriculture in India.
- Knight.*—Mr. F. Noyce, C.S.I., C.B.E., I.C.S., lately Financial Adviser to the Royal Commission on Agriculture in India.
- C.I.E.*—Mr. F. J. Plymen, Director of Agriculture, Central Provinces.
- Sardar Bahadur.*—Sardar Sahib Jagat Singh, Assistant Professor of Chemistry, Agricultural College, Lyallpur.
- Rao Bahadur.*—Rao Sahib Bhimbhai Morarji Desai, Deputy Director of Agriculture, Bombay (retired).



MR. M. S. A. HYDARI, I.C.S., has been appointed Secretary to the Imperial Council of Agricultural Research with effect from the 1st June 1929.



MR. A. D. MACGREGOR, M.R.C.V.S., Principal, Bengal Veterinary College, has been allowed leave on average pay for the period from 1st July to 16th December, 1929, in continuation of the college vacation beginning from 17th April, 1929.



MR. R. T. DAVIS, Vice-Principal, Bengal Veterinary College, has been appointed to act as Principal of that College during the absence of Mr. A. D. MACGREGOR on leave or until further orders.



MR. V. NARAYANASWAMI, Senior Systematic Assistant, Botanical Survey of India, Calcutta, has been appointed Systematic Botanist, Madras, in a temporary post outside the cadre of the Madras Agricultural Service.

MR. H. P. PARANJPYE has been appointed to act as Horticulturist to Government, Bombay, *vice* Dr. G. S. CHEEMA granted leave for three months from 6th May, 1929.



MR. ALI MAHOMED ULVI has been appointed to act as Live Stock Expert to Government, Bombay, *vice* Mr. E. J. BRUEN granted leave.



DR. P. E. LANDER, M.A., D.Sc., Agricultural Chemist to Government, Punjab, has been granted combined leave for one year from 14th March, 1927. Dr. DALIP SINGH, Second Agricultural Chemist, has been placed in charge of the duties of Dr. LANDER, during the latter's absence, in addition to his own.



MR. F. B. HARROP, Poultry Expert to Government, Punjab, has been granted combined leave for six months from 11th March, 1929. Mrs. F. F. HARROP will be in charge of the duties of Poultry Expert during Mr. Harrop's absence on leave.



MR. W. TAYLOR, M. R. C. V. S., has been appointed to officiate as Director, Civil Veterinary Department, Punjab, *vice* Mr. T. F. QUIRE granted leave for 8 months with effect from 12th March, 1929.



CAPT. U. W. F. WALKER, M.R.C.V.S., Professor of Surgery, has been appointed to officiate as Principal, Punjab Veterinary College, Lahore, *vice* Mr. W. TAYLOR on other duty.



LALA DURGADAS has been appointed to officiate as Professor of Surgery, Punjab Veterinary College, Lahore, *vice* Captain Walker on other duty.



MR. A. HAYES, A.M.I. Mech. E., has been appointed Agricultural Engineer in Class I of the Burma Agricultural Service with effect from 3rd April, 1929,

MR. F. WARE, F. R. C. V. S., I. V. S., Director, Veterinary Services, Madras, has been appointed to officiate as the Director of the Imperial Institute of Veterinary Research, Muktesar, with effect from the 12th June 1929.



MR. T. J. HURLEY, Professor of Surgery and Acting Principal, Madras Veterinary College, has been appointed to act as Director, Veterinary Services, *vice* Mr. F. WARE or until further orders.



MR. V. KRISHNAMURTI AYYAR, Professor of Pathology and Bacteriology, has been appointed to act as Principal, Madras Veterinary College, *vice* Mr. T. J. HURLEY or until further orders.



MR. W. YOUNGMAN, Ph. D., Economic Botanist to Government, Central Provinces, has been granted combined leave for 10 months with effect from 17th May 1929.



MR. J. F. DASTUR, M. Sc., D. I. C., Mycologist to the Government of the Central Provinces, has been appointed to officiate as Imperial Mycologist, Pusa, *vice* Dr. W. McRAE, with effect from the 24th June, 1929.

REVIEWS

Locusts and Grasshoppers. A Handbook for their study and control.—By B. P. UVAROV, Imperial Bureau of Entomology, 1928. Small quarto: Pp. xiii + 352, text-figs. 118, map, 9 plates. Price, 21 shillings.

This book is divided into two parts, the first treating of grasshoppers under general headings, such as external morphology, anatomy, development, behaviour, natural enemies and control, the second part dealing with special grasshoppers in relation to particular areas. It gives a very complete account of all published information on grasshoppers (including locusts) in all parts of the world and will be found a necessary adjunct to the libraries of all Economic Entomologists.

This being so, it seems unnecessary to attempt a resumé of this bulky volume and it will be sufficient to notice a few points on which the author advances statements based rather on his own opinion than on first-hand knowledge. Thus (p. 68), he doubts whether the fluid emitted by *Aularches miliaris* has any defensive significance: anyone who has ever seen this grasshopper under natural conditions, and handled it in a living state, is not likely to have much doubt of the protective value of its warning colouration and emission of strong-smelling froth: it is perhaps noteworthy that a precisely similar form of protection has been evolved in the Zygaenid moth, *Erasmia sanguiflua*.

The author's remarks on control methods seem to be too general in their scope to secure entire acceptance, especially in a country such as India. Thus, he does not consider destruction of egg-masses by ploughing or digging to be of any practical use (p. 172), he considers the collection of hoppers by means of nets as 'primitive and unpractical' (p. 173), he regards the use of flame-throwers and burning generally as methods without any future and is very surprised that flame-throwers are now being introduced into Palestine, Syria and Iraq (p. 175), and thinks that the use of ditches and barriers (pp. 175-178) is ineffective. After reviewing spraying, he concludes (p. 179) that this method "has no future before it" and pins his faith on the use of poisoned baits, for which "the substances recommended for carriers are bran, sawdust, horse manure and other suitable local materials... As poisons, Sodium arsenite, White arsenic and Paris green may be used. The addition of molasses or aromatic substances (particularly amyl-acetate) is not necessary, but may prove useful; the addition of salt cannot be definitely recommended" (p. 188). The author's subsequent remark (pp. 192-193) that "extensive experience in North America and various parts of Russia has proved that no cases of poisoning stock can occur if the bait is scattered in small fragments, as it

should be" does not inspire confidence in the recommendation of this method under the very different conditions found in an Indian village.

In Chapter IX, on the organization of control, the author makes various remarks which are apparently based on his experience in Russia but which are not likely to be endorsed in other countries. In India, for example, the main breeding grounds of locusts are outside of India and it is therefore not possible to concentrate control measures on the breeding grounds and never to allow locusts to increase in them and to transform into the swarming phase (p. 214).

Chapter XI, on the Migratory Locust, *Locusta migratoria*, so far as the Indian inquirer is concerned, rather reminds us of the song of the Goldfinch, "A very little bread and no cheese", as India does not seem to be mentioned definitely beyond a statement that this Locust occurs in the Himalaya up to 15,000 feet. The Desert Locust (*Schistocerca gregaria*), however, is shown in Chapter XII as extending into the extreme northwest of India (map, p. 252), and is stated to breed in Persia, Baluchistan and the Punjab, and to occur as far East as Assam. It may be added that there has been considerable confusion in the past between these two species in the literature on Indian Locusts. The swarms which invaded Northern India in 1927 were composed of *Schistocerca gregaria*, so far as we have seen specimens, and this is the species referred to in this Journal (Vol. X, pp. 159-166, plates 7-8: 1915) under the name of *Acridium peregrinum*.

Chapter XVIII contains some account of the smaller grasshoppers (*Hisroglaphus*, *Oxya*, etc.), which in India probably do more real damage than locusts, although their attack is not so spectacular, as they occur all over India as regular pests of staple crops. *Chrotogonus* is a notable omission.

To sum up, this book should be of considerable use to all engaged in grasshopper control, as containing a valuable summary of the subject; but the author's recommendations for control require considerable modifications to suit local conditions in India and should therefore be taken with the proverbial pinch of salt which he considers unnecessary to put in his poison-baits. [T. B. F.]



Sugarcane and Its Cultivation, by Franklin S. Earle.—Pp. VIII+356; fig. 21, (New York, John Wiley and Sons, Inc.; London: Chapman & Hall, Ltd.) Price, 22 s. 6 d.

The atmosphere of this book, as the author truly remarks, is that of the cane field rather than that of research laboratory, but this in no way detracts from its great value as a general review of the cane sugar world and the countries connected with it. The author's comments are eminently practical and to the point, and what is of special interest to India is the testimony he pays to Dr. Barber's work on the Co. canes and the candid valuation from the world point of view which he places

on Co. 210, Co. 213 and Co. 281, *vide* pages 60, 61 and 62, albeit his remark anent Co. 281 "that this really remarkable cane seems to have attracted no attention in India" sounds rather hard in the ears of one who has consistently attempted to grow it on Gangetic soils for the last five years and is all too alive to its value. However, our loss appears to be Cuba's gain in this case though the suitability of North Indian Co. canes to tropical countries is hard to realize. Of great interest and value to all workers on cane is the annotated list of cane varieties which represents a really heroic attempt to elucidate the correct nomenclature of the known canes in cultivation and should enable many workers to realize that they may be working on a cane which has already been experimented with under another name. Especially valuable are the notes on Cuba and the eminently frank summing up of the present position there "that Cuba needs higher cane yields with the consequent lower costs of production rather than higher prices for sugar".

On the agricultural side, the author's plea for ratoons will not find endorsement everywhere, especially in India, but a comparison of the different countries shows how high India's estate cane cultivation stands.

The author regards, and probably rightly so, mosaic as the future cane disease and makes the pertinent remark that the *S. Barberi* are fully susceptible, but so tolerant as to be scarcely injured by the presence of the disease. Descriptions and criticisms of the various methods of planting and cultivating cane together with what we can only hope is the final statement on the origin of the Uba cane are further points of interest in a book, the welcome appearance of which has been so unduly saddened by the sudden death of the author, to the lasting regret of all who knew him and his work for cane. [W. S.]

NEW BOOKS

On Agriculture or Allied Subjects

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Adulteration of Butter and Ghee with Animal Fat and Vegetable Ghee and its Detection, by P. B. Sanyal, M.Sc. (Chemical Series, Vol. X, No. 3.) Price, As. 5 or 6 *d.*
2. A List of the Generic names used for Microlepidoptera, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Entomological Series, Vol. XI.) Price, Rs. 3 or 5 s. 3 *d.*

Bulletins.

3. Life-History, Bionomics and Control of *Mytillocerus maculosus* Dcsb. (Curculionidae : Coleptera), by Kidar Nath Trihan, M.Sc. (Bulletin No. 181.) Price, As. 14 or 1 s. 6 *d.*
4. The Cultivation of Lac in the Plains of India, *Laccifera lacca*, Kerr. By Rai Bahadur C. S. Misra, B.A. (Revised Edition : Bulletin No. 185.) Price, Rs. 4 or 6s. 9*d.*
5. Studies in Inheritance in Cotton. The Improvement of Dharwar-American Cotton by Hybridization, by R. K. Kulkarni, B.Ag., and T. R. Khadilkar, B.Ag. (Bulletin No. 189.) Price, Rs. 2-2 or 4s.
6. Description of a new species *Dipylidium catus*, n.sp., with a Note on the genus *Dipylidium* Leuckart, 1863, by Amar Nath Gulati, M.Sc. (Bulletin No. 190.) Price, As. 6 or 8*d.*
7. Agricultural Implements and Machinery at Pusa, Part I. Cultivation Implements and Machinery, by G. S. Henderson, N.D.A., N.D.D., and Arjun Singh, L.Ag. (Bulletin No. 191.) Price, As. 12 or 1s. 3*d.*
8. Agricultural Implements and Machinery at Pusa, Part II. Harvesting and Threshing Implements and Machinery, by G. S. Henderson, N.D.A., N.D.D., and Arjun Singh, L.Ag. (Bulletin No. 192.) Price, As. 6 or 8*d.*
9. Agricultural Implements and Machinery at Pusa, Part III. Special and Miscellaneous Implements and Machinery, by G. S. Henderson, N.D.A., N.D.D., and Arjun Singh, L.Ag. (Bulletin No. 193.) Price, As. 9 or 1s.
10. Agricultural Implements and Machinery at Pusa, Part IV. Power Implements and Machinery, by [G.S. Henderson, N.D.A., N.D.D., and Arjun Singh, L.Ag. (Bulletin No. 194.) Price, As. 12 or 1s. 3*d.*

Report.

11. Review of Agricultural Operations in India, 1927-28. Price, Rs. 2-6 or 4s. 3*d.*

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ORIGINAL ARTICLES

THE PROBLEM OF STERILITY IN INDIAN CROPS AND FRUIT TREES.*

BY

MAHBUB ALAM, M.Sc.,

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THE keynote of all our modern agricultural and horticultural developments is to enable the plant to reproduce itself in large numbers. This ability of the plant to bring forth living young ones is termed fertility, and the converse of this is sterility which may be defined, in short, as failure of the sex act completely or partially.

The subject of sterility in crops and fruit trees is very wide in scope and far-reaching in its effect. Many of its problems can only be solved with the co-operation of physiologists, mycologists, ecologists, cytologists and geneticists. In the following pages, however, only the more important aspects of this problem have been dealt with, and an endeavour has been made to study the various factors which bring about the different forms of sterility. Some measures of combating against them, wholly or partly, have also been suggested.

The ability to reproduce is naturally one of the first things for which cultivated forms have been selected. In most cases a marked increase over the primitive condition of reproduction has been achieved. The larger cultivated varieties of corn reproduce themselves a thousand-fold which is several times more than the wild ones. One of the greatest losses in agriculture is due to the failure to secure a satisfactory stand of plants in the field. The conditions which determine good germination are, to a large extent, beyond the control of the seed, but part of the poor germination is due to actual germinal sterility. Hence an increase in fertility of all the crops is an important means of improvement and this problem must be tackled with the utmost care.

Although inherited defects may stop the growth of the plant at any stage, most of the manifestations of the effects of sterility centre around the process of reproduction. This is the critical time in the life-history of any organism. At any time from the beginning of the development of sex-organs, through the reduction division, until after fertilization and the start of the embryo in the following generation, something may go wrong and interfere with normal fertility. This lack of fertility

* Woodhouse Memorial Prize Essay, 1928-29.

(i.e. sterility) may be caused by various agencies which may be roughly classed into two groups :—

- (1) Environmental agencies : largely external to the organism and beyond its control.
- (2) Germinal agencies : always internal and peculiar to the organism.

I. Environmental agencies.

The environmental causes of sterility are so numerous and complex that they cannot be treated in detail here, but a few important aspects of these may be considered.

(a) *Nutrition.* Sterility may be induced by either a deficiency or an excess of food. Every plant and animal must have sufficient nourishment to reproduce itself properly. It is not enough that food be supplied in sufficient quantities, but it must also be properly balanced. The limiting points of all environmental factors are three, namely, (i) Minimum, (ii) Optimum and (iii) Maximum.

Only under the optimum conditions the life processes go on satisfactorily : when the minimum or maximum is reached, the balance is disturbed and abnormal features set in. Thus Kraus and Kraybill¹ find that fruitfulness in tomatoes is dependent upon a suitable relation between mineral salts, and the starches and sugars manufactured by the plants. They find four general conditions of the relation of nitrates, carbohydrates and moisture within the plant itself. These are :—

- (i) An abundance of moisture and mineral nutrients, including nitrates, without an available carbohydrate supply, results in weakened vegetation and the plants are non-fruitful. (Limiting factor for fruiting is the scarcity of carbohydrates.)
- (ii) An abundance of moisture and mineral nutrients, especially nitrates, coupled with an available carbohydrate supply, makes for increased vegetation, barrenness and sterility. (Limiting factor for fruiting is the abundance of nitrates.)
- (iii) Decrease in nitrates in proportion to the carbohydrates makes for an accumulation of the latter ; and also for fruitfulness, fertility and lessened vegetation. (Optimum conditions for fruiting.)
- (iv) A further reduction of nitrates without inhibiting a possible increase of carbohydrates makes for a suppression both of vegetation and fruitfulness. (Reduction of nitrates is the limiting factor both for vegetation and fruiting.)

Thus an excess of certain food ingredients is prejudicial to full fertility. Fruitlessness is not associated with maximum nitrates or carbohydrates but with a condition of the balance between them (optimum condition). Fruit trees that are liberally

¹ Kraus, E. J.; and Kraybill, H. R. (1918) : Vegetation and reproduction with special reference to the tomato : *Oregon A. E. S. Bull.* 149.

fertilized and cultivated, so as to stimulate vegetative growth, are slow in bearing. Even if blossoms are formed, these are dropped off shortly after pollination. Similar conditions we find in agricultural crops. When the environmental conditions are such as to stimulate vegetative growth, fertility is reduced. An instructive example of this is seen from Table I. It shows the effect of over-irrigation on the relative

TABLE I.
*Yield of wheat with varying quantities of irrigation water.*¹

Inches of irrigation water applied	Bushels of grain to the acre	Pounds of straw to the acre	Pounds of straw for each bushel of grain	Bushels of wheat for each inch of water
1	2	3	4	5
5.0	37.81	2,986	79	7.56
7.5	41.54	3,301	79	6.39
10.3	43.53	3,452	79	4.35
15.0	45.71	3,954	87	3.05
25.0	46.46	4,311	93	1.86
35.0	48.55	4,755	98	1.30
50.0	49.38	5,332	108	0.99

¹ Widstoe : *Principles of Irrigation Practice*, 1914.

yield of straw and grain in wheat. The figures in the fourth column point out that an increase of irrigation water from 5 to 10 inches brings about the rise in yield of straw and grain in equal proportions, but further additions of water give a greater proportion of straw. This is more clearly shown in Table II, which has been framed from the data of Table I. In the fourth column of this table, we get the rise in the

TABLE II.
The effect of irrigation water on the yield of grain and straw.

Inches of irrigation water applied	Rise in the amount of grain per acre with each increase of irrigation water	Corresponding rise in the amount of straw to the acre	Ratio Rise in straw Rise in grain
1	2	3	4
5.0	Bushels	lb.	
7.5	3.73	315	84.5
10.3	1.99	151	75.5
15.0	2.18	502	230.2
25.0	0.75	357	476.0
35.0	2.09	444	212.5
50.0	0.83	577	695.0

amount of straw for the increase of each bushel of grain ; the figures show a remarkable rise in the amount of straw for each bushel of grain, when irrigation water exceeds ten inches. With increase of irrigation water from 5 to 10 inches, the rise in straw is about 80 lb. for each bushel of grain, while with the increase of water from 35 to 50 inches the rise in the amount of straw is about 700 lb. per bushel of grain. The fact that the actual amount of grain increases all the time shows, however, that the limit of grain production has not been reached.

The fact that heavy nitrogenous manuring often increases the vegetative growth and decreases the amount of seed has been established by several workers. It offers an interesting example of the effect of environment on the yield of a crop. Table III,

TABLE III.
The effect of organic manure and sodium nitrate on the yield of some leguminous crops.

	INDIGO 1918-19			GRAM 1918-19			SWEET PEAS 1918-19		
	DRY WEIGHT IN GRAMMES		RATIO	DRY WEIGHT IN GRAMMES		RATIO	DRY WEIGHT IN GRAMMES		RATIO
	Veg.	Seed		Veg.	Seed		Veg.	Seed	
Control	68	32	2.10	719	409	1.76	994	259	3.84
Organic matter (well rotted leaf mould)—									
10 per cent. by volume	..	..	..	1,158	403	2.87	2,175	535	3.09
30 per cent. by volume	907	577	1.56	1,136	361	3.14	2,201	526	4.19
50 per cent. by volume	..	..	..	1,276	421	3.03	2,351	525	4.48
Sodium nitrate—									
2 cwt. per acre	..	..	..	1,170	627	1.87	1,190	398	2.99
4 cwt. per acre	..	..	..	1,127	651	1.76	1,215	356	3.41
8 cwt. per acre	191	115	1.66	..	..	..	..	..	..

originally given by Howard¹, shows the relative percentage increase in vegetation and seed production in some leguminous crops caused by an addition to the nitrogen content of the soil. It is evident from this table that not only is the effect of nitrogenous manure different on the seed and the green parts of the plants, but also that these three crops are very dissimilar in their reaction to the same manurial treatment. With heavy nitrogenous manuring a large amount of weak, sappy growth is produced, without a corresponding increase in the amount of seed. The evil effects of heavy nitrogenous manuring are well marked in this country—a very leafy crop with weak straw which easily lodges and is very liable to rust is obtained.

(b) *Light.* The amount of light and the relative duration of daylight and darkness have a profound effect upon growth and reproduction in plants. By studying

¹ Howard, G. L. C. (1923) : The role of plant physiology in agriculture : *Agri. Jour. India*, XVIII.

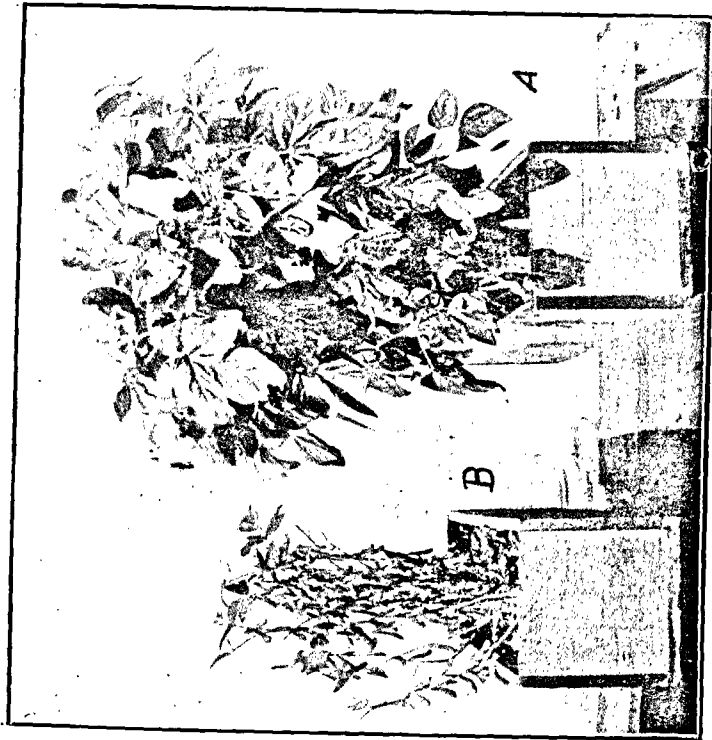


Fig. 1. Plants in box A exposed to light from 6 a.m. to 6 p.m. (12 hours daily). Plants in box B exposed to light from daylight to 10 a.m. and from 2 p.m. to dark (9—10 hours daily).
N.B.—In soybean, seed production and early maturity is favoured by decreasing the length of the daily period of sunlight.
(After Garner and Allard : *Journ. Agri. Res.*)

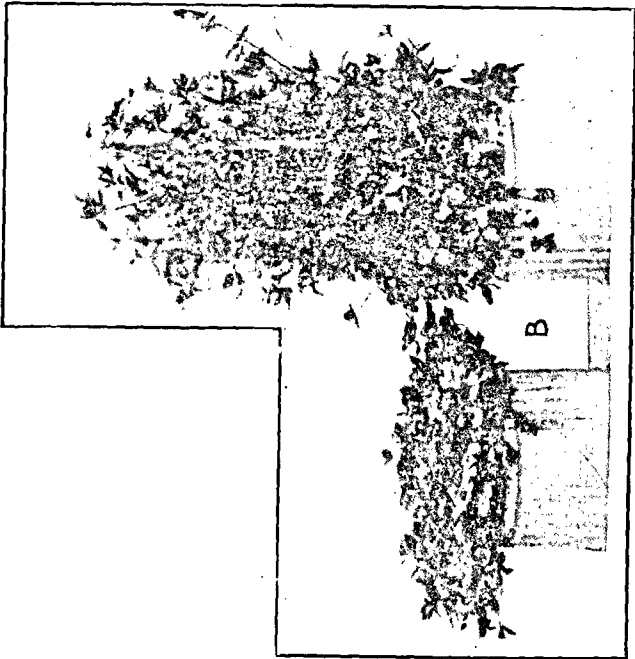


Fig. 2. Red clover is prevented from flowering by shortening the exposure to sunlight.
(After Garner and Allard : *Yearbook of U. S. D. A.* 1920.)

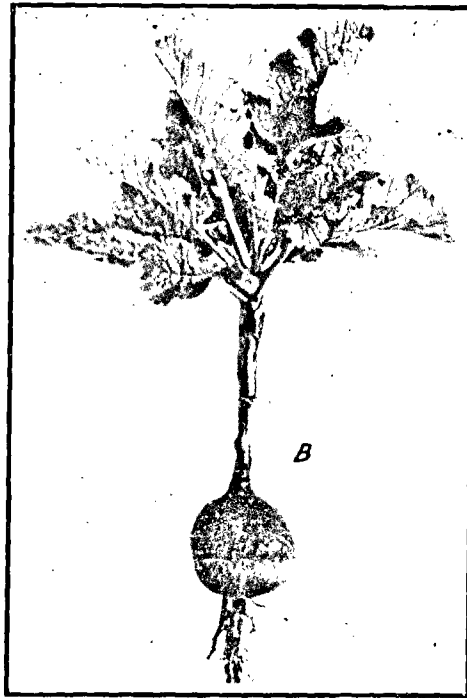


Fig. 3. Radish plant in which the seed stalk was transformed into a vegetative shoot through the influence of the decreasing length of day.
(After Garner and Allard : *Journ. Agri. Res.*)

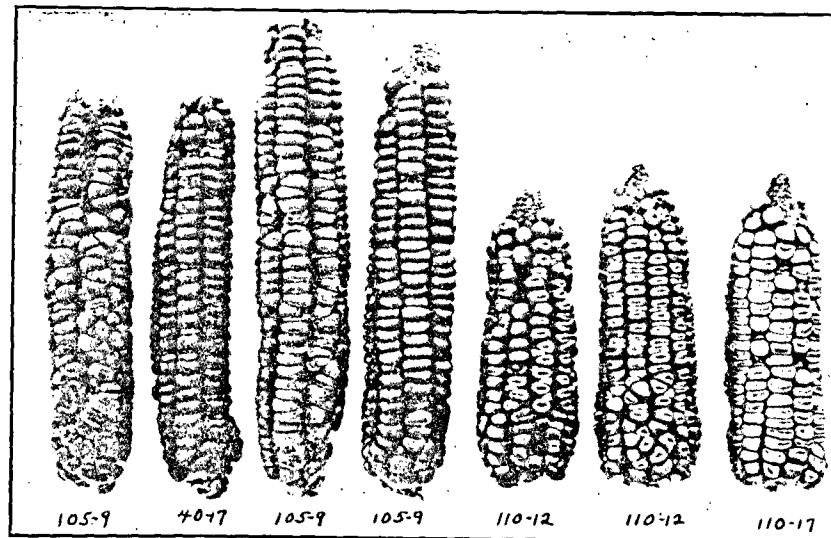


Fig. 8. Self-fertilized ears of maize showing defective seeds.
(After A. F. Jones : *Journ. of Hered.*)

a number of species, Garner and Allard¹ have found that normally plants can attain the flowering and fruiting stages only when the length of day falls within certain limits and consequently these stages are reached only during certain seasons of the year : shortening or lengthening the period of light causes many plants to stop vegetative growth and to flower and set seed. In this respect some species and varieties respond to relatively long days, while others to short days. Garner and Allard² have noticed that many varieties of soy-bean when grown in the North (being exposed to light for about 12 hours) make a rank growth of stems and leaves but produce few flowers ; when these same plants are kept in darkness and exposed to day light for a shorter period, they flower early and produce a heavy crop of seed: the plants grow to about half the usual size (Fig. 1).

On the other hand, clover retains a prostrate habit in reduced light and does not flower, while under normal conditions it grows to the usual size and bears flowers and fruits (Fig. 2). Similarly radish, which normally sends up a flower stalk in mid-summer, sets seed and dies, will produce only leaves if the daylight period is artificially shortened (Fig. 3).

Thus in certain species, in the absence of favourable length of day required for reproduction, vegetative development may continue indefinitely, while under the influence of suitable length of day, precocious flowering and fruiting may be induced. An example of this is to be met with in the indeterminate type of tobacco, which arose as a mutation in a field of tobacco at Connecticut. This tobacco type differs from the normal plant in its relation to light conditions. Under ordinary conditions, it shows much vegetative growth, producing large and numerous leaves—a desirable quality for a commercial variety—but does not blossom. When these abnormal plants are grown in the green house during winter they set seed freely like normal plants ; this fact is taken advantage of in producing seed of this type in large quantities. But for the favourable effect of shorter duration of light on its reproduction, this desirable variety would have been lost to the world. In this way certain species or varieties may act as early or late maturing, depending simply on the length of daylight to which they are exposed. The early planting of certain vegetable crops, such as peas and spinach, is necessary in order to adjust the plants to their optimum light requirements.

The relation between the length of the day and the time of flowering is of great importance in crop yields, and in many cases the necessity for seeding at the proper time is obligatory. The length of the day is the most potent factor in determining the relative proportions between the vegetative and the fruiting parts of many crop plants. In fact fruiting may be completely suppressed by a length of day either too long or too short.

¹ Garner, W. W., and Allard, H. A. (1920) : Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants : *Jour. Agri. Res.*, XVIII.

² Garner, W. W., and Allard, H. A. (1920) : Flowering and fruiting of plants controlled by the length of day : *U. S. D. A. Year-book*, 1920.

(c) *Humidity.* This is no less an important environmental factor in bringing about unproductiveness and sterility. Its effect is often seen on various crops in the diminished yield resulting from prolonged cloudy weather at flowering time. Some crops are more susceptible to it than others and as a rule leguminous crops suffer much from a prolonged cloudy weather. In gram, the writer has made some observations in February 1928 on the effect of cloudy weather on setting of pods. Some of the pure line cultures grown at Pusa were studied, and the observations made are given in Table IV. Several branches of a few plants, belonging to four different types, were labelled on a cloudy day. This weather continued for about a week. The number of flowers that opened during the cloudy weather were recorded, and the number of pods formed by the flowers opening during and after the cloudy weather were also noted as given in the table. The percentage of setting is comparatively very high in the flowers that opened after the cloudy weather.

TABLE IV.

The effect of cloudy weather on setting of pods in gram.

Variety	FLOWERS OPENED DURING THE CLOUDY WEATHER			FLOWERS OPENED AFTER THE CLOUDY WEATHER		
	No. of flowers	No. of pods formed	Percentage set	No. of flowers	No. of pods formed	Percentage set
T. 1	40	3	7.5	64	31	48.5
T. 2	27	3	11.1	43	29	67.5
T. 18	28	5	17.8	49	41	84.0
T. 25	19	1	5.2	41	30	73.0

On setting, the effect of moist air, round the flower, in bright weather, is very similar to this. At Pusa, it has been found that for most leguminous crops manilla paper bags, when used for bagging, bring about practically complete failure of setting on account of the moist atmosphere that they produce round the flowers. Muslin bags, however, do not prevent setting as in this case the circulation of air is possible.

This type of sterility which is caused by high humidity may be explained in two ways :—(1) The pollen grains may absorb enough moisture to swell and burst prematurely, or (2) The sex act may be circumvented by hard rain coming immediately after pollination and thus wash the pollen grain off the stigma.

(d) *Disease.* It is one of the most important non-hereditary causes of sterility among crops and fruit trees. The rust of wheat, red-rot of sugarcane, wilt disease of pigeon-pea (*rahar*), gram and linseed, and the mosaic disease of tobacco are too well known to most agriculturists and need not be dealt with in detail. In

certain years, they actually cause havoc to these crops. The effect of most of these diseases upon vigour is so marked that it results in large decrease in productiveness. In addition to these mycological diseases, the agriculturist has to face the problem of entomological pests, which are no less virulent in their action. The boll-worm of cotton is still a problem unsolved and occasionally it brings about, more or less, a total failure of the cotton crop in certain localities. Similarly the moth-borer is said to kill one cane shoot in three and the rice grass-hopper occasionally destroys paddy over a whole division. However, much loss of this type can be prevented by proper treatment. An extensive discussion of the effect of diseases and the method of their control is beyond the limits of this short essay. It involves two important branches of agricultural science, namely, mycology and entomology.

II. Germinal agencies.

The effect of environmental factors upon fertility is not well defined and, as we have seen in the previous pages, their effect may range from full fertility to complete sterility. On the other hand, the hereditary sterility which is controlled by internal factors, acts in a more definite way. It can be grouped into two well-defined classes :—

INCOMPATIBILITY. This is a type of sterility in which the organism is fully developed and functionally normal in every way, except that fertilization cannot take place in certain matings but is brought about in other combinations (Self and Cross-sterility).

IMPOTENCE. In this case the organisms are not normally developed in respect to their reproductive organs and are unable to produce viable germ-cells, or the embryos after fertilization may be incapable of development. (All other forms of sterility.)

(a) INCOMPATIBILITY.

Incompatibility may be caused by—

- (1) Large evolutionary tendencies.
- (2) Phenomena of heredity.

The first form of incompatibility has been achieved in several groups of flowering plants through the perfection of devices favouring cross-pollination. This includes protandry and protogyny, dioecism, etc. But they are more of theoretical interest than of practical importance.

The other type of incompatibility, which is based on heredity, is a phenomenon which has loomed up as a great practical problem during the last few years. It occurs only (i) when the organisms are alike with respect to particular sterility factors or (ii) when they are germinally too dissimilar. The latter condition is of no

special significance but the first type of incompatibility, due to germinal similarity, is found in many varieties of cultivated fruits which are self-sterile, *i.e.*, the plants are unable to fertilize their flowers and set fruit with their own pollen. Unless pollen is supplied by some compatible variety, the trees are entirely barren or only partially fruitful. The pollen, which is unable to fertilize the flowers of the same plant, is fully capable of functioning on other plants of a different variety. Two plants may be entirely self-sterile, but reciprocally fertile.

An interesting example of this has been noted at Pusa in loquats.¹ Two varieties of loquats, Pale-yellow and Golden-yellow, were formerly grown in the Botanical Area and both varieties bore fruit profusely. After some years, all the Pale-yellow trees were cut out and only the Golden-yellow type remained in the garden; this type failed to set fruit after the removal of the Pale-yellow variety. The Golden-yellow loquat used to flower profusely but no setting would take place. Experiments were carried out and it was found that both these varieties were self-sterile. Some Pale-yellow loquats were obtained and planted near the Golden-yellow plants. In 1925-26 the new Pale-yellow variety formed some flowers and the same year the neighbouring branches of the Golden-yellow formed fruits. Now both the varieties are bearing fruits.

Another case of self-sterility has been noticed in grapes in Bombay. The Pandhari-Sahebi grape is regarded in the Deccan as the best strain in quality, but it has a great disadvantage in giving a low yield. From the experiments carried out at Kirkee, Deshmukh² concludes that the lack of yield in this variety is due to self-sterility, but he attributes the self-sterility to comparatively short size of the stamens and reflexed stigmas. Hence it is not definitely a case of incompatibility. He has neither tried hand-pollination with self-pollen nor examined the pollen-grains, which would have decided this point.

This phenomenon of self-sterility has been observed in various fruit trees, such as plums, loquats, almonds, apples, pears, berries and grapes. Such plants may be perfectly healthy and may flower abundantly and yet fail to set fruit unless suitable pollen is available. In cases of self-sterility, it is immaterial whether the pollen comes from the same flower, from different flowers on the same tree or from different trees of the same clonal variety, as has been shown by Gowen³ while working, at Maine, on apples. (Table V). Self-sterility is undoubtedly common in fruit trees and very often noticed in many of the cultivated flowering plants, but its occurrence in rye is rather remarkable. Rye is outstanding among cereals in being incapable of setting seed freely with its own pollen. Among the agricultural crops tobacco has offered a wide field for investigations elucidating the problem of self-sterility.

¹ *Sci. Repts. A. R. I., Pusa*, 1925-26.

² Deshmukh (1924): *Agri. Jour. India*, XIX.

³ Gowen, J. W. (1920): Self-sterility and cross-sterility in the apple. *Maine A. E. S. Bull.* 287.

TABLE V.

The result of pollinating apple flowers with pollen from various sources within the same variety.

(Data from Gowen, Maine A. E. S. Bull. 287.)

Variety	FLOWER CLUSTER HAGGED AND LEFT		POLLINATED WITH POLLEN OF SAME TREE		POLLINATED WITH POLLEN OF DIFFERENT TREES OF SAME VARIETY	
	Fruit matured	No. of fruit	Fruit matured	No. of fruit	Fruit matured	No. of fruit
Baldwin	2	11	3	22	2	2
Ben Davis	..	65	..	229	..	26
Crab	..	3	..	..	..	..
Duchess	..	..	1	3	..	..
Early Harvest	..	6	..	7	..	..
Golden Russett	..	15	..	46	..	..
Hurbbert Sweet	..	5	..	10	..	..
McIntosh Red	..	16	..	13	..	..
Northern Spy	..	1	..	34	..	..
Red Astrachan	..	..	..	4	..	..
Rhode Island Greening .	1	2	..	10	..	2
Wealthy	..	..	..	..	..	..
Per cent. fruitful. . . .	2.36		1.03		2.50	

By crossing self-sterile and self-fertile species, East¹ has demonstrated that self-sterility behaves like a simple Mendelian recessive to self-fertility, only one factor determining the difference between the two conditions. In other plants the situation may be different. East and Park² have further made an attempt to analyse the relation of self-sterile plants *inter se* by crossing two species of tobacco, namely, *Nicotiana forgetiana* and *N. alata*. They found that self-sterile plants were consistently cross-fertile in F₂ (Table VI). From this the authors conclude that

¹ East, E. M. (1919): Studies on self-sterility, III—The relation between self-fertile and self-sterile plants: *Genetics*, IV.

² East, E. M.; and Park, J. B. (1917): Studies on self-sterility, I—The behaviour of self-sterile plants: *Genetics*, II.

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could classify the plants into five groups, A, B, C, D, and E, such that all the plants of any one group were both self-sterile and cross-sterile within the group but fertile with every individual of every other group (Table VIII).

TABLE VIII.

Plants of the fifth generation of a cross of *N. forgetiana* × *N. alata*, grouped in accordance with their behaviour in intercrosses.

(Data from East and Park, in *Genetics*.)

Group	Ped No.	Number of crosses fertile within group					Number of crosses sterile within group				
		A	B	C	D	E	A	B	C	D	E
A	3	0	5	2	3	1	5	0	0	0	0
	7	0	4	3	3	1	4	1?	0	0	0
	10	0	3	3	3	1	3	1?	0	0	0
	11	0	4	3	1	1	3	1	0	0	0
	13	0	5	3	2	1	2	0	0	0	0
	18	0	5	3	3	..	5	0	0	0	..
B	2	5	2	2	1	1	0	3	0	1	0
	5	4	1	2	3	1	1	3	0	0	0
	9	5	1	3	2	1	1	2	0	0	0
	16	6	2	3	3	1	0	3	0	0	0
	19	6	2	3	3	..	0	2	0	0	..
	20	..	0	1	..	..	..	3	0	..	..
C	6	5	4	0	3	1	0	0	2	0	0
	14	6	5	0	3	1	0	0	2	0	0
	15	6	5	0	3	1	0	0	2	0	0
D	8	4	4	3	0	1	0	0	0	2	0
	12	6	5	3	0	1	0	0	0	2	0
	17	4	3	3	0	1	1	1	0	2	0
E	1	5	4	3	3	0	0	0	0	0	0

It is interesting to note that the percentage of sterile combinations increased from F_2 to F_5 as given below :—

F_2	F_3	F_4	F_5
Per cent.	Per cent.	Per cent.	Per cent.
14.4	19.1	26.2	22.2

This shows that there were fewer factor differences in F_5 than in F_2 as would be expected in ordinary Mendelian inheritance. However an exact factorial analysis has not been possible as yet.

The theoretical interpretation given by East and Park is very plausible, in pointing out a new line of work for the analysis of sterility. At a recent international conference on flower and fruit sterility held in New York in 1926,¹ several investigators working with widely different plants arrived independently at conclusions

¹ *Mem. Hort. Soc., New York*, III, edited by A. B. Stout.

which are essentially the same. They have provided a factorial interpretation of the phenomenon of self- and cross-incompatibility, which is said to be determined by genetic factors just as are morphological characters but the behaviour and inheritance of incompatibility is naturally complex. Brieger and Mangelsdorf¹ have established linkage between morphological characters and factors for self-sterility: this is especially interesting as it corroborates East's interpretation of sterility and also establishes a unique example of linkage.

As a result of these investigations, we find that incompatibility is only the result of likeness of sterility factors; morphologically the plants may be quite different but still they may belong to the same incompatible group, within which all self- and cross-pollinations fail.

East and Park² have also made a careful study of the pollen-tube growth in the self-sterile and fertile types of *Nicotiana* and they have obtained very interesting results. The floral parts of self-incompatible plants are typically normal and produce abundant pollen which germinate normally on the self-stigmas, but is unable to grow fast enough to reach the ovary, before the pistil withers and falls off. Length of the pollen-tube when plotted against time, the graph formed is a straight line (Fig. 4). Pollen-tubes produced after a compatible cross are stimulated to a more rapid

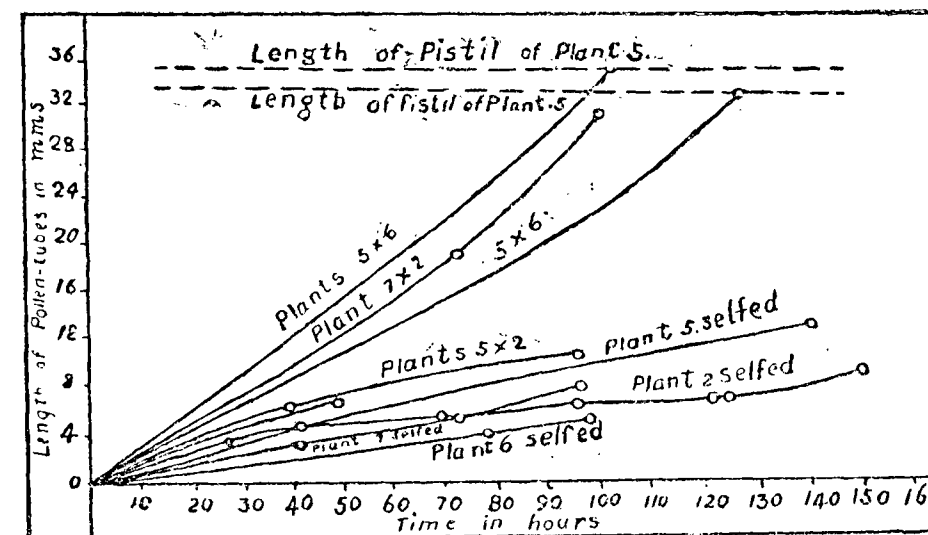


Fig. 4. Growth curves of pollen tubes from pistils of plants of *Nicotiana angustifolia*. Plants 5 & 2 are cross-sterile with each other.

(After East and Park in *Genetics*.)

¹ Brieger, F. G.; and Mangelsdorf, A. J.: Linkage between morphological characters and factors for self-sterility: *Mem. Hort. Soc., N. Y.*, III.

² East, E. M.; and Park, J. B. (1918): Studies on self-sterility, II—Pollen-tube growth: *Genetics*, III.

growth, as though they were receiving some stimulus, and reach the ovary in time for fertilization to take place. Here the growth becomes constantly more and more rapid. Length plotted against time produces a curve that resembles that of an autocatalytic reaction (Fig. 5). In cross-sterile combinations the rate of pollen-

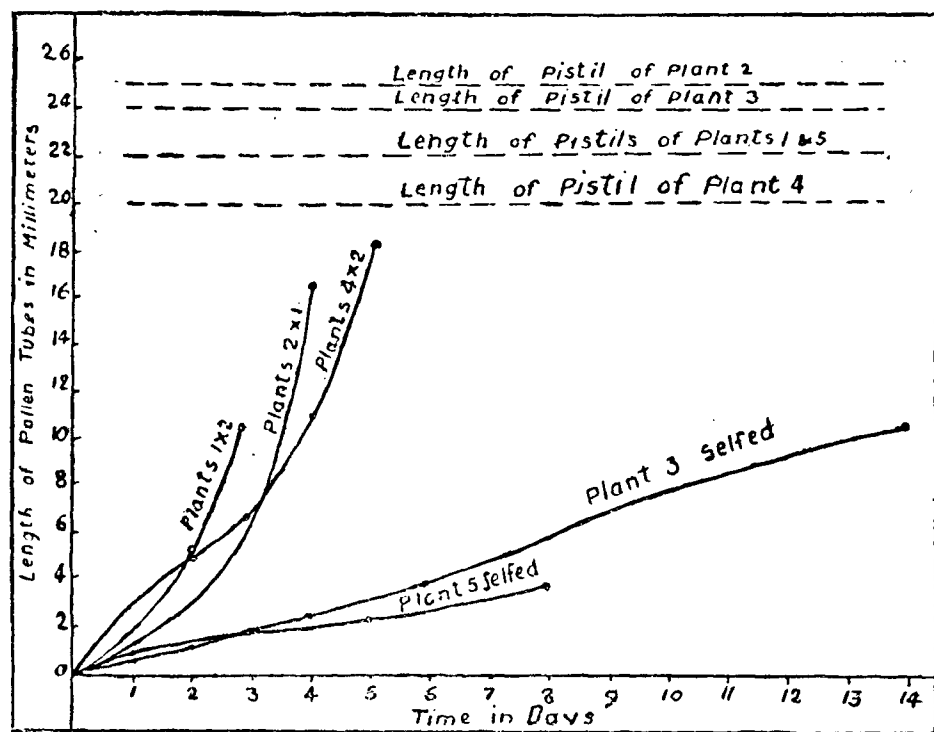


Fig. 5. Growth curves of pollen tubes from selfed and from crossed pistils of plants of *Nicotiana forgetiana*.
(Alter East and Park in *Genetics*).

tube growth resembles that of selfed plants (Fig. 4). While at the wane of the flowering season the rate of growth of self pollen-tubes becomes more rapid resulting in pseudo-fertility. This study of the pollen-tube growth has elucidated several obscure facts observed in the *Nicotiana* crosses. It has provided us with a physiological explanation of the peculiar behaviour of the cross- and self-sterile and self-fertile plants.

The problem of cross- and self-sterility has been dealt with rather in detail because of its so frequent occurrence in most fruit trees. The setting and development of fruit takes a foremost place among the problems with which the fruit grower is confronted, and as this is dependent on efficient pollination and fertilization, the problems associated with these processes cannot fail to be of vital

concern to the pomologist and fruit grower. To explore these processes fully, genetical and cytological studies are essential. Consequently although such studies are frequently regarded as within the realm of pure science their practical importance is direct and self-evident.

Sterility due to incompatibility is a special function which operates to promote cross-fertilization. Economically, it is mostly undesirable and causes considerable loss annually, especially in fruit-growing. Inferior varieties have to be grown in orchards for supplying the need of suitable pollen. We have seen that Pandhari-Sahebi grapes are self-sterile and for obtaining a good produce other inferior varieties have to be grown for the sake of their pollen alone. Similar is the case of the Golden-yellow variety of loquat at Pusa. Future breeding operations should aim to remove this type of sterility as far as possible. The attempt to overcome this physiological barrier to full fertility by inbreeding is not only useless but it will even increase the occurrence of the very trouble which it is desired to remedy. From the work of East and Park it is clear that sterility due to incompatibility can only be eliminated when the hereditary factors for self-fertility are present in the material or introduced by crossing.

(b) IMPOTENCE.

Impotence results from the structural derangement of various parts that are concerned directly with reproduction. This also may be caused by—

- (1) Large evolutionary tendencies.
- (2) Phenomena of heredity.

The structural derangement of reproductive parts, as a result of evolutionary tendencies, has been noticed in several crops and fruit trees, especially in those which are essentially hermaphrodite but show a tendency towards mono- or dioecious condition. An instance of this type of sterility may be given from the observations made at Pusa in plums.¹ Two varieties of plum, namely (i) Black-Small-Early plants with inferior quality fruits and (ii) Large-Red-Late plants with good quality, were grown at Pusa. It was noticed that every plant of the early variety (Black-Small) bore nicely, while all the plants of the late variety (Large-Red) were almost barren. This sterility in the late variety was due to:—

- (1) The defective stamens which do not form pollen at all; and
- (2) the late flowering which prevents pollination from the early variety whose flowering period ceases before the late variety comes into flower.

Some varieties of the same flowering season as the "Large-Red" and with good pollen have now been procured and in the very first year of the flowering of the new plants, the plants of the "Large-Red" variety have simultaneously set

¹ *Agri. Jour. India*, XXIII (1928).

some fruits. In this way the defective bearing of this “Large-Red” variety could be removed successfully.

This type of sterility is also found in sugarcane, where the percentage of sterility of anthers and ovary has been studied by Venkatraman¹ who found the various varieties of sugarcane to vary in this respect, some showing a very high percentage of male sterility and others female sterility (Table IX). This has enabled the

TABLE IX.

(Data from Venkatraman, *Agricultural Journal of India*.)

(♀) PANSAHI GROUP.				SARETHA GROUP (♂).			
Variety	ANTHESIS			Variety	ANTHESIS		
	Open	Slightly open	Closed		Open	Slightly open	Closed
	Per cent.	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.
Pansahi . . .	0	2	98	Saretha . . .	97	0	3
Merthi . . .	5	10	85	Labri . . .	95	0	5
Dikchan . . .	11	6	83	Saretha desi . .	97	1	2
Sanachi . . .	3	9	88	Messangon . . .	91	0	9
Kahu . . .	1	2	97	Katha . . .	95	0	5
Maneria . . .	0	5	95	Kansar . . .	96	0	4

separation of certain groups of canes as predominantly male or female and some of them show both male and female sterility, e.g., J. 36. Advantage has been taken of this fact in avoiding emasculation in sugarcane hybridization, where emasculation would be practically impossible on account of the extremely delicate nature of the cane flowers. This difficulty in emasculation is evident from a Cuba report, where four years of continuous work yielded only two seedlings.

¹ Venkatraman, T. S. (1917) : *Agri. Jour. India*, XII.

Definite hereditary factors may bring about various forms of impotence which may express itself in—

(i) *Aborted pollen*. Many plants show a varying proportion of aborted pollen grains which may be due to evolutionary tendencies, as mentioned above, or may be due to definite hereditary factors as found by Belling¹ in velvet-beans. He made a cross between two races of beans, both of which were completely fertile. The resulting hybrids were semi-sterile. Uniformly just one-half of the pollen grains appeared empty and collapsed, while one-half of the ovules had no embryo-sacs. Belling calls this condition as semi-sterility, and he has explained it on Mendelian principles as shown diagrammatically in Fig. 6 ; pollen grains and embryo-sacs are

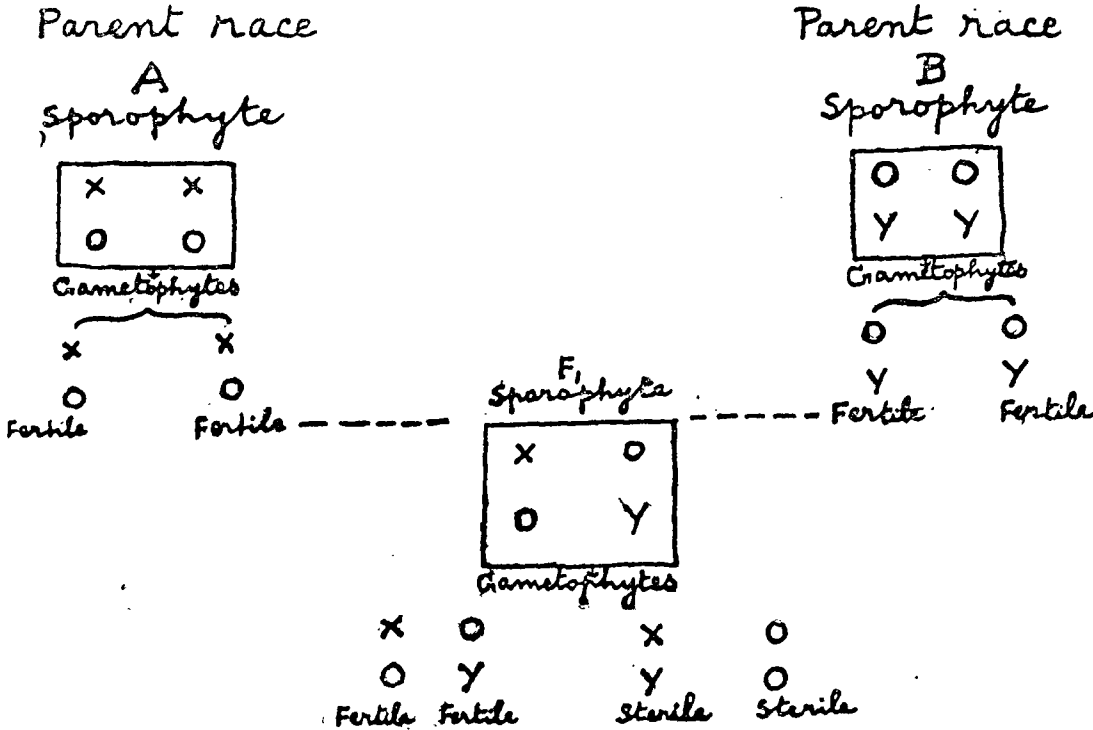


Fig. 6. Diagram illustrating Belling's explanation of semi-sterility.

represented as gametophytes and the two races are assumed to have complementary factors X & O and O & Y for fertility. When these complementary factors break up the gametes become non-functional. In F₂ it was actually observed that one-half of the plants had perfect pollen and ovules ; the other half had a mixture of equal numbers of good and bad pollen grains in all their flowers. In F₃ all the

¹ Belling, J. A. (1914) : Study of semi-sterility : *Jour. Her.*, V.

descendants from the fertile plants had perfectly good pollen and ovules, but the progeny of semi-sterile plants again split up into fertile and semi-sterile plants as shown in the scheme in Fig. 7.

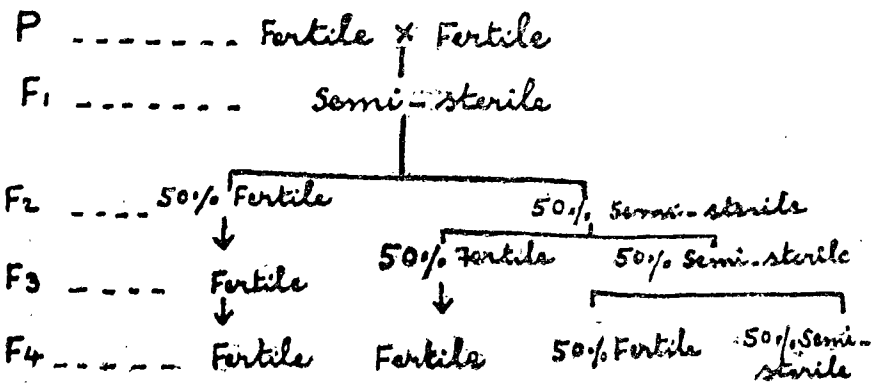


Fig. 7 Segregation of Fertile and semi-sterile Plants.

Belling has also found similar conditions in rhododendron, a plant in which the pollen grains adhere in tetrads. Certain plants of this species have half of their pollen grains aborted and in every case two of the cells of each tetrad are empty.

(ii) *Aborted embryos*. Most generally lethal factors result in the destruction of the embryo soon after fertilization. Such cases are found in several plants. In self-fertilized plants, lethal factors of this kind are automatically eliminated soon after they occur, but in a naturally cross-fertilized plant they can be perpetuated in heterozygous condition and may remain in the stock for an indefinite period. In corn, whenever embryo abortion takes place the defective seeds are easily seen scattered uniformly over the entire ear (Figs. 8 & 9). They appear as empty capsules interspersed among the well developed grains. The ratio of defective to normal seeds has been worked out by Jones¹ who found it to be about 3 : 1. The behaviour of this character indicates that it is recessive and due to a single factor difference. Defective kernels due to various causes other than heredity are also found on many ears of corn, but they are usually very few and rarely distributed evenly over the entire ear. Embryo abortion has also been noticed by the writer in gram, where some of the pods are fully developed but they contain only aborted

¹ Jones, D. F. (1921) : Heritable characters of maize, IV—A lethal factor-defective seeds : *Jour. Her.*, XI.

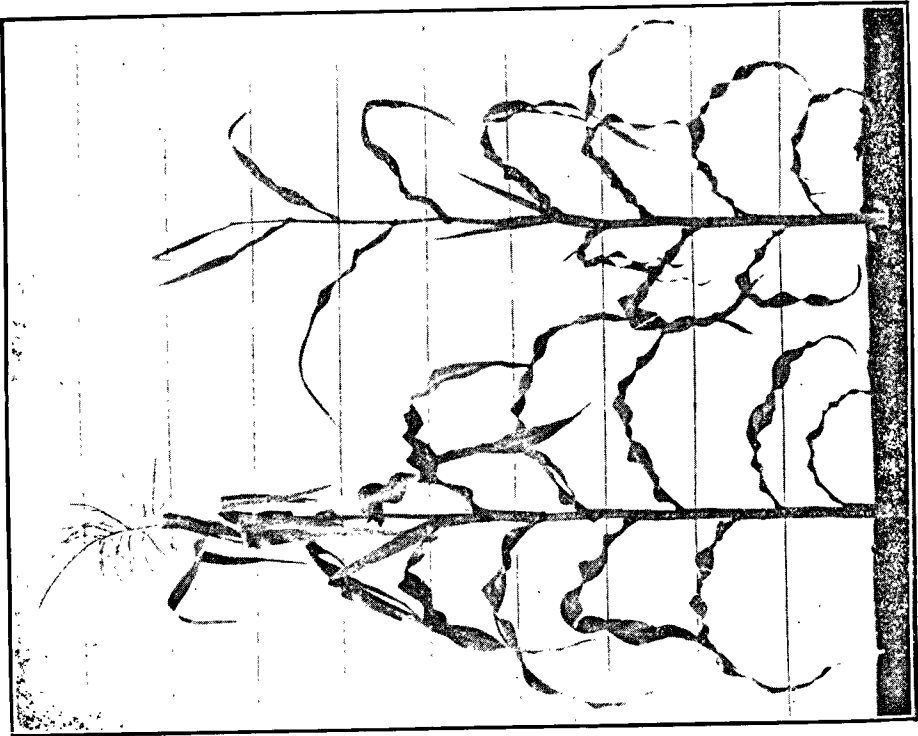


Fig. 10. Normal and barren-sterile plants.

The barren-sterile plant shows no tassel. Shoots are present but no cobs and no silks. This barren-sterile plant shows more vegetative vigour than most of them because it is one of a progeny obtained by crossing heterozygous plants belonging to different lines segregating for this type of sterility. Since barren-sterile plants do not ordinarily produce seed, the character can only be perpetuated through heterozygous plants.

(After C. M. Woodworth : *Journ. of Hered.*)

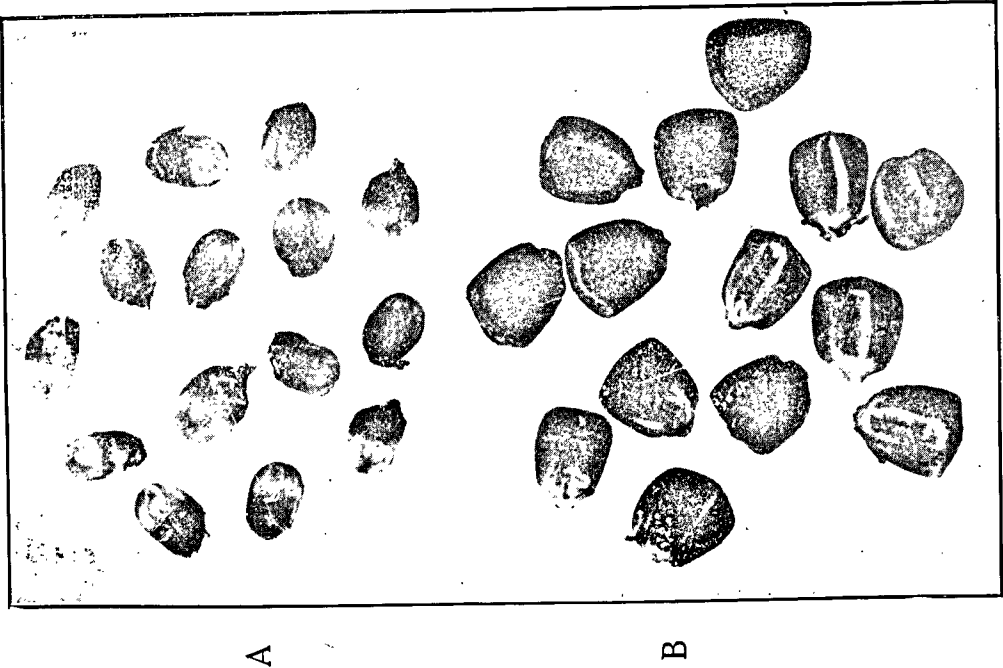


Fig. 9. Defective (A) and normal (B) seeds compared. N.B.—The pericarps of defective seeds are nearly empty as indicated by their transparency.

(After D. F. Jones : *Journ. of Hered.*)

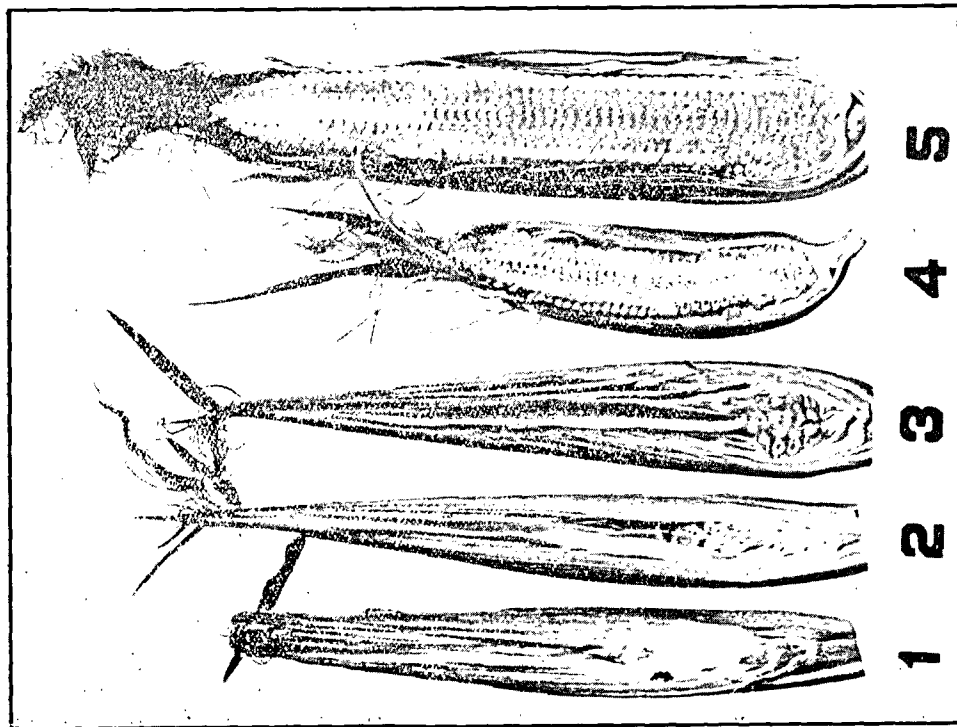


Fig. 11. Five ear types obtained in the hybrid progenies. (1) Just a vestige of a cob bearing four or five silks. In the typical barren-sterile shoot, neither cob nor silks are found. (2) A still larger cob than shown in (1). (3) A little larger cob bearing more silks than in (1). (4) An intermediate type approaching the normal in size of ear. (5) Normal ear. (After C. M. Woodworth : *Journ. of Hered.*)

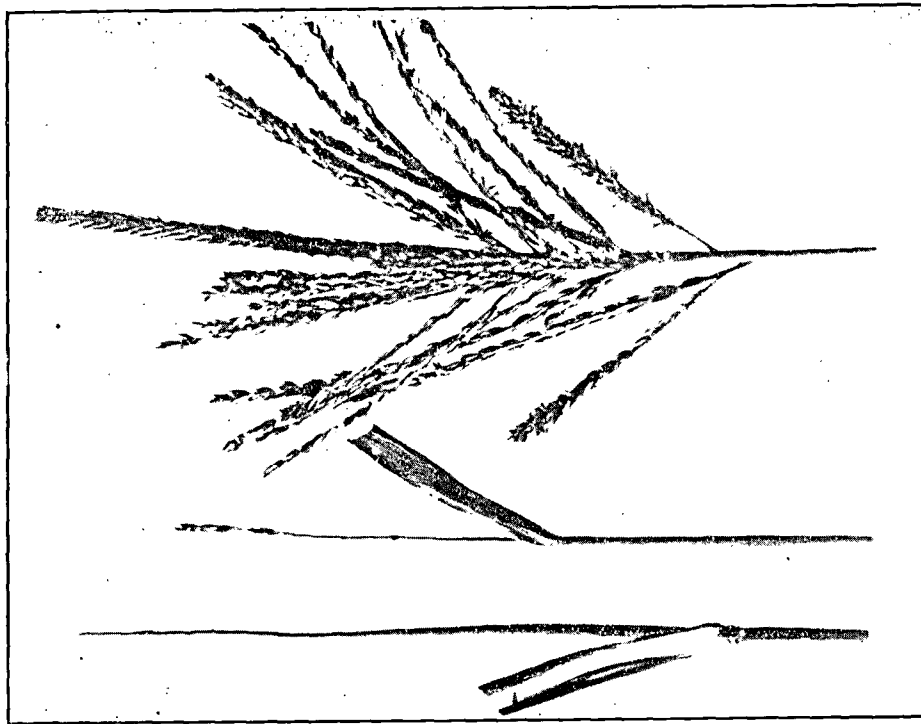


Fig. 12. Three tassel types obtained in hybrid progenies. Normal tassel at right. In centre, a much reduced tassel consisting of only a shortened central stem. At left is shown a tassel stem which bears no flowers whatever. (After C. M. Woodworth : *Journ. of Hered.*)

embryos. Some of the pure line cultures show a very high percentage of such sterile pods and consequently their yield is much reduced. The investigation is still in progress and no definite conclusions have so far been arrived at. In some cases this sterility may be due to hereditary factors ; in others it may be the result of environments. This type of sterility is met with in practically all the crops where a certain percentage of sterility always exists. In wheat some of the basal spikelets are always sterile. Grantham and Groff¹ have shown that there is a positive correlation between the total number of spikelets and the number of sterile spikelets in wheat. This sterility is, therefore, not merely absolutely but relatively more frequent in varieties with a larger number of spikelets.

There are other recessive factors in plants which permit normal development of the seed, but the seeds fail to germinate or the seedlings show abnormal features and die. This condition is also found in corn, where albinism is caused by hereditary factors and the seeds containing this factor germinate but soon die, when the food stored in the seed is exhausted. Such albino seedlings appear in many other plants as well and they are very often caused by hereditary factors.

Sometimes both the types of gametes may abort. Such a condition we obtain in sterility caused by chromosome irregularities.

Blackeslee² and Belling have obtained Jimson-weeds with an odd number of chromosomes, due to some inequality in the reduction division. Such plants produce gametes half of which have an even number and half an odd number of chromosomes. The gametes with the odd number of chromosome regularly abort. Chromosome aberrations of this kind are now believed to be an important cause of partial sterility which may persist in many plants and animals.

(iii) *Abortion of floral parts.* There are many illustrations of entire or partial derangement of floral organs. A factor which almost entirely destroys both types of flowers in maize has been described by Woodworth,³ and he calls that type as barren-sterile because it bears neither tassel nor cob and silk (Fig. 10). In inheritance, barren-sterile behaves as a simple Mendelian recessive. A few lines of corn on self-fertilization throw the barren-sterile regularly, giving a ratio of 3 normal to 1 barren-sterile. The reproductive shoots of normal and barren-sterile maize plants are shown in Figs. 11 and 12. Similar occurrences have been reported in sweet-peas, flax and potatoes, where anthers are defective and produce no viable pollen. In most of these cases simple Mendelian factors are responsible for the sterility and these are always recessive.

Impotence based on heredity most usually results from crosses between different species and different genera. It is the result of the inharmonious interaction of

¹ Grantham, A. E. ; and Groff, F. (1916) : Occurrence of sterile spikelets in wheat : *Jour. Agri. Res.*, VI.

² Blackeslee, A. F. (1921) : Types of mutations and their possible significance in evolution : *Am. Nat.*, 55.

³ Woodworth, C. M. : Heritable characters of maize, XXVIII—Barren-sterile : *Jour. Her.*, XVII. No. 11.

very dissimilar germ plasm. Sterility resulting from wide crosses may be partial or total. Sexual reproduction is dependent upon the harmonious interaction of all the elements that go to make up the body. In some cases of wide crosses, where diverse elements are brought together all the germ cells may be completely sterile or only a part of them may be able to function.

An instance of complete sterility is to be met with in a cross, made by Malloch,¹ of two species of barley, differing greatly in all parts of the plant. Two F_1 hybrid-seeds were produced and they germinated but both seedlings were very abnormal, consisting of a single leaf, a few inches long, and they soon died. Here the F_1 plants were of reduced size and lessened vigour.

Another extreme limit of hybridization is well illustrated by the radish and cabbage (belonging to different genera) cross. Here, the F_1 plants grew enormously and the rampant hybrid flowered but produced no viable seed.² So far we have been dealing with such types of sterility which are economically undesirable, but now we shall come across a type which is of great value in breeding. Partial sterility resulting from certain wide crosses is of much economic importance. As a result of such partial sterility certain classes of gametes fail to develop while others are able to survive. The elimination is selective, and generally the surviving ones contain a major portion of the chromosomes of one or the other parent. The aborted gametes contain part of the one or the other and are unable to develop because of the lack of adjustment between the diverse elements.

The selective elimination of gametes is shown in several species-hybrids whose self-fertilized progenies have been grown and found to give some offsprings which are an exact return to one or the other parental type. In crosses where the parental species differ greatly, with random assortment of the gametes and fertility of all combinations, the parental types could be expected only rarely (a few in thousands and millions). The recovery of parental types in appreciable numbers suggests that many mixed gametes are not viable. An interesting example of this is found in the *wheat-rye hybrid*. Several investigators have attempted to make this cross but only a few of them have succeeded. Jesenko³ obtained a few crossed seeds, but all the hybrid plants had no viable pollen. Back-crosses were, however, successfully made and the resulting plants were strikingly similar to each parent with which they were pollinated. Love and Craig⁴ at the New York Station have obtained a fertile plant from the cross of wheat and rye without back-crossing. The F_1 plant had all the characters of a wheat-rye hybrid and was almost sterile but it did produce one seed when self-pollinated. The F_2 plant again formed only one seed but the F_3 plant produced a large number of seeds and the resulting plants gave a wide

range of type which were more like wheat than rye. They did however show many of the qualities of rye and the character which is being chiefly followed is the winter hardness of rye.

Similar results have been obtained by Goodspeed and Clausen¹ with *tobacco* species. The F_1 plants are almost completely sterile; when they are grown under reduced conditions of culture they set some seed with pollen of either parent but will never produce more than about 1 per cent. of the number of seeds which the parents do normally. The resulting back-cross plants are variable in type but about 10 per cent. closely resemble the parent which supplied the pollen and others reduplicate the F_1 plant.

The possibility of producing radically new forms from combinations in partially sterile hybrids is found in a cross of *Nicotiana rustica (humilis)* and *N. paniculata*, made by East.² Both parents are very uniform and fully fertile; the F_1 hybrid exhibited features of both, but it produced only 3 to 4 per cent. of the seed normally produced by both parents. The F_2 plants were extraordinarily variable in most features such as height, size, and shape of leaves, texture and colour. In 300 individuals every plant could be classed as a different variety. A few plants were like the parents. Fertility ranged from almost total sterility up to the full fertility of the parents. In succeeding generations, however, these hybrid plants showed an unexpected uniformity in their progenies. They almost bred true to their individual type showing that they must have been nearly homozygous in the F_2 generation.

In general, we can say that results obtained from the partially sterile *species-hybrids* differ from those of the usual *variety cross* in two outstanding features:—

- (1) The grand parental types are recovered even in comparatively small number of individuals, showing that all the possible recombinations are not realized.
- (2) The F_2 individuals are much more homozygous than similar plants from fully fertile crosses. This also points to the same fact that all the recombinations are not realized.

Such partially sterile species-hybrid crosses are of great importance in practical plant breeding. Crossing, as a rule, brings about variability, but when there is normal fertility the inter-grading forms are so numerous and the difference between them are so small that it is difficult to obtain individuals really better than the existing forms. Even if they are found, they may be heterozygous and must be fixed by selection for several generations. On the other hand, in partially sterile hybrids the incompatibility of many chromosome combinations leaves only a small residue which is able to function. Further, the greater the differences in the species that are crossed, the more is the opportunity for entirely new variations some of which

¹ Malloch, W. S. (1921): An F_1 species cross between *Hordeum vulgare* and *Hordeum Muranum*: *Am. Nat.*, 55.

² Gravatt, F. (1914): A radish cabbage hybrid: *Jour. Her.*, V.

³ Jesenko, F. (1913): Über Getreide Speziesbastarde (Weizen-Roggen): *Zeit. ind. Abs. Vererb.*, X.

⁴ Love, H. H.; and Craig, W. F. (1919): Fertile wheat rye hybrids: *Jour. Her.*, X.

¹ Goodspeed, T. H.; and Clausen, R. E. (1917): The nature of F_1 species-hybrids between *N. Sylvestris* and varieties of *N. tabacum* with special reference to the conception of reaction system contrasts in heredity: *Univ. Calif. Pub. Bot.*, V.

² East, E. M. (1921): Study of partial sterility in certain hybrids: *Genetics*, VI.

may be really valuable. Hence, the greatest opportunity for plant breeders to originate radically new and valuable plants lies in the crossing of races which are as different as are possible to give some degree of fertility in their offspring.

Summary and Conclusion.

An outline of the subject has been presented to show what parts of the problem are being tackled by the scientists. Sterility may result from environmental as well as germinal influences, but more frequently definite hereditary factors are responsible for it. The work of Garner and Allard and that of Kraus and Kraybill point to the importance of environmental factors which may bring about total sterility without any germinal influence. In certain cases artificial environments may turn out to be of great advantage as seen in the case of indeterminate type of tobacco. Most usually environmental factors determine the relative proportions between the vegetative and reproductive parts of the plant.

Inherited sterility is of two kinds: incompatibility and impotence. Incompatibility is mostly undesirable and future breeders should always aim at removing this type of sterility by introducing the factor for self-fertility as suggested by the work of East and Park. Wherever self-sterility could not be eliminated the inter-planting of self-sterile plants with other varieties with which they are mutually inter-fertile and which flower at the same time is highly desirable. A newly introduced variety, or indeed any variety, should never be planted in large blocks unless it is known to be capable of producing an economic yield with its own pollen.

Impotence may have a relatively simple factorial basis or may be the result of the inharmonious inter-action of very dissimilar germ plasm. Sterility of this type comes to light most usually when cross-bred organisms are intensively in-bred as in case of defective kernels in corn. In-breeding, however, is never responsible for their origin, as it was formerly believed, but it simply brings them into visible expression. In-breeding is the panacea for sterility of the type of impotence; rigid and most intense in-breeding is the only certain cure for this serious handicap to plant and animal production. When the hereditary factors that cause sterility are once got out completely, they are out to stay. The occurrence of partial sterility in wide crosses is of definite advantage in breeding operations and this type of sterility is not always undesirable as is the case of incompatibility. Great possibilities lie in such partial sterility as exhibited in wide crosses.

SOME ASPECTS OF THE RICE PROBLEM IN SIND.*

BY

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At first sight it may sound anomalous to say that the most popular crop, and the most extensively grown crop in Sind, is rice, because here we have the most arid tract in India associated with the most water-demanding crop. Yet, nevertheless, it is true. In Sind, rice is the "dream crop" of every zemindar. All would prefer to grow it in preference to any other crop, not excluding cotton. It occupies an area of 12 lakhs of acres, or upwards of 40 per cent. of the total *kharif* cereal area. No other crop except *bajri* (*Pennisetum typhoideum*) can show an area comparable with this. Its cultivation is limited only by the irrigation facilities and by certain Government restrictions. From the standpoint of Government, rice is not a very desirable crop, because it consumes, relatively to other crops, much more water, while the difference between the assessment rates of rice and other crops is comparatively small. The highest water assessment for rice in Sind at the present time is Rs. 5-12-0 per acre, whilst the corresponding figures for cotton and wheat are Rs. 5 and Rs. 4-4-0 respectively. Rice, however, consumes from two to three times as much water as cotton which in turn consumes about twice as much water as wheat, per unit of time and area. The reasons for the great popularity of this crop are several, including safety and profit. Speaking generally, rice is free from serious pests and diseases, whilst cotton has several formidable enemies. The crop is generally grown according to the half and half share system, and it has been estimated that the net profits of an average zemindar in the Larkana District amount to Rs. 37 per acre, after payment of the assessment which includes both land and irrigation charges.

A large portion of the rice-tract in Sind, including the zone which grows the finest and best varieties, will come under the command of the new canals, based on the Lloyd Barrage at Sukkur, and thus there will be a transformation in the irrigation facilities of the zemindar. Under the new system it is proposed to provide the canals serving the rice zone with a six months' supply of water, which is hardly comparable with the present supply obtained from the inundation canals, as these respond to every caprice of the river (Indus). Sometimes the irrigation season starts late, sometimes it ends prematurely, sometimes it is intermittent, and sometimes all three adversities occur in the course of a single season. The cultivator,

* Paper read at the Indian Science Congress, Madras, 1929.

moreover, loses a considerable period of time at the beginning of the season while growing his seedlings, as this generally cannot be arranged in advance owing to the well water being brackish. Under the existing precarious system it may happen that the crop receives irrigation for a month only, after transplantation. An instance in point occurred at the Larkana Farm in 1920-21 when a variety known as "Sathri" received canal water for 30 days only. It was arranged, however, in this case to give one irrigation from a pump three weeks later, and this resulted in a yield of 2,000 lb. of paddy per acre. As the rainfall in Middle Sind is negligible, the crop is wholly dependent upon irrigation water, and it is exposed throughout its growth to a very hot sun with shade temperatures going up to 120° F. The atmosphere is not so dry as one might expect owing to the high intensity of the crop and the consequent presence of water everywhere, giving rise to the growth of grasses and other vegetation, and so during the night and well into the forenoon, the humidity is fairly high. Still the evaporation during the growing period is about half an inch per day from a free water surface. One of the fundamental questions which the framers of the Barrage Project had to ask themselves was, what "duty" should we assume for rice under the new conditions? For the information of those who are not familiar with the technical meaning of the word "duty" it may be said that this term means the number of acres of a crop which can be brought to maturity on a supply of one cubic foot of water per second running continuously throughout the season. Under present conditions the highest "duty" obtained is about 40 acres of rice; when the writer conducted investigations into this question at Larkana, some years ago, a figure ranging from 37 to 41 was obtained. At that time some interesting and significant results were obtained, showing that the "duty" is not a constant throughout the season. It starts low and gradually rises. At the very beginning of the season it was found to be very low—about 24 acres. But subsequently it rose, and reached a figure of about 96 acres at the close of the season. The framers of the Barrage Project have assumed a steady "duty" of 50 throughout the season. This is definitely an assumption, and perhaps no zemindar would admit the possibility of such a high "duty" for rice, but there is this to be said in support of the figure quoted, namely, the supply will be available for six months, and hence the transplanting period which demands such large quantities of water, could be spread out over a longer period of time, possibly from the end of April to the beginning of August.

In certain parts of Sind there exists among rice-growing zemindars a practice called "Panco." It consists in filling up a rice field with water until the surface is within a few inches of the tops of the plants, and then, after some time, draining out this water and replacing it with fresh water. The practice is prevalent where the supply is intermittent, and may have taken its origin in a device to safeguard the crop. But apart from this, some zemindars maintain that it is necessary to drain off the water from their fields if it has been standing for some time, because the temperature of the water rises, and the concentration of salts increases and aeration

decreases, and so the conditions are unfavourable to plant growth. This "Panco" water question has been a bone of contention between the zemindars and the Irrigation Department for many years, the latter questioning the necessity, and the Agricultural Department has been asked to advise—especially in connection with whether the practice should be allowed under the Barrage Canals System, because if it is not necessary it should be stopped, owing to the prodigal consumption of water which it entails. At present the Department of Agriculture has no actual figures with which to prove the necessity of the practice, but it is obvious that the removal of hot, concentrated, stagnant water from a rice field, is eminently desirable, as apart from eliminating the direct damage to which the crop is being exposed from such an unfavourable environment, there is the positive gain brought about by aerating the soil for the benefit of the roots. It is, moreover, understood that a very similar practice exists in certain other parts of India, while the same service is usually rendered by Nature where rice is grown on terraces of varying elevation, over which the rainfall water slowly trickles.

Good progress has been made with the improvement of several of the best known rices in Middle Sind, through selection. Thus at Larkana the Botanical staff have produced an improved strain of Sugdasi which yields 15 per cent. above the ordinary variety. Again an improved strain of Kangani yields 20 per cent. above the local variety.

An important question, now before the department, is, where should Sind market her surplus crop? Exports have grown enormously in the last 50 years. Thus in 1886-87 the exports of rice from Sind through Karachi and minor ports were 140,000 cwt., while post-war exports have exceeded 1,000,000 cwt. in a single year, but the quantity fluctuates a good deal from year to year. At present the exports of Sind rice are confined to the Persian Gulf and Red Sea markets, and none find their way into the European market, whereas it is understood that Burma rice is largely exported to Europe. The export trade in rice from Sind has certain peculiar features. Thus much of the exported rice is boiled up-country by a process which is known as "Josh." The paddy is placed in water in earthen pots or iron vessels, and this is heated over a fire for a whole night. On the following day the water is drained off and the paddy is subjected to a second heating in shallow iron pans kept on the fire. It is then hulled. The advantage of the "Josh" treatment is that the rice keeps for a much longer time. Under the new irrigation scheme the area under rice will increase by about a lakh of acres, and hence the marketing problem assumes great importance, because not only may the Persian Gulf not absorb the whole of the exports, but the improved irrigation facilities may enable Sind to enter the Western market.

THE HYPOTHESIS OF "UNFREE WATER" IN SOILS

BY

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Bouyoucos and his co-workers, in a series of papers,¹ have studied the concentration of soil solution *in situ* by the freezing point method. They found that as the water content of a soil decreased in an arithmetic progression, the freezing point depression increased in a geometric progression. As an explanation of this, the hypothesis was offered that some of the water contained in the soil was either loosely chemically combined or physically absorbed or both, in which event this portion of the water was not free to act as a solvent but was removed from the liquid phase and took no part in the lowering of the freezing point.

The question as to whether any water in the soil does exist as "unfree," is of great importance; because if a part of the water in the soil is such that it takes no part in dissolving the salts, etc., and Bouyoucos' results show that this quantity is by no means inconsiderable, then a knowledge of it is indispensable for any study of water requirements of plants.

Keen, who subjected Bouyoucos' data to a comprehensive mathematical analysis,² arrived at the conclusion that if the abnormal freezing point depression of soils at a low moisture content was due to a part of the water being "unfree", then the quantity of water thus rendered unfree must vary with the total moisture content.

This will be clear from Table I, wherein are recorded the results of the lowering of the freezing point of a clay soil at different moisture contents (examined by Bouyoucos). The theoretical freezing point depression has also been calculated assuming the inverse proportionality law to hold. From the theoretical freezing point depression and the freezing point depression actually found the amount of unfree water has been calculated.

¹ Michigan Agri. Coll. Expt. Sta. Tec. Bull. 24 (1915), 31 (1916), 36 (1917), 42 (1918). Also in Jour. Agri. Res., 8 (1917), p. 195; 15 (1918), p. 331.
² Jour. Agri. Sci., 9 (1919), p. 405.

TABLE I.

Lowering of the freezing point of a clay soil at different moisture contents, with the calculated unfree water (Bouyoucos).

Moisture content per cent.	Theoretical F. P. D.	F. P. D. found	Calculated unfree water per cent.
34	0.034	0.034	..
32	0.036	0.042	4.5
30	0.039	0.062	11.1
28	0.041	0.082	14.0
26	0.044	0.127	17.0
24	0.048	0.212	18.56
22	0.053	0.307	18.21
20	0.058	0.580	18.00
18	0.064	0.922	16.75

It is thus seen that in order to account for the abnormal freezing point depression we have not only to postulate the existence of unfree water but its amount must be supposed to vary with the moisture content. Later on Bouyoucos developed another method for finding the amount of unfree water, which he called the dilatometer method.¹ The principle of this is based upon the fact that water expands on freezing; knowing the coefficient of expansion of water upon freezing and also the total water content of a soil, the amount of water that freezes (free water), and does not freeze (unfree water), can be calculated.

The moist soil is held in a dilatometer filled with ligroin and frozen at different degrees of super-cooling. For classifying the moisture into various forms the following principle was followed :—

All the water in the soil that freezes at or slightly below 0° C. is considered free water because pure water in mass is known to freeze at this temperature. All the water that freezes from this temperature down to —78° C., is regarded as capillary absorbed water, while all the water that fails to freeze is considered unfree water.

Using this method he found that the amount of water which the soils are able to render unfree does not vary with different moisture contents but that it appears to remain constant.²

¹ Mich. Agri. Expt. Sta. Tech. Bull. 36 (1917).
² Soil Sci., 11, p. 255 (1921).

This discrepancy between the results of the freezing point depression and the dilatometer methods leads to two alternatives : either the abnormal freezing point depression is due partly to unfree water which is constant and partly to an unknown factor which is variable ; or the unfree water that causes the abnormal freezing point depression is not identical with the unfree water that fails to freeze even at -78°C .

- Parker in a series of papers ¹ has arrived at the following conclusions :—
- (1) That a much greater increase in the freezing point depression of soils with a decrease in the moisture content, than is indicated by the law of inverse proportion, is due to the solid material and not to the existence of unfree water which would cause a greater concentration of the soil solution. This is supported by experimental evidence where it is shown that solid material causes a depression of the freezing point of water, benzene and nitrobenzene in the film or capillary condition.
 - (2) Alcohol and glycerine solutions are not made more concentrated when added to dry soil, as would be the case if part of the water was rendered unfree by the soil. Therefore all the water must act as a solvent and exist in the liquid condition.
 - (3) It is possible to displace part of the soil solution from a soil the moisture content of which is less than that of the unfree water.

The evidence brought forth by Parker would seem to be fairly conclusive against the hypothesis that a part of the water in soils is inactive or unfree, *i.e.*, does not act as a solvent. However recently McCool and Weidemann have shown that when soil is added to sucrose solution,² it extracts some water leaving the sucrose solution more concentrated.

By measuring the increase in concentration of molar sucrose solution when brought into contact with different soils and soil separates by means of the freezing point method, they found that some organic soils can render as much as 26 to 35 per cent. water unfree.

They have also recorded some experiments on the increase in concentration of potassium in potassium chloride solution when brought in contact with soils. This result is similar to that obtained in an earlier work by McCall, Hildebrandt and Johnson ³ who noticed negative absorption in the case of potassium. These results, however, cannot be cited in support of the hypothesis of unfree water as sufficient attention was not paid to the phenomenon of base exchange and the distribution equilibrium of solute between the soil and the solvent.

Sucrose, on the other hand, is not absorbed by the soil nor reacts with it, and therefore the results obtained with this substance are of considerable interest ; because if the increase in the concentration of the sucrose solution as measured

¹ *Jour. Amer. Chem. Soc.*, V, 43, p. 1011 (1921). *Soil Sci.*, 12, p. 209 (1921) ; 13, p. 43 (1922).
² *Soil Sci.*, 20, p. 243 (1925).
³ *Jour. Phys. Chem.*, 20, p. 51 (1917).

by the freezing point method cannot be accounted for by any other way, then not only will the hypothesis of unfree water be substantially correct but we are provided with a simple means of measuring the capacity of soils for rendering water unfree.

It seems, however, that the authors have overlooked two important factors, namely, the possibility of inversion of sucrose by the soil which will result in a lowering of the freezing point and causing the solution to appear as if it has become more concentrated. That such inversion does take place is shown by the work of Hanley, Rice and Osugi, and others.¹ The authors themselves found that considerably more water was removed from the sugar solution by the samples when maintained at a temperature higher than that existing in the laboratory. This is evidently due to the enhanced rate of inversion at higher temperatures.

Another point is that the concentration of the sugar solution used was very high and not in any way comparable to the concentration of the soil solution, and even if a certain phenomenon is observed in a solution having such a high osmotic pressure and molecular association, we are not justified in supposing that the same will be true in the case of the soil solution, unless we could show that approximately the same amount of water is rendered unfree by the sugar solution of a concentration comparable to that of the soil solution.

It was therefore decided to study this phenomenon, using sugar solutions of varying concentrations and under conditions that will preclude the possibility of results being vitiated by inversion.

Experimental.

Four soils were examined for this purpose. These are given in Table II, along with their clay content and moisture absorption at 50 per cent. humidity.

TABLE II.
Soils used.

Soil	Clay (·002 mm.)	Hygroscopicity at 50 per cent. humidity
1. Gonbri (Pusa)	43·6	2·65
2. Montgomery	73·0	4·06
3. Hoos Field (Rothamsted)	35·2	3·37
4. Akola (Black cotton soil)	60·6	10·00

NOTE. Hygroscopicity and clay values refer to the acid treated dry soils.

The soils were first freed from all soluble salts and replaceable bases, by exhaustive treatment with $\frac{N}{20}$ HCl followed by prolonged leaching with water. This was

¹ Hanley, *Jour. Agri. Sci.*, 6, p. 63 (1914). Rice and Osugi, *Soil Sci.*, 5, p. 333 (1918).

done to prevent side reactions such as changes in the equilibrium concentration of absorbed ions in the presence of sugar. After treatment the soils were dried over sulphuric acid in vacuum desiccators.

The usual Beckmann technique of determining the freezing point was used to study the changes in concentration.

To 25 c.c. of redistilled water varying amounts of pure sucrose were added and the freezing point noted ; 25 gm. of dry soil were then quickly added and the freezing point again noted. A change in the freezing point was a measure of the change in concentration. Equilibrium was attained in about 15 minutes and was noted when three consecutive readings agreed within .002° C. ; as a rule the agreement was even better.

To prevent inversion of sucrose by soil it is important that the temperature of the mixture should never be allowed to rise above 5-6° C. At this low temperature no inversion was noticed even on keeping for 24 hours.

The results given in Table III and plotted in Fig. I show that up to a concentration ranging from 4 to 8 per cent. approximately, depending on the nature of the soil, the latter is able to absorb the sugar solution as such. From concentrations higher than a certain minimum the soil evidently takes up a solution of a weaker concentration, the amount of which is more or less constant for a given soil.

TABLE III.

Change in the freezing point depression of sugar solutions due to the addition of 25 gm. of dry soil.

Conc. of water in gm. of sugar added to 25 c.c. of water	F. P. D. (°C.)			
	Soil No. 1	Soil No. 2	Soil No. 3	Soil No. 4
0	·010	·010	·011	·008
0·5	..	·010	·010	·008
1	·010	·010	·010	·011
2	·012	·010	·011	·032 (9·92%)
3	·012	·018 (4·84%)	..	·061 (10·72%)
4	·013	·030 (4·88%)	·029	·090 (10·88%)
5	·011	·041 (4·72%)	·041	·117 (10·64%)
6	·015	·052 (4·44%)	·050	·142 (10·28%)
8	·018	..	·069	·195 (10·04%)
8·555 (mol. conc.)	..	·080 (4·34%)	..	..

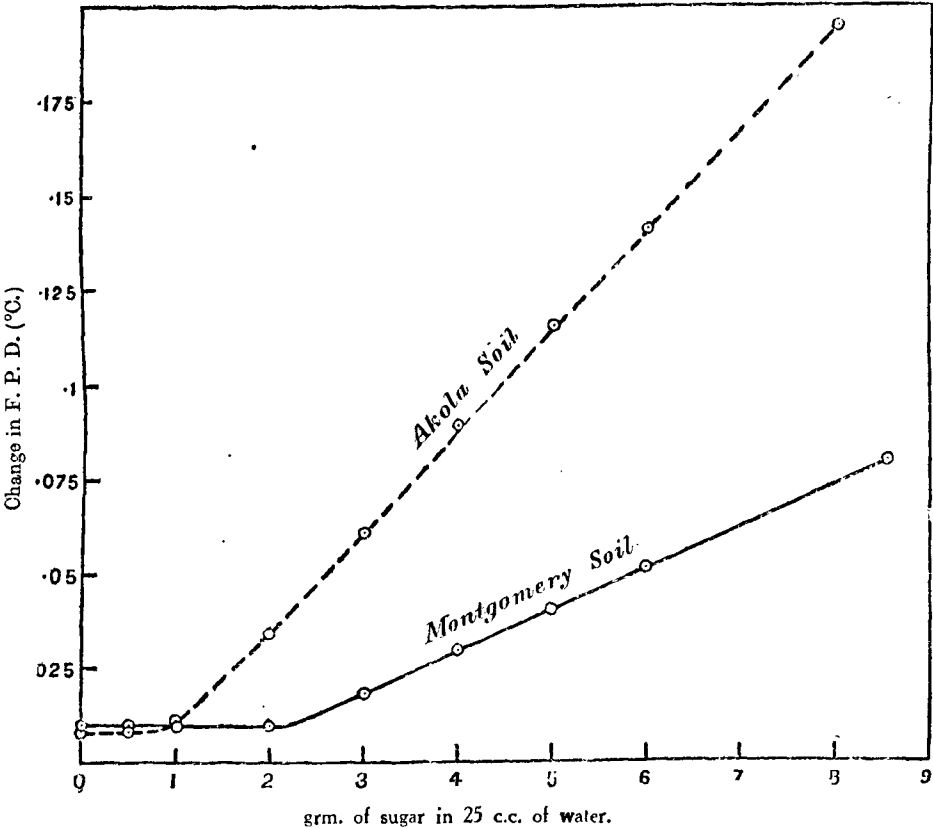


Fig. I. Change in F. P. D. of sugar solutions due to the addition of 25 gm. of dry soil.

Figures in brackets indicate the percentage of sugar solution of a weaker concentration absorbed by the dry soil (=x). These have not been calculated for soil No. 1 as it shows very little absorption and it is not possible to find definitely where the two portions of the curve meet, which would obviously be the concentration of sugar solution that the soil is able to absorb. These figures have been calculated by the formula—

$$x=4 \left\{ 25 - \frac{25 (F-F')}{(F-F')-(L-L')} \right\}$$

Wherein F=F. P. of sucrose solution.
F'=F. P. of sucrose solution the soil is able to absorb as such (i.e., the point of intersection of the two portions of the curve obtained by plotting the concentration of sugar solution as abscissa, and F. P. D. as ordinate).
L=F. P. lowering produced in the solution by soil.
L'=F. P. lowering produced in water by soil.

The phenomena noticed in the case of sugar solutions might be due to a critical molecular association of the sugar and water molecules, and the limiting size of the minute capillaries that are largely responsible for moisture absorption.¹ Such cases of negative adsorption with substances of high molecular weight, are not unknown in the domain of colloid chemistry, and it would be stretching the analogy too far to suppose that the same cause operates in the case of soil solution where we are generally dealing with much lower concentrations of salts composed of simpler molecules. In using $\frac{N}{20}$ and $\frac{N}{10}$ solutions of chlorides and nitrates of potassium and sodium the writer did not find any increase in the concentration of nitric acid or chlorine ions when shaken with dry Akola soil, which shows the highest negative absorption in sugar solutions. Before shaking with potassium chloride and sodium chloride, the soil was saturated with potassium and sodium respectively so that there was no interference from base exchange.

It is of interest to note that the values for sugar solution absorption run parallel to water absorption at 50 per cent. humidity and bear no relation to the clay content (Table II).

Summary.

- (1) The previous work on the hypothesis of unfree water has been briefly reviewed.
- (2) It has been shown that dry soils are unable to remove any water from sugar solutions of concentrations from 4 to 8 per cent. At high concentrations there is evidence that a weaker solution is taken up leaving the sugar solution more concentrated. As in soil solutions we are generally dealing with much lower concentrations of simpler molecules than sucrose, it is extremely unlikely that any unfree water exists in the soils.

¹ Crowther and Puri. *Proc. Roy. Soc., A*, Vol. 106, p. 232 (1924).

NOTE ON A FIELD METHOD OF ARRANGING PADDIES IN ORDER OF DIFFICULTY OF THRESHING.

BY

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CERTAIN paddies at present being distributed by the Agricultural Department in Lower Burma have been found to be difficult to thresh. The matter was brought to the attention of Mr. D. Rhind, the Economic Botanist, Burma, and myself by the Deputy Director of Agriculture, Southern Circle, Rangoon. He himself had looked into the matter sufficiently to be able to say that the complaint of the cultivators was a real one. As he was going on leave, he suggested we might try and solve the problem of how to measure the difference in this respect between the various paddies being distributed.

The solution of the problem was by no means an easy one. It was at first thought that a laboratory method was the only hopeful line. To use a threshing machine (however small) meant that we would be using a machine which was overpowered for the job in hand. The machine would group together paddies which might vary in difficulty of threshing within very wide degrees. To use bullocks seemed at first to be equally useless. The difficulty here was to get bullocks of the same weight, and then, having got that, to ensure that each group trod round on the paddy the same number of times in a given period of time.

In the end it was decided to take three paddies which are very easy to pick out from one another, namely, Mandalay Ngasein 2014, Hmawbi Ngasein C 10 and Mandalay Taungdeikpan. It was recognized as impossible to get absolutely equal weights of each variety with the same proportions between straw and grain. Fifty bundles each of Mandalay Ngasein and Hmawbi Ngasein were taken and two lots of fifty bundles of Taungdeikpan.

Two threshing floors were made. On one of them 50 bundles of Hmawbi Ngasein and 50 bundles of Taungdeikpan were laid down alternately in a circle ready for threshing. Similarly 50 bundles each of Mandalay Ngasein and Mandalay Taungdeikpan were laid down ready for threshing by bullocks on the other floor.

Two lots of bullocks were obtained and made to tread out the grain until most of it had been threshed. The bundles or sheaves were then separated into varieties and the grain left on was threshed off by hand and weighed. There can be no mistake in separating these varieties as they are so dissimilar, but for the sake of

training the staff in future work the sheaves of one variety in each lot were tied round with Government red tape.

A heap of mixed grain was left on each threshing floor. It had been thought that it would be a comparatively easy matter to separate the varieties from one another, but it was not realized that while it is easy to do so with quantities of a few ounces, the strain imposed on the eyes becomes too great when even such a small quantity as 5 lb. is separated.

With the Hmawbi Ngasein-Taungdeikpan heap an attempt was made to separate the paddies by means of a sieve as the grains are very different in shape and size. Complete separation was impossible, the result being that we were left with two unequal heaps instead of one.

Finally it was decided to take five samples from each heap and separate these by hand and after averaging the results to assume the different heaps to consist of the varieties concerned in the proportions found in the sample.

Two methods of sampling were tried:—

- (1) Where equal volumes were taken.
- (2) Where equal weights were taken.

It is considered that either is correct. We found it simpler to take equal weights. Both methods are shown.

Results I—Taungdeikpan Hmawbi Ngasein C 10.

Variety	Number of bundles	Total weight of bundles	Weight of grain threshed by bullocks	Weight of grain threshed by hand	Total weight of grain columns 4 and 5	Per cent. threshed by bullocks
1	2	3	4	5	6	7
		lb.	lb.	lb.	lb.	lb.
Taungdeikpan . . .	50	409	152·945	5	157·945	96·8
Hmawbi Ngasein C 10 . .	50	446	149·43	21	170·43	80·9

In this experiment an attempt was made to separate the varieties by sieving, since there is a big difference in size and shape between the varieties.

The only result was to make two heaps of unequal proportions.

An attempt was also made to separate all the grains but this was soon stopped. The two heaps of grain were weighed and had 5 samples taken from each.

1st heap (where equal volumes were taken).

	oz.	Per cent.
(1) Hmawbi Ngasein	4·125	or 18·3
Taungdeikpan	18·375	
	22·5	
(2) Hmawbi Ngasein	4·25	or 18·78
Taungdeikpan	18·375	
	22·625	
(3) Hmawbi Ngasein	4·187	or 18·45
Taungdeikpan	18·5	
	22·687	
(4) Hmawbi Ngasein	4·125	or 18·13
Taungdeikpan	18·625	
	22·75	
(5) Hmawbi Ngasein	4·00	or 17·58
Taungdeikpan	18·75	
	22·75	
AVERAGE	..	18·24

2nd heap (where equal weights were taken) Weight of each sample 25 oz.

	oz.	Per cent.
(1) Hmawbi Ngasein	16·687	or 66·75
(2) Ditto	16·625	or 66·5
(3) Ditto	16·875	or 67·5
(4) Ditto	16·562	or 66·25
(5) Ditto	16·75	or 67·00
AVERAGE	..	66·79

	Hmawbi Ngasein	Taungdeikpan
	lb.	lb.
1st heap—Weight of mixed paddy, 74·625 lb.	13·61	61·015
2nd heap—Weight of mixed paddy, 173·75 lb.	116·07	57·68
Separated—		34·25
Taungdeikpan	19·75	..
Hmawbi Ngasein		
TOTAL THRESHED BY BULLOCKS . .	149·43	152·945

Results II.—Taungdeikpan Mandalay Ngasein 2014.

Variety	Number of bundles	Total weight of bundles	Weight of grain threshed by bullocks	Weight of grain threshed by hand	Total weight of grain (columns 4 and 5)	Per cent. threshed by bullocks
I	2	3	4	5	6	7
		lb.	lb.	lb.	lb.	lb.
Taungdeikpan . . .	50	391	139.795	5.25	145.045	96.5
Mandalay Ngasein . .	50	374	130.155	6.875	137.03	94.9

An attempt was made to separate by hand the grain threshed by the bullocks, but it was soon seen that although it could be done easily enough it was going to take too long. Part was separated from the mixed heap by hand and is shown below. From the remainder, 5 samples of 25 oz. weight were taken and the varieties separated and weighed.

Sample	Variety	Weight oz	Percentage
(1)	Ngasein .	12.3125	49.248
(2)	Ditto .	12.1875	48.748
(3)	Ditto .	11.75	47.000
(4)	Ditto .	12.00	48.000
(5)	Ditto .	12.00	48.000
AVERAGE .			48.2

	Taungdeik-pan	Mandalay Ngasein
	lb.	lb.
Total weight of mixed paddy—262.25 lb.	135.86	126.39
Weight of Taungdeikpan separated	3.935	..
Weight of Mandalay Ngasein separated . . .	..	3.765
TOTAL THRESHED BY BULLOCKS .	139.795	130.155

Making Taungdeikpan the standard in each case with a standard value of 100 points, the three varieties may be arranged in order of difficulty of threshing as under. The lower the number of points the greater the difficulty in threshing.

Taungdeikpan	100
Mandalay Ngasein	98.3
Hmawbi Ngasein	83.6

This arrangement is in accordance with the beliefs of cultivators. Mandalay Ngasein is considered to be just a little more difficult to thresh than Taungdeikpan because the whole head or panicle breaks off readily. In Taungdeikpan it resists the treading for a longer time and the grains fall off leaving the stem of the panicle still attached to the straw. Hmawbi Ngasein is definitely considered to be much more difficult to thresh.

A NEW METHOD OF DISPERSING SOILS FOR MECHANICAL ANALYSIS.

BY

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It is well known that the values obtained in the mechanical analysis of soils are greatly affected by the preliminary treatment to which the soil is subjected.

The International Society of Soil Science, after a careful survey of the various methods, has come to the conclusion that, in order to attain maximum dispersion, treatment with dilute HCl is necessary. This forms the basis of the International method A recommended for universal adoption. The treatment with hydrogen peroxide though primarily intended for humus soils has been included in the above method for some reason or other.

The writer has shown elsewhere¹ that treatment with hydrogen peroxide is quite unnecessary for Indian soils which contain, as a rule, very little humus.

The International method has not met with universal approbation because there is a large body of opinion against treating the soil with acid preliminary to its being analysed mechanically. It has been rightly pointed out that such a drastic treatment can materially alter the mechanical composition, especially in the case of calcareous soils which might contain as much as 30--40 per cent. calcium carbonate.

A new method has been worked out in this laboratory, which possesses all the advantages of the International method as regards reproducibility and attainment of maximum dispersion, and at the same time is free from the objection that any acid treatment must involve the loss of varying amounts of soil constituents.

A full discussion of the principles underlying the new method, and a comparison with other methods is given elsewhere². The following brief description, it is hoped, will be useful to soil workers.

DESCRIPTION OF THE NEW METHOD.

10--20 grm. of soil are left with 100--200 c.c. of N NaCl for about half an hour with occasional stirring. The suspension is then filtered and washed with about 500 c.c. of the same solution on the filter paper. It is finally washed with a few c.c. of $\frac{N}{10}$ NaCl solution, and when the whole of it has been drained off the remaining

quantity is displaced with 10--20 c.c. of water. The suspension is then transferred to a stout beaker with 3 to 5 hundred c.c. of water, and $\frac{N}{10}$ NaOH gradually run in till it is alkaline to phenolphthalein (used as an external indicator). The suspension is then mechanically shaken for one hour or left for 5--6 hours with occasional hand shaking.

Mechanical shaking or rubbing with a rubber pestle seems to be essential for certain red soils; for all other soils it could be dispensed with.

It is not necessary to use pure NaCl for replacement: sodium chloride containing not more than 1 per cent. calcium or magnesium salts is equally effective and can be easily prepared from ordinary common salt by adding Na_2CO_3 . When the bulk of calcium and magnesium salts are precipitated the excess of Na_2CO_3 is then just neutralized by adding dilute HCl.

The details of the method can be varied to suit individual taste; what is required is to replace all or at least a greater part of the exchangeable ions by sodium in the clay complex.

There is practically no loss of soil constituents involved and a more rational picture of the size distribution of the various particles is obtained by this method than by the acid treatment.

¹ *Agri. Res. Inst., Pusa, Bulletin* 175 (1928).

² *Mem. Dept. Agri. Ind., Chemical Series*, Vol. X, No. 8 (in the press).

STUDIES IN COTTON POLLEN.

BY

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In recent years the study of pollen has received attention from investigators all over the world and many new facts have been elucidated. The importance of this study is now well recognized by systematic and economic botanists alike. Gamble¹ in his flora of Madras has based the classification of the family of Convolvulaceæ chiefly on pollen characters. Pollen dimorphism and segregation into definite Mendelian ratios have been noted by Parnell², Demeric³ and others. The literature on cotton pollen is, however, rather meagre. Watt in his book on the " Wild and Cultivated Cotton Plants of the World " has classified pollen grains according to the configuration of the external wall. Bailey⁴ in Egypt has recently shown the mode of inheritance of the size of the grains in the ' conjugate ' generation. Kearney⁵ in America, investigating the inheritance of the colour of pollen in a cross between Holden and Pima cottons, found definite Mendelian segregation in the second hybrid generation, and concluded from further evidence that the pale yellow colour was a simple recessive. Badami⁶ in Mysore claims to have germinated cotton pollen in a medium of cold drawn castor oil under moist conditions.

MATERIAL.

The investigations had to be confined to the pure line cultures available at the Coimbatore station which were as follows:—

- (1) *Gossypium hirsutum* Mill. (Cambodia.)
- (2) " *barbadense* L. (Ratto Sea Island.)
- (3) " *indicum* L. (Nandyal 14.)
- (4) " *herbaceum* L. (Hagari 25.)
- (5) " *cernuum* Todaro.
- (6) " *neglectum* Todaro, var. *rosea*.

¹ Gamble, J. S. *Flora of the Madras Presidency*, Part V (1923), pp. 901-903.
² Parnoll, F. R. Note on the detection of segregation by examination of the pollen of rice. *Jour. of Genetics*, Vol. XI (1921), pp. 209-212.
³ Demeric, M. A case of pollen dimorphism in maize. *American Journal of Botany*, Vol. XI, No 7 (1924), pp. 461-463.
⁴ Bailey, A. M. *Third Annual Report, Cotton Research Board Ministry of Agriculture, Egypt*, p. 41 (1922).
⁵ Kearney, T. H. A hybridization between different species of cotton. *Journal of Heredity*, Vol XV, No. 7 (1924), pp. 315-318.
⁶ Badami. *Adminis. Report Mysore Agri. Dept., 1922-23*, Parts I and II, p. 33.

GENERAL OBSERVATIONS.

Pollen of *Gossypium* is characteristically spherical in shape. The colour observed for all the cottons studied was yellow, excepting Cambodia which is characterized by creamy yellow or whitish pollen. Cotton pollen has a very high osmotic pressure, it imbibes water at the least contact and ejects its contents forcibly, it is also characterized by numerous points of emergence. Microchemically examined, the grains gave positive reactions for starch only. Indications as to the presence of protein and sugar were also noted, but by other tests (Xanthoproteic reaction and Phenylhydrazine test). The thickness of the wall in general may be reckoned as between 4 to 10 microns. The size of the grains varies to a certain extent as will be seen from the table given below. For convenience the data have been arranged in class ranges of five microns.

TABLE I.
Size of pollen grains (in microns).

Species	CLASS DIFFERENCE 5 μ																TOTAL	Mean
	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170			
<i>G. hirsutum</i> . .	..	..	..	..	1	1	1	2	8	26	26	20	12	2	1	100	149.55	
<i>G. barbadense</i> . .	..	..	..	..	..	..	1	15	42	38	4	..	..	..	..	100	141.45	
<i>G. indicum</i> . .	..	3	20	15	30	19	11	2	..	..	..	..	..	..	..	100	119.15	
<i>G. neglectum roseum</i> . .	..	..	..	5	23	41	25	6	..	..	..	..	..	..	..	100	125.20	
<i>G. cernuum</i> . .	..	..	..	3	24	36	26	10	1	..	..	..	..	..	..	100	125.95	
<i>G. herbaceum</i> . .	1	5	18	38	22	8	7	1	..	..	..	..	..	..	..	100	116.60	

It will be noted that the pollen grains of Indian cottons studied are considerably smaller in size than those of Upland and Sea Island cottons. *Cernuum* and *roseum* have the same average diameter, while there is not much difference in this respect between *indicum* and *herbaceum*. The measurements of the diameters include the spines. In all cases fresh pollen grains from a large number of flowers were taken for examination. The grains were mounted in castor oil as this medium has the advantage of clearing the grains to a certain extent and no shrinkage is noted for a considerable length of time. Bailey¹ used 4½ per cent. formalin solution as the medium for measuring the grains, but here fresh pollen grains in the same medium were found to burst within five minutes.

TYPES OF POLLEN GRAINS.

The external markings of the grain, or in other words, the size, shape and sculpturings of the exine, afford characters by which pollen of different species can be

¹ Bailey. *Loc. cit.*

identified. Watt¹ has classified cotton pollen into four chief types according to the nature of the exine. He also mentions the fact that in some cases more than one form and size of grain has been noted in the same androecium. Critical microscopic examination of pollen grains of different species of cotton grown here revealed the presence of two different types of pollen grain in the same androecium only in the case of *herbaceum* cottons (Hagari 25). The types are represented in Figures 6 and 7 in Plate XXIX. It will be noted that the difference lies mainly in the nature of spines. In Figure 7, the spines are short with obtuse ends, whereas in Figure 6 they are comparatively longer and acute. These two types were, however, not of general occurrence. In some cases the presence of the acute type only was met with; in others both types were detected in the same flower. In no case, however, was the obtuse type found to be of exclusive occurrence. Measurements of the pollen grains and microchemical tests failed to indicate dimorphism in other respects. Specific differences were noted in the rest of the material examined though no distinct types were found in any one of them. A brief account of the nature and origin of spines as observed for the different species is given below:—

G. hirsutum Mill. The spines appear to be inserted on a flat rimmed base (buttress). In some cases the base is very little developed, in others it is very pronounced. There is no sharp distinction between the two forms, and it is extremely doubtful if these could be classified as separate types (Fig. 4).

G. barbadense L. Buttress not very well developed; spines appear in some cases to be directly inserted on the cell wall. Spines long, acute with broad base (Fig. 5).

G. indicum Lamk. Buttress very slightly developed, spines acute (Fig. 8).

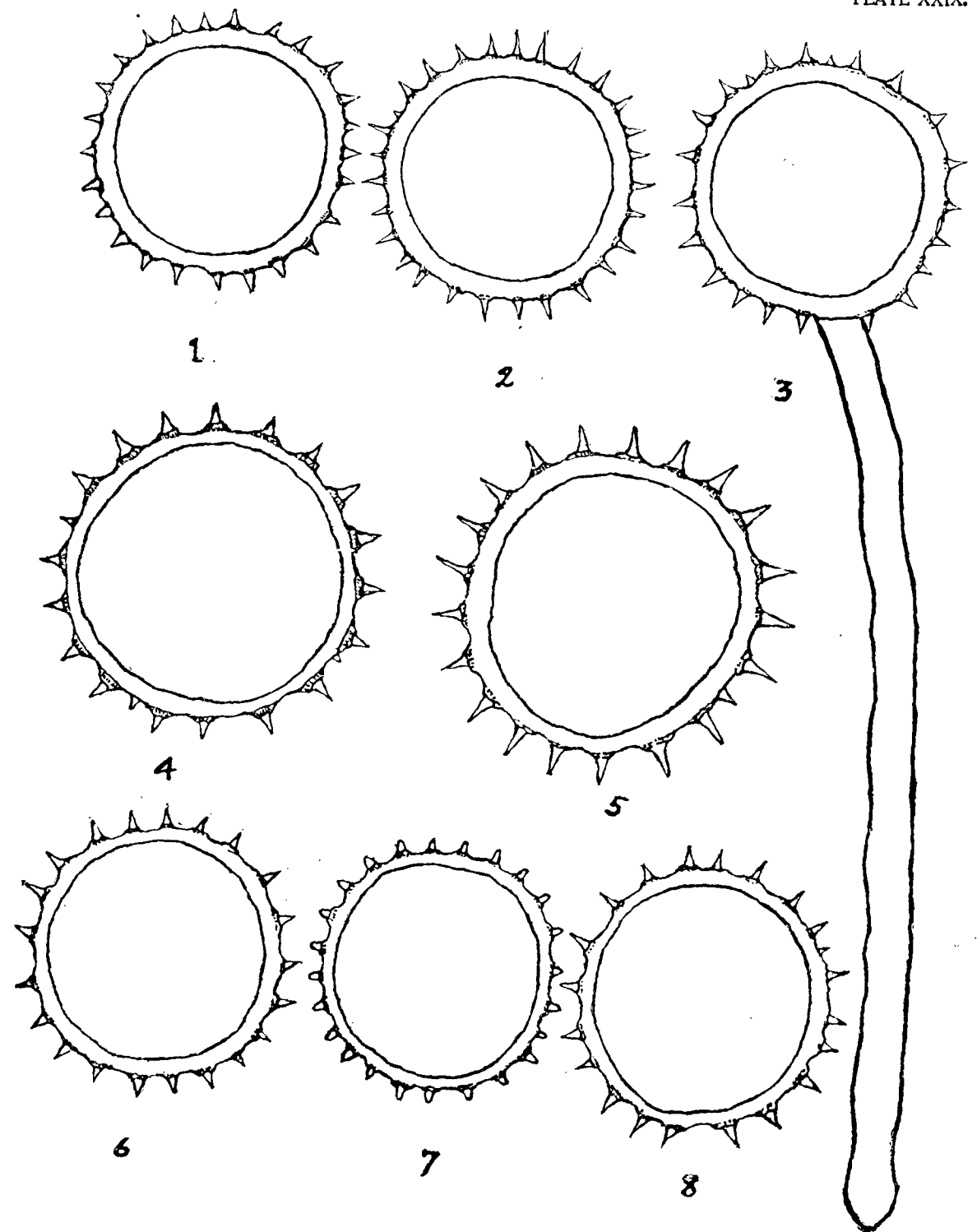
G. herbaceum L. Two types of pollen grains (previously described) have been noted in the same androecium in some cases. In others the acute type is exclusively found, though some grains are noted amongst them with comparatively shorter and obtuse spines which, however, do not corresponded with type 7. Buttress very well developed in some cases and not so in others (Figs. 6 and 7).

G. neglectum Tod., var. *rosea*. Buttress not very pronounced, spines acute with broad base (Fig. 1).

G. cernuum Tod. Buttress very faintly developed in some cases and not at all in others. Spines appear to be linear acute (Fig. 2).

GERMINATION.

In an attempt to find out the viability of cotton pollen under natural conditions with the idea of prolonging it if necessary and making it economically useful for



POLLEN OF GOSSYPIMUM.

¹ Watt. *The Wild and Cultivated Cotton Plants of the World*, 1907.

pollination purposes, unexpected difficulties in the artificial germination of pollen were met with.

The literature on the germination of pollen (in general) is extensive. A complete account of it has been given by Martin¹ and also by Anthony and Harlan.²

Cold drawn castor oil which was successfully used under moist conditions by Badami³ was tried but with partial success. Most of the grains only showed signs of germination; the tubes in no case were seen to be more than thrice the diameter of the grains and the percentage of germination was not always quite satisfactory. Various other oils were tried but with no success. Cane sugar solution was next tried, concentrations ranging from one per cent. to saturated solution. In the lower percentages the grains burst, in the higher concentrations they plasmolysed, or remained quiescent; in some cases knobs were formed at the germ pores due to the protrusion of the cell contents. Glucose was then tried in different concentrations and the result was practically the same. Varying quantities of agar-agar (0.5 to 2.0 gm.) with sucrose solutions of different strengths were resorted to but with no success. Agar-agar replaced by gelatine in no way improved matters. All these tests were carried out under normal laboratory conditions with fresh pollen and fresh media every time and were repeated more than once. Having failed to germinate pollen in all these media Martin's⁴ method of germinating pollen on parchment paper was next tried but without success. Moist chamber methods with Van Tieghem cell as used by Anthony and Harlan⁵ was next resorted to and the result was practically the same as before. Pollen grains kept in a dry watch glass inside a covered petri dish containing a small quantity of water gave unmistakeable evidence of germination. The tubes in general were about five times the diameter of the grains and the percentage of germination was fairly satisfactory. No germination was however obtained when the position of the petri dishes was reversed, that is, when the watch glass standing over water was covered by the smaller dish making the chamber air-tight. The former experiment was repeated a number of times when it was found that the results were not very consistent. This might be explained as due to the fact that as there were no definite means of controlling moisture inside the chambers, it was extremely possible that the pollen grains might not in all instances have had the requisite amount of moisture on which successful germination depends.

Examination of pollen from previous day's flowers on a humid morning after an overnight rain of 84 cents showed that quite a fair percentage of pollen grains had germinated inside the flower itself. This phenomenon was noticed in

¹ Martin, N. The physiology of the pollen of *Trifolium pratense*. *The Botanical Gazette*, Vol. LVI (1913), pp. 117-119.

² Anthony, S., and Harlan, H. V. Germination of barley pollen. *Jour. Agri. Res.*, Vol. XVIII (1920), pp. 525-528.

³ *Loc. cit.*

⁴ *Loc. cit.*

⁵ *Loc. cit.*

good many flowers examined, belonging to different species. A typical pollen tube is represented in Fig. 3 in Plate XXIX. The absence of any signs of germination of pollen in such flowers under normal weather conditions when examined the following morning, and the fact that satisfactory germination was obtained when pollen grains were kept under moist conditions, lead us to believe that germination of the pollen of cotton, like that of wheat, barley, and some other plants, depends upon delicate moisture requirements, and that further work on this line should aim at finding out the optimum percentage necessary.

The above results lead us to doubt the efficacy of castor oil as a medium for cotton pollen germination. Pollen grains showed signs of germination in the above medium only when the cultures were kept under moist conditions, no trace of germination having been noted under ordinary laboratory conditions. When it is remembered that the pollen grains lie on the surface of the aforesaid medium and are therefore liable to be influenced by the surrounding conditions, the presence of germination under moist conditions and its absence under ordinary conditions appear to indicate that this process is dependent more upon moisture supply than on anything else. Further, the results obtained without castor oil under moist conditions add more evidence to that obtained before and leave no doubts about the inefficacy of castor oil as a medium for artificial cotton pollen germination.

The viability of cotton pollen under natural conditions was determined by pollinating live stigmas of cotton flowers (sixty in number), which were emasculated and bagged the evening preceding anthesis, with pollen twenty-four and forty-eight hours old respectively taken from previously tagged flowers bearing the date and time of bursting of the anthers. After pollination the flowers were bagged once again for a period of thirty hours to prevent ingress of foreign pollen. The results obtained show 65 per cent. setting with twenty-four hours old pollen and none at all with forty-eight. This indicates that under natural conditions a fairly high percentage of pollen grains retain their viability up to the 24th hour after their liberation from the microsporangium and lose their potency within the next 24 hours.

RATE OF POLLEN TUBE GROWTH.*

Special experiments were conducted to determine the rate of pollen tube growth *in vivo* under Coimbatore conditions. The method adopted was to emasculate and bag as many flowers as were possible the evening preceding anthesis, to hand pollinate them with pollen from other flowers of the same species at 10 A.M. in the morning, allow a definite interval to elapse, and then excise the style close to the ovary. If the pollen tube (with the generative nucleii) had traversed the stylar length during the interval allowed, then excision would have no effect and we should get the average percentage of bolls. Table II gives an account of the results obtained with varying periods.

* Experiments conducted on Cambodia cotton.

TABLE II.

Rate of pollen tube growth as measured by the degrees of fertilization attained when styles were excised at successive intervals.

No. of flowers operated on	No. of hours from pollination to excision of pistils	Percentage of bolls developed	Mean No. of seeds per lock
100	4	..	..
100	6	1	2.0
100	8	1	2.7
100	10	2	2.9
100	12	30	4.1

From the above it is clear that the pollen tube traverses the entire stylar length (mean 24.7 mm. for Cambodia cotton) between ten and twelve hours after pollination. It is interesting to note that Kearney and Harrison¹ working on "selective fertilization" with Pima cotton obtained similar results, both with like and unlike pollen. Zaitzev² in an experiment conducted says "ten hours after pollination one half of the pollen tubes have had the time to pass through the whole length of style (17 mm.)."

Under normal field conditions Cambodia cotton contains an average of 8.35 seeds per lock. The figures obtained under the last column of the table do not compare favourably with the above and seem to suggest that only the more active pollen tubes are able to traverse the entire stylar length within twelve hours after pollination. In order to determine the percentage of flowers developing into bolls at that part of the season and also to find out if emasculation had any effect on shedding, two sets of control experiments were started. In the first case the flowers were simply tagged and the percentage developing into bolls noted (Control A). In the other case the flowers were emasculated and bagged as in the original experiment, pollinated at 10 A.M., and left without excision (Control B). In both cases one hundred flowers were taken as unit. The comparative results obtained are given in Table III below.

¹ Kearney, T. H., and Harrison, C. J. Selective fertilization in cotton. *Jour. Agri. Res.*, Vol. XVIII, No. 6 (1924).

² Zaitzev. Flowering, fruit formation and dehiscence of the bolls of cotton plants. *Agri. Jour. Ind.*, Vol. XX, No. 3 (1925).

TABLE III.

Percentage of flowers developed into bolls under normal conditions and under differential treatment at that part of the season when the original experiments were conducted.

Experiments	No. of flowers treated	Percentage of bolls developed
Control A	100	43
Control B	100	38
12 hour series	100	30

The results show that emasculation had practically no effect on the setting of bolls and the results obtained with the 12 hour series could be considered to be significant.

INHERITANCE.

The inheritance of pollen colour was investigated in a natural cross of Sea Island cotton which was characterized by deep yellow pollen grains. In the F₂ generation segregation into the following two types were noted—deep yellow and creamy yellow. Out of a total of 890 plants examined, the two types occurred as follows :—

Deep yellow	682
Creamy yellow	208

The proportion is 3·2 to 1, and is undoubtedly suggestive of a simple Mendelian ratio.

Twelve plants were selected from the F₂ generation the pollen colour of which was distributed as follows—Deep yellow 9, Creamy yellow 3. The following results were obtained.

TABLE IV.

Inheritance of pollen colour.

Number of culture	Colour of parent	Total No. of plants	Deep yellow	Creamy yellow
35 N	Deep yellow . .	39	39	0
33 S	Ditto . .	29	29	0
33 N	Ditto . .	41	41	0
TOTAL		109	109	0
EXPECTATION		..	109	0

TABLE IV—concl'd.

Inheritance of pollen colour—concl'd.

Number of culture	Colour of parent	Total No. of plants	Deep yellow	Creamy yellow
27 S	Deep yellow . .	22	17	5
28 N	Ditto . .	83	62	21
29 N	Ditto . .	63	46	17
38 N	Ditto . .	30	25	5
31 S	Ditto . .	64	46	18
34 S	Ditto . .	60	43	17
36 N	Ditto . .	40	28	12
TOTAL		362	267	95
EXPECTATION		..	271·5	90·5
30 N	Creamy yellow .	42	0	42
30 S	Ditto . .	25	0	25
32 N	Ditto . .	51	0	51
37 N	Ditto . .	13	0	13
37 S	Ditto . .	26	0	26
TOTAL		157	0	157
EXPECTATION		..	0	157

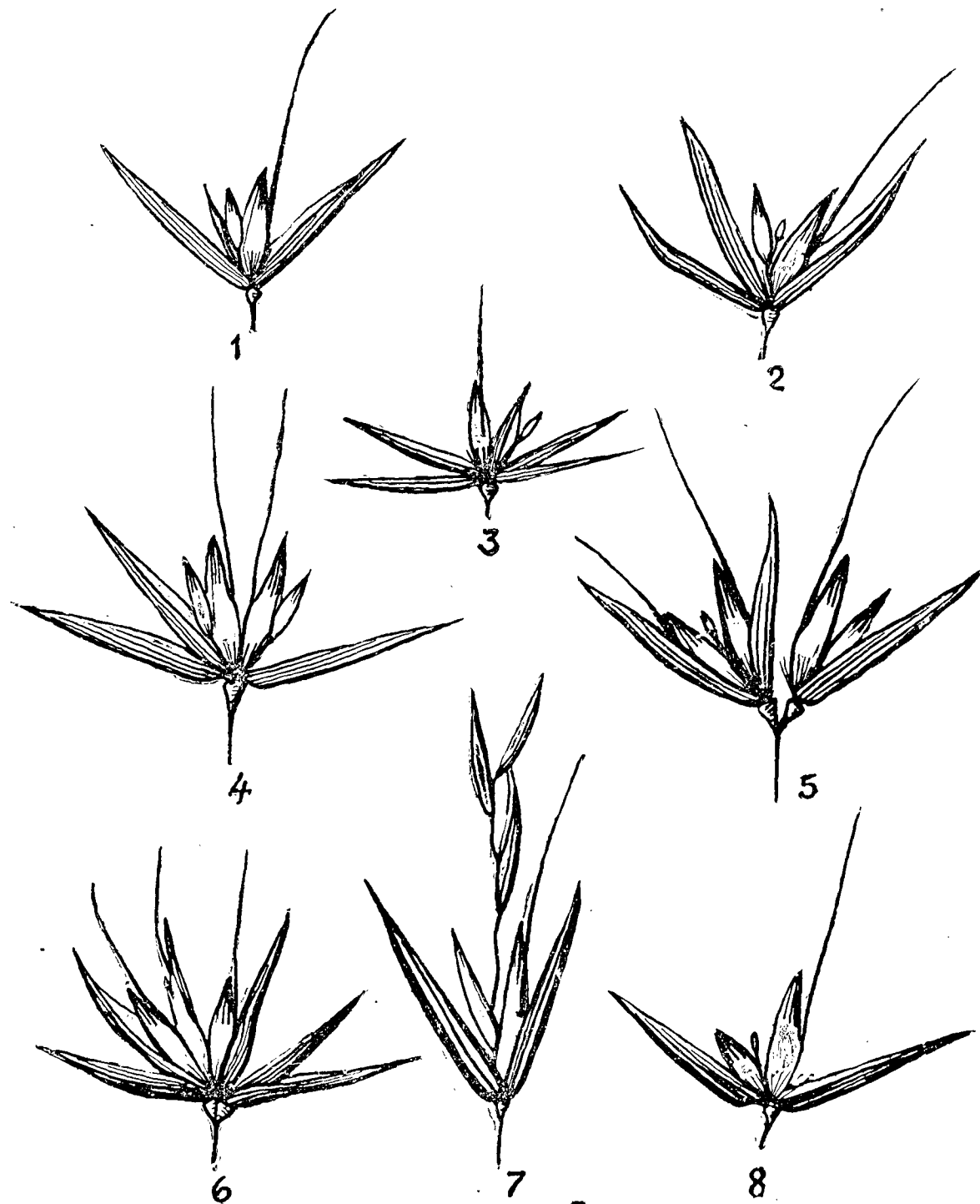
It will be noted that creamy yellow breeds true and appears to be a recessive character in this cross. Out of the nine yellows two breed true, the rest split into proportions which very closely approach a simple 3 : 1 ratio.

The above results indicate the existence of a factor Y in the Sea Island cotton which is responsible for the deep yellow colouration of its pollen. This factor was absent in the pollen parent. The F₁ plant had the constitution of Yy and was therefore predominantly yellow. The F₂ and F₃ results support the unifactorial theory of segregation.

SUMMARY.

- (i) Cotton pollen is characteristically spherical in shape ; it has numerous points of emergence. The mean diameter of the Indian cottons studied measured from spine to spine is between 116.60 to 125.95 microns.
- (ii) Comparative differences in the size, shape and sculpturings of the exine were noted in all the cottons studied. Two forms of pollen grains characteristically different and occurring in the same androecium were noted in some cases in *herbaceum* cottons (Hagari 25).
- (iii) From the evidence at hand it appears that artificial cotton pollen germination depends upon delicate moisture requirements. Pollen grains retain their viability under natural conditions up to the twenty-fourth hour after their liberation from the microsporangium and lose their potency within the next twenty-four hours.
- (iv) The more active pollen tubes were found to have traversed the entire stylar length (mean 24.7 mm. from Cambodia cotton) within twelve hours after pollination.
- (v) The inheritance of pollen colour in a natural cross of Sea Island cotton studied is dependent on a single Mendelian factor.

The above work was carried out at Coimbatore during the tenure of my scholarship on Cotton Breeding under the Indian Central Cotton Committee. My thanks are due to Mr. R. C. Broadfoot for facilities and continued interest during the progress of the work.



SOME FREAKS IN OAT SPIKELETS.

SOME FREAKS IN OAT SPIKELETS.

BY

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DURING the course of breeding work in oats a number of abnormalities in the spikelets of this crop have been observed from time to time. Most of them are nothing but freaks or "Nature's fancies" coming up side by side with normal spikelets on the same panicle and have no heritable properties.

The normal spikelet of oats consists mainly of two dorsally rounded outer glumes which are unequal, thin, persistent, empty and awnless; and two flowering glumes which are 9-veined, bisexual and dorsally awned—these enclose the essential organs, the androecium and the gynecium. There are usually two fertile and one abortive florets in each spikelet (Fig. 8).

The main abnormalities observed are :—

I. SIMPLE SPIKELETS WITH ABNORMAL OUTER GLUMES :—

- (1) Outer glumes three in number, two of normal size and one smaller (Fig. 1).
- (2) Outer glumes three in number, but all large (Fig. 2).
- (3) Outer glumes five in number, all unequal in size. An abortive small floret also developed at the dorsal side of the main floret—an unusual place for its development (Fig. 3).

II. COMPOUND SPIKELETS WITH ABNORMALITY IN THE OUTER GLUMES AS WELL AS IN THE NUMBER OF FLORETS :—

- (4) Twin spikelets consisting of 2 sets placed end to end but developed on a common stalk, 3 outer glumes, 2 on one side and 1 on the other (Fig. 4).
- (5) Twin spikelets developed from the same stalk but having the peduncles somewhat separated. Two sets of spikelets; 1 set complete with 2 outer glumes but on either side, the other set incomplete with only one outer glume (Fig. 5).
- (6) Six outer glumes in the shape of a rosette and 3 awned florets each developing by the side of the other.

More than one abnormal spikelet was never observed on a single plant, nor was there any constancy in their occurrence in any pure line culture. Some seed was collected in 1927-28 and sown the following year but none of the abnormalities was inherited in any of the progenies from abnormal plants.

III. MULTIFLOROUS SPIKELETS :—

(7) A number of plants with multiflorous spikelets as shown in Fig. 7 were observed in 1928-29 in the second hybrid generation of a cross between Abundance (*Avena sativa* L.) and Pusa oats (*A. sterilis* L.). In these the two outer glumes were very much elongated and completely enclosed all the florets during the first few days of the emergence of the panicle. The spikelets were multiflorous and had from 4 to 6 florets in each. The lowest floret only was awned. From the second floret the third was borne on rather a long rachilla. The third gave rise to a fourth and so on.

Out of a total population of 297 plants in the F₂ generation 8 plants exhibited this character. These multiflorous spikelets were borne, however, side by side with normal spikelets on the same panicle. The frequency of normal and abnormal spikelets per plant was studied in a number of cases and is tabulated below :—

Plant No. (1928-29)	NO. OF SPIKELETS PER PLANT			Ratio of Multiflorous to Normal	REMARKS
	Multiflorous	Normal	Total		
III—80 . .	5	1,120	1,125	1 : 224.0	All plants with <i>A. sativa</i> type of base.
III—109 . .	5	310	315	1 : 62.0	
III—198 . .	182	964	1,146	1 : 5.3	
III—250 . .	17	566	583	1 : 33.3	
III—256 . .	11	827	838	1 : 75.2	
III—283 . .	107	913	1,020	1 : 8.5	
TOTAL .	327	4,700	5,027	1 : 14.4	

Normal and abnormal seeds from the same panicles have been kept separately and will be sown next season with a view to study their genetic behaviour in the next and subsequent generations.

Coffman and others¹ have also observed similar multiflorous spikelets in the Burt oat and have found this character to be heritable, though they declare that there is considerable variation in the progenies with respect to the percentage of kernels remaining inclosed in the lemmas after threshing.

¹ Coffman, F. A., Parker, J. H., and Quisenberry, K. S. A study of variability in the Burt oat. *Jour. Agri. Res.*, 30, 1925, 57-59.

SELECTED ARTICLES

LEAGUE OF NATIONS ENQUIRY ON SUGAR.*

I. Dr. Geerligs' Report on the Production of Cane Sugar.

At its 26th session last October the Economic Committee of the League of Nations decided to apply to certain sugar experts of world-wide reputation to prepare for them memoranda on certain specific aspects of the problem. Below we give a summary of, and extracts from, the Note prepared by Dr. Prinsen Geerligs on the production of cane sugar.¹

After a preliminary survey of the conditions of production, in the course of which he outlined the geographical limits, the climatic factors, including the incidence of drought, hurricanes, etc., the varying periods of crop growth, the conditions of labour, and finally the differing types of sugar produced, Dr. Geerligs went on to deal with the problem of estimating costs of production in the different producing countries. He cited a previous attempt that had been made, *viz.*, by the American Tariff Commission in 1923, which body went thoroughly into the question in all its bearings; but, as President Coolidge's reply to the Commission's findings clearly bore out, this Government Commission with full authority was unable, after a searching investigation into costs of production in certain well administered countries, to arrive at a result from which any conclusion of value could be drawn.

"If an official commission (to quote Dr. Geerligs), carrying on its investigations with the utmost zeal, can produce no better result than this, it is certainly not possible for much less excellently equipped enquirers to obtain an accurate idea of the cost of production of cane sugar in countries where they must depend for their information on the goodwill of the manufacturers, or where the latter have themselves no knowledge of the true state of affairs. On this point, Maxwell remarks on page 92 of his book²: 'Reliable data relating to costs of production in the cane sugar industry are, generally speaking, not readily available. Indeed, in certain quarters, an attempt at obtaining such figures is invariably met at the best with a polite rebuff.' This may be so, but in the majority of cases the manu-

* Reprinted from *Int. Sugar Journal*, No. 366.

¹ Taken from "Sugar: Memoranda prepared for the Economic Committee, by Dr. H. Prinsen Geerligs, Messrs. F. O. Licht and Dr. Gustav Mikusch". *League of Nations Publications, II, Economic and Financial*, 1929, II, 20.

² Francis Maxwell, D.Sc., M.I.Mech.E., F.C.S.: *Economic Aspects of Cane Sugar Production*, London, E.C.3, Norman Rodger, 1927.

facturer himself does not know what should and what should not be included in the cost of production, so that a 'polite rebuff' is often due to pure ignorance and not to secretiveness.

"To take a few instances: should interest on initial capital and working capital be included in cost of production or not? Should depreciation of plant and premises be included or not? If so, up to what percentage of original cost? Should rates and taxes—when they are not levied expressly in return for services rendered by the authorities, but when their yield is used to help and promote industry, *e.g.*, for irrigation, railways, canals, etc.,—be included in cost of production or not? Should profits from by-products and accessory profits be deducted from cost of production? We are faced, therefore, by a number of questions which would need the knowledge and experience of a first rate accountant, who would, moreover, have to be thoroughly acquainted with the special circumstances under which each firm works. Consequently, it is not surprising that manufacturers should receive a request for particulars of costs of production with a 'polite rebuff'.

"Accordingly, it is the business of the enquirer to sort the replies out in the light of local circumstances, so that similar cases are grouped separately from other groups of similar cases of a different kind. Owing to the great diversity of conditions in the cane sugar industry in different countries, this is an extremely difficult task. Moreover, even if accurate figures could be compiled for cost of production in all the factories in one country, these figures would vary so greatly for different firms that it would be quite unfair to take the arithmetic mean of the figures in question as representing the average cost of production of sugar in that country.

"If there are two works, A and B, in the same country and owing to better soil or other factors A produces half as much sugar again as B on the same area and at about the same cost, and consequently produces its sugar for 2 cents a lb. while B's sugar costs 2.70 cents, then the average cost of production will be 2.35 cents. If, however, the selling price is 2.50 cents, then by a simple calculation B makes a profit of 0.15 cents per lb., whereas in actual fact it makes a loss of 0.20 cents. These discrepancies are considerable enough in any comparison between concerns working under approximately similar conditions; when, however, we compare firms, or even averages of firms, in different regions or producing countries, the variations become wider. A few instances will suffice.

"In Java and Hawaii, nearly all the cane used is planted, harvested, transported and worked up by sugar manufacturers under their own direction and for their own account. The sugar is extracted from the juice of the cane, packed, sold and transported to harbour, all under their own direction. There are no by-products of any importance: all residues (bagasse) are consumed in the furnaces, and the profit from the sale of molasses is negligible. Once it is agreed which items of expenditure are to be reckoned as capital expenditure and which as working expenses, we can note down all items of the latter class, add them up, and divide them by the weight of sugar extracted, thus obtaining the exact cost price per lb.

of sugar of the kind extracted. It will be seen that the cost price is affected only by the permanent factors—output of cane and sugar—and not by the price of sugar, though in Hawaii the work people permanently employed receive a bonus if the price of sugar at New York rises above a certain point, so that the price of sugar is not entirely without influence on costs. In Java, bonuses depend on profits and consequently do not increase the actual cost of production.

"In certain of the British West Indies and in Egypt, the manufacturers buy, in addition to their own crops, cane from tenant planters at a fixed price, based on the weight of cane delivered, irrespective of the sugar content. They also work up the cane and treat the sugar as stated above. Here, therefore, the output of cane per unit of area is of no importance, while the sugar content is a serious factor. Here also the cost of production is independent of the market price of sugar.

"In Natal, Queensland and Demerara, the manufacturers buy the cane by weight and sugar content and work up the sugar as described above. In these cases, again, the factor of the sugar content of the cane ceases to operate, since the manufacturer only buys the actual amount of sugar in the cane irrespective of whether it was grown on a large or small area. The market price of sugar is of no importance here.

"In Cuba, the Philippines, Porto Rico, Reunion and Mauritius, the manufacturers buy, in addition to what they have planted themselves, cane from tenants or independent planters in return for from 5 to 7 per cent. of the weight of sugar in the cane, or its equivalent in cash at the market price on day of delivery of the cane, or at the average market price during a fixed period. The cost of production in these cases is not influenced by the output of cane per unit of area, but by the sugar content of the cane, and in particular by the market price of sugar. If in any one year the sugar should sell at twice as high a price as in any other year, then in the former year the item "raw material" in the calculation of cost of production must also be twice as high as in the other year, although it is quite possible that, in point of fact, the cost of producing the cane was the same. The charges connected with the transport and working-up of the cane and the preparation, packing, sale and despatch of the sugar, remain unchanged if the sugar content of the cane is also unchanged, and consequently the proportion of the cost of production represented by the raw material varies very widely from one year to another".

Other complications cited by Dr. Geerligs are the difficulties occasioned by attempting to calculate costs where the product turned out (raw or white sugar) is not the same as at other factories or in other districts; where the by-products are variously disposed of, being either thrown away or used for production of rum or alcohol, and where the bagasse is alternately used as fuel or as the basis of building material. In short, concludes Dr. Geerligs, there is such a wide variety of factors influencing the cost of production of sugar that it is clearly impossible to give figures capable of comparison. He furnishes the Economic Committee with

a number of examples culled from various sources, which may be taken as merely illustrating how costs of production are calculated, but he avers that these do not in the least represent an average cost of production for a whole country or a whole region over a number of years.

As regards Cuba, Hawaii, Porto Rico and Louisiana, Dr. Geerligs quotes the figures of the American Tariff Commission above referred to (see *I. S. J.*, 1924, page 3, for the net cost figures). These show that as regards Cuba the 1921 crop averaged 3.975 cents per lb. in cost of production, that of 1922, 2.146 cents, and that of 1923, 3.67 cents, these differences being due to the sale price of cane varying in accord with the market price of sugar. Actually in 1922, some 36 per cent. of the Cuban factories produced their sugar at 2 cents per lb. or less, and 57 per cent. at from 2 to 3 cents or less. As regards the other countries, 3 per cent. of the Porto Rico factories produced sugar at 3 cents, while 50 per cent. of the Hawaiian output, 35 per cent. of that of Porto Rico and 85 per cent. of that of Louisiana cost from 4 to 6 cents or even more.

Other costs of production are quoted or calculated by Dr. Geerligs as follows:—

Philippines.—Cost price c.i.f. New York, 3.06 to 3.20 cents.

Java.—In 1925 gross cost was 2.82 cents, net cost 2.24 cents per lb. In 1926 the gross cost was 2.47 cents. Two factories selected at random, one producing white, and the other raw sugar, returned their costs as 2.34 cents for the white sugar factory and 2.72 cents for the raw sugar one. These include carriage and depreciation.

Queensland.—Maxwell's work on economic aspects quotes the cost of production in Queensland as about £25 per ton, but allows nothing for interest, depreciation, and carriage of sugar. These should amount to £3 per ton, so that the cost per ton is nearer £28, or 6.60 cents per lb.

STATISTICS OF PRODUCTION OF CANE SUGAR.

Dr. Geerligs next deals with the problem of estimating production of sugar per unit of area, which in most cases is not too easy to ascertain for any one year. The reasons for this are various and include: the difficulty of ascertaining the actual area in many countries where small planters do not make returns of their areas under cane to a central institution; the fact in some cases that the whole planting is not harvested in one year; the point whether newly planted cane or ratoons are grown; the fact that in many places not all the cane harvested is made into sugar—the main product may be cattle food, sweetmeat, syrup, rum or alcohol; and finally the very wide differences in the quality of the sugar obtained.

Mr. Rudolf E. Grotkass, remarks Dr. Geerligs, attempted a comparison of unit production in the *International Sugar Journal* (1927, 467) but limited it to the period of growth and ignored all the other factors which influence the result. After

reproducing Mr. Grotkass's figures from that article referred to, Dr. Geerligs comments as follows: "So far Mr. Grotkass. He somewhat arbitrarily halves the official figures for Hawaii and Peru, while leaving others which need revision for the same reasons unchanged. Nor does he take into consideration the other factors which may influence the comparability of his figures. He arrives at figures for output per hectare ranging from 1.51 tons in Brazil to 13.71 in Java, which latter figure had already risen to nearly 15 in 1927-28. In any case, his figures show what wide differences are at present to be found between the yield in different producing countries, how the production of sugar per hectare is generally on the increase, but also how much room there still is for improvement in many countries."

Dr. Geerligs on his part submits a few production figures for countries of which "we can judge well of their accuracy." The following is a summary of his data, which refer to metric tons per hectare:—

India.—In the five years to 1929 production was 2.66 metric tons.

Formosa.—3.33 tons in 1922 and 6.05 tons in 1927.

Philippines.—In 1923 newly planted cane yielded an average of 6 tons of sugar per hectare. For a number of concerns in Negros the yields averaged 3.8 tons.

Java.—Java has risen from 10.2 tons in 1913 to 15 tons in 1928.

Louisiana.—In 1927-28 the average was 2.11 tons.

Cuba.—Assuming a yield of about 11 per cent., an average of 5 tons.

San Domingo.—At 10 per cent. yield, an average of 6 tons.

Porto Rico.—At 10 per cent. yield, 6.7 tons.

Peru.—For the last ten years output of sugar per area harvested has varied between 10.3 and 11.7 tons.

Argentina.—In 1927 the yield was 2.73 tons.

Mauritius.—With a yield of 10.5 per cent., 4.75 per hectare.

Queensland.—In last 13 years, output has varied between 4.78 and 6.08 tons per hectare harvested.

Hawaii.—14.3 tons of sugar per hectare harvested.

FUTURE PROSPECTS.

As for future prospects, Dr. Geerligs remarks that it has been frequently stated that Cuba or Java or Formosa had reached its peak of production, but in every case the assertion proved wrong. It is therefore better not to offer any forecast on those lines.

The possibility of unlimited expansion for some time to come cannot be regarded as wholly non-existent. In Cuba, Argentina, India, the Philip, ines, Queensland, Natal, China, Africa, Brazil and elsewhere, plenty of land suitable for cane growing is still available. In many countries the sugar yield per unit of area is still

so much lower than it might be that an immense increase could be secured by improving the variety of cane, planting equipment, methods of cultivation, manuring, manufacture, etc. If in a country like Java it is possible in the space of a few years to increase by 30 per cent. the sugar yield of a given area, the potentialities of countries where efficiency is not yet so high are incalculable.

2. Consultation of Experts on Beet Sugar Production.

The delegation of the Economic Committee, enquiring whether international action would be desirable and feasible with a view to remedying or mitigating the depression in the sugar industry, consulted experts on beet-growing on May 13th and 14th.

The experts had been informed of the results of the sugar enquiry held at the beginning of April. The International Institute of Agriculture had, moreover, in view of this consultation, prepared a memorandum on beet-growing, emphasizing the advisability of not considering beet-growing merely from the point of view of the requirements of the sugar industry, but of taking account of the fact that one of the effects of beet-growing is considerably to enhance the productive capacity of agriculture.

The experts were first invited to describe the position as regards beet-growing from the point of view of their respective countries. They gave information bearing on the general organization of the sugar industry (more particularly, the relationship between farmers, factory owners and refiners), the extent to which increase in output or decline in demand had affected prices and rendered production unremunerative; factors affecting beet-growing, such as recent scientific discoveries, tariffs, subsidies and other government measures, wages and prices; the prospects of an increase in production and the influence of prices and government action on consumption.

The experts laid particular emphasis on the effect of the depression in the sugar industry on the agricultural situation in the principal European countries in view of the bearing of beet-growing on agriculture. This industry must be considered from two points of view; on the one hand, it ensures the existence of numerous agriculturists; on the other hand, it plays a considerable part in crop rotation and in cattle breeding. The European beet and sugar production does not at present exceed the pre-war standard and, in the opinion of the experts, cannot be considered as responsible for the general depression in the sugar industry. Beet producers consequently do not consider that, in the present circumstances, measures to reduce production would be desirable or even feasible. Although the consumption of sugar has increased more in Europe than anywhere else, producers would be willing to assist in any action for increasing world consumption, whatever form that action might take. They further consider that no action would have any chance of success without the close co-operation of beet-growers and the sugar industry.

Certain experts said that they would be prepared to take part in an international action for applying an immediate remedy to the sugar depression, which would take the form of rationing the exports from countries whose production exceeds their own requirements, pending such development of world consumption as would make it possible to absorb the normal surplus of exporting countries. They, nevertheless, recognized the practical difficulties of such an action which, in their opinion, should not be conducted by the governments.

Various questions were then put to the experts. They bore upon the possibility of replacing the beet by other crops without detriment to the general agricultural position; on a possible improvement of beet production; on the possibility of using the beet roots as cattle fodder; on the use of denatured sugar; on the possibility of developing cane sugar production; on measures for increasing consumption; on the effect of a decrease in the tax on consumption; on the possible effect of beet production and on the desirability of League action in regard to the sugar industry.

The replies showed that there was some difference of opinion. Several of the experts, but not the majority, were more or less in favour of replacing the beet root by other crops. The development of cane sugar production was generally regarded as a serious menace for beet production; on the other hand, the opinion of the minority was that protectionist measures in favour of beet production constituted a greater danger. A decrease of consumption duties on sugar was generally recommended, but one of the experts thought that such a decrease should be accompanied by a reduction of customs duties.

The Delegation of the Economic Committee was composed of M. Trendelenburg (President), Sir Sydney Chapman (Vice-President), and MM. Brunet, Nederbragt and Stucki, assisted by MM. Asher Hobson and Georges Ray, representing the International Institute of Agriculture.

The following were the experts consulted:—

Germany.—Oberamtman Wentzel.

Great Britain.—Sir Daniel Hall, of the Board of Agriculture.

Belgium.—M. Mullie, Senator, Agriculturist.

Denmark.—M. Petersen, Chairman of the International Association for Seed Tests, Copenhagen.

France.—M. Mommirel, Chairman of the Confédération générale des Planteurs de Betteraves.

Netherlands.—M. Minderhoud, Professor at the University of Agriculture.

Hungary.—M. Serban, Secretary-General of the Hungarian National Chamber of Agriculture.

Italy.—M. de Vecchi, of the Fascist National Agricultural Federation.

Poland.—M. Humnicki, Chairman of the Federation of Beet Seed Planters.

Rumania.—M. Filipescu, Inspector-General, Agricultural Engineer.

S. C. S. Kingdom.—M. Jouritch, of the School of Agriculture.
Czechoslovakia.—M. Erdlik, Former Minister of Agriculture.

A NOTE BY MR. WYNNE SAYER.

The summary of this conference makes curious reading and shows how impossible it will be to produce any permanent combination of beet and cane interests while things remain as they are.

Dr. Prinsen Geerligs' memorandum on the cane sugar world and its production costs, though in many places erring on the high side, has at once reduced the beet champions to calling evidence as regards the value of beet to general agriculture. From a sugar basis no argument apparently exists. The whole position is one of extreme gravity. Cane keeps on reducing costs, increasing yields and improving factory technique, in short, behaving like a live industry. Beet in desperation, so far from even trying for any improvements, merely builds up a tariff wall and sits behind it. It then accuses cane of over-production. The sum total of the evidence given before the League can be condensed as follows:—The cane industry as symbolised by Java continues to reduce costs, increase yields and improve factory technique, while the beet industry, in its separate national units giving up all hope of being able to produce any further improvement in yield or reduction of costs, abandons the unequal fight and retires behind a tariff wall, calling itself a key industry or whatever name is most likely to bring it the protection it requires. It is to be noted that this protection is not to enable an industry to be built up; it is to protect an industry which before the war invaded India, and before whom Java even trod carefully.

The position of the United States beet crop under these circumstances should be carefully watched. Here we have the beet sugar industry really at close quarters with the largest cane and sugar producer—Cuba—while between them is wedged Louisiana, whose cane sugar industry is one of the most inefficient in the world. These are the three chickens upon which the United States is brooding and she will have to hold a separate League of Nations enquiry on her own if she is to find a price for sugar which will satisfy all three *and her own consumers*. She has lent Cuba money to such an extent that she claims a substantial share in the sugar industry. She is propping up the crippled cane industry of Louisiana as an internal industry to be fostered for the sake of the farmer. Last but not least she is being urged to support home industries by raising a tariff wall against Cuba for the sake of the expansion of her own beet industry. Under such circumstances the action taken by the United States may well give a lead to the League enquiry. The fact that the American farmer does not like beet or any other crop he has got to do hand labour in, matters nothing. The fact that "curly top" limits expansion South equally is disregarded, but the final fact that any alteration of the immigration laws would extinguish the U. S. A. beet industry may possibly result in an alteration of present ideas, as virtually all the actual field work is done by immigrants.

The facts in U. S. A. are equally true of Europe; beet field costs will not come down, the increase in the standard of living has seen to that. Factory improvements cannot cope with rise of costs elsewhere. Crop yields will not rise unless cultivation is of the highest class. Countries must face facts. They can keep their beet sugar industry as they keep their botanical gardens but not as an open competitor in an ever expanding world industry.

WYNNE SAYER.

METHODS OF SELFING COTTON FLOWERS.*

It is customary in most experiment stations to prevent the cotton flowers from opening in order to insure self-fertilization. It is open to the worker to select the method he will employ from several alternative procedures, which include tying with string or with wire, slipping a wire noose over the bud, sewing the flower-bud with needle and thread, and bagging it with either gauze or paper.

In the hope that it might be helpful to members of our staff abroad to learn what advantages and disadvantages had been found in practice to be associated with the several kinds of technique enumerated above, the Corporation asked members of their staff to give details of their practice, stating the advantages which had led them to adopt it, and the disadvantages attaching to any other methods that they had tried. A summary of the replies received is published below, and it is hoped that by posting the information thus obtained, other workers in cotton experiment stations may find therein useful suggestions for improving their present practice, or may be able to inform their fellow-workers, through the Corporation, of any means whereby the disadvantages experienced with any particular method of selfing may possibly be overcome.

The Corporation wish to extend their hearty thanks to all those who have, at considerable trouble, given detailed accounts of the methods of self-fertilization of cotton flowers employed by them, and the reasons that have led them to adopt any particular technique.

TYING THE BUDS.

This method has the advantages of cheapness, speed, and simplicity. The end of the unopened flower-bud is closed by means of either string, wire, wool, or a rubber band. In some countries this can be done on the morning on which the flower will open, while in others there is not time then in bright weather, and the process has to be completed on the previous afternoon. The buds are tied about $\frac{1}{4}$ inch below the apex, care being taken that the petals are not cut through in the process. Later in the day, or on the following day, the selfed flowers are tagged with wool or coloured cloth tied to the flower-stalk.

In Southern Rhodesia an experiment is being made with a small vulcanite clip as a means of closing the ends of the petals, while in Nyasaland an attempt is being made with a quick-drying gum. If successful, this latter method recommends itself by reason of its simplicity and cheapness. The gum is contained in a small bottle, the end of which is just large enough to admit the tip of the flower-bud, which is moistened by tilting the bottle. This method also involves the minimum

amount of handling of the plant. Inspection of the treated flowers on the following day, when they should be due to open, shows those which are successfully selfed. These are then marked by a coloured tag.

Below is a sketch of a flower-bud which has been self-fertilized by tying with string.



WIRING.

In this method soft copper wire is cut into suitable lengths, then twisted into spirals and a spiral slipped over the bud on the evening before it opens, or early in the morning of the same day. Care must be taken not to bind the wire too tightly round the petals, so as to avoid risk of cutting them through as the bud expands. A small loop is made at the lower end of the wire and a piece of very fine fishing cord attached to it; this is tied to the fruiting branch close to the peduncle and acts as a label. The wire spirals can, of course, be used repeatedly, and if the cord is dipped in oil before use, it also will last many seasons. The cost of material is given as being about 4s. 6d. for 1,000 buds.

STITCHING.

An ordinary needle and thread are used. The needle is run several times through the tip of the bud about $\frac{1}{4}$ inch below the apex for American types, and a little slack is left between the bud and the bract to allow the former to elongate without tearing out the cotton. If a record is wanted of the date of selfing, a label can be threaded on the thread: in a very moist climate it is advisable to dip the label

* Reprinted from *The Empire Cotton Growing Review*, Vol. VI, No. 1.

in melted paraffin wax after writing on it. The work goes on throughout the day, and it is not necessary to confine it to buds that are certain to open on the following day. Those buds which are sewn two days before they would open are found to set quite satisfactorily. In these younger buds the stigma is sometimes pierced by the needle, but this does not appear to affect the setting.

With a properly sewn bud, the corolla swells out below at opening time, but remains well closed. After setting, the corolla falls off and hangs by the thread to the bract, thus labelling the boll.

An examination is made at intervals of a few days to a week, and all properly selfed bolls are marked by tying a piece of coloured wool round the peduncle. It is most important to be able to check the work easily and certainly, and this method therefore possesses a great advantage in that the effect cannot be faked, since a corolla which has once opened and has been tied up again can be readily detected. The plant is generally affected slightly by the handling and trampling, but this cannot be avoided, and the setting is on the whole as good as with untouched flowers, though there appears to be a tendency for selfed bolls to be very slightly lighter than unselfed.

In South Africa it has been found that native labour does stitching of flowers better than tying with cotton or wool. Under Nyasaland conditions, on the other hand, the stitching method has been found to cause more damage to the flowers through handling than does tying them with wool or soft tobacco twine.

BAGGING OR NETTING.

The practice of enclosing the flowers in bags or nets is used in many countries. It is claimed that when the work has to be done by native labour this method is safer than tying or wiring the flowers. Further, nets show up plainly on the cotton plots, which facilitates checking. Their initial cost is naturally higher than wire, but they can be used repeatedly, adherent pollen being destroyed by stirring up the nets in boiling water after removal from the plants. Netting takes longer than wiring or tying, but by making the nets cone-shaped it is claimed that they can be pulled over the flowers very quickly without damage; the open end is then secured by twisting a small piece of soft aluminium wire once round the flower-stalk.

It may be of interest to include here details of the cost of material in the Sudan.

The cone-shaped nets have the dimensions shown:  Fine sandfly

netting costs in Khartoum 1s. 11d. a yard, and fifty bags can be made from one yard. The cost of sewing works out at 16s. per 1,000 bags, so that their total cost is £2 15s. per 1,000. The wire used is No. 22 w.g. aluminium wire, of which 350 feet, costing 1s., is sufficient for 1,000 bags. Mr. Bailey reports that during the season 1927-28 he used 3,000 bags, by means of which about 37,000 flowers were

selfed in three months by a staff of six to eight small boys. The proportion of selfed flowers that set was about 95 per cent.

Whether bags are used or not must naturally depend among other things on the readiness with which they can be made locally. To overcome this difficulty in Nyasaland Mr. Ducker has used an 8-inch square of netting converted into a bag by means of a small rubber ring which grips the gauze and the flower-stalk. This gave satisfactory results, save for the fact that in the rainy season the bags must not be left on more than a few days on account of the marked tendency for bolls thus treated to suffer from boll rot.

When it is possible to leave the bags on the plant from pollination until the opening of the boll, they afford in addition protection against attacks by bollworms which injure buds and bolls, as well as against boring beetles and stainers, which will cause damage to bolls at all stages.

The following details of routine practice supplied by Mr. Bailey, the Corporation's Plant Breeder in the Sudan, may be of general interest, though they may not be found to be generally applicable, or to commend themselves without modification to workers elsewhere. Nets are placed over buds the day before the latter are due to open (judged by size); they are left on until the third day, when they are removed, dropped into boiling water and spread out to dry. In order to be able to tell at a glance which bags are due for removal three colours are used: blue bags are put on on Saturdays and Tuesdays (removed on Tuesdays and Saturdays), white bags are put on on Sundays and Wednesdays (removed on Wednesdays and Sundays), yellow bags are put on on Mondays and Thursdays (removed on Thursdays and Mondays). Friday is a holiday for labour in the Sudan. At the time of removal of the nets a note is made of all flowers which have failed to set, and a small dated label is tied round the stalk of all that have set satisfactorily.

In a note on bagging by Kearney and Porter which appeared in the *Journal of Heredity*, an account is given of experiments in which paper bags were used instead of nets. This method was found to be more successful with Egyptian than with Upland varieties: with the latter varieties wiring or tying caused less shedding than did the use of bags.

When bags are employed, these are slit at the side so that they can be placed astride the fruiting branch carrying the bud, and are closed tightly beneath the branch by a loop in a piece of wire. It has been observed that selfed flowers produced by bagging produce only about 80 per cent. of the number of seeds that are formed in naturally pollinated flowers. The less complete fertilization of the bagged flowers is doubtless due to the fact that under this condition pollen reaches only that part of the stigma which is in contact with or immediately above the uppermost anthers. Examination of the pistils in flowers thus enclosed shows to what a narrow zone the pollen grains are restricted. In unenclosed flowers, on the other hand, bees and other pollinating insects carry pollen to all parts of the stigmatic surface soon after the corolla has expanded. Bagged flowers are better fertilized

when the whole surface of the stigmas is covered with pollen by hand than when the pollen is confined to the basal portion.

When using different coloured paper bags to enable those due for removal on any day to be picked out readily, it has been noted that flowers enclosed in brown bags were not so well fertilized as those in white bags. This has been attributed to the absorption of heat by the brown bag, raising the temperature of the enclosed flower to a degree unfavourable to fertilization. No significant difference was found in respect of degree of fertilization when using white bags of different thicknesses and glaze.

At the Plant Breeding Station at Barberton, Transvaal, Mr. Parnell is testing the efficiency of thin paper squares such as are used for wrapping oranges. A very light tissue paper used for crossing work has been found successful in surviving several heavy rains. Mr. Parnell points out, however, that a disadvantage attaching to the use of bags, as compared with tying the buds, is the difficulty of checking the work in order to avoid the possibility of opened flowers having been enclosed.

In thus summarizing the information which members of the Corporation's staff have been good enough to supply, and that obtained from the note by Messrs. Kearney and Porter describing the experiments at the U.S. Field Station, Sacaton, Arizona, the Corporation venture to express the hope that those who have thus enabled this article to be compiled will not find that any vital detail of the practice described has been omitted or incorrectly rendered. It should be understood that no one method is here recommended as superior to others, but, on the contrary, it is hoped that those interested may find in this summary suggestions that may be of service to them in their work.

NOTES

CO. 221 CANE IN LEEWARD ISLANDS.

It is mentioned in the report on "Sugarcane Experiments in the Leeward Islands in the season 1927-28" that on calcareous soils Co. 221 yielded the highest tonnage of cane per acre—31.85 tons per acre for plant crop—and occupied the twelfth place in order of sucrose production with a juice of saccharine richness 1.721 lb. per gallon. On clay soils, as a ratoon crop also this variety topped the list in yield giving 24.35 tons per acre.

Coimbatore seedlings 210, 213, 214 and 221 were introduced into Antigua in the year 1923 through the Sugar Bureau, Pusa, and were included in the sugarcane experiments in the season 1925-26 when Co. 221 gave the results on volcanic soils as above.

It is interesting to note that Co. 221 was one of the original four selections at Pusa. It was rejected subsequently for the White Sugar Tract in India on account of its inability to resist high winds and its liability to attack by jackals, and was sent later to the West Indies where its success in heading the tonnage tests shows that in the testing work at Pusa we have far more exacting conditions to cater for. [WYNNE SAYER.]



PERCENTAGE OF DIFFERENT CANE VARIETIES PLANTED IN JAVA FROM 1912 TO 1929.

The Sugar Experiment Station at Pasoeroean, East Java, has published a statement showing the percentage of different cane varieties planted in Java during the last 18 years from 1912 to 1929. Out of 197,085 hectares* planted there during the year 1929, the station has received information only for 185,886 hectares, i.e., 94.3 per cent. of the planted area. The statement on p. 358 gives the percentage of different varieties.

It will be seen from this table how that wonder cane of Java, P. O. J. 2878, which occupied only 0.75 per cent. of the planted area in 1926 rose to 12.5 per cent. in 1927, 66.5 per cent. in 1928 and 93 per cent. in 1929. The increase that has

* 1 hectare = 2.471 acres.

Crop year	ZW Cher.	247 B	100 POJ	EK 2	90 F	DI 52	EK 28	EK made	SW 3	2878 POJ	Other POJ varieties	Other varieties:
1912	8.5	54	32	0.5	..	..	..	..	..	..	..	5
1913	5.5	58	29.5	1	..	..	..	..	..	..	..	6
1914	5	57.5	30	1.5	0.5	..	..	..	..	..	..	5.5
1915	5	54.5	30	2.5	1	0.5	0.5	..	..	..	..	6
1916	4	48.5	30.5	4	2	1.5	2	..	0.5	..	..	7
1917	3.5	40.5	28.5	4	3.5	4	6	..	1	..	..	9
1918	3	33	24	5	4	8.5	12	..	1.5	..	..	9
1919	1	28.5	16.5	5.5	4	13	22.5	..	1.5	..	..	7.5
1920	0.5	26.5	10	6.5	3	14	31.5	..	2	..	..	6
1921	0.5	20.5	6.5	6.5	3	15	39	..	2	..	..	7
1922	..	17	4	6.5	3	19	39	0.5	2.5	..	3.5	5
1923	..	15.5	2.5	6	3	21.5	40	0.5	2.5	..	3.5	5
1924	..	12.5	1.5	6	3	22.5	43.5	1	3	..	3	4
1925	..	8.5	1	6	3	25	46	1.5	2.5	..	3.5	3
1926	..	5	0.5	5	2.5	28	44	2.25	3	0.75	6	3
1927	..	1.5	0.25	4	2	26	35.25	2.75	2.25	12.5	10.5	3
1928	..	0.25	..	0.75	0.5	11.75	13	1	0.5	66.5	4.75	1
1929	..	..	..	0.25	..	1.75	2.5	0.25	..	93	2	0.25

taken place in Java's production of sugar has been very striking as given below, and bears testimony to the high yielding power of this new seedling cane.

Year	Total production of sugar in Java	Area under cane in Java in hectares	Yield of cane per hectare in quintals*	Rendement
	Tons.			
1926	1,991,390	179,804	1,057	10.38
1927	2,360,079	185,742	1,156	11.09
1928	2,939,164	194,813	1,319	11.45
1929 (estimate)	2,997,000	197,085	..	..

* One quintal = 220.4 lb.

[WYNNE SAXER.]



WOODHOUSE MEMORIAL PRIZE.

In memory of Mr. E. J. Woodhouse, Late Economic Botanist and Principal of Sabour Agricultural College, who was killed in action in France in 1917, a prize in the form of a silver medal and books of a combined value of Rs. 85 will be awarded to the writer of the best essay on a subject of botanical interest to be selected from the list below. The length of the essay should not exceed 4,000 words. The competition is open to graduates of Indian Universities and to Diploma holders and Licentiates of recognized Agricultural Colleges in India who are not more than 30 years of age on the date of submission of their essays. Papers should be forwarded to the Director of Agriculture, Bihar and Orissa, Sabour, Bhagalpore, East Indian Railway Loop, before November 1st, 1929. Failing papers of sufficient merit no award will be made.

List of subjects for 1929 prize :—(1) Intermittent bearing of the mango tree—its cause and cure ; (2) The value of hybridization in the improvement of crops ; (3) The law of organic growth ; (4) The bearing of the study of root development to agriculture ; (5) The bearing of cytological research on heredity, more specially in relation to plant-breeding.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

SIR FRANK NOYCE, Kt., C.S.I., C.B.E., I.C.S., has been appointed Secretary to the Government of India, Department of Education, Health and Lands, *vice* MR. G. S. BAJPAI placed on special duty. SIR FRANK NOYCE has been appointed also a member of the Governing Body of the Imperial Council of Agricultural Research.

MR. B. C. BURT, M.B.E., B.Sc., Offg. Director of Agriculture, Bihar and Orissa, has been appointed as Agricultural Expert, Imperial Council of Agricultural Research.

THE Inter-University Board, India, has elected the following as their representatives on the Advisory Board of the Imperial Council of Agricultural Research :—

DR. N. GANGULEE, C.I.E., Khaira Professor of Agriculture, University of Calcutta.

DR. LESLIE COLEMAN, Director of Agriculture, Mysore.

MR. C. T. MUDALIYAR, Principal, Agricultural College, Coimbatore.

DR. L. K. HYDER, Professor of Economics, Aligarh.

MR. W. ROBERTSON BROWN, Agricultural Officer, North-West Frontier Province, has been nominated as representative of Minor Administrations under the Government of India to the Advisory Board of the Imperial Council of Agricultural Research.

DR. F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S., has been confirmed in the appointment of Imperial Economic Botanist, Agricultural Research Institute, Pusa, with effect from 8th December, 1928, *vice* MR. A. HOWARD, C.I.E., retired.

MR. G. R. HILSON, B.Sc., has been appointed to officiate as Director of Agriculture, Madras, *vice* MR. R. D. ANSTEAD granted leave from 1st September, 1929, up to 1st June, 1931.

MR. P. H. RAMA REDDI, M.A., B.Sc., has been appointed to act as Principal, Agricultural College, Coimbatore, *vice* MR. TADULINGAM MUDALIYAR on leave.

DR. W. BURNS has been appointed to officiate as Director of Agriculture, Bombay Presidency, *vice* MR. T. F. MAIN granted leave for six months from 7th September, 1929.

RAI BAHADUR P. C. PATIL, M.Sc., L.Ag., Professor of Agricultural Economics, has been appointed to officiate as Principal, Agricultural College, Poona, in addition to his own duties, *vice* DR. BURNS on other duty.

MR. D. R. SETHI, M.A., B.Sc., Deputy Director of Agriculture, has been appointed to act as Director of Agriculture, Bihar and Orissa, with effect from 15th July, 1929, until further orders.

MR. T. D. STOCK, I.A.S., Deputy Director of Agriculture, Burma, has been transferred from Meiktila and placed on duty in the Office of the Director of Agriculture, Burma, with effect from the 15th June, 1929.

MR. W. HEAD, Superintendent, Government Gardens, on return from leave, has been appointed to officiate as Deputy Director of Gardens, United Provinces, with effect from the 23rd June, 1929, *vice* MR. A. E. P. GRIESSON, granted leave preparatory to retirement.

MR. JIWAN SINGH, M.Sc., has been appointed to hold charge of the post of Mycologist to Government, Central Provinces, during the absence of MR. DASTUR on other duty.

The next session of the Indian Science Congress will be held at Allahabad from the 3rd to the 8th January, 1930, under the presidency of COL. S. R. CHRISTOPHERS. MR. G. CLARKE, C.I.E., Director of Agriculture, U. P., will preside over the Agricultural Section.

NEW BOOKS

On Agriculture and Allied Subjects

1. The Tropical Crops, by Otis W. Barrett, B.Sc. (New York : The Macmillan Company.) Price, 17s.
2. Heredity in Poultry, by Reginald Crundall Punnett, F.R.S. (London : Macmillan & Co.) Price, 7s. 6d.
3. The Determination of Hydrogen Ions, by W. Mansfield Clark, M.A., Ph.D. Third Edition. (London : Bailliere, Tindall & Cox.) Price, 30s.
4. Special Cytology, Vols. I and II, edited by Edmund V. Cowdry. (London : Oxford University Press.) Price, 94s. 6d.
5. Grain, by S. J. Duly, M.A. (Cantab.). Pp. viii and 164 with text-figures and 6 plates. (London : Oxford University Press.) Price, 8s. 6d. net.
6. Abstracts of Papers on Agricultural Research in the United Kingdom, published during the year October, 1927 to September, 1928. (London : H. M. Stationery Office.) Price, 1s. net.
7. Laboratory Manual of General Microbiology, by Edwin Brown Fred, Ph.D., and Selman A. Waksman, Ph.D. (New York : McGraw-Hill Book Company.) Price, 10s.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Adulteration of Butter and Ghee with Animal Fat and Vegetable Ghee, and its detection, by Phanibhusan Sanyal, M.Sc. (Chemical Series, Vol. X, No. 3.) Price, As. 5 or 6d.
2. The Application of the Antimony Electrode to the Determination of the p H Value and the Lime requirement of Soils, by W. H. Harrison, D.Sc., and P. N. Vridhachalam, B.A. (Chemical Series, Vol. X, No. 4.) Price, As. 5 or 6d.

Bulletins.

3. Some Diseases of Crops in the Andaman Islands, by M. Mitra, Ph.D., M.Sc., F.L.S. (Bulletin No. 195.) Price, As. 4 or 5d.
4. The Cotton White-Fly (*Bemisia gossypiperda*, n. sp.), by Rai Bahadur C. S. Misra, B.A., and Karam Singh Lamba, M.Sc. Price, As. 10 or 1s.



DAVID CLOUSTON, Esq., C.I.E., M.A., D.Sc.

ORIGINAL ARTICLES

DAVID CLOUSTON, Esq., C.I.E., M.A., D.Sc.

AN APPRECIATION.

SINCERE feeling, mingled of admiration and regret, is evoked by the loss to the Agricultural Service of Dr. Clouston, Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute at Pusa. His departure on 13th April, 1929, on leave preparatory to retirement, marks the close of 24 years of successful service in this country, the final six of which were spent in the highest post open to an officer of the Agricultural Service.

Dr. Clouston was born on 13th April, 1872, in the Orkney Isles. That bare and barren land breeds grit in its sons and Dr. Clouston proved himself true to the traditions of his cradling soil. That the grim necessity of wresting a livelihood from unwilling earth develops qualities which carry men far, is exemplified by the unusual fact that two neighbouring Orcadian parishes provided the chiefs of the Agricultural Services during coincident years in Egypt, the Soudan and India.

As a boy Dr. Clouston received his early education in Deerness Public School, Orkney, and later chose Edinburgh as his Alma Mater. Here he graduated in both Arts and Science and gained the academical distinctions which formed the foundation of his capability for the posts he subsequently held. Dr. Clouston came to this country in 1905 where his first appointment to the Indian Agricultural Service was that of Deputy Director of Agriculture in the Central Provinces. During his 12 years' occupancy of this post, his work lay mainly in the Southern and Western Circles of the province. In 1917 he was promoted to be Director of Agriculture of the Central Provinces in an officiating capacity, in 1919 was confirmed in the post and continued to hold it until 1923. This period was marked by a remarkable development in cultivation in the province whose agricultural operations he directed. The introduction of improved methods of farming in so backward an agricultural community as that of Chhattisgarh, the spread of Roseum cotton which, as later testified by the Royal Commission on Agriculture, has brought many crores of increased income to the ryot, and the creation of an organization for seed distribution described by the same authority as more highly developed than anywhere else, are some of the outstanding achievements associated with Dr. Clouston's tenure of service in the Central Provinces. That this work was considered valuable both by his University and by Government is evidenced by a double recognition—that of award of D.Sc. by the former and the conferment of C.I.E. by the latter.

In 1923 Dr. Clouston was appointed Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute at Pusa. In this

responsible post his abilities as administrator and organizer found a fitting scope. That Government made such a wise choice at that particular time was fortunate for the Service, for Dr. Clouston's six years as Chief synchronized with important changes and developments in the Department. The establishment of new post-graduate courses at Pusa qualifying for the highest appointments in the Agricultural Service, the provision of facilities for dairy research and the expansion of sugarcane breeding work at Coimbatore are items in the history of progress of the Department under Dr. Clouston's guidance. Perhaps, however, his greatest service to the cause of agricultural research in this country was associated with his help and advice given to the Royal Commission on Agriculture. When that body was appointed, Dr. Clouston was given the strenuous post of Liaison Officer and filled it with a continuous and untiring diligence. Before the arrival of the personnel of the Commission in India, he spent months collecting valuable data for their knowledge and use. In his evidence before the Commission, he made an important recommendation which is likely to have a far-reaching effect on the progress of agriculture in this country. Since the Reforms, the Provincial Departments of Agriculture have been in the all-important matter of research left without the stimulus of a central organization which could guide and co-ordinate their policy. This lack of co-ordination has necessarily led to overlapping of work in some directions and an accidentally universal lack of investigation in others. Dr. Clouston's advice to the Commission was partly responsible for a series of recommendations by that body relating to the creation of a co-ordinating agency and thus to the provision of the Imperial Council of Agricultural Research recently appointed by the Government of India. That the activities of this body will prove of unestimable advantage to scientific research in the Service is a safe prediction.

Infected by Dr. Clouston's enthusiasm, various eminent men during his term as Agricultural Adviser were induced to take a sympathetic interest in the activities of the Department. This stimulus reached its climax when His Excellency the Right Hon'ble Baron Irwin, Viceroy and Governor-General of India, visited Pusa in January of this year. His Excellency's keen interest in and obviously sincere appreciation of the work done by the Institute is a valuable memory in its history.

The Department owes much to Dr. Clouston as an administrator; of his sympathy and goodwill as a friend its officers were assured. His thoughtfulness, his patience, his keen sense of humour, often pawkily expressed, and his unfailing courtesy in social life will long be remembered. Added to the good wishes which follow Dr. Clouston to Scotland is the confident hope that the homeland will not fail to make use of his valuable knowledge, wide experience and the physical fitness which is his to a surprising degree after so many years of unflagging industry in a tropical land.

W. M. R.

SUGARCANE SEED IN VIZAGAPATAM DISTRICT: ITS IMPROVEMENT.

BY

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AND

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INTRODUCTION.

A FEW years ago the system of cultivating cane known as "short planting" was introduced into India by the Sugar Bureau, and an account of this practice and its advantages have been recorded by Sayer.¹ The method has also been used on the Imperial Cane Breeding Station, Coimbatore, and has been of value in maintaining the vitality of numerous varieties under cultivation. There is no record, however, of the comparison in yield of crops propagated from short planted material and that grown for the dual purpose of seed and sugar.² This article is intended to supply the information, and it has also been written with the object of recording how the system of short planting has been adapted to conditions somewhat different to those existing either at Pusa or Coimbatore.

The experiments have been carried out on the Government Sugarcane Testing Station, Anakapalli, Vizagapatam District, where conditions are representative, in a general way, of typical cane-growing areas of the Northern Circars. The material at the outset, except where otherwise stated, was a crop of J. 247 (known also as B. 247) which had not been short planted for twelve years and which had been grown continuously as a 10 to 11 months crop. A quantity of the stalks was short planted for the first time and the cropping power of the setts obtained was compared with that of the original material.

The average rainfall in the district is about 35 inches per annum. There are usually early showers in April and May followed by the south-west monsoon in June. In October, the north-east monsoon breaks and the rains last up to November. During this period a rainfall of not less than 10 inches is expected.

¹ *Agri. Jour. India*, Vol. XVIII, Part III; Vol. XX, Part II.

Irrigation is common and water is obtained from the rivers at intervals of two to three weeks from the middle of July to November, and this is supplemented by lifting water from pits at intervals over a further period of four months. The capacity of these crude wells, however, varies, and although the water table is high, they do not usually give sufficient water at one time to irrigate more than 20 cents of land.

There are two classes of soil on which sugarcane is grown : one is a clay formed by the deposition of silt from the rivers and which is made heavy by puddled rice cultivation. It cracks deeply in the hot weather, and owing to the low level of the country and the lack of drainage the soil cannot be cultivated regularly in the dry state except from November to May. The other, which is not so widely distributed, is a sandy loam that can be tilled at almost any time of the year.

Sugarcane is planted from February to the end of April and harvest takes place 9 to 11 months later. The land is thoroughly dried out in preparation for planting and artificial irrigation is invariably used at the time of putting in the setts. As long as the supply lasts, water is again applied at intervals of ten days to a fortnight until the break of the rains.

A practice peculiar to the Northern Circars is the wrapping of the dead leaves of the plants round the stalks, and this is done on an elaborate scale four to seven times during the season according to the growth of the crop. It is said to stimulate growth and to improve the quality of canes. The use of props is also necessary, mainly owing to frequent cyclones, and the wrapping of the leaves provides means by which these can be held to the stools.

There are two methods of growing cane for seed : the first and most common is the cultivation of a ten months crop which is used for both sugar and seed. Milling and *gur* (raw sugar) manufacture proceed simultaneously with planting, and the latter is usually delayed until there is an accumulation of tops which are mixed and planted with setts from the whole stalks. The second method involves planting out of the normal season with the object of producing immature material, and to do this the ryot deliberately exposes his crop to adverse conditions. He plants in May and before the break of the monsoon the majority of the primary shoots have either withered or succumbed to borer attack, and in July the crop consists mainly of secondary growth. When once the rains set in, paddy soils are no longer fit for cultivation, and one of the effects of this is a continuation of growth from the base of the stools and towards the end of the season the crop carries a large proportion of immature growth. Late planted crops of this kind mature slowly and stand on the land without deterioration for 11 months.

The Vizagapatam ryot plants his setts carrying three buds at the heavy rate of 20,000 to 25,000 per acre, which weigh from two to three tons. Seed, therefore, is a big item in cultivation expenses, and when large quantities are used the cost will be from Rs. 100 to Rs. 120 per acre.

SHORT PLANTING.

In the Vizagapatam District, swamp rice cultivation in rotation with sugarcane limits the extent to which the land can be tilled during the rains, and short planting is therefore only possible on high paddy lands and on light sandy loams.

In growing a short crop, the setts are put down in February and the canes are cut seven months later for planting out in September. In this month the setts are planted at about 16,000 per acre and the crop will be ready for cutting and use as seed from the beginning of March until the early part of May.

The system of cultivation follows the same lines as when the crop is being grown for sugar, but its shorter period makes it possible to grow green manure, fodder or an early food crop before planting. On the local system, the cane stands for at least nine months and no other crop can be grown during the year.

THE COST OF CANE SETTS.

We have already referred to two local systems of growing cane for seed, and the method most widely adopted will be taken as a basis of comparison with short planting.

In the local method ten to fifteen irrigations are given in a normal year. In the case of well-irrigated land, the water is lifted by man and bullock power which adds to the expense of cultivation. About 5,000 bamboos per acre are required to protect the crop against cyclones, and allowing for a life of three years, the annual cost will be Rs. 50, excluding the cost of erection. In the case of a short crop, no wrappings are necessary and bamboos can be dispensed with entirely, and owing to the crop being grown in the rainy season irrigation charges are much reduced.

We have found that a crop will grow more vigorously when planted in September than in the normal season. Trials on soil of average fertility have extended over a period of four years, in the course of which both thin, medium and thick canes have been grown. On an average, 23 tons of stripped cane per acre has been harvested seven months after planting, and in one year the figure was 30 tons, which compares favourably with the yield of a 10 to 11 months crop (Plate XXXII). Comparative records of cost of production by the local method and short planting have been maintained, and on an average the latter saves 24 per cent.

GERMINATION.

Some of the factors influencing germination of sett buds have been studied by Venkatraman¹, and his investigations show the importance of the internode in the nutrition of the young plant.

Varieties of cane vary much in length and girth of internode, and although such variations may be due to inherent qualities, there is no doubt that these characteristics differ according to the conditions under which the crop is grown. In pro-

SUGARCANE J. 247; SHORT CROP.
Age: 6 months 10 days, Yield: 30 tons cane per acre.

¹ Studies in Sugarcane Germination. *Agri. Jour. India*, Vol. XXI, Part II.

ducing seed cane a study of variations due to external causes is necessary, as the length of internode is concerned with the quantity of seed required to plant a given area.

A large number of tests of germination of thin, medium and thick canes have been made on the Anakapalli Station, and we have not been able to find any definite correlation between length or girth of internode and high germinating capacity. In growing seed material, therefore, we have endeavoured to produce stalks of the maximum girth and carrying, within certain limits, as large a number of buds as possible for a given length of cane.

In making counts of the number of buds that germinate to the number planted, the figures have not usually exceeded 50 to 60 per cent. in any variety. This, of course, refers to seed cane propagated by local methods which, as already stated, involves the growing of a crop that stands on the land for 9 to 11 months. In planting short cropped material we found that germination was superior to that of canes grown over a longer period and trials were started to test the capacity to germinate in the two kinds of seed.

In season 1925-26, twenty samples, each consisting of 198 buds, were planted out on identical areas and in the following year the number of duplications was reduced but the size of the samples was increased to 1,600 buds. The first counts were taken 15 days after planting and the second 7 to 21 days later.

The results are tabulated below :—

TABLE I.
Counts of germination.

Year	7 months crop (Short crop)	10 to 11 months crop	Difference
	Per cent.	Per cent.	Per cent.
1927-28	55.06	44.88	10.18
1926-27	62.55	34.22	28.33
1925-26	65.20	52.07	13.13

In season 1926-27 rain delayed planting throughout the Vizagapatam District, and in consequence the material grown by local methods was standing on the land for 11 months. This caused deterioration and the difference between mature and immature setts was greater than would have been the case if the weather had been more favourable. It may be noted, however, that rain in April is not uncommon and the damage thus caused may not only result in lower yields of jaggery, but an inferior quality of planting material for propagation. The figures show that short cropped material will produce considerably better results than more mature stalks.

TILLERING.

The extent to which a crop tillers has an important bearing on the yield and some of the factors influencing the growth of underground branching have been investigated by Dr. Barber. In a memoir,¹ he refers to the influence of light as perhaps the most important, but states that in view of tillering being an essential characteristic of the growth of the plant, branching of this kind will be assisted by anything that induces a better physical condition.

In examining this character in relation to the vitality of seed material, we have encountered a certain amount of difficulty. In the course of a season a proportion of the stalks produced by single plants die, while others fail to mature and are thinned out. There is also the effect of damage by borers which tends to increase tillering in an irregular manner and at first sight appears to destroy uniformity. This latter point has been examined in some detail and we have endeavoured to ascertain, among other things, the proportion of stalks at harvest to the number of buds planted. Although our observations are incomplete, we have evidence that in the case of borer attack the difference in the number of tillers carried by individual plants on account of external damage early in the year disappears as the season progresses.

In recording the character of branching there are two possible methods, viz., (a) to count the mature stalks produced on a given area, and (b) the calculation of the number of stalks per clump. Figures of this kind ignore the question of death rate and therefore cannot be taken as an accurate comparative representation of the tillering capacity of seed material. They do show, however, in a practical way differences at harvest time that may be accounted for by the quality of seed used.

The recording of the number of tillers carried by individual plants is a laborious task, and owing to more urgent work on hand this was not undertaken. The following statement shows the number of stalks harvested per acre which indicates that short planted material promotes tillering.

TABLE II.
Average number of tillers per unit area.

Year	Area	7 months crop (Short crop)	10 to 11 months crop	Difference per cent.
1927-28	3 cents	1,061	948	11.80
1926-27	"	898	768	16.92
1925-26	"	962	842	14.25
1924-25	"	1,008	900	12.00

¹ Studies in Indian Sugarcanes, No. 4 (Part II). Mem. Dept. Agri. India, Bot. Ser., Vol. X.

The figures are the average of eight to ten samples in each series taken annually over the whole crop at the time of harvest. In seasons 1924, 1925 and 1926, the areas were 1 and 1.5 cents respectively, but for the purpose of comparison the samples have all been calculated on the basis of the produce of 3 cents.

THE QUALITY OF JUICE.

We are indebted to the Government Agricultural Chemist, Coimbatore, and his staff for making a series of chemical analyses of the crops under comparison.

In carrying out work of this kind, errors are liable to arise in sampling and difficulty may be experienced in deciding when a crop is ripe. If the best results are to be obtained, sampling must be completed within as short a time as possible, as a crop is liable to change in constitution when left standing on the land. It therefore follows that the number of samples must be reduced to the minimum consistent with obtaining accurate results within the margin of error. Unfortunately, we have no very definite information on this latter point, as far as local conditions are concerned, and we have relied on taking as large and as many samples as possible. We have had one advantage in using a variety of cane that matures very slowly and does not deteriorate readily after reaching maturity.

Each sample was taken from the juice obtained from the produce of plots 3 cents in area comprising 800 to 1,000 canes. In 1925-26, ten samples of each series were analysed, and in view of the significant figures obtained only four were taken in the years following. In each case sampling was at random and from different parts of the field. In deciding when the crop was ripe the procedure followed was that recommended by Viswanath.¹ In view of our experience over a number of seasons of the ratio of total solids in the top and bottom halves of canes that may be expected in J. 247 at the time of maturity, the method was found to be very satisfactory.

TABLE III.
Chemical analysis.

Year	No. of samples	Brix.	Average sucrose	Glucose ratio
Short crop 1927-28	4	19.66	17.18	6.04
Mature crop „	4	19.63	17.17	5.78
Short crop 1926-27	4	18.57	16.28	4.72
Mature crop „	4	18.45	15.81	5.32
Short crop material 1925-26	10	18.25	16.17	7.30
Mature crop „	10	18.78	16.10	7.67

¹ Mem. Dept. Agri. India, Chem. Ser., Vol. VII, No. 6.

In season 1925-26, owing to reliance being placed on the appearance of the crop as an indication of ripeness, the series were harvested before maturity. The figures, with the exception of those for glucose ratio in season 1927-28, favour crops propagated from short crop material, and it may be concluded that the use of vigorous planting material influences the quality of juice at harvest.

THE YIELD OF CANES.

The foregoing remarks show the importance of using good seed and its influence on the ultimate yield of the crop. There are no sugar factories in the district and the cane, with the exception of that required for seed, is converted into *jaggery* or *gur* by local methods. Calculations of results on the basis of raw sugar prepared in this way will not be of much value owing to wastage and the inevitable errors arising on that account. We have therefore taken the production of stripped cane as an indication of the cropping power of the two grades of seed under comparison. The figures are given in Table IV.

TABLE IV.
Yield of canes.

Year	AVERAGE WEIGHT OF CANE PER PLOT IN LB.		Mean difference	P. E. of difference
	Short crop	Mature crop		
1927-28	2,802	2,570	232	±47.80
1926-27	2,701	2,338	363	±53.07
1925-26	1,247	1,045	202	±19.31
1924-25	1,260	996	264	±27.90

It will be seen that over a period of four seasons an increase in favour of short cropped seed material was obtained. A reference to Table I shows that in 1926-27 the number of buds that germinated in the short cropped material was 28.33 per cent. greater than in that obtained from a ten months crop, and it is therefore evident that the increase of light and space afforded on that account compensated to a considerable degree.

CONCLUSION.

The cultivation of sugarcane as a short crop is a definite improvement on the local system, and results not only in a saving in the cost of seed material, but an increase in the yield of crops that are propagated from such setts. The growing of a crop of long duration that matures in the hot weather results in the produc-

tion of hard buds that are liable to damage. This is specially the case in the Vizagapatam District where it is usual to transport the setts in baskets over bad roads. Under irrigation and intensive cultivation in a moist climate canes grow to a greater height than in Central and Northern India; and it is not uncommon in the case of J. 247 to see a third of the stalks throwing roots at the nodes. This particular growth is also caused by borers, but we have found that a September planted crop is not damaged to the same extent as one planted in the normal season, and that the shorter period of growth restricts the height to which the stalks grow.

Large areas in the district suitable for garden land cultivation, i.e., land commanded by well-irrigation and not cultivated with rice, are being brought under paddy and cease to be of any use for short crop cultivation. There are, however, considerable areas along the banks of the rivers where conditions for short cropping are ideal, and the ryots are beginning to follow this practice.

YIELD TRIALS WITH SOME PUSA BARLEYS.

BY

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Imperial Economic Botanist;

AND

RAKHAL DAS BOSE, B.Sc., F.L.S.,
Research Assistant to Imperial Economic Botanist.

BARLEY is an important crop in northern India, the total acreage under this crop being nearly seven million acres, of which about 60 per cent. is in the United Provinces. The average annual production is about three million tons and the approximate outturn per acre ranges from 800 to 1,400 lb.¹ It is a *rabi* crop, sown in October or November, and harvested in March or April. It is sown either singly or mixed with wheat, gram, peas or lentils, and thrives best on light and sandy soils which, as a rule, are not highly manured.² It is generally put in soils which are rather too light for wheat. The local crop is a mixture of various unit species and can be improved by selection as regards yielding capacity, standing power, disease-resistance and time of maturity. A number of pure lines has been isolated at Pusa and three of these have been tested for yielding power³ against the local mixed type. This paper is an account of the results obtained.

The comparison of the yielding power of several different types involves the laying out of a field trial and the application of statistical methods to the observations of the yields of a number of plots.⁴ If fields were of uniform fertility over their whole area, a yield trial would be a relatively simple experiment, but the variations in fertility from one part of a field to another introduce into the experiment a varying uncontrolled factor, which may entirely obscure the differences due to different treatments. The lay-out of a yield trial, therefore, has for its object the elimination of this factor of varying fertility, or soil heterogeneity, from influence on the experimental result. A method of estimating the soil heterogeneity has been worked out by Harris⁵ and is based on the determination of the co-efficient

¹ *Agri. Statistics for India*, 1924-25.

² Watt, *Commer. Prod. of India*, 1908, p. 641.

³ Harris, J. A. On the significance of variety tests. *Science*, N. S., 36, 1912, 318-320; and 37, 1913, 493-494.

⁴ Fisher, R. A. *Statistical Methods for Research Workers*, 1925.

⁵ Harris, J. A. On a criterion of substratum homogeneity (or heterogeneity) in field experiments. *Amer. Nat.*, XLIX, 1915, 430-454.

of correlation between the yielding powers of adjacent plots. Usually the soil heterogeneity of the field which is being used for a yield trial is not known and we endeavour to counteract its influence by several methods.

The field which is selected for a yield trial should be typical of the soil which is usual for the particular crop or manurial treatment which is under investigation and should be as uniform as possible. It must be divided up into a number of plots of a size, shape and distribution¹ such as to secure for each treatment under investigation a free random distribution among the variations of fertility in the field. This random distribution may be obtained either by arranging the plots² in a series of long strips stretching right across the field or by the division of the field into a number of small square plots. The method of long strips presents certain disadvantages in that the distribution of the strips may coincide with a definite fertility gradient from one side of the field to another.³ This can be counteracted by reversing, alternately, the order of the treatments as shown in Text-fig. 1.

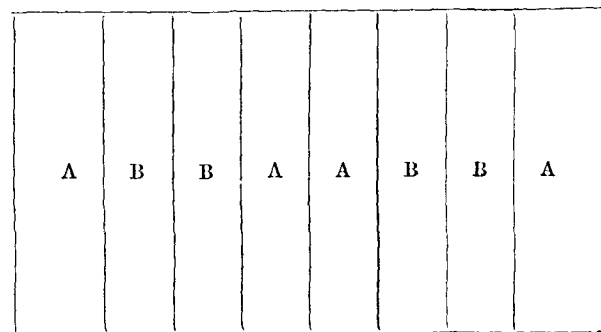


Fig. 1 Showing the correct arrangement of experimental plots.

The division of the field into a number of small squares has the advantage that each treatment occurs repeatedly in small areas of the field, that the "border" effect is reduced to a minimum, and that the replication of each treatment in a number of plots is effective in reducing the experimental error.^{4 5 6} Replications are a most important factor in controlling the variability in yields in a field trial

¹ Day, J. W. The relation of size, shape, and number of replications of plots to probable error in field experiments. *Jour. Amer. Soc. Agron.*, **12**, 1920, 100-105.

² Fisher, R. A. The arrangement of field experiments. *Jour. Min. Agri.*, London, **33**, 1926, 505-513.

³ Beaven, E. S. Trials of new varieties of cereals. *Jour. Min. Agri.*, London, **29**, 1922, Nos. 4 and 5.

⁴ Love, H. H. Experimental error in field trials. *Jour. Amer. Soc. Agron.*, **11**, 1919, 212-216.

⁵ Mercer, W. B., and Hall, A. D. Experimental error in field trials. *Jour. Agri. Sci.*, **4**, 1911, 107-132.

⁶ Parnell, F. R. Probable error in field experiments. *Jour. Madras Students' Union*, 1917, 171-181.

Series - I					Series - II				
1	21	41	61	81	101	121	141	161	181
2	22	42	62	82	102	122	142	162	182
3	23	43	63	83	103	123	143	163	183
4	24	44	64	84	104	124	144	164	184
5	25	45	65	85	105	125	145	165	185
6	26	46	66	86	106	126	146	166	186
7	27	47	67	87	107	127	147	167	187
8	28	48	68	88	108	128	148	168	188
9	29	49	69	89	109	129	149	169	189
10	30	50	70	90	110	130	150	170	190
11	31	51	71	91	111	131	151	171	191
12	32	52	72	92	112	132	152	172	192
13	33	53	73	93	113	133	153	173	193
14	34	54	74	94	114	134	154	174	194
15	35	55	75	95	115	135	155	175	195
16	36	56	76	96	116	136	156	176	196
17	37	57	77	97	117	137	157	177	197
18	38	58	78	98	118	138	158	178	198
19	39	59	79	99	119	139	159	179	199
20	40	60	80	100	120	140	160	180	200
Series - III					Series - IV				
301	302	303	304	305	306	307	308	309	310
311	312	313	314	315	316	317	318	319	320
321	322	323	324	325	326	327	328	329	330
331	332	333	334	335	336	337	338	339	340
341	342	343	344	345	346	347	348	349	350

A = 
 B = 
 C = 
 D = 

and no result can be regarded as trustworthy unless it is based on an adequate appreciation of this fact. Moreover, the reliability of statistical calculations is increased by including a larger number of varieties.

The experiment was carried out in 1928-29 with three varieties of barley which had been selected at Pusa and with a local type grown from a bazaar sample of seed. The three Pusa types were B-4, B-23 and B-20, all of which had given indications of high yielding power in previous years. The arrangement of the experiment was by the division of the field into a number of small square plots, each plot being 4 feet square. The four different barley types were then distributed in these plots as shown in the diagram facing this page (Fig. 2); this shape and distribution of plots is known as the chess-board method.¹

By this distribution the four types of barley were so scattered about the field that the combined plots of any one type were thoroughly representative of the whole experimental area and each of the four types had a random distribution among the varying grades of soil fertility.

The variations in the yields of plots will depend upon the variety which is sown in the plot and upon the varying fertility of the soil. The application of statistical mathematics to the observations of yield enables us to determine how far the observed differences are significant of an inherent difference in the yielding capacity of the varieties and how far they are due to random variations of soil fertility. Mathematical methods² are, of course, simply a test of the reliability of results; that reliability is primarily dependent upon the care and accuracy with which the experiment has been carried out and the observations have been recorded. The need for the use of statistical mathematics in the interpretation of field results^{3, 4} depends upon the fact that field experiments are subject to a multiplicity of factors which cannot be under that exact control which prevails in other types of experiments in the laboratory.

A number of methods are available for determining the significance of the differences between two or more series of observations. Three methods have been employed in the present study:—

- (1) *Bessel's method* consists of determining the means, standard deviations and the probable errors of the means of the yields of the two varieties under comparison and then determining the ratio of the difference of the two means to the probable error of their difference. If this ratio be more than 3.2 times the probable error of the difference the results are said to be statistically significant. This method is reliable where

¹ Engledow, F. L., and Udney Yule, G. The Principles and Practice of Yield Trials. *The Empire Cotton Growing Rev.*, III, 1926, 253-260.

² "Student." Mathematics and Agronomy. *Jour. Amer. Soc. Agron.*, 18, 1926, 703-719.

³ Wood, T. B. Interpretation of experimental results. *Jour. Bd. Agri.*, London, Supplem. 7, 1911, 15-37.

⁴ Wood, T. B., and Stratton, F. J. M. Interpretation of experimental results. *Jour. Agri. Sci.*, 3, 1910, 417-440.

there is no correlation between the different observations as in many chemical and physical determinations, but it is less reliable in its application to field trials where there may be a high correlation between the yielding powers of adjacent plots.¹

- (2) *Student's method* consists of tabulating the differences between the yields of two varieties and determining the ratio :—

$$\frac{\text{Mean difference}}{\text{Standard deviation of the difference}} = \text{“Z”}.$$

From this ratio the odds are read off from tables^{2 3} which express the probability in terms of the value of “Z”. The most important condition of this method is that the lay-out should be such as to lend itself to the pairing of observations, *e.g.*, yields of adjacent plots, and that there must be a large number of controls or checks to obtain significant results. This pairing of plots allows for the influence of the correlation between the yielding powers of adjacent areas. It is obvious that with a given mean difference the odds will increase as the standard deviation decreases, that is to say, that as the variability of the difference decreases this method shows that the reliability of the observations increases. In extreme cases some authors⁴ consider that this is a defect in this method.

- (3) *Engledow and Yule* have recently published a *method*⁵ by which a number of varieties can be compared at the same time. The standard deviation of the differences of two sets of comparable plots from their means is determined and the standard error of this is calculated from the formula —

$$Ed = \frac{\sigma}{\sqrt{n}}$$

The significance of the difference between two varieties is given by the ratio of the difference of their means to the standard error. If this ratio is greater than **2.1**, the odds against the observed difference being due solely to errors of random sampling are **30 : 1**, and the result is considered to be significant.

The experiment was divided into four series.

Series I consisted of a bed divided into 100 small plots, each plot containing eight lines with a distance of six inches between the lines. Each line was sown

¹ Iliffe, R. O., and Viswa Nath, B. The conduct of field experiments. *Madras Dept. Agri. Bull.* 80, 1928, p. 40.

² Pearson, Karl. *Tables for Statisticians and Biometricians*, Part I, p. 36.

³ Love, H. H. A modification of Student's Table for use in interpreting Experimental Results. *Jour. Amer. Soc. Agron.*, 16, 1914, 68-73.

⁴ Salmon, S. C. Some misapplications and limitations in using Student's method to interpret Field Experiments. *Jour. Amer. Soc. Agron.*, 16, 1924, 717-721.

⁵ Engledow, F. L., and Udney Yule, G. The Principles and Practice of Yield Trials. *The Empire Cotton Growing Rev.*, III, 1926, 124-128.

with 26 seeds, sown two inches apart. In order to eliminate “border”¹ effects a six-inch border was cut away at harvest from each plot and the remaining square yard of plants was harvested and weighed.

Series II consisted of 200 similar plots which were sown in a different manner. The method of sowing in the previous series is that which is generally used in this type of experiment, but this proved rather slow and tedious and hence a slight modification was resorted to. The two end lines of each plot in this series were sown with linseed and served for differentiating one plot from the other. The intermediate six lines were sown with barley after the hand plough and were finally thinned out to a constant number of plants in each line.

Series III and IV were included to fill in a vacant space at the end of the field. Series III consisted of 24 strips, six strips of each type, each strip was 25 ft. by 2 ft. and contained four lines sown 6 inches apart. The strips were separated by lines of linseed. Series IV consisted of 24 strips, six strips of each type; each contained three lines, sown at a distance of one foot apart, and separated similarly with lines of linseed.

No spaces or paths were left between any plots and great care was taken not to trample the soil and to keep the proper tilth of the soil. The whole field was protected with rabbit wire. At harvest after cutting away a six-inch border from each plot the remaining plants in a plot were reaped and the seed threshed out by hand on a small sheet; the seed was then weighed after drying in the sun.

The following Table gives the yields of all the plots in the experiment. For convenience plots containing Type B-4 are marked **A**, Type B-23 are marked **B**, Type B-20 are marked **D**, and the local variety is marked **C**. The types are referred to as **A, B, C, D**, in the rest of this paper :—

TABLE I.

Yield in gm. per plot of the four types of barley, 1928-29.

Series	Plot No.	Yield of A	Plot No.	Yield of B	Plot No.	Yield of C	Plot No.	Yield of D
I	1	452	2	385	3	270	4	526
	5	352	6	546	7	210	8	318
	9	450	10	385	11	217	12	335
	13	455	14	328	15	227	16	386
	17	372	18	325	19	202	20	395
	24	262	21	315	22	113	23	157

¹ Army, A. C. Border effect and ways of avoiding it. *Jour. Amer. Soc. Agron.*, 14, 1922, 266-278.

TABLE I—contd.

Yield in gm. per plot of the four types of barley, 1928-29—contd.

Series	Plot No.	Yield of A	Plot No.	Yield of B	Plot No.	Yield of C	Plot No.	Yield of D
I	28	275	25	183	26	95	27	123
	32	332	29	127	30	121	31	240
	36	252	33	102	34	85	35	228
	40	442	37	204	38	62	39	195
	43	204	44	182	41	108	42	214
	47	208	48	58	45	210	46	233
	51	280	52	248	49	66	50	295
	55	278	56	261	53	60	54	255
	59	201	60	370	57	35	58	168
	62	231	63	212	64	39	61	243
	66	313	67	173	68	84	65	282
	70	181	71	200	72	22	69	265
	74	312	75	256	76	72	73	187
	78	182	79	158	80	172	77	178
	81	472	82	445	83	222	84	318
	85	380	86	123	87	135	88	459
	89	316	90	310	91	56	92	253
II	93	358	94	288	95	122	96	312
	97	308	98	333	99	108	100	348
	104	380	101	592	102	208	103	280
	108	618	105	412	106	342	107	400
	112	497	109	327	110	352	111	482
	116	751	113	370	114	258	115	495
	120	396	117	442	118	280	119	467
	123	352	124	239	121	159	122	315
	127	323	128	287	125	165	126	258
	131	333	132	315	129	152	130	294

TABLE I—contd.

Yield in gm. per plot of the four types of barley, 1928-29—contd.

Series	Plot No.	Yield of A	Plot No.	Yield of B	Plot No.	Yield of C	Plot No.	Yield of D
II	135	188	136	360	133	138	134	235
	139	385	140	288	137	214	138	312
	142	366	143	241	144	123	141	341
	146	344	147	248	148	87	145	298
	150	544	151	276	152	76	149	285
	154	307	155	432	156	108	153	223
	158	416	159	214	160	193	157	328
	161	633	162	408	163	134	164	523
	165	630	166	300	167	177	168	401
	169	231	170	309	171	148	172	315
	173	361	174	346	175	111	176	254
	177	280	178	212	179	101	180	252
	184	575	181	637	182	183	183	542
	188	487	185	487	186	232	187	463
	192	298	189	480	190	260	191	323
	196	510	193	432	194	177	195	396
	200	507	197	488	198	99	199	391
	203	274	204	365	201	401	202	447
	207	546	208	548	205	273	206	496
	211	464	212	455	209	235	210	437
	215	623	216	635	213	357	214	384
	219	636	220	520	217	245	218	560
	222	438	223	242	224	118	221	465
	226	295	227	280	228	112	225	218
	230	268	231	312	232	85	229	295
	234	291	235	220	236	103	233	207
	238	388	239	312	240	268	237	282

TABLE I—concl'd.

Yield in gm. per plot of the four types of barley, 1928-29—concl'd.

Series	Plot No.	Yield of A	Plot No.	Yield of B	Plot No.	Yield of C	Plot No.	Yield of D
II	241	418	242	266	243	102	244	257
	245	372	246	315	247	173	248	278
	249	270	250	280	251	78	252	220
	253	293	254	314	255	125	256	227
	257	238	258	254	259	160	260	220
	264	345	261	366	262	142	263	297
	268	344	265	320	266	197	267	350
	272	340	269	290	270	270	271	298
	276	372	273	318	274	75	275	321
	280	435	277	248	278	125	279	198
	283	478	284	392	281	288	282	420
	287	377	288	442	285	240	286	385
	291	585	292	400	289	270	290	547
	295	465	296	465	293	226	294	498
	299	605	300	490	297	198	298	318
III	301	1980	302	1585	303	380	304	1448
	305	1905	306	1600	307	585	308	1400
	320	1355	319	1180	318	445	317	1730
	324	1470	323	1462	322	585	321	1390
	335	905	336	750	333	790	334	625
	339	1170	340	1230	337	560	338	1160
IV	310	2355	311	2067	312	1637	309	2265
	314	3330	315	2325	316	2805	313	2375
	328	2166	325	2465	326	1426	327	1790
	332	3615	329	1920	330	1085	331	2155
	343	2270	344	1755	341	1350	342	2090
	347	2695	348	2490	345	1495	346	1880

The curves shown in Figs. 3 and 4 represent the frequency distributions of plot yields for each type of barley in Series I and II, the frequencies being expressed on a percentage basis.

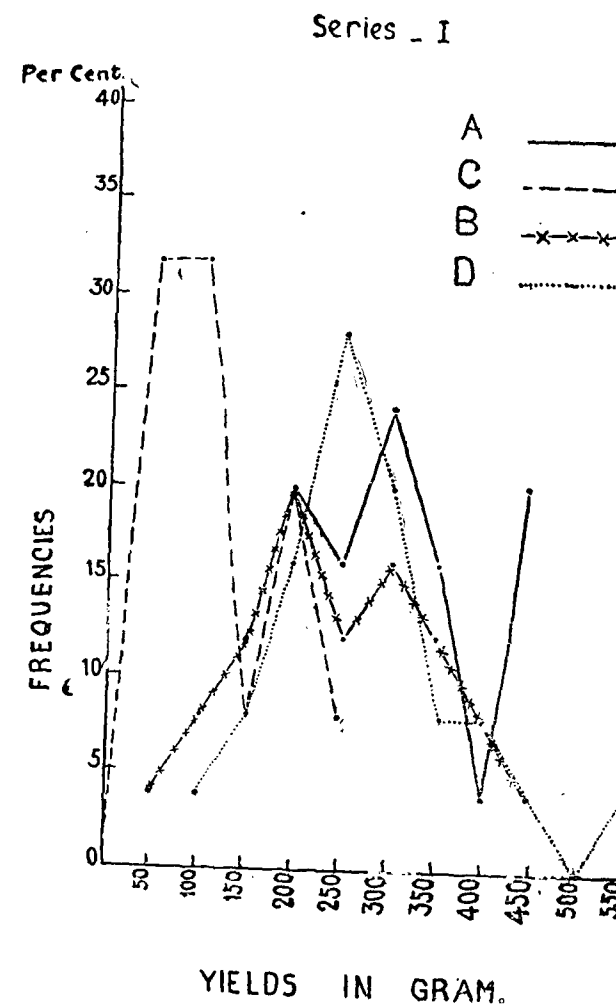


Fig. 3

Series - II

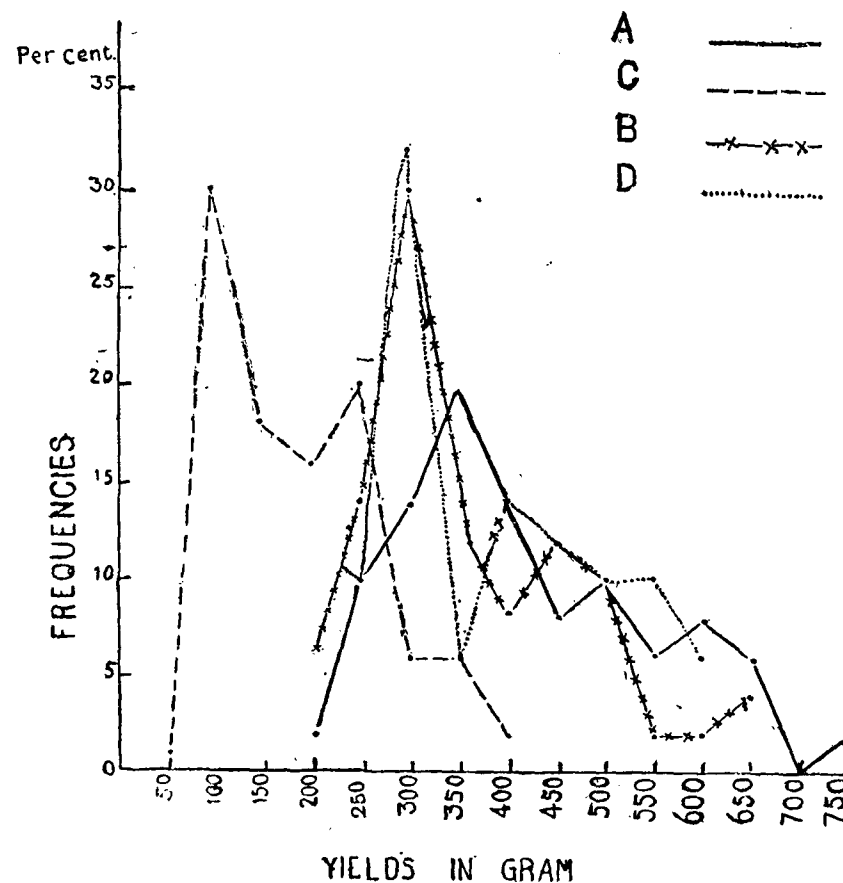


Fig. 4.

The expression of frequencies on a percentage basis was necessary as Series I contained 25 plots of each type while Series II contained 50 plots of each type. It is evident from these graphs that Type B-4 (Plots A) gives the highest yields and the local variety (Plots C) gives the lowest yields, while Types B-23 and 20 (Plots B and D) are intermediate in yielding power. The yields in Series II are considerably higher than in Series I. This is almost certainly due to the fact that a fixed number of seeds (208) was sown in Series I in each plot, while in Series II a larger amount of seed was sown in each plot and the plots were afterwards thinned out so that each plot contained an equal number of plants. In Series II, therefore, losses due to

defective germination are eliminated, hence the higher yield in this series. The following Table gives the mean yields, standard deviations and the probable errors of the mean for each of the four types in all the series.

TABLE II.

Mean yields and other statistical constants for the four types of barley in Series I, II, III and IV.

Series	Variety	Size of plot	No. of plots	Mean	S. Dev.	P. E. of Mean
I	A (B-4)	3' x 3'	25	314.72	89.19	12.03
	B (B-23)	3' x 3'	25	260.68	113.35	15.29
	C (Local)	3' x 3'	25	124.52	69.93	9.43
	D (B-20)	3' x 3'	25	276.52	94.01	12.68
II	A (B-4)	3' x 3'	50	417.44	128.39	12.25
	B (B-23)	3' x 3'	50	363.82	108.58	10.36
	C (Local)	3' x 3'	50	186.86	81.12	7.74
	D (B-20)	3' x 3'	50	349.96	116.14	11.08
III	A (B-4)	25' x 2'	6	1464.167	417.509	114.98
	B (B-23)	25' x 2'	6	1301.166	322.26	88.75
	C (Local)	25' x 2'	6	557.5	141.24	38.90
	D (B-20)	25' x 2'	6	1292.167	374.11	103.03
IV	A (B-4)	25' x 3'	6	2738.5	602.38	165.89
	B (B-23)	25' x 3'	6	2170.333	302.9	83.42
	C (Local)	25' x 3'	6	1633.0	602.64	165.94
	D (B-20)	25' x 3'	6	2092.5	223.67	61.60

The method of calculating biometrical constants for Series I is shown in Tables III and IV, the latter Table being the method which is usually adopted for use with a calculating machine.

TABLE III.
Calculation of the standard deviation, etc., in Series I by the Assumed Mean Method.

A—ASSUMED MEAN = 330					B—ASSUMED MEAN = 270					C—ASSUMED MEAN = 130					D—ASSUMED MEAN = 300				
Plot Nos.	Yields in gm.	Deviations from assumed mean squared		Plot Nos.	Yields in gm.	Deviations from assumed mean squared		Plot Nos.	Yields in gm.	Deviations from assumed mean squared		Plot Nos.	Yields in gm.	Deviations from assumed mean squared					
		—	+			—	+			—	+			—	+				
1	452	122	14884	2	385	115	13925	3	270	140	19600	4	526	226	51076				
5	352	22	484	6	546	276	7678	7	210	80	6400	8	318	18	324				
9	450	20	14400	10	385	115	13925	11	217	87	7369	12	335	35	1225				
13	455	25	15625	14	328	58	3364	15	227	97	9469	16	380	86	7396				
17	372	42	1764	18	323	55	3025	19	202	72	5184	20	395	95	9025				
24	262	68	4624	21	183	45	2025	22	113	17	289	23	157	13	20449				
28	275	55	3025	25	182	57	3249	26	163	29	4681	27	123	17	31329				
32	332	22	6884	29	102	13	2049	30	195	39	1560	31	240	60	3600				
36	332	22	13556	33	102	13	2049	34	102	13	2049	35	228	72	5184				
40	442	78	15856	37	204	168	4276	38	62	48	4624	39	195	105	11025				
43	204	136	14884	44	183	88	7744	45	210	22	80	42	214	86	7396				
47	208	122	2300	48	58	212	4464	49	66	64	4096	50	253	45	225				
51	280	50	2704	52	201	9	81	53	60	70	4800	54	253	45	225				
55	278	52	2704	56	270	9	10000	57	85	95	9025	58	168	132	17424				
59	301	129	16641	60	912	58	3364	64	39	91	8281	65	243	57	3249				
62	231	59	289	63	173	97	9409	67	84	108	2116	68	282	18	324				
66	313	17	2201	68	200	70	4900	72	22	168	11664	69	265	35	1225				
70	181	149	324	71	200	70	4900	76	72	58	3364	73	187	113	12769				
74	312	18	21004	73	256	14	196	76	172	58	3364	77	178	113	12769				
78	182	148	21004	78	138	112	12544	80	172	58	3364	79	178	113	12769				
81	472	..	20164	82	443	175	30625	83	135	..	8464	84	318	..	18				
85	380	..	25600	86	233	147	21025	87	135	..	8464	85	459	..	159				
89	316	14	196	90	310	..	1600	91	156	74	5476	86	459	..	159				
93	358	..	784	94	288	..	824	95	122	22	64	90	312	..	12				
97	308	..	484	98	333	..	3969	99	108	22	484	100	348	..	48				
Total		-1147 + 765	204690			-1293 + 1060	323431			-832 + 695	123013			-1284 + 697	234705				
C (correction factor)					C = -1293 + 1060 = -9.32					C = -832 + 695 = -5.48					C = -1284 + 697 = -23.48				
Mean = 330 - 15.23 = 314.72					Mean = 270 - 9.32 = 260.68					Mean = 130 - 5.48 = 124.52					Mean = 300 - 23.48 = 276.52				
$\sigma = \sqrt{\frac{\sum d^2}{n} - \left(\frac{\sum d}{n}\right)^2}$					$\sigma = \sqrt{\frac{\sum d^2}{n} - \left(\frac{\sum d}{n}\right)^2}$					$\sigma = \sqrt{\frac{\sum d^2}{n} - \left(\frac{\sum d}{n}\right)^2}$					$\sigma = \sqrt{\frac{\sum d^2}{n} - \left(\frac{\sum d}{n}\right)^2}$				
$= \sqrt{\frac{204690}{25} - \left(\frac{-15.23}{25}\right)^2}$					$= \sqrt{\frac{323431}{25} - \left(\frac{-9.32}{25}\right)^2}$					$= \sqrt{\frac{123013}{25} - \left(\frac{-5.48}{25}\right)^2}$					$= \sqrt{\frac{234705}{25} - \left(\frac{-23.48}{25}\right)^2}$				
$= \sqrt{8187.60 - 0.3348}$					$= \sqrt{12937.24 - 0.0016}$					$= \sqrt{4920.52 - 0.0008}$					$= \sqrt{9385.20 - 0.53131}$				
$= \sqrt{7934.12 = 89.19}$					$= \sqrt{12936.24 = 113.85}$					$= \sqrt{4890.49 = 69.93}$					$= \sqrt{8836.89 = 94.01}$				
$E_m = \frac{0.6745 \times 89.19}{25} = 12.03$					$E_m = \frac{0.6745 \times 113.85}{25} = 15.29$					$E_m = \frac{0.6745 \times 69.93}{25} = 9.43$					$E_m = \frac{0.6745 \times 94.01}{25} = 12.68$				

TABLE IV.

Calculation of standard deviation, etc., in Series I by the Yield Square Method, especially adapted for machine calculations.

A			B			C			D		
Plot No.	Yield	(Yield) ²	Plot No.	Yield	(Yield) ²	Plot No.	Yield	(Yield) ²	Plot No.	Yield	(Yield) ²
1	452	204304	2	385	148225	3	270	72900	4	526	276676
5	352	123904	6	546	298116	7	210	44100	8	318	101124
9	450	202500	10	385	148225	11	217	47089	12	335	112225
13	455	207025	14	328	107584	15	227	51529	16	386	148996
17	372	138384	18	325	105625	19	202	40804	20	395	156025
24	262	68644	21	315	99225	22	113	12769	23	157	24649
28	275	75625	25	183	33489	26	95	9025	27	123	15129
32	332	110224	29	127	16129	30	121	14641	31	240	57600
36	352	123904	33	102	10404	34	85	7225	35	228	51884
42	442	195364	37	204	41616	38	62	3844	39	195	38025
43	442	195364	44	182	33124	41	108	11664	42	214	45796
47	208	43264	48	58	3364	45	210	44100	46	233	54289
51	278	77284	52	248	61504	66	66	4356	50	295	87025
53	278	77284	56	261	68121	53	60	3600	54	255	65025
59	291	84681	60	370	136900	57	35	1225	58	168	28224
62	291	84681	63	212	44944	64	39	1521	61	243	59049
66	313	97969	67	173	29929	68	84	7056	65	292	85264
70	181	32761	71	200	40000	72	22	484	69	265	70225
74	312	97344	75	236	55696	76	72	5184	73	187	34969
78	182	33124	79	158	24964	80	172	29584	77	178	31684
81	472	222784	82	445	198025	83	222	49284	84	318	101124
85	380	144400	86	123	15129	87	135	18225	88	459	210681
89	316	99856	90	310	96100	91	56	3136	92	253	64009
93	358	128164	94	288	82944	95	122	14884	96	312	97344
97	308	94864	98	333	110889	99	108	11664	100	348	121104
Total	7868	2075070		6517	2020111		3113	509893		6913	2132505
Mean = 314.72			Mean = 260.68			Mean = 124.52			Mean = 276.52		
$\sigma = \sqrt{\frac{2675070}{25} - \left(\frac{314.72}{25}\right)^2}$			$\sigma = \sqrt{\frac{2020111}{25} - \left(\frac{260.68}{25}\right)^2}$			$\sigma = \sqrt{\frac{509893}{25} - \left(\frac{124.52}{25}\right)^2}$			$\sigma = \sqrt{\frac{2132505}{25} - \left(\frac{276.52}{25}\right)^2}$		
$= \sqrt{107002.80 - 99048.6784}$			$= \sqrt{80804.44 - 67954.062}$			$= \sqrt{20395.72 - 15505.23}$			$= \sqrt{85300.2 - 76403.31}$		
$= \sqrt{7554.12 = 89.19}$			$= \sqrt{12850.38 = 113.85}$			$= \sqrt{4890.49 = 69.93}$			$= \sqrt{8836.89 = 94.01}$		
$E_m = \frac{0.6745 \times 89.19}{25} = 12.03$			$E_m = \frac{0.6745 \times 113.85}{25} = 15.29$			$E_m = \frac{0.6745 \times 69.93}{25} = 9.43$			$E_m = \frac{0.6745 \times 94.01}{25} = 12.68$		

APPLICATION OF S STATISTICAL TESTS.

(I) *Bessel's Method.*

In Table V, the three Pusa selections, **A, B, D**, have been compared with the local type, **C**, by Bessel's method and the odds that the observed differences between yields are significant of a true varietal difference in yielding powers have been determined. When the ratio of the standard deviation to the probable error gives a value of **7.0** the odds against the observed deviations being due merely to errors of random sampling are **434702 : 1**. This ratio in Series I and II always gives a value of more than **7.0** and the odds in favour of the Pusa types are, therefore, very high. In Series II the odds are even higher than those in Series I; this is due to the increased reliability of the results obtained due to the larger number of replications in Series II. Similarly Series III and IV with a smaller number (6) of replications give lower odds. In all the series, however, the odds are in favour of the Pusa types, although in Series IV, in the case of types **B** and **D**, the odds are scarcely high enough to be significant. In all the series the highest odds are in favour of type **A**.

TABLE V.
Calculation of statistical significance by Bessel's method.

Series	Variety	Mean	P.E. of Mean	Diff. of Mean	P. E. of diff. = $\sqrt{E_1^2 + E_2^2}$	Ratio of Mean diff. P. E. of diff.	Odds against C
I	A (B-4)	314.72	12.03	190.2	$\sqrt{(12.03)^2 + (9.43)^2} = 15.285$	$\frac{190.2}{15.285} = 12.45$	Very high.*
	C (Local)	124.52	9.43	136.16	$\sqrt{(15.29)^2 + (9.43)^2} = 17.96$	$\frac{136.16}{17.96} = 7.58$	427000 : 1
	B (B-23)	260.68	15.29				
	D (B-26)	276.52	12.68	152.0	$\sqrt{(12.68)^2 + (9.43)^2} = 15.8$	$\frac{152.0}{15.8} = 9.62$	65,000,000,000 : 1
	C (Local)	124.52	9.43				
II	A (B-4)	417.44	12.25	230.58	$\sqrt{(12.25)^2 + (7.74)^2} = 14.49$	$\frac{230.58}{14.49} = 15.91$	Very high.*
	C (Local)	186.86	7.74	176.96	$\sqrt{(10.36)^2 + (7.74)^2} = 12.93$	$\frac{176.96}{12.93} = 13.69$	Very high.*
	B (B-23)	363.82	10.36				
	D (B-20)	349.96	11.08	163.1	$\sqrt{(11.08)^2 + (7.74)^2} = 13.51$	$\frac{163.1}{13.51} = 12.07$	Very high.*
	C (Local)	186.86	7.74				
III	A (B-4)	1464.167	114.98	906.667	$\sqrt{(114.98)^2 + (38.90)^2} = 121.38$	$\frac{906.667}{121.38} = 7.47$	427000 : 1
	C (Local)	557.5	38.90	743.666	$\sqrt{(88.75)^2 + (38.90)^2} = 96.9$	$\frac{743.666}{96.9} = 7.67$	14,700,000 : 1
	B (B-23)	1301.166	89.75				
	D (B-20)	1292.167	103.03	734.667	$\sqrt{(103.03)^2 + (38.90)^2} = 110.13$	$\frac{734.667}{110.13} = 6.67$	427000 : 1
	C (Local)	557.5	38.90				
IV	A (B-4)	2738.5	165.89	1105.5	$\sqrt{(165.89)^2 + (165.94)^2} = 234.6$	$\frac{1105.5}{234.6} = 4.71$	6533 : 1
	C (Local)	1633.0	165.94	537.33	$\sqrt{(83.42)^2 + (165.94)^2} = 185.68$	$\frac{537.33}{185.68} = 2.89$	1882 : 1
	B (B-23)	2170.333	83.42				
	D (B-20)	2092.5	61.60	459.5	$\sqrt{(165.94)^2 + (61.6)^2} = 176.95$	$\frac{459.5}{176.95} = 2.60$	11.58 : 1
	C (Local)	1633.0	165.94				

* When the ratio is more than 10 the odds are more than 65,000,000,000 to 1.

(II) *Student's Method.*

This method ^{1 & 2} as already explained involves the pairing of adjacent plots. In this experiment the following pairs are possible :—

A with B
B with C
D with C
 and **A with D**

A cannot be compared with **C** as none of the plots under these two types are contiguous (cf. Fig. 2). Although there were 25 plots under each type it will be obvious from the plan that 25 different pairs are not possible in each comparison. Thus in three cases, 24 pairs are possible while in one case only 23 are available. For Series I the calculations for the value of "Z" are shown in Table VI.

¹ Sarkar, B. N. On the probable error in variety trials with paddy. *Agri. Jour. India*, **18**, 1923, 475-486.

² Mahalanobis, P. The probable error in field experiments on agriculture. *Agri. Jour. India*, 20, 1925, 96-116.

TABLE VI.

Calculation of statistical significance by Student's Method in Series I.

PAIRS A & B										PAIRS B & C										PAIRS D & C										PAIRS A & D																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
Plot Nos.		Yields in gm.				d		d ²		Plot Nos.		Yields in gm.				d		d ²		Plot Nos.		Yields in gm.				d		d ²		Plot Nos.		Yields in gm.				d		d ²																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
		A	B	A	B							A	B	A	B							A	B	A	B	A	B					A	B																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
1	2	452	385	67	4489	115	13225	4	3	2	3	385	270	115	13225	526	270	256	65536	5	4	352	526	352	526	174	30276	5	4	352	526	352	526	174	30276																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
1	5	332	546	194	37636	336	112896	8	7	6	7	546	210	336	112896	318	210	108	11664	9	8	450	318	450	318	132	17424	9	8	450	318	450	318	132	17424																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
9	10	430	385	65	4225	168	28224	12	11	10	11	385	217	168	28224	115	217	118	13924	13	12	435	385	435	385	120	14400	13	12	435	385	435	385	120	14400																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
13	14	455	328	127	16120	101	10201	20	19	18	19	328	227	101	10201	135	227	159	25521	17	16	372	328	372	328	14	196	17	16	372	328	372	328	14	196																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
17	18	372	325	47	2209	123	15129	23	22	22	23	325	202	123	15129	395	202	193	34849	24	23	262	325	262	325	105	11025	24	23	262	325	262	325	105	11025																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
24	25	262	183	79	6241	202	40804	20	19	18	19	183	113	202	40804	113	113	44	1436	28	27	275	113	275	113	152	23104	28	27	275	113	275	113	152	23104																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
28	29	325	197	148	21904	183	33489	95	88	77	88	183	95	88	33489	23	95	28	784	32	31	332	23	332	240	8464	32	31	332	240	8464	32	31	332	240	8464																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
32	33	382	102	230	52900	137	121	6	36	31	30	137	121	6	36	210	121	119	1401	36	35	352	210	352	228	24	576	36	35	352	228	24	576	36	35	352	228	24	576																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
36	37	232	204	62	3204	102	85	17	289	35	34	102	85	17	289	228	85	143	20449	40	39	452	228	452	195	247	61009	40	39	452	228	452	195	247	61009	40	39	452	228	452	195	247	61009																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
44	45	182	210	62	3204	142	20164	42	41	41	42	210	108	142	20164	223	108	108	11236	47	46	208	223	208	223	25	625	47	46	208	223	208	223	25	625	47	46	208	223	208	223	25	625																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
51	52	280	248	32	1024	43	49	58	66	8	8	248	66	8	248	229	66	229	52441	55	54	278	229	278	255	33	1089	55	54	278	255	278	255	33	1089	55	54	278	255	278	255	33	1089																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
55	56	278	261	17	939	52	53	53	248	60	60	261	53	53	248	230	60	195	38025	60	59	265	230	265	230	168	33	1089	60	59	265	230	265	230	168	33	1089	60	59	265	230	265	230	168	33	1089																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
59	60	270	370	169	28561	56	57	261	35	226	61	35	226	61	35	226	195	60	195	38025	61	60	271	195	271	243	12	144	61	60	271	243	271	243	12	144	61	60	271	243	271	243	12	144																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
62	63	281	212	19	361	63	64	212	39	173	73	84	39	173	73	84	243	39	243	59049	66	65	313	243	313	282	31	961	66	65	313	282	313	282	31	961	66	65	313	282	313	282	31	961																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
66	67	313	173	140	9600	67	68	173	84	89	79	84	79	84	79	84	181	79	181	32761	70	69	181	181	181	265	84	7056	70	69	181	265	181	265	84	7056	70	69	181	265	181	265	84	7056																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
71	72	361	200	19	361	71	72	200	22	178	31	22	178	31	22	178	22	163	22225	74	73	312	178	312	187	125	15625	74	73	312	187	312	187	125	15625	74	73	312	187	312	187	125	15625																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
74	75	316	256	56	3136	74	75	256	56	184	38	56	184	38	56	184	106	72	106	11236	77	76	177	106	177	178	4	16	77	76	177	178	77	178	4	16	77	76	177	178	77	178	4	16																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
78	79	182	158	24	576	78	79	158	24	148	70	158	172	14	196	77	76	83	6916	80	79	182	182	182	318	62	3844	80	79	182	318	182	318	62	3844	80	79	182	318	182	318	62	3844																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
81	82	427	445	27	729	81	82	445	27	223	43	223	135	144	144	144	222	96	324	104976	85	84	350	318	350	318	143	20449	85	84	350	318	350	318	143	20449	85	84	350	318	350	318	143	20449																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
85	86	380	123	36	900	85	86	123	36	91	310	56	91	310	56	91	135	56	135	33809	89	88	358	310	358	253	105	11025	89	88	358	253	358	253	105	11025	89	88	358	253	358	253	105	11025																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
89	90	310	258	70	4900	89	90	258	70	160	27536	96	95	312	122	190	36100	122	96	9216	97	96	312	312	312	312	4	16	97	96	312	312	312	312	4	16	97	96	312	312	312	312	4	16																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
93	94	358	258	70	4900	93	94	258	70	225	50625	100	99	348	108	240	57600	108	100	10000	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	240	100	99	348	348	348	348	108	24

In Table VII the odds for these comparisons in all the series are shown, and as in the previous method appear heavily in favour of the Pusa types.

TABLE VII.
Statistical constants obtained by Student's Method for Series I—IV.

Series	Pairs	Mean difference	Standard deviation of difference	Ratio "Z" Mean diff. of Std. dev.	Odds in favour of Pusa types
I	A and B	51.0	98.92	0.516	79 : 1
	B and C	130.917	95.91	1.365	Very high.*
	D and C	155.37	72.57	2.18	Very high.*
	A and D	11.74	98.91	0.117	2.1 : 1
II	A and B	68.9	123.73	0.557	Very high.*
	B and C	175.56	99.26	1.77	Very high.*
	D and C	160.18	80.91	1.98	Very high.*
	A and D	58.8	94.92	0.619	Very high.*
III	A and B	161.33	186.67	0.86	14 : 1
	B and C	804.42	556.63	1.21	22.9 : 1
	D and C	734.66	598.78	1.23	44.9 : 1
	A and D	178.0	253.98	0.68	5.4 : 1
IV	A and B	451.8	397.76	1.13	22.9 : 1
	B and C	608.8	440.77	1.38	40 : 1
	D and C	659.4	441.2	1.49	49 : 1
	A and D	646.0	600.52	1.07	34 : 1

* Where the odds are greater than 9999 : 1 they are not calculated in the tables.¹
¹ Pearson's and Love's Tables—*Loc. cit.*

(III) *Engledow and Yule's Method.*

This method allows the comparison of all the types which are included in the experiment. Table VIII gives the yields of all plots in Series I, the mean yield of each type and the deviation of each plot yield from the mean of the type. Table IX shows the differences (d) between these deviations, and the squares (d²) of these differences, for all pairs of plots in each comparison. Thus the deviation of the yield of plot 1, Type A, from the mean yield of all plots of Type A is 137.3, and similarly for plot 2, Type B, the deviation from the mean yield for all B plots is 124.3; the difference "d" in this case is, therefore, 137.3—124.3=13 and "d²" is 169. The value of "d²" is calculated in this way for all possible pairs of plots. In this experiment there are six possible comparisons of types.

- A with B
- B with C
- C with D
- A with C
- A with D
- and B with D

with 25 pairs in each comparison. There are, therefore, 150 (25×6) values of "d²" and the standard deviation of the difference is obtained by the formula $\sigma d = \frac{\sqrt{\sum d^2}}{150}$. The standard error "E_d" is given by $\frac{\sigma d}{\sqrt{n}}$ where n is the number of plots under each type, in this case 25.

TABLE VIII.

Calculation of statistical significance by Engledow and Yule's Method in Series I.

Yields in grams				Deviations from the mean			
A	B	C	D	A	B	C	D
452	385	270	526	137.3	124.3	145.5	249.5
352	546	210	318	37.3	285.3	85.5	41.5
450	385	217	335	135.3	124.3	92.5	58.5
455	328	227	386	140.3	67.3	102.5	109.5
372	325	202	395	57.3	64.3	77.5	118.5
262	315	113	157	-52.7	54.3	-11.5	-119.5
275	183	95	123	-39.7	-77.7	-29.5	-153.5
332	127	121	240	17.3	-133.7	-3.5	-36.5
252	102	85	228	-62.7	-158.7	-39.5	-48.5
442	204	62	195	127.3	-56.7	-62.5	-81.5
204	182	108	214	-110.7	-78.7	-16.5	-62.5
208	58	210	233	-106.7	-202.7	85.5	-43.5
280	248	66	295	-34.7	-12.7	-58.5	18.5
278	261	60	255	-36.7	0.3	-64.5	-21.5
201	370	35	168	-113.7	109.3	-89.5	-108.5
231	212	39	243	-83.7	-48.7	-85.5	-33.5
313	173	84	282	-1.7	-87.7	-40.5	5.5
181	200	22	265	-133.7	-60.7	-102.5	-11.5
312	256	72	187	-2.7	-4.7	-52.5	-89.5
182	158	172	178	-132.7	-102.7	47.5	-98.5
472	445	222	318	157.3	184.3	97.5	41.5
380	123	135	450	65.3	-137.7	10.5	182.5
316	310	56	253	1.3	49.3	-68.5	-23.5
358	288	122	312	43.3	27.3	-2.5	35.5
308	333	108	348	-6.7	72.3	-16.5	71.5
Mean 314.7	Mean 260.7	Mean 124.5	Mean 276.5	..	..	..	..

TABLE IX.
Engledow and Yule's Method—Differences of deviations for all possible pairs of treatments.

Pairs A and B		Pairs B and C		Pairs C and D		Pairs A and C		Pairs A and D		Pairs B and D	
d	d ²	d	d ²	d	d ²	d	d ²	d	d ²	d	d ²
13.0	169	-21.2	449.44	-104.0	10816	-8.2	67.24	-112.2	12588.84	-125.2	15675.04
-248.0	61504	199.8	39920.04	44.0	1936	-48.2	2323.24	-4.2	17.64	243.8	59438.44
11.0	121	31.8	1011.24	34.0	1156	42.8	1831.84	76.8	5898.24	65.8	4329.64
73.0	5329	-35.2	1239.04	-7.0	49	37.8	1428.84	30.8	948.64	-42.2	1780.84
-7.0	49	-13.2	174.24	-41.0	1681	-20.2	408.04	-61.2	3745.44	-54.2	2937.64
-107.0	11449	65.8	4329.64	108.0	11664	-41.2	1697.44	66.8	4462.24	173.8	30206.44
38.0	1444	-48.2	2323.24	124.0	15376	-10.2	104.04	113.8	12950.44	75.8	5745.64
151.0	22801	-130.2	16952.04	33.0	1089	20.8	432.64	53.8	2894.44	-97.2	9447.84
96.0	9216	-119.2	14208.64	9.0	81	-25.2	635.04	-14.2	201.64	-110.2	12144.04
184.0	33856	5.8	33.64	19.0	361	189.8	36024.24	208.8	43597.44	24.8	615.04
-32.0	1024	-62.2	3868.84	46.0	2116	-94.2	8873.64	-48.2	2323.24	-16.2	262.44
96.0	9216	-288.2	83059.24	129.0	16641	-192.2	36940.84	-63.2	3994.24	-159.2	25344.64
-22.0	484	45.8	2097.64	-77.0	5929	23.8	566.44	-53.2	2830.24	-31.2	973.44
-37.0	1369	64.8	4199.04	-43.0	1849	27.8	772.84	-15.2	231.04	21.8	475.24
-223.0	49729	198.8	39521.44	19.0	361	-24.2	585.64	-5.2	27.04	217.8	47436.84
-35.0	1225	36.8	1354.24	-52.0	2704	1.8	3.24	-50.2	2520.04	-15.2	231.04
86.0	7396	-47.2	2227.84	-46.0	2116	38.8	1505.44	-7.2	51.84	-93.2	8686.24
-73.0	5329	41.8	1747.24	-91.0	8281	-31.2	973.44	-122.2	14932.84	-49.2	2420.64
2.0	4	47.8	2284.84	37.0	1369	49.8	2480.04	86.8	7534.24	84.8	7191.04
-30.0	900	-150.2	22560.04	146.0	21316	-180.2	32472.04	-34.2	1169.64	-4.2	17.64
-27.0	729	86.8	7534.24	56.0	3136	59.8	3576.04	115.8	13409.64	142.8	20391.84
-203.0	41209	148.2	21963.24	-172.0	29584	54.8	3003.04	-117.2	13735.84	-320.2	102528.04
-18.0	324	117.8	13876.84	-45.0	2025	69.8	4872.04	24.8	615.04	72.8	5299.84
16.0	256	29.8	888.04	-38.0	1444	45.8	2097.64	7.8	60.84	-8.2	67.24
-79.0	6241	88.8	7885.04	-88.0	7744	9.8	96.04	-78.2	6115.24	0.8	0.64
Total	273353		295709.40		150824		143674.00		156856.00		36364.74

$$\Sigma d^2=273358\cdot0+295709\cdot4+150824\cdot0+143674\cdot0+156856\cdot0+36364\cdot74=1384064\cdot14$$

$$\Sigma d^2=1384064\cdot14$$

$$\sigma d=\sqrt{\frac{1384064\cdot14}{150}}=96\cdot06$$

$$Ed = \frac{\sigma d}{\sqrt{n}} = \frac{96\cdot06}{5} = 19\cdot21$$

The "significance" of the difference between two types is given by the ratio of the mean difference or difference of their means to its standard error (E_d). In Series I, therefore, the difference between

$$\text{A and C} = \frac{314\cdot7-124\cdot5}{19\cdot21} = \frac{190\cdot2}{19\cdot21} = 9\cdot90$$

$$\text{B and C} = \frac{260\cdot7-124\cdot5}{19\cdot21} = \frac{136\cdot2}{19\cdot21} = 7\cdot09$$

$$\text{D and C} = \frac{276\cdot5-124\cdot5}{19\cdot21} = \frac{152}{19\cdot21} = 7\cdot91$$

When this ratio is greater than 2·1 the chances of superiority of one type over the other are over 30 : 1.

Thus the superiority of varieties A, D, and B over C is statistically significant (in the order given).

Table X summarizes the results of the application of this method to all the series.

TABLE X.

Statistical constants obtained by Engledow and Yule's Method in Series I—IV.

Series	Pairs	Mean difference in gm.	Standard error	Ratio of Mean difference standard error	Remarks
I 25 plots each	A and C	190·2	19·21	9·90	When this ratio is greater than 2·1 the chances of superiority of the first named variety over the other are about 30 : 1 and are then considered to be statistically "significant".
	B and C	136·2	19·21	7·09	
	D and C	152·0	19·21	7·91	
II 50 plots each	A and C	230·58	14·872	15·50	
	B and C	176·96	14·872	11·90	
	D and C	163·10	14·872	10·97	
III 6 plots each	A and C	907·0	149·88	6·05	
	B and C	744·0	149·88	4·96	
	D and C	735·0	149·88	4·90	
IV 6 plots each	A and C	1105·0	216·8	5·10	
	B and C	537·0	216·8	2·48	
	D and C	459·0	216·8	2·11	

Table XI is a summary of the ratios obtained by the application of the above three statistical methods. All methods give the same conclusions. Types B-4 (A), B-23 (B) and B-20 (D) are all shown to be superior to the local variety (C), B-4 being the highest yielding type.

TABLE XI.

Summary of statistical ratios obtained by Bessel's, Student's and Engledow and Yule's Methods between different pairs of barley in 1928-29.

Series and No. of Plots under each type	BESSEL'S METHOD (a) RATIO OF MEAN DIFFERENCE : PROBABLE ERROR OF DIFFERENCE			STUDENT'S METHOD (b) RATIO OF MEAN DIFFERENCE : STANDARD DEVIATION OF THE DIFFERENCE.				ENGLEDOW AND YULE'S METHOD (c) RATIO OF MEAN DIFFERENCE : STANDARD ERROR		
	A and C	B and C	D and C	A and B	B and C	D and C	A and D	A and C	B and C	D and C
I. 25 plots	12·45	7·58	9·02	0·77	1·45	2·18	0·49	9·90	7·09	7·91
II. 50 plots	15·91	13·09	12·07	0·56	1·77	1·93	0·62	15·50	11·90	10·97
III. 6 plots	7·47	7·67	6·67	0·86	1·21	1·23	0·68	6·05	4·96	4·90
IV. 6 plots	4·71	2·89	2·60	1·13	1·38	1·49	1·07	5·10	2·48	2·11

(a) Ratio of 3·2 gives odds greater than 30:1.
(b) In the case of 6 plots when the value of Z is 1·1 or more the results are significant (i.e., more than 30:1).
For 25 plots values of Z above 0·4 are significant.
In the case of 50 plots an even lower value of Z than 0·4 would be significant.
(c) Ratio of 2·1 gives odds greater than 30:1.

The superiority of Type B-4 was indicated by an experiment which was conducted in 1928-29 to observe the efficacy of the intermittent hot water treatment as a measure of control of the stripe disease (*Helminthosporium*). One-tenth acre plots of each variety were sown with treated seed and a similar area with ordinary dry seed as control. The hot water treatment consists of putting the seeds in cloth bags and placing them in water at about 104° F. for 2 hours, and then in water at 118°F. for 10 minutes, then dipped again for about a minute in a bath at 104°F.

and left for 2 hours in a warm room. Equal weights of seed were sown in each plot and the final yields obtained are shown below :—

TABLE XII.

Yields of three types of barley in 1928-29.

Variety	YIELD OF GRAIN IN LB. IN 1/10 ACRE PLOTS	
	(1) Dry series	(2) Hot water treated series
B-4	344	426
B-23	266	283
B-20	252	256

The yields in all treated plots were higher than those in the corresponding controls and appreciably so in variety B-4 where the incidence of *Helminthosporium* was markedly less in the treated plot. This result by itself would be valueless as the plots were not replicated and we have therefore no means of estimating its significance, hence the necessity for the yield trial.

A NOTE ON THE POLLINATION OF BLACK AND GREEN GRAMS IN THE GODAVARI DISTRICT.

BY

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BLACK and green grams (*Phaseolus Mungo* Linn. and *P. radiatus* Linn.) often follow a "Saruva"* crop of paddy in the fertile lands of the Godavari and Kistna deltas and in the Yeleru tract. A large variation in the habit, duration and prolificacy of the plants, as well as in the colour, size and shape of the grain of both the crops having been found, pure line selection in these crops was considered worthy of study.

But so far as the easily accessible literature on the pollination of the different pulse crops is concerned, authors appear to differ somewhat in their observations, and the possibility of pure line selection on the crops referred to seemed at first doubtful. Rao Bahadur K. Rangachariar, in his "Elementary Botany for India" (2nd edition), while dealing with the essential organs of flowers and their functions, states that the flowers of the genus *Phaseolus* depend upon insects for pollination, and that "the arrangement of the petals and the position of the essential organs are such that self-pollination cannot take place."¹ Howards and Abdur Rahman Khan of Pusa, in their studies of the pollination of Indian crops, state that, in the case of red gram, all the flowers are self-pollinated before the flowers open, but the great majority fall without setting any seed² though self-fertilization readily takes place under dry bright conditions. They also state that "natural crossing is common in the pigeon pea".³ In the case of sann-hemp it is noted that self-pollination does not occur if the flowers are protected from insects, and other facts point to the possibility of extensive natural crossing in this crop.³ In the case of Java indigo, they write that "very little self-fertilization takes place in the case of protected flowers".⁴ In the end they conclude that in the case of these three crops, which are closely allied to green and black grams, mass selection would be a more feasible line of improvement than pure line selection. Hays and Garber in their publication "Breeding crop plants" classify peas and beans as naturally self-pollinated.

* The paddy crop is grown under swamp conditions from June to November and the pulse crop sown over the standing crop 4 to 8 days before its harvest.

¹ Rangachariar, K. *Elementary Botany for India*, p. 271.

² *Mem. Dept. Agri. India, Bot. Ser.*, Vol. X, No. 5, p. 202.

³ *Mem. Dept. Agri. India, Bot. Ser.*, Vol. X, No. 5, pp. 199 and 200.

⁴ *Mem. Dept. Agri. India, Bot. Ser.*, Vol. X, No. 5, p. 207.

nated crops. Piper records that natural crossing occurs in cowpea, but rarely in most localities. Knuth, in his "Handbook of flower pollination" (Vol. 2), states that he seldom saw insects visiting the flowers of kidney beans (*P. vulgaris*) and that automatic self-pollination takes place in a large majority of cases, though Darwin was of contrary opinion. It is also noted in the same book that, according to Ogle, the flowers of *P. multiflorus* are infertile when bees are excluded, while Kirchner holds the contrary view.

It was therefore considered necessary to study first the manner of pollination of flowers in the two crops (Plate XXXIII) under the local conditions.

The following are the chief lines of investigation pursued with the two crops which resemble each other in most respects :—

A. Observation of the time of opening of the flowers, dehiscence of anthers, and pollination; and their correlation.

B. Study of the result of selfing and of the behaviour of seeds obtained from pods produced by the selfed flowers.

C. Study of the occurrence of cleistogamy and its significance.

A. TIME OF THE OPENING OF FLOWERS, DEHISCENCE OF ANTHERS AND POLLINATION.

Flower buds burst from about 5-30 to 7-30 A.M. though a few do so from about 3-30 P.M. onwards on the previous evening, and the opening of the flowers is completed by about 10 A.M. for the day. The petals commence closing back from about 10-30 A.M., and the majority of flowers fold up completely by about 3 P.M. on the day they open, almost resembling unopened buds but for the faded condition of the standard. The corolla is shed the next morning if there is any external disturbance, but is generally pushed up and carried along by the developing pod within.

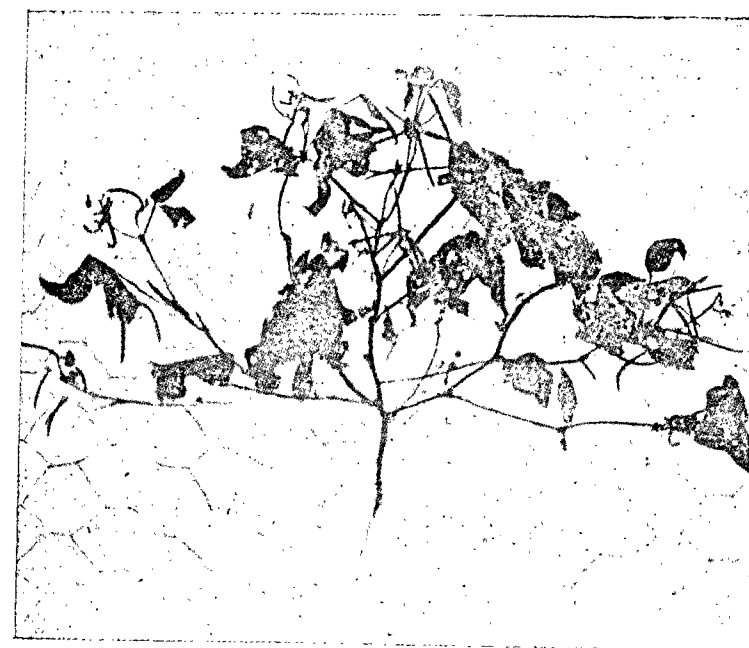
But, strange to note, the time at which the essential organs mature does not synchronize with the opening of the flower, as an examination of the internal structure of well developed buds expected to open the next morning reveals the following facts.

Till about 9 P.M. there will not be much pollination, but the pollen grains will be just seen being let out of their sacs. By about 11 P.M. there will be a thorough dusting of the stigma in the majority of cases, and by 1-30 A.M. pollination will be complete in almost all cases. In about 75 per cent. of the cases, the stigma will now be found actually encircled by the anthers on all sides, as if smothering it with pollen grains. It will be of interest to note that the stigmatic hairs in turn react to the different stages of maturity of the stigma. Till a day before the bud opens the stigmatic hairs are invariably reflexed. By about sunset, they gradually assume a perpendicular position with reference to the style and by about 11-12 in the night, they further incline towards the stigma and finally point towards it.

The accompanying graphs (Plate XXXIV) show the time of dehiscence of anthers during the night and that of the opening and closing of the flowers on the

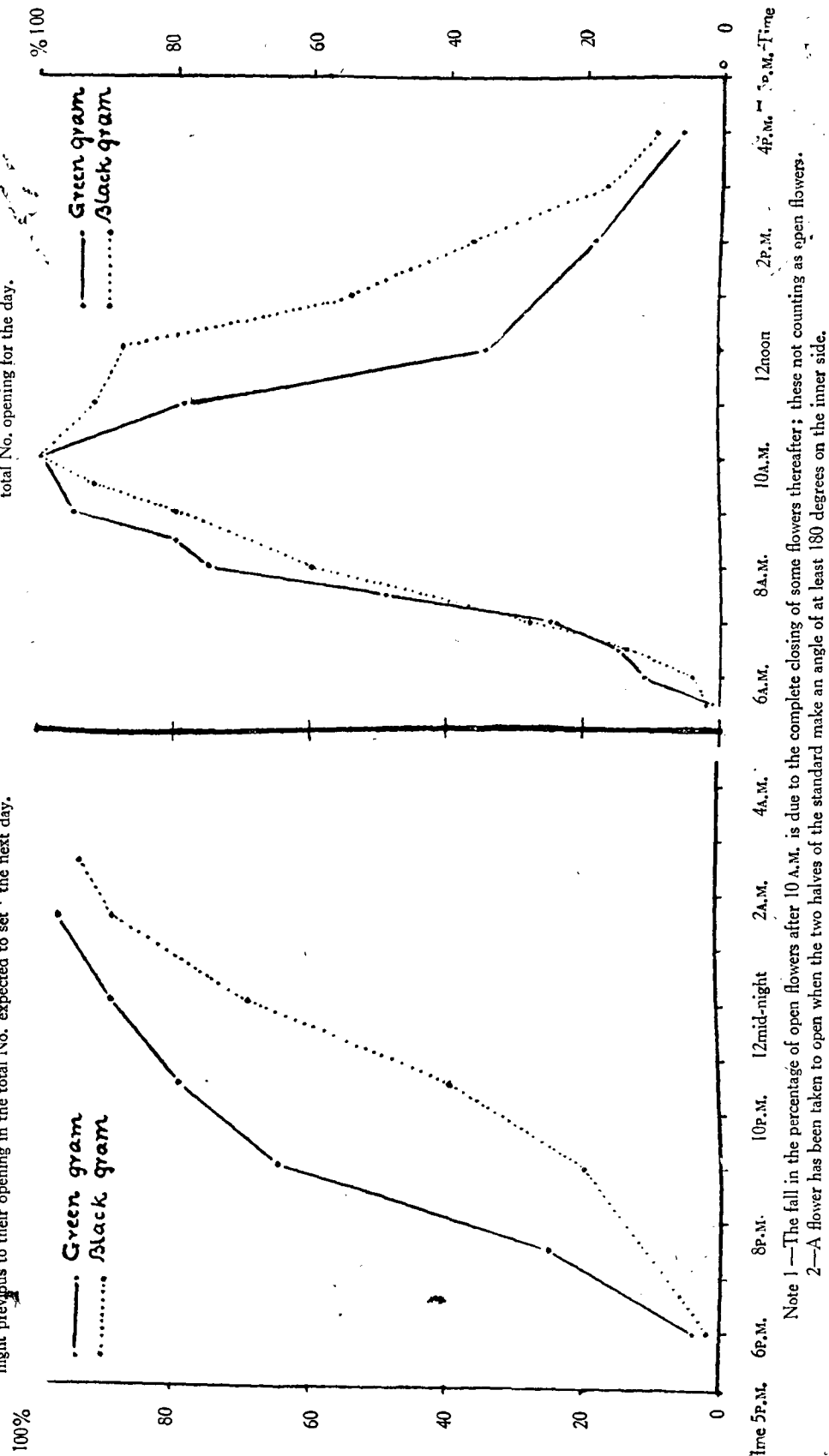


Black gram
(*Phaseolus Mungo* Linn.)



Green gram
(*Phaseolus radiatus* Linn.)

Graph showing the percentage of buds with dehiscent anthers at different hours in the night previous to their opening in the total No. expected to set * the next day.



Note 1—The fall in the percentage of open flowers after 10 A.M. is due to the complete closing of some flowers thereafter; these not counting as open flowers.
2—A flower has been taken to open when the two halves of the standard make an angle of at least 180 degrees on the inner side.
* The number includes the free-opening as well as cleistogamous flowers.

day following. Taking 10 per cent. of the cases as rather abnormal in their behaviour, the minimum interval between the time of dehiscence of anthers and the opening of flowers is about $4\frac{1}{2}$ hours (1-30 A. M. to about 6. A.M.) and it can be considered long enough for fertilization to take place.

Microtomic work being impossible, a simple method was resorted to, to ascertain if fertilization would take place before flowers open. In the morning, just before the buds were about to burst, they were artificially split, and the stigmas with the stigmatic hairs at their bases having been carefully severed with a sharp knife and removed, the buds were labelled and covered with paper bags to protect them from the direct action of the sun; and it was found that nearly 50 per cent. of such buds stood the drastic treatment and formed normally developed pods.

B. EFFECT OF SELFING AND BEHAVIOUR OF SEED OBTAINED FROM SELFED FLOWERS.

A number of mature buds of green gram * that were expected to open the next day were selfed with small paper bags, and an equal number were labelled and left to flower in the open. The following table shows the percentage of setting in the two cases.

Serial No. of observation	BUDS THAT WERE ALLOWED TO FLOWER IN THE OPEN				BUDS THAT WERE SELFED			
	No. of buds observed	No. eaten away by insects	No. that did not set	No. that developed pods	No. of buds observed	No. eaten away by insects	No. that did not set	No. that developed pods
1	25	3	11	11	25	1	13	11
2	25	6	8	11	25	2	14	9
3	25	3	9	13	25	1	5	19
4	25	7	2	16	25	6	5	14
5	25	2	7	16	25	3	13	9
6	25	7	3	15	25	4	9	12
7	25	8	3	14	25	0	2	23
8	25	4	3	18	25	3	2	20
9	25	1	3	21	25	5	2	18
10	25	7	1	17	25	3	3	19
Total	250	48	50	152	250	28	68	154
Percentage of setting ignoring buds eaten by insects					75.2			
					69.4			

* Even in black gram the percentage of setting in the case of the selfed flowers has been noted to be as high as in green gram.

The percentage of setting was, as seen from the figures, about the same in both the cases, and the pods from the selfed flowers also developed normally and produced quite healthy and viable seed.

C. OCCURRENCE OF CLEISTOGAMY.

Incidentally it is interesting to note that cleistogamy is prevalent in both the grams even up to 46 per cent., but attempts to determine when it would be at its maximum or minimum were not successful. The percentages of normally developed pods from the free flowered and cleistogamous flowers, as observed at different periods of the "Paira"* season, are noted below, and it will be seen that there is practically no difference in the percentage of setting in the two cases.

Serial No. of observation	No. of buds observed	No. eaten by insects	No. that opened free	CLEISTOGAMOUS BUDS		NO. OF MATURE PODS DEVELOPED FROM		PERCENTAGE OF SETTING IN	
				No.	Per cent.	free flowered buds	cleisto- gamous buds	free flowered buds	cleisto- gamous buds
Green gram									
1	50	10	22	18	45	6	6	27	33
2	50	10	35	5	12	22	2	63	40
3	50	13	20	17	46	8	12	40	71
4†	50	16	20	14	41	..	..	..	..
5†	50	15	19	16	46	..	..	..	..
Aver.					38.0			43	48
Black gram									
1	50	9	26	15	37	14	10	54	67
2	50	5	28	17	38	13	12	46	71
3	50	14	25	11	31	20	5	80	45
4†	50	2	31	17	35	..	..	..	..
5†	50	5	26	19	42	..	..	..	..
Aver.					36.6			60	61

* November—February.

† As the plants under observation were accidentally pulled out before they were ready, the number of pods produced and the correlated figures could not be noted.

The occurrence of cleistogamy to such a high degree in the crops grown in the "Paira" season suggests that self-fertilization is the rule in both the crops.

The figures in the above table are not, however, quite applicable to all varieties and in all seasons, or for the same variety on all days as it has been noted that this character is subject to much variation. Cleistogamy is not much in evidence in the "Tholakari"* season crop. Attempts to know beforehand the sort of buds that develop into cleistogamous flowers are being continued.

From the facts detailed above it may be stated that though the structure of the floral parts in green and black grams indicates their suitability for insect pollination, self-pollination appears to be of common occurrence under Godavari conditions. Pure line selection in these two crops may therefore be said to be a possible line of work.

* Sown in June—July.

THE PRESERVATIVE VALUE OF SPICES USED IN PICKLING
RAW FRUITS IN INDIA

BY

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RAW mangoes and other fruits are used in making pickles every year all over India, chiefly for home consumption and for local sale, also to a very limited extent for export.

The methods of preparation of the pickles vary in different localities, and several kinds of spices are used for the purpose. The use of the spices is governed by the empirical knowledge obtained in each locality concerning the kind of flavour imparted to the pickle and also by the observed effect of the spices in preserving the pickles. However any recipe based on such empirical knowledge does not always lead to successful preservation of the pickle, as spoilage, resulting in loss, often occurs. Examination of a few samples of spoiled pickles showed that the spoilage was caused by the growth of micro-organisms which enter during the preparation of the pickles. Once these micro-organisms established themselves in the pickle they cause chemical changes, and if the proportion of spices used is insufficient for preservation, the chemical changes produced by the micro-organisms finally lead to fermentation and putrefaction, and the product becomes unwholesome and unfit for use. Although it is not possible to determine the loss due to spoilage in India, yet it is likely to be very large, considering the extent to which the pickles are prepared. In order to avoid this spoilage, it was considered worth while to examine a few of the spices used in the preparation of pickles in order to ascertain their antiseptic properties and thus to place the use of these spices on a rational basis. The spices used were selected out of a large number common to many recipes, by eliminating those used solely for imparting flavour. The fruit chosen for observing the effect of the spices was the mango of the Biju variety (grown from seed and not from graft). The plan of the experiments consisted in adding to the mango pieces varying proportions of different spices.

EXPERIMENTAL.

Raw mangoes of Biju variety were cut into small pieces and divided into several lots of 100 grams each. The spices used in the experiments were ground to fine powder before use. There were four series of experiments with different treatments carried out.

1st series.

In the first series, to each lot of the raw mango pieces was separately added a certain quantity of the particular kind of spice. The quantity of the spice added was varied in order to find out the optimum quantity necessary for preserving the cut mango pieces from spoilage. After treatment each lot was stored in a beaker with a loose paper cover and kept under observation at room temperature (28°C.—32° C.). The results given in the following table record the length of time for which the mango pieces are preserved from spoilage by the use of the particular spices.

TABLE I.

Number of days after which spoilage of mango occurred after addition of varying amounts of spices.

Spices used	PROPORTION OF SPICES USED						
	0.0 per cent.	0.5 per cent.	1.0 per cent.	2.0 per cent.	2.5 per cent.	5.0 per cent.	10.0 per cent.
1. Control	2	..	..	..	..	..	..
2. Methi (Fenugreek) . .	..	2	2	..	..	..	..
3. Mustard	..	2	2	2	..	..	..
4. Mongrela	..	2	2	2	..	..	..
5. Cinnamon	..	2	2	3	..	..	..
6. Cloves	..	3	11	Not spoilt for over 6 months.	..	..	..
7. Turmeric	..	..	..		2	2	3
8. Pepper	..	..	..		2	2	2
9. Cayenne pepper . . .	..	..	..		2	2	2
10. Common salt	..	..	..	..	2	2	5

In all the lots except Nos. 6 and 10, treated with salt or cloves, fungus growth was found to occur after the number of days noted under each treatment, and whenever the growth of fungus took place it spread rapidly throughout the whole mass. In the case of treatment with salt, however, the fluid which was extracted from the mango pieces by the salt partly covered the mango pieces ; it was noticed that the fungus growth was confined to the pieces above the fluid and did not pene-

trate into the pieces below the fluid, suggesting that if the whole mass were immersed in this fluid, growth of fungus would probably have not appeared. The addition of 1 per cent. cloves prevented the attack for 11 days, while 2 per cent. appears to have checked it more or less completely, and although the mango pieces lost moisture and dried, no attack of fungus was observed during the period of observation which lasted for over six months.

2nd series.

In the second series, raw mango pieces in 100 gram lots were treated with 5 per cent. common salt and then the different spices were added in varying proportions as in the first series. Salt was added to all the lots of the mango pieces in this series as it was found that salt is used in most of the recipes for making mango pickles; when added to the cut mango the salt withdraws the acid juice of the fruit by osmosis. It was considered that this acid juice itself might be of use as a preserving agent and also might be further helpful by drawing out the active principle of the spice; moreover, there was a possibility that some of the spices, if not all, might act better in combination with salt than alone. Table II gives the results of this series.

TABLE II.

Number of days after which spoilage of mango pieces occurred. Treatment—5 per cent. common salt and different spices in varying proportions.

Spices used	PROPORTIONS OF SPICES USED							REMARKS
	0.0 per cent.	0.5 per cent.	1.0 per cent.	2.0 per cent.	2.5 per cent.	5.0 per cent.	10.0 per cent.	
1. Control (without salt and spice).	2	..	..	..	..	..	..	Fungus, yeast and bacteria.
2. Methi	..	..	2	2	..	2	..	Yeast.
3. Mustard	..	..	2	2	..	..	2	Do.
4. Mongrela	..	3	3	3	..	..	..	Fungus.
5. Cinnamon	..	3	4	5	..	..	..	Yeast in 0.5 per cent. and fungus in rest.
6. Cloves	..	19	..	..	..	..	..	Fungus.
7. Turmeric	..	..	..	..	4	5	5	Yeast.]
8. Pepper	..	..	..	..	3	3	3	Do. ']
9. Cayenne pepper	..	..	..	..	4	4	4	Do.

In this series it is worth noticing that the fungus attack was confined to the control (without addition of salt) and three other lots. In the remainder the mango pieces were softened to the touch and were considered as spoiled, but on microscopic examination only yeast cells were found. No other putrefactive organisms

had appeared and it was not certain whether in all cases softening represented complete spoilage or only a change in the consistency of the tissue. The addition of 0.5 per cent. cloves to the salted mango pieces increased the time of preservation to 19 days, compared with 3 days when 0.5 per cent. cloves alone were used without the salt. (Compare Table I.) Higher proportions of cloves with salt were not tried as in these proportions the cloves themselves were effective.

3rd series.

In the third series, lots of raw mango pieces after treatment with spices as in the first series were steamed for half an hour at 100° C. The reason for this additional treatment was that it is employed in some localities, and as many micro-organisms are killed in the process, it might be expected to assist in the preservation of the pickle. Heating to 100° C. might be further helpful in extracting the essential principles out of some of the ground spices, thus making the spices more effective than when used in the cold. It has the disadvantage, however, that it softens the fruit. The results are recorded in Table III.

TABLE III.

Number of days after which spoilage occurred in mango pieces treated with different proportions of spices and heated at 100° C. for half an hour.

Species used	PROPORTIONS OF DIFFERENT SPICES							REMARKS
	0.0 per cent.	0.5 per cent.	1.0 per cent.	2.0 per cent.	2.5 per cent.	5.0 per cent.	10.0 per cent.	
1. Control (heated but not spiced).	0	..	..	..	..	..	..	Fungus Aspergillus sp.
2. Methi	..	..	17	17	..	..	..	Do.
3. Mustard	..	..	6	17	..	..	..	Cladosporium sp.
4. Mongrela	..	..	4	4	..	..	..	Aspergillus sp.
5. Cinnamon	..	4	4	Not spoilt.	..	..	..	Do.
6. Cloves	..	Not spoilt.	..	..	..	..	..	
7. Turmeric	..	..	..	..	5	5	5	Aspergillus sp.
8. Pepper	..	..	..	..	6	14	..	Do.] st
9. Cayenne pepper	..	..	..	..	..	14	Not spoilt.	Do.]

These results show that the treatment with spices combined with heating generally delays spoilage. Cloves were effective in 0.5 per cent. strength in suppressing all growth, cinnamon, 2 per cent. and 2.5 per cent., proved completely effective, and 10 per cent. cayenne pepper was also effective. In all other cases some kind of fungus grew on the mango pieces.

As already suggested above, one point that emerges out of the results of this series is that the preserving effect observed with some of the spices in this series might be due to the extraction of the active principle out of some of these spices. This point received some attention and led to the observation of the antiseptic properties of the essential principles of some of the spices on the cultural growth of many of the spoilage organisms isolated from the pickles. These observations will form the subject of a separate paper.

4th series.

In the fourth series, 10 per cent. and 20 per cent. salt was added to different lots of mango pieces and when the salt had apparently finished the extraction of the fluid from the mango, sarson (*Brassica* sp.) oil was added to form a film on the fluid; in one case the extracted fluid was replaced by a quantity of sarson oil which completely covered the mango pieces. The same plan of treatment was applied to another set with the difference that this latter set was steamed for half an hour at 100° C. All these lots, heated and unheated, after exposure to the air for some time, were covered with paper.

This series of experiments was carried out because it was thought possible that although the organisms initially present on the mango might be suppressed by the treatment with spices, yet subsequent contamination by other organisms might occur in the top layer and this might not be suppressed. To prevent this contamination, a layer of sarson oil was poured over the surface of the fluid in the beaker.

One lot of mango pieces to which the spices, salt, and a small quantity of oil were added according to one recipe, was kept without heating in order to observe the effect of the combination. The results are given in Table IV (a) and IV (b).

TABLE IV (a).

Number of days after which spoilage occurred in raw mango pieces kept with varying quantities of common salt and sarson oil.

Mango pieces with a mixture of spices, salt and oil	Control mango pieces with 10 per cent. salt	SARSON OIL SUPPLIED TO FORM A SURFACE FILM ON THE EXTRACTED SALT WATER		SARSON OIL SUPPLIED TO REPLACE THE EXTRACTED FLUID
		Salt 10 per cent.	Salt 20 per cent.	Salt 10 per cent.
Over 6 months . . .	4 days . . .	Over 6 months . Microscopic examination shows yeast cells. Mango pieces have become soft.	Over 6 months . Microscopic examination does not reveal any micro-organisms.	Over 6 months. Microscopic examination does not reveal any micro-organisms.

TABLE IV (b).

Number of days after which spoilage occurred in raw mango pieces heated for half an hour at 100° C. and kept with varying quantities of salt and sarson oil.

Control mango pieces with 10 per cent. salt	SARSON OIL TO FORM ONLY A FILM ON THE SURFACE		SARSON OIL SUPPLIED TO REPLACE THE EXTRACTED FLUID
	Salt 10 per cent.	Salt 20 per cent.	Salt 10 per cent.
6 days	6 months . . . Mango pieces have become soft.	Over 6 months . Microscopic examination does not reveal any micro-organisms.	Over 6 months. Microscopic examination does not reveal any micro-organisms.

From the results in the two tables it is evident that the treatment of the mango pieces with 20 per cent. salt and covering with a layer of oil was quite effective in preserving the mango for over six months (not spoilt up to the time of writing, viz., 10 months). Complete immersion in oil to replace the extracted fluid is equally effective.

It is noteworthy that the recipe in which a mixture of spices (salt 10 per cent., five spices (each) 0.1 per cent. and oil 5 per cent.) is used is quite effective. The good result may be due to the oil film on the mango.

SUMMARY.

None of the spices, except cloves, when used by themselves for pickling mango have any preservative value. When used alone, an addition of 2.0 per cent. cloves is necessary to prevent spoilage. In combination with 5 per cent. salt a lower proportion of cloves may be used. The fact that 0.5 per cent. cloves, 2 to 2.5 per cent. cinnamon and 10 per cent. cayenne pepper with steaming preserve the pickles indefinitely shows that the extraction of the essential oils by steaming makes the spices more effective. Steaming alone does not prevent the growth of fungus on the mango, as spoilage is brought about by contamination after steaming. Such secondary contamination is easily prevented by covering the pickles with a thin layer of sarson oil. Probably other kinds of oil may be used for this purpose. The addition of 20 per cent. salt completely suppressed the growth of contaminative organisms.

A NEW PERCOLATING CYLINDER AND SOME OF ITS USES.

BY

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PERCOLATING cylinders are required for many soil investigations, such as obtaining the soil solution by the displacement method, studying the rate of percolation, base exchange phenomenon, etc. Those ordinarily employed are usually wide glass tubes provided with a constriction and a narrow neck at one end, in which some sand or other coarse material is filled. Metal percolating cylinders with perforated bottom are also used. There is evidently some need for improvement in these devices. The following description of a percolating cylinder, it is hoped, will be of use to soil scientists.

The cylinder* (Fig. 1), which is 2.5" in diameter, is provided with a stout flange at the bottom, against which is ground a perforated glass disc; the other side of the latter is ground to the flange of a funnel. A filter paper (preferably Watman 50) is interposed between the cylinder and the perforated disc. The whole thing together with the funnel is clamped as shown in Fig. 1 (p. 409).

The joint between the cylinder and the perforated disc is made water-tight by running a little molten wax round the edges. The cylinder is then ready for use. Dismantling, cleaning and remaking takes about five minutes.

MEASUREMENT OF SOIL TEXTURE.

It is well known that the ordinary mechanical analysis of soils gives only an imperfect picture of the state of aggregation of the particles as they exist in the field. The rate of movement of air and water has been used, with some success, to measure some factor connected with this state of aggregation; but the greatest difficulty in such measurements is that there is no satisfactory method of packing the soil and as the results are very largely affected by the manner of packing, they are not reproducible. With the help of the cylinder described above, it is possible to get a reasonably reproducible measure of factor that is related to the soil texture. The method in effect consists in measuring the rate of percolation of water with this difference that the soil is allowed to pack by itself. The procedure is as follows:—

100 gm. of the soil are left with about 250 c.c. of water overnight after stirring them together once. Next morning the suspension is transferred to a measuring flask and the total volume made up to 500 c.c. After bringing to a uniform consistency by turning the flask up and down few times, the whole of it is transferred to the cylinder. The percolation starts almost immediately and goes on at a

gradually diminished rate. After every hour (sooner if the volume of percolate is more than 100 c.c.) the clear percolate is gently poured back into the cylinder. After about 5-6 hours the rate becomes almost constant; this is taken as the factor related to soil texture.

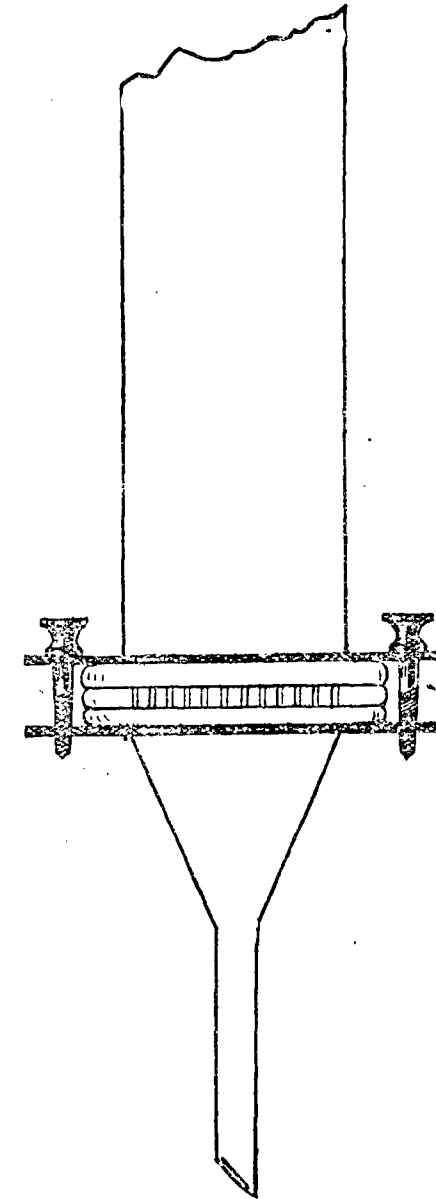


Fig. 1. Diagram of the percolating cylinder.

* Manufactured by the Scientific Glass Blowing Co., Manchester (England).

It must be admitted that the method is not capable of great precision without modifications, but as the technique is very simple the results can be reproduced by different workers, provided the diameter of the cylinder is the same in all cases. In Table I are given the rates of percolation (c.c.'s of percolate collected per hour) for six soils. Several measurements were made with each soil. The clay content of each soil determined on complete dispersion by the pipette method is also recorded.

TABLE I.

Rate of percolation of six soils and their clay content.

Soils	RATE OF PERCOLATION (C.C.'S PER HOUR)									Clay per cent. (0.02 mm.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Mean	
1. Pusa	(P1) 13.5	12	12	12.5	12	14	14	12	12.7	17.8
2. Pusa	(P8) 15	15.5	15	15.5	17	16.5	16	16.5	15.9	9.4
3. Akola	10.5	16.5	14	15	17	17	16	17	16.1	51.6
4. Dacca	172	176	176	164	..	..	..	..	172	35.9
5. Punjab	6	6	6	6.5	9	7	7	6	6.7	9.0
6. Madras	22.5	17.5	17.5	19.5	25	25	25	..	22.5	21.8

It will be seen that the method gives values that are reproducible, but at the same time are not related to the clay content. Attention is drawn specially to soil No. 4. This was a highly acid soil from Dacca (Bengal); nothing would grow in the soil and water is not retained in it for any length of time. The addition of lime to the soil not only corrects the acidity, but also makes it less pervious to water, which is thus held for a longer period for the use of the crop. This will be clear from Table II where the effect of increasing amounts of lime on the rate of percolation is shown.

TABLE II.

Effect of lime on the rate of percolation of a highly acid soil from Dacca.

Milli Eq. of lime added to 100 gm. of soil	Rate of percolation (c.c.'s per hour)
0	104
1.0	106
2.0	82
3.0	64
4.5	60
6.0	28

In this experiment the soil suspension containing the requisite amount of lime was left with the soil and 250 c.c. of water. The suspension was frequently stirred

thoroughly to complete the action of lime. This stirring has brought the rate of percolation of the control soil also from 172 c.c. to 104 c.c. It is therefore necessary not to stir the soil as far as possible; it should be simply left with water after once mixing with a glass rod.

The method proved particularly useful for the study of alkali soils. It is shown that those soils where the barrenness is due to sodium entering into the exchange complex and thus rendering the soil practically impervious to water, can be easily picked up. The effect of addition of gypsum is also shown in a striking manner. The following soils were obtained from Bara, a vast stretch of barren alkaline soil in the Punjab :—

Soil No.	Particulars of sample.
1	Fair land.
2	Typical Bara.
3	Gypsum treated where crops doing well (1st ft.)
4	Gypsum treated where crops doing well (2nd ft.)
5	Untreated (1st ft.)
6	Untreated (2nd ft.)
7	Gypsum treated where crops not doing well (1st ft.)
8	Gypsum treated where crops not doing well (2nd ft.)

The rates of percolation of the above soils are given in Table III which brings out in a striking manner the cultural difference in them. It will be seen that samples No. 7 and 8, though gypsum treated, do not produce any crop. It is clear from the percolation figures that the gypsum applied is insufficient to bring about the flocculation of the soil.

TABLE III.

Rate of percolation of Bara soils.

Soil sample	Rate of percolation (c.c.'s per hour)
1	27
2	1
3	42
4	46
5	1
6	1
7	1
8	1

It is also possible to find out the minimum dose of gypsum that would improve the tilth of the soil by rendering it more pervious to water. This will be clear from Table IV, in which are recorded the rates of percolation of soil sample No. 5 (untreated Bara) with increasing amounts of gypsum.

TABLE IV.

Effect of increasing amounts of gypsum on the rate of percolation in an alkali soil (untreated Bara).

	Grams of gypsum per 100 gm. of soil	Rate of percolation (c.c.'s per hour)
(1)	0	1
(2)	·0595	1
(3)	·1191	2
(4)	·2383	20
(5)	·3574	26
(6)	·4764	28

The gypsum requirement for this particular soil works out to be 2 tons per acre (up to 6" depth) at the outside. It is hoped the method will prove useful in the practical reclamation of alkali soils. Mention might be made of other purposes for which the percolating cylinder has been successfully used:—

- It is particularly suited for all studies of base exchange phenomena where the soil has to be washed continuously with various solutions. Ten to 20 gm. of soil are generally employed for the purpose.
- For studies of soil reaction. A clear filtrate can be obtained in a short time except in the case of alkaline soils where the rate of percolation is extremely slow.
- For obtaining the soil solution by displacement methods.

SELECTED ARTICLES

SUGARCANE CULTIVATION AND FIELD OPERATIONS IN INDIA.*

BY

NOEL DEERR AND C. G. ATKINS.

Soils. Generally in India four types of soils are recognized and sugarcane is grown on all these four types. The types of soil are:

The Indo-Gangetic alluvium. This term is generally confined to the soils of the Ganges Valley including therein the areas watered by its large tributaries. If the soils formed by the Indus and its tributaries, which also derives from the Himalayas be included, this type of soil will account for over 2,000,000 acres of cane. Generally, these soils will be classified as light sandy loams well supplied with lime and potash, but deficient in nitrogen and phosphates. These soils not infrequently overlie beds of a nodular limestone called kunkar.

In Bombay the soil generally consists of decomposed trap rock overlying in depth from a few inches to several feet, a substratum known as murrum and formed as a secondary deposit from trap.

In Madras the principal type of soil is the black cotton soil or regur with laterites and locally alluvial soil occurring.

In 1925-26, the net cropped area and area under cane were as given below:—

Province	1925-26		Per cent.
	Net area actually sown	Sugarcane	
	Acres	Acres	
United Provinces	34,800,050	1,418,964	4·07
Bihar and Orissa	25,146,300	290,200	1·15
Punjab	26,015,013	389,927	1·49
Bombay	31,285,312	68,426	0·21
Madras	33,837,082	112,821	0·33
Assam	5,828,473	40,636	0·69
Bengal	23,841,200	215,000	0·90
Central Provinces	24,870,181	22,942	0·09
North-West Frontier Province	2,304,531	48,124	2·08
Burma	17,273,801	23,276	0·13
TOTAL OF BRITISH INDIA	224,201,943	2,630,316	1·17

* Report to Committee of International Society of Sugarcane Technologists. Reprinted from *Planter and Sugar Manufacturer*, Vol. LXXXII, No. 12.

Returns from self-ruling States are incomplete. The above figures refer to 1925-26, and are taken from the Statistical Abstract for British India from 1916-17 to 1925-26.

In all 1·17 per cent. of the net. cropped area of British India is under sugarcane, and of this area 80 per cent. lies in Northern India on alluvial soils derived from the Himalayas through the agency of the Indus, the Ganges and the rivers which are tributary to these main streams.

The preparation of the land is effected almost always with the wooden ox-drawn plough, the depth of ploughing being only a few inches. In some districts iron ploughs and deeper tillage are being used, but generally the type of plough and depth of tillage are restricted by the tractive force of the draught cattle available.

Land for cane may follow autumn rice or may be fallow as much as a year, and also frequently follows maize taken off in August. The number of ploughings depends on this interval, and will vary from 8 to 20. The plough only furrows the soil 2 to 3 inches deep. The plough used is without mould boards due to the light build of the draft animals. On European owned properties which represent a very insignificant proportion of the whole, tractor cultivation is practised and there are at work a few sets of steam tackle.

Body seed is nearly always used and unhappily the peasant cultivator reserves for seed that cane which is the worst of his cultivation, following a system of short-sighted fallacious economy; this is prevalent in all peasant agriculture. Generally the cane is planted on the flat (and exceptionally in holes about 2 to 3 inches below the surface), a very shallow furrow being traced with the plough. The plough is little more than an iron pointed piece of wood. In Northern India the distance between rows is from 1 foot 6 inches to 2 feet.

European planters with improved appliances are adopting planting in furrows and with the improved sexual variants, plant up to 3 feet apart.

After planting behind the plough the field is levelled by drawing across the furrows the "Hanga" or wooden beam upon which the cultivator himself stands. This has the effect of burying the seed cane.

Cultivation and weeding in the early stages is effected with the "khurpi" or trowel, and after the cane is established the "kodali" or hoe with blade at right-angles to the shaft is used to work the soil.

These methods which are described as for Bihar differ but little from those common all over the Peninsula. On the European owned properties, harrows, spring tooth cultivators and other modern implements, cattle or tractor drawn, are in use.

Ratoon crops are not grown usually in India, except in the Deccan. This may be due to the harvest taking place in the cold weather, whereby a healthy germination from the rhizome is prevented, and it may also be connected with the poor heart of the land generally.

Apart from recently introduced sexual variants (seedlings) the extension of which is now proceeding but the total acreage of which is still small compared with that occupied by the traditional canes, the principal varieties grown are :—

North Bihar and the United Provinces.

In the great sugar area of India defined by the natural barriers of the Himalayan foothills and the Gogra, Ganges and Kosi rivers, the dominant cane is that known by the names Mungo, Hemza, Bhurli or Reora. These names are synonymous.

Nearer the northern limits of this naturally defined area, but in comparatively smaller quantities are found various varieties falling into Barber's Nargori group which includes Nargori=Hathooni, Baruk, Semali=Sewari and Kewali. These canes are grown in swamp lands and in areas subject to inundation. Fields partly rice and partly cane may be observed. Of less frequent occurrence is a cane of Barber's Pansahi group of which one variety has been noted; Pansahi=Chinia=Merthi=Agaul=Ketari. This cane is the *Saccharum sinense* of Roxburgh.

Punjab.

In the Punjab separated from the above defined area by the Rajputana desert the varieties of cane belong mainly to Barber's Saretha group, the main varieties being Katha, Chin=Chunnee, Lalri and Kansar. Chin is of great interest as having been brought from India to Java by Kobus. Almost all the canes bred in Java can claim descent from Chunnee and probably through Chunnee to a wild *Saccharum*.

In the Jullundur District, canes of Barber's Sunnabile group, particularly Dhau, occur and in the southeast of the Punjab where conditions approach those of the United Provinces, Pansahi=Merthi=Agaul=Chinia is extensively grown.

North-West Frontier Province.

In the North-West Frontier Province, 34°N. and 1,000 feet above sea level, the dominant cane grown is the Otaheite=Bourbon=Lahaina introduced here in 1867 and into India *via* Mauritius in 1827 by Sleeman. Mixed with this is another cane of somewhat similar appearance and habit.

Bombay.

In the Bombay Presidency the dominant cane is one called Pundhia (the name is probably the Marathi variant of the Hindi Paunda generally applied to all thick or noble canes) which has been identified by Jeswiet as *White Japara of Java*. This cane is only grown in irrigated districts. Elsewhere a cane belonging to Barber's Saretha class and known as Hullu Kabbu or Kalkya is grown, and the type member of Barber's Sunnabile group appears as the dominant cane in the southern areas of Belgaum.

Bengal.

In Bengal Paunda or noble canes are mainly grown, the dominant variety being called Shamsara (*i.e.*, Scimetar or curved cane) which it is suspected is Otaheite.

Puri which definitely is the West Indian Creole cane is also grown and this cane also appears in Bihar, south of the Ganges which geographically is a part of Bengal.

Burma.

In Burma two canes are mainly found, the Otaheite introduced about 1840 and locally known as Zewddaia or Yellow Toungoo (two districts in Burma) and a stout red cane called locally Pyinmanna Red.

Of other parts of India, we are unable to write. An interesting feature is the extraordinary extension of the Otaheite cane all over the Peninsula grown near large towns for purposes of chewing.

The sexual variants which have become established, are Co. 210, 213, 214, 223 and Shahjehanpur 44 and 48. Co. 205 and 290 are under trial on the large scale, and 281 and 287 are being multiplied with a view to large scale trials. Of these canes, the following statements can be made :

The Sarethia group is frost resistant and hence is grown in the more northerly parts, *e.g.*, the Punjab.

The Nargori class succeeds in swamp lands and possesses a high content of sugar early in its history, *i.e.*, 8 to 9 months after planting. Co. 205 is also a swamp cane but does not share the early high sugar content habit.

Co. 214 is remarkable for early high sugar content but is not a swamp cane though somewhat resistant to untoward conditions of this nature.

Statistics segregated as to varieties are not available but a census would probably give results not far from these :—

	Acres
Mungo group	1,250,000
Sarethia group	300,000
Sunnabito group	200,000
Pansahi group	100,000
Nargori group	20,000
Traditional noble canes	400,000
Recently introduced sexual variants	150,000

The following diseases among others have been observed and described in India :—

Mosaic prevalent all over the Peninsula.
 Red Rot (*Colletotrichum falcatum*).
 Collar Rot (*Hendersonina Sacchari*).
 Wilt (*Cephalosporium Sacchari*).

The last three may perhaps be regarded as associated diseases, of which the first named is the most aggressive.

There are present various leaf spots, of which *Cercospora longipes* (Butler) is most common. *Helminthosporium Sacchari* very close to, probably identical with, *Cercospora Sacchari* is also common.

Various "rind fungi" are also present. Of these diseases, Mosaic and Red Rot cause annually much damage.

Of the insect pests present in India, the two most important are :—

- (1) Moth borer, *Chilo* sp. or top borer operating in no way different from other borers. This pest appears to come in cycles.
- (2) White ants *Termes* sp. which annually do great damage in destroying cane after planting and before germination has started.

A system of quarantine is followed in India to prevent the introduction of new pests and diseases. In isolated instances seed selection is practised.

While in other parts of the world, the growing of maize has been prohibited by legislation *mem. con.*, the state of illiteracy of the great bulk of the population of India, would make such legislation impossible.

Irrigation.

The great proportion of cane in India is grown under irrigation. The source of water is either canals controlled by Government or from shallow wells. The areas depending on Government controlled canals are in the Punjab and in the west of the United Provinces, in Bombay, in Madras and in the North-West Frontier Province. Well irrigation is also frequent in the Punjab, in areas not served by canals, and especially in the east of the United Provinces including the districts of Basti, Gonda and Gorakhpore.

In Bihar accounting for about 250,000 acres, irrigation either from wells or canals is infrequent in the area north of the Ganges. In a few instances lift irrigation from rivers has been adopted with remarkable results, 30 short tons of cane per acre having been regularly grown on the large scale in Northern India.

About 65 per cent. of the total area of cane in India depends in whole or in part on irrigation.

LEAGUE OF NATIONS ENQUIRY ON SUGAR.*

THE BEET SUGAR INDUSTRY AND ITS PROSPECTS.

Among the memoranda prepared for the Economic Committee of the League of Nations dealing with the sugar question, besides that on cane sugar submitted by Dr. H. C. Prinsen Geerligs (the gist of which was given in the *Agricultural Journal of India*, September 1929) there was one by Messrs. F. O. Licht of Magdeburg, on the World Production of Beet Sugar and its Prospects. In what follows we summarize their principal points and quote here and there from their statement.

The authors emphasized at the outset how enormously the conditions of beet sugar production may vary, not only in different countries, but even in different parts of the same country, given only the influence of the usual factors. These, apart from technical marketing factors and prices, include agricultural factors such as climate, soil, the general level of agriculture and methods of cultivation, seed and fertilizers, etc., as well as the more technical factors of the manufacturing side, such as size and equipment of factories, the more or less scientific methods of working, the utilization of by-products, etc. But exceptional influences, of which the Great War was the biggest example, have caused a decisive revolution in the conditions of production and accentuated the competition with cane sugar.

At the commencement of the century the supremacy of beet sugar in the world market was unchallenged, but since then it has gradually declined, the consequences of the Brussels Convention enacted in 1903 proving very unfavourable for beet sugar, while simultaneously the improvement and cheapening of cane sugar production in overseas countries owing to better methods of seed selection and cultivation, the rationalization of manufacture and improvements in selling methods, have gone far to reverse the supremacy and give a decided ascendancy to cane. But it was the coming of the war which effected the complete revolution in the world sugar industry. Thereby beet sugar production dropped, till in 1919-20 it amounted to little over 2½ million tons, while Cuba started on her career of big cane sugar crops. The European area under beet which had amounted roughly to 2,200,000 hectares in 1913-14 reached its lowest figure in 1920-21, with only 1,279,346 hectares. The production of raw sugar fell from 8,179,010 tons in 1913-14 to 2,589,923 tons in 1919-20. This great fall in production is primarily due, of course, to the smaller area under the crop, but also in some degree to the smaller

yield per hectare in all the belligerent countries; this was the natural outcome of unsatisfactory cultivation, insufficient manure, etc., and it has not yet been fully remedied in many countries. The extent to which the different countries have been affected by these changes varies of course considerably, according as to whether they did or did not take part directly in the war. Nevertheless in the later post-war period a slow and steady recovery in European beet growing has been achieved; but only now is the production of 1913-14 being approximately attained.

Costs of production. Messrs. Licht affirm that "the cost of production of beet sugar is extremely difficult to determine. The mere division into the three stages of production—beets, raw sugar and refined sugar—presents difficulty on account of the difference in conditions. The difficulty is far greater if we attempt to estimate the original cost for the areas under cultivation, first by the unit of weight in individual undertakings and then on the average for a whole country. We must reckon, besides, with the fact that, even in countries which lead the way in industry and statistics, really reliable figures are obtainable only to a limited extent. Where these are forthcoming they almost invariably relate only to parts of the country in question, e.g., the area of a particular industrial group, etc. The data available to the public from trade periodicals and the daily press, or from economic memorials, preambles to laws, etc., are generally very incomplete. In many cases the representatives of the industry profess to be unable, for reasons of internal policy or on other grounds, to make any disclosures as to their costs of production, which they regard as a trade secret."

In the short time available for dealing with the question Messrs. Licht, although they were able to obtain valuable material from a few quarters, were not able to make sufficiently extensive investigations to justify them in giving any comparative figures regarding the cost prices of European sugar production and they therefore refrain from offering any. But they remark that the scanty material they possess "is sufficient to prove that the cost of production of European beet sugar, both for the agricultural and the manufacturing side of the industry, is much higher than in the pre-war period. In Germany, for instance, with her enormously increased taxes, shorter working hours, social burdens, and the reparation debt which weighs so heavily on the whole economic structure, this rise must be estimated on the average at 170 per cent. for the agricultural and 150 per cent. for the manufacturing side."

Future prospects of beet sugar production. Even before the war European beet sugar production was admittedly hard pressed and the further advance of cane sugar could only have been checked, if at all, by exceptional measures. At the same time there can be no doubt that the sensational advance of cane sugar would have been a far slower process but for the economic changes caused by the war, which eliminated the production of the Central European beet countries from the market for some years.

* Reprinted from *Int. Sugar Journal*, No. 367.

The advantage possessed by cane production over that of beet is however illustrated by the following figures, which give the respective productions per land unit :—

—	Yield per hectare in metric quintals	Yield per cent.	Yield of raw sugar per hectare in metric quintals
Cane	1,000	10	100
Beet	300	16	48

“ On a rough average, therefore, about 100 per cent. more cane than beet sugar is produced per hectare. Moreover—and this is a material factor in beet-growing, which calls for more intensive labour than any other crop—wages are now much higher in Europe. We may cite further the high cost of land and the heavy taxes, duties, social burdens, etc., which fall with greater or less weight on producers in all European countries; in Germany, agriculture and the sugar industry, like all other industries, have to bear an additional heavy burden in the shape of reparation charges. Almost all these adverse factors, which had already begun to tell on beet sugar production before the war, have been intensified by war and post-war conditions, so that to-day it is unlikely that any beet sugar-producing country could compete with cane sugar on the free world market. For this reason, almost all European countries have sought to protect their home markets from foreign sugar by means of higher tariffs; England has also followed a similar course and has created a native beet sugar industry by granting subsidies on a large scale. The European countries take this line for reasons financial, technical and socio-economic.

“ The reason why all Governments cling so stubbornly to beet culture is not to be found mainly in considerations of financial policy, but in agricultural and social considerations. Beet culture in itself, without reference to sugar production, is for many reasons a vital condition of all intensive agriculture. From the strictly agricultural point of view, it is universally recognized that beet-growing insures a good rotation of crops, clean fields, a richer yield of other crops following on beet, and a general improvement of the soil. Not less important are the many uses of the residual by-products of the beet, such as slices or pulp, leaves and molasses, which enable the farmer to keep larger stocks of cattle and so increase the production of meat, milk, butter and cheese. Molasses are also increasingly used in many chemical processes. Sugar beet culture, inclusive of leaves, slices and tops, yields on the average a far higher proportion per hectare of starch equivalent and proteins (76·70 and 3·51 metric quintals respectively) than any other crop.

“ The labour problem in relation to the sugar industry must also be examined. Beet growing, as a highly intensive form of cultivation, provides employment for a considerable portion of the rural population, whose numbers would be greatly

reduced if this crop were discontinued; the sugar factories enable many field labourers to earn good wages during the winter months when they would otherwise be unemployed. In terms of men's working years, the number of hands employed in intensive farming on good soil, without beet crops, is 3 per 25 hectares; in the same conditions with 10 per cent. beet crops it is 5 per 25 hectares, with 20 per cent. beet crops 6 per 25 hectares and with 30 per cent. beet crops about 7·5 per 25 hectares.

“ These reasons explain why the vast majority of European countries protect their sugar industry even at the cost of burdening the consumer with prices considerably in excess of those ruling on the world market. This state of things is bound to continue in the future, and even Governments which base their policies purely on the consumer's interests will certainly be swayed by the above considerations.

“ A special problem arises in countries whose production exceeds their own requirements and which accordingly are obliged to try to place a percentage of the output on free international market. Here they have to compete with cane sugar, the cost of production of which, as we have already seen, is materially below that of beet sugar. The latter therefore can only hold its own if it is granted special treatment by the importing countries or if the producing country is particularly well situated in relation to its markets. Otherwise, the sugar exports must be assisted at the expense of the home consumer; in other words, the higher price charged for sugar for home consumption, and bounties in various shapes and forms, must cheapen the exported sugar sufficiently to enable it to compete in the world market. There are, however, limits to this selling policy (dumping). They are fixed by the poor financial position—recognized on all sides—of the sugar industry and by the economic depression everywhere prevailing in post-war Europe.”

After setting down the above more or less theoretical reflections, Messrs. Licht proceeded to discuss *seriatim* the prospects of the different European beet sugar producing countries. Their final conclusion is that in the existing state of things the possibilities of development for European beet sugar production can be set down as only limited. Beet sugar is not in a position, without special measures, to compete with cane in the open market. “ On the one hand, a decline in production seems probable in all countries whose output exceeds their home requirements, unless exportation is fostered by quite exceptional circumstances. On the other hand, in a number of countries a rise in home consumption—and hence in sugar production—may be regarded as possible. European sugar production as a whole should remain during the next few years at about the same level as at present; a slight increase is, however, by no means impossible.”

The remedy for world sugar depression. Dealing with the question of remedies for the present world sugar crisis, Messrs. Licht refer to Cuba's policy of restriction now abandoned and remark that “ this expedient might well secure some temporary measure of success; but all the principal exporting countries that compete on the international market would have to work together and strive honestly and wholeheartedly to solve the problem. Their task will be materially lightened by

the fact that the number of these countries is relatively small. One drawback, however, is of course the great diversity of interests and the heavy sacrifices involved. But all such artificial ways of regulating production and export can never provide a lasting remedy, because they run counter to the natural course of economic development. All experience goes to show that, owing to the many-sidedness of economic life, any such action releases natural forces which operate in the opposite direction and defeat the artificial economic measures. For the same reason, we do not anticipate any relief from the conclusion of an agreement on the lines of the Brussels Convention.

"On the other hand, there seems no reason why an attempt should not be made to solve the problem from the consumer's side. The chief merit of this method is that a rise in consumption will obviously be to the immense advantage of the sugar industry in all countries. Here, then, is a universally accepted, indisputable and well-founded basis of negotiation ready to hand.

"Without entering into details, we suggest, by way of such a solution, the appointment of an International Committee for encouraging the consumption of sugar, whose function would be to increase consumption by propaganda of every kind, to discover new scientific applications for sugar by means of prize competitions and other measures, etc. That such a movement, if properly exploited, may achieve success is proved by the results of advertisement and propaganda, within the national frontiers, that have been obtained by the German and other European sugar industries. The International Committee would, of course, devote its attention primarily to countries with a relatively small *per capita* consumption. Great possibilities of success lie in this direction, if political conditions in these countries become more stable and the buying-power of the population greater. Even if the costs were considerable, they might be covered easily enough by levying a very small percentage on production.

"These private efforts would be enormously assisted if Governments would simultaneously decide to reduce the sugar taxes, which in some countries are unduly high. The resulting fall in home prices would necessarily be followed by a rise in home consumption. Concurrently, of course, agriculture and the beet industry in every country must continue their efforts to bring down the cost of production by cultivation and scientific management."

NOTES

SUGAR REFINED FROM GUR IN INDIA IN 1927-28.

THERE were 30 concerns in India in the year 1927-28 capable of refining *gur* or raw sugar by modern methods. Out of these, eleven did not work during the season. One new refinery was erected in Travancore.

Returns have been received from 19 factories, out of which nine are situated in the United Provinces, four in Bihar and Orissa, four in Madras and two in the Punjab.

It may be mentioned here that in 1926-27 twenty-two factories submitted their returns, out of which eight did not work this season. It will thus be seen that out of the 19 factories which have submitted their returns 14 have been in continuous operation and the remaining five undertook refining operations either for the first time or after discontinuing in the previous season.

The figures of *gur* or raw sugar melted, sugar made, and molasses obtained in the whole of India during the season 1927-28 are given below. The figures for the concerns in the United Provinces, Bihar, and Madras and the Punjab, are also given separately for the information of those interested.

	UNITED PROVINCES		BIHAR AND ORISSA		MADRAS AND THE PUNJAB		GRAND TOTAL FOR INDIA	
	1927-28	1926-27	1927-28	1926-27	1927-28	1926-27	1927-28	1926-27
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
<i>Gur</i> or raw sugar melted.	1,696,644	1,852,314	300,452	656,743	764,816	577,842	2,761,912	3,086,899
Sugar made	800,879	893,652	151,294	331,639	464,753	366,706	1,416,920	1,591,997
Molasses obtained	714,135	767,734	117,150	258,678	229,028	159,619	1,060,313	1,186,031

A Note published in the *Agricultural Journal of India*, XXIV, No. 1, gives the total quantity of sugar produced by factories making sugar direct from cane for the two seasons 1927-28 and 1926-27 as follows:—

		Mds.		Tons
1927-28	.	1,845,752	or	67,808
1926-27	.	1,716,426	„	63,067

If the quantity of sugar refined from *gur* or raw sugar in India by modern processes during these seasons be added to the above figures, the total production will amount to 3,262,678 maunds or 119,863 tons, as compared with 3,308,423 maunds or 121,543 tons in the previous season.

A table is given below showing the production of sugar direct from cane and from refining *gur* or raw sugar during the last nine seasons.

Production of sugar.

Year	Direct from cane	Refined from <i>gur</i>	TOTAL
	Mds.	Mds.	Mds.
1919-20	628,920	1,211,274	1,840,194
1920-21	669,291	1,324,645	1,993,937
1921-22	753,638	1,303,433	2,057,071
1922-23	651,415	1,368,126	2,019,541
1923-24	1,044,856	1,538,304	2,583,160
1924-25	921,950	916,121	1,838,071
1925-26	1,445,061	1,047,420	2,492,481
1926-27	1,716,426	1,591,997	3,308,423
1927-28	1,845,752	1,416,926	3,262,678

It will be seen that the quantity of sugar refined from *gur* in 1927-28 shows a decrease, making the total sugar production lower than in the preceding season. With the present range of prices, it does not appear probable that in the near future *gur* refining will be able to make a better showing.

In conclusion, the writer wishes to express his obligations to the managing agents, proprietors and managers of the various concerns for kindly furnishing the figures worked up in this note. [WYNNE SAYER.]



GROWTH OF TRADE WITHIN THE EMPIRE.

REMARKABLE evidence of how trade within the Empire has developed is contained in the Third Annual Report of the Empire Marketing Board published in July 1929. "The newness of many of the great exporting industries of foodstuffs and raw materials in the oversea Empire is not" states the Report, "perhaps, quite adequately appreciated. Every one of the Dominions and many of the Colonies have advanced within the last fifty years from a relatively modest position into that of important contributors to and purchasers in the great markets of the world. There has been an extraordinary development of the Empire's resources even since the beginning of the present century.

A survey confined only to the leading exports shows that Australia's shipments of wool have risen in this period from slightly over 500 million lb. to about 800 million lb., and her exports of wheat from half a million tons to two million. Canada's wheat exports have grown from about a quarter of a million tons to approximately seven million tons, and her exports of newsprint from next to nothing to two million tons. New Zealand's principal exports are wool and dairy produce; the first has gone up from under 150 million to over 200 million lb., and butter from less than a quarter million, and cheese from 100,000 cwt. to nearly one and a half million cwt. in each case. In the Union of South Africa shipments of wool have risen from 90 to 260 million lb. Newfoundland has developed, since the beginning of the century, an export trade in paper to the annual value of £2½ million. India, which cannot, of course, be compared with the Dominions for newness, nevertheless shows a similar advance. Exports of nearly all her numerous products have shown progress in the present century. Raw cotton, her main export, has increased from 400 million to nearly 1,500 million lb. last year and tea from 190 million lb. to 360 million lb.

In the Colonies an even more marked development has occurred. Cocoa exports, for instance, have risen from less than half a million to 110 million lb. in Nigeria, and from less than one and a quarter million to 490 million lb. in the Gold Coast. Exports of rubber from British Malaya have grown from nothing to about 370,000 tons, although some part of the rubber exported has its origin outside British territory. Tea from Ceylon has gone from 140 million to 228 million lb., rubber from 73 cwt. to one and a quarter million cwt., and copra from less than half a million to two million cwt. Bananas from Jamaica (8¼ million to 17 million bunches last year) may be quoted as a further instance.

RANGE OF EMPIRE SUPPLIES.

The development of the natural resources of the oversea Empire is thus being carried out with steady effectiveness. The significance of this to people in the United Kingdom may be seen more vividly, perhaps, from another angle. The range of Empire products available in this country is year by year spreading. A revolution in Empire supplies has happened within the lifetime of those who are now barely middle aged. Memories are short in such matters and this revolution has hardly been noticed by the general public which has been so considerably affected by it. An article, not to be found in the land yesterday, appears as a curiosity and a luxury in a limited number of shops to-day and comes down within reach of everybody to-morrow. But its former rarity is quickly forgotten and the new contribution to the variety of diet (and often also to health) is accepted without curiosity. That this should be so is natural. The additions made and being made by the Dominions and Colonies to our supplies deserve, however, to be emphasized in any consideration of the progress of Empire marketing.

Two generations ago, the United Kingdom derived only a very limited range of its requirements from overseas parts of the Empire. The fiftieth anniversary of the first shipment of frozen meat from Australia will take place towards the end of this year, while New Zealand's meat trade only began in the eighties. Fifty years ago only small quantities of butter and cheese came from the Southern Dominions; the tea industry of Ceylon was no more than a few years old; Canada had not yet begun to export apples, and no pears, plums, grapes, or peaches from South Africa and no apples or pears from Australia had reached this country. Rubber from Malaya, bananas from Jamaica and cocoa from West Africa were equally unknown. A quarter of a century later, in 1904, these products had all appeared on the United Kingdom market; some of them, such as frozen meat and dairy produce, had become firmly established, others were in their infancy. But there were still hardly any Australian currants or raisins, no New Zealand apples or pears, no South African oranges or grapefruit and no Kenya coffee. Year by year the gaps were filled up. But as recently as the end of the war were no eggs from the Southern Dominions and scarcely any home produced beet sugar or canned fruits. In the last two or three years cigarettes made from Rhodesian tobacco have become familiar in our shops, cigarettes from Cyprus and Mauritius have been obtainable and canned fruit from Fiji, chilled salmon from Newfoundland and grapes from Palestine have, for the first time, been shipped to this country. Nor has this steady spreading of the range of Empire supplies ceased. New experiments in production are constantly reported and experimental consignments from many and scattered parts of the Empire give promise of an expansion in the future not less notable than in the past.

RECENT RECORDS.

High record shipments of various Empire grown foodstuffs have been achieved in this same brief period of two years. Australian sultanas and raisins imported in 1927 were 160,000 cwt. greater than in any previous season, while Australian wine more than doubled its previous highest figure. Severe frosts towards the end of 1927 lowered these imports in 1928, but Australian apples, pears and canned fruit all made records. Imports of frozen lamb, frozen pork and cheese from New Zealand in 1927 reached higher points than ever before, but in the cases of the first two were surpassed in 1928, while butter and cheese came respectively within two and three and a half per cent. of the record, and apples and pears both established new records. Shipments of oranges, grapefruit, peaches, grapes and wine from the Union of South Africa were all higher in 1927 than ever before. In 1928 grapes, oranges and grapefruit declined slightly, but were larger than in any year before 1927, while pears, raw sugar and wine all made records. Wheat and tobacco from Canada, coffee from East Africa and tobacco from Rhodesia are other commodities shipped to this country in 1928 in greater quantities than in any earlier year.

Such figures suggest that the marketing of Empire produce is being actively pursued in this country. Many agents, some of them outside human control (the weather, for instance), have intervened. But one conclusion may safely be drawn. The tide of Empire trade is flowing strongly. The Dominions and Colonies are able to supply more and more of the needs of the United Kingdom and, in return, the United Kingdom is finding in the overseas Empire a growing demand for British goods. Already, with many of the Dominions and Colonies only on the threshold of their economic manhood, the overseas Empire, while it comprises only one quarter of the world's surface and population, absorbs nearly half the exports of the United Kingdom.

The Empire Marketing Board has found in this active, stirring world of Imperial trade many new objectives in the last year towards the attainment of which its funds might properly and usefully be employed. It is naturally best known to the public through its publicity work, particulars of which are given in the body of the Report. But its other activities have been no less vigorously pursued.

These, seen as a whole, may be defined as the making possible of an Empire-wide effort in scientific co-operation. Such hopeful developments of the last year as the establishment of eight new Imperial scientific Bureaux, jointly financed by the Governments of the Empire, and the appointment of the Colonial Advisory Council of Agriculture and Animal Health show how strongly the tide is flowing in favour of co-operation. Scientists and economists can between them offer four main contributions towards the furtherance of Empire marketing. First, they can help to develop to the full the at present barely tapped natural resources of the Empire. Secondly, they can help to render production as economical as possible by reducing waste in the field, in transit and in store. Thirdly, they can help to ensure that regularity of supply and uniformity of quality which are two essentials of progressive modern marketing. Lastly they can provide knowledge, on the one hand, of crop prospects and general trade conditions in any producing industry and, on the other hand, of the special demands and preferences of the consuming public and of the traders through whom that public is reached. All the Board's expenditure on research and on economic investigation serves one or more of these ends.

It is essential in such work to take long views; the prizes at stake are tremendous and, while the trend of trade cannot be changed in a day, there is no discoverable limit to the rewards that may fall to wisely directed research and well planned economic organization. Certainly no industry that seeks to hold its own and still more to advance under the prevailing conditions of world competition dare turn its back on the scientist or the economist.

In conclusion, it need only be added that the Board has been encouraged by the evidence it has received from official and from commercial sources that its work is considered useful by those who may be termed its clients, that is, by the producers of the Empire at home and overseas."

THE CO-ORDINATION OF COTTON RESEARCH IN THE UNITED STATES OF AMERICA.

The "Official Record" No. 25 (June 20th, 1929) of the United States Department of Agriculture contains a most interesting account of the steps taken by that department to co-ordinate and develop all branches of its research work bearing upon the growth, marketing and manufacture of cotton. A special Committee of experts has been set up with the object of unifying and intensifying the attack on all cotton problems in the States from the seed to the consumer. The personnel of this Committee is most comprehensive, including, as it does, various specialists in agriculture, soil physics and chemistry, farm management, agricultural economics, agricultural engineering, marketing and costing, entomology and textiles and clothing. The chief duties of the Committee will be to examine, report upon and make recommendations with regard to all the cotton research projects of the department, with special reference to the effectiveness and adequacy of work under way and its modification or expansion in the future. The Committee will have no administrative functions other than those conferred upon it by the department, but it is felt that such a body will be able to exercise a most beneficial influence on unifying the programme of cotton research in the States from the first steps of cotton breeding and production through ginning, processing and manufacture up to the final consumption of cotton products. In addition, it is anticipated that the Committee will prove to be of great value in co-ordinating research work on the one hand, with extension work, *e.g.*, marketing, distribution and consumption, on the other, both from a Federal and a State standpoint.

[W. J. JENKINS.]



THE CAULIFLOWER.

This is perhaps the most esteemed of the varied forms of vegetables which have sprung from *Brassica Oleracea* (wild cabbage). Acclimatized as well as imported seeds are used to raise this vegetable in the plains. The former is used for early monsoon sowing and the latter for the late or autumn sowing. To get a long succession of heads in season, it has been recommended that both classes of seed should be used. The crop grown from acclimatized seeds comes into use from the beginning of November. The imported varieties are in season from the beginning of December to the end of February.

In addition to using acclimatized and imported seeds to ensure a long succession of crops, several sowings at intervals of ten or fifteen days are recommended, as the flower-heads soon shoot up and run into seeds. The market gardener would be in a sad plight if his whole crop were to be ready at the same time, thus causing the supply to be far in excess of the demand in the market. The kitchen gardener,

too, would not like to have more of his crop ready for use than he can consume; it means waste to him also.

Sowings made frequently at intervals are troublesome, as for every sowing made, all the operations of planting and transplanting have to be repeated. The frequency of sowings can, however, be considerably reduced if a method can be devised whereby the flower-heads can be kept in good condition for some time longer than usual.

The writer was at Jalaun for a few years where fresh vegetables are not easily procurable and so arrangements had to be made to maintain a regular supply of vegetables in his garden. It so happened that in January 1926 more cauliflowers were ready for use than could be consumed. The flower-heads began to shoot up. As an experimental measure, some of these plants were taken out, the number of leaves was reduced and they were transplanted to a different site, to gather seed from them. It was noticed that the plants stopped shooting up into flowers and the heads remained in good condition for a few days longer than those of the other plants remaining in the original site.

The success of this trial led the writer to believe that the splitting up of flower-heads can be retarded by shortening the supply of food material to the plant, and as there were sufficient plants in the garden, this experiment was extended to a number of them. The roots were pruned, the leaves were reduced to three or four, and the plants with full grown flower-heads were transplanted in a partially shaded place where the hot rays of the sun would not impart colour to the white head. It was found that the heads could be maintained in good condition from two to three weeks longer. This method was tried with a number of varieties, *viz.*, Early Snowball, Sutton's Purity, Walchern and a few others, and almost uniform success was met with in every case.

The method described may not be found paying and practicable for a big grower, as the extra cost of labour and trouble involved might not be covered by the price fetched in the market. But it is undoubtedly of certain use to a kitchen gardener who grows vegetables as a pleasurable pursuit and for personal use. The writer has not been able to try this method on other members of the family. It may be effective in arresting the development of woody fibres in knol-khol and in holding the heads of cabbages compact. [RAJKISHORE SINGH.]



VITAMIN CONTENT OF DRIED FRUITS.

Dried fruits which have been treated with sulphur dioxide gas maintain their vitamin C content, and therefore their ability to prevent scurvy, according to a study to be reported in "The Journal of Biological Chemistry," by Agnes Fay Morgan and Anna Field, of the University of California. The same fruits dried and not subjected to the sulphur dioxide treatment lose their vitamin value.

Fruits and vegetables are known to contain vitamin C, and it has been considered that these foods must be fresh when used to prevent scurvy. Since the danger of scurvy is greater under circumstances where an adequate supply of fresh vegetables and fruits is most difficult to obtain, much interest has been shown in the effect of methods of preservation upon the vitamin C content of foods. Numerous studies have been made upon citrus fruit juices, cabbage, milk, potatoes and tomatoes.

Apparently the more acid foods, such as citrus fruits and tomatoes, are not only more richly endowed with vitamin C, but are also better able to resist destruction of this vitamin by drying or processing.

Because of the inconsistency in previously reported work by other experimenters, and because of the economic importance of the commonly used dried fruits, the experimenters used peaches as the basis for their work.

Fresh, completely ripe peaches were used. They were picked, pitted and ground in a food chopper. Some of the batch were sun-dried and some dried in dehydrators. Part of the dried batch was submitted to the action of sulphur dioxide over night. Then feeding experiments were made using guinea-pigs. It was found that the sulphured fruit retains the full vitamin C content of the fresh fruit, but the unsulphured dry fruit retained no detectable amount of this vitamin. The sulphured, dried peaches were found to rank with orange juice, raw tomatoes and other highly potent antiscorbutic foods. [*Science*, N. S., Vol. LXX, No. 1803.]



A RAPID METHOD OF TESTING VIABILITY OF SEEDS.

Dead or alive? That is the question thousands of agricultural laboratories in all parts of the world have to answer when testing seeds and grains. If the seed is dead, it will not germinate when sown. A new test derived by a Russian botanist, Dr. D. N. Nelubov of Leningrad, will answer this important question in a few hours, instead of several days required by the ordinary methods. Aniline dyes are used by Dr. Nelubov to tell apart seeds that are dead and alive. The seeds are steeped in a weak dye solution for three to four hours. Those able to germinate are not affected at all by the treatment, while the "dead" ones give themselves away by getting deeply coloured. If seeds have hard husks they must be first broken, to enable the dye to penetrate to the embryo. Not all aniline dyes are suitable for this work. Dr. Nelubov finds that the best results are obtained with indigo-carmin. About one-fifth of an ounce of the dye is required per one gallon of water. [*Science*, N. S., Vol. LXX, No. 1804.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

DEWAN BAHADUR SIR T. VIJAYARAGHAVACHARYA, K.B.E., has been appointed Vice-Chairman of the Imperial Council of Agricultural Research and ex-officio Agricultural Adviser to the Government of India, with effect from 14th September, 1929.



DR. D. CLOUSTON, C.I.E., M.A., D.Sc., Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, has been permitted to retire from service, with effect from 12th October, 1929.



DR. W. H. HARRISON, D.Sc., has been appointed to officiate as Director, Imperial Institute of Agricultural Research, Pusa, with effect from 6th October, 1929.



DR. W. McRAE, M.A., D.Sc., F.L.S., has been appointed to officiate as Joint Director, Imperial Institute of Agricultural Research, Pusa, with effect from 6th October, 1929, in addition to his own duties as Imperial Mycologist.



DR. A. E. PARR, Deputy Director of Agriculture, Western Circle, United Provinces, has been granted further leave for six months in extension of the leave for six months previously granted to him from 11th April, 1929.



The Government of Bombay have created a special temporary post on Rs. 320—40—1,200 from 7th September, 1929, up to the date on which the new Provincial Agricultural Service is constituted and have appointed Mr. G. B. Patwardhan to hold it while doing duty as Economic Botanist to Government, Bombay.



SETH MUHAMMAD SARWAR, M.R.C.V.S., has been appointed to a special post in the Civil Veterinary Department for a period of two years from 13th July, 1929, pending the formation of the Superior Provincial Veterinary Service, and placed under the Director, Civil Veterinary Department, Punjab, for training.

MR. R. C. BROADFOOT, N.D.A., C.D.A., Deputy Director of Agriculture, Madras, has been posted to the VIII Circle, Coimbatore, *vice* Mr. Munro granted leave.



MR. B. RAMAYYA, B.Sc., Deputy Director of Agriculture, Madras, has been posted to the VI Circle, Madura, *vice* Mr. Broadfoot transferred.



MR. R. T. DAVIS, M.R.C.V.S., Civil Veterinary Department, Bengal, has been granted leave for 12 months, with effect from 12th September, 1929.



MR. H. F. ROBERTSON, B.Sc., Professor of Agriculture, Agricultural College, Mandalay, has been granted leave for eight months from 12th September, 1929.

NEW BOOKS

On Agriculture and Allied Subjects

1. Farm Economics. Management and Distribution, by F. App. Pp. 700; 248 illus. (London: J. B. Lippincott.) Price, 12s. 6d.
2. The Plant Rusts (Uredinales), by J. C. Arthur and others. Pp. 446. (London: Chapman and Hall.) Price, £1-12-6.
3. The Application of Science to Crop-production—An experiment carried out at the Institute of Plant Industry, Indore, by Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A. Pp. 82; illus. (Oxford University Press.) Price, Rs. 6.
4. Sisal: Production and Preparation, edited and brought up to date by H. Hamel Smith. Pp. 384; illus. (London: John Bale, Sons and Danielsson, Ltd.) Price, 21s. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. The Calculation of Linkage Values. A Comparison of Various Methods, by Mahbub Alam, M.Sc. (Botanical Series, Vol. XVIII, No. 1.) Price, Re. 1 or 1s.
2. Some Digestibility Trials on Indian Feeding Stuffs, IV. Some Punjab Hays, by P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Agri.) (Chemical Series, Vol. X, No. 5.) Price, As. 7 or 9d.
3. Some Digestibility Trials on Indian Feeding Stuffs, V. Feeding Trials on American and Indian Cotton Seeds, by P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Agri.) (Chemical Series, Vol. X, No. 6.) Price, As. 7 or 9d.

List of Agricultural Publications in India from 1st February to 31st July 1929.

No.	Title	Author	Where published
GENERAL AGRICULTURE			
1	The <i>Agricultural Journal of India</i> , Vol. XXIV, Parts II, III and IV. Price, Re. 1-9-0 or 2s. per part. Annual subscription, Rs. 6 or 9s. 6d.	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	The <i>Journal of the Central Bureau for Animal Husbandry and Dairying in India</i> , Vol. III, Parts I and II. Price, As. 10 per part or Rs. 2-8-0 per annum.	Ditto	Ditto.
3	Review of Agricultural Operations in India, 1927-28. Price, Rs. 2-6 or 4s. 3d.	Issued by the Agricultural Adviser to the Government of India.	Ditto.
4	Estimates of Area and Yield of Principal Crops in India, 1927-28. Price, As. 14 or 1s. 6d.	Issued by the Department of Commercial Intelligence and Statistics, India, Calcutta.	Ditto.
5	Agricultural Implements and Machinery at Pusa, Part I: Cultivation Implements and Machinery. Pusa Agricultural Research Institute Bulletin No. 191. Price, As. 12 or 1s. 3d.	G. S. Henderson, N.D.A., N.D.D., and Arjun Singh, L.Ag.	Ditto.
6	Agricultural Implements and Machinery at Pusa, Part II: Harvesting and Threshing Implements and Machinery. Pusa Agricultural Research Institute Bulletin No. 192. Price, As. 6 or 8d.	Ditto	Ditto.
7	Agricultural Implements and Machinery at Pusa, Part III: Special and Miscellaneous Implements and Machinery. Pusa Agricultural Research Institute Bulletin No. 193. Price, As. 9 or 1s.	Ditto	Ditto.

No.	Title	Author	Where published
GENERAL AGRICULTURE—contd.			
8	Agricultural Implements and Machinery at Pusa, Part IV: Power Implements and Machinery. Pusa Agricultural Research Institute Bulletin No. 194. Price, As. 12 or 1s. 3d. 4	G. S. Henderson, N.D.A., N.D.D., and Arjun Singh, L. Ag.	Government of India Central Publication Branch, Calcutta.
9	Villagers' Calendar (Madras) for 1929-30. (Tamil, Telegu and Kanarese.)	Issued by the Madras Department of Agriculture.	Government Madras Press,
10	Madras Agricultural Department's Year Book, 1928.	Ditto	Ditto.
11	Note Book of Agricultural Facts and Figures. (English, 4th Edition.)	R. Cecil Wood, M.A.	Ditto.
12	Points to note in preparing dry Seed Beds for Paddy (Tamil, Telegu, Malayalam and Kanarese). Madras Department of Agriculture Leaflet No. 52.	Issued by the Madras Department of Agriculture.	Ditto.
13	Training of Practical Cultivators, Maistries or Field Coolies (Tamil, Telegu, Malayalam and Kanarese). Madras Department of Agriculture Leaflet No. 53.	Ditto	Ditto.
14	Conditions to be fulfilled for the grant of Government Premium for Breeding Bulls maintained by Private Bodies (English). Madras Department of Agriculture Leaflet No. 54.	Ditto	Ditto.
15	A Note on Varieties of Sugarcane in the Vizagapatam District (English). Madras Department of Agriculture Leaflet No. 57.	Ditto	Ditto.
16	Cultivation of Plantains on wet lands in the Godavari Delta (Tamil and Telegu). Madras Department of Agriculture Bulletin No. 93.	Ditto	Ditto.
17	The Work of the Livestock Section (in English). Madras Department of Agriculture Bulletin No. 95.	R. W. Littlewood, N.D.A., N. D.D.	Ditto.
18	The Cultivation of Grapevines (in English). Madras Department of Agriculture Bulletin No. 96.	Issued by the Madras Department of Agriculture, Madras.	Ditto.

No.	Title	Author	Where published
GENERAL AGRICULTURE—contd.			
19	A Preliminary Note on the possibilities of the development of the Lemon Industry in Western India. Bombay Department of Agriculture Bulletin No. 157 of 1929. Price, As. 2.	Dr. G. S. Cheemo and P. G. Dani.	Government Central Press, Bombay.
20	Agriculture in Sind under the Barrage Canals system. Bombay Department of Agriculture Bulletin No. 159 of 1929. Price, As. 6.	T. F. Main, O.B.E., B.Sc.	Ditto.
21	Home Canning of Fruits. Bombay Department of Agriculture Leaflet 4 of 1928.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press.
22	Excellent Rice Variety (Kolamba No. 42): What it is and where to get it. Bombay Department of Agriculture Leaflet 5 of 1928.	Ditto . . .	Ditto.
23	Rations for Cattle when Fodder is scarce. Bombay Department of Agriculture Leaflet 8 of 1928.	Ditto . . .	Ditto.
24	Hay, its making, and the use of the Mowing Machine. Bombay Department of Agriculture Leaflet 9 of 1928.	Ditto . . .	Ditto.
25	The use of Poudrette and Town-sweepings as Manures for dry crops of <i>Jowar</i> and Cotton in the Transition Tract of the Karnatak. Bombay Department of Agriculture Leaflet 10 of 1928.	Ditto . . .	Ditto.
26	Livestock Section Extension Service—The Tick-proof Perch. Bombay Department of Agriculture Leaflet 11 of 1928.	Ditto . . .	Ditto.
27	Livestock and Dairy Section Service—Clean Milk and how to produce it. Bombay Department of Agriculture Leaflet 12 of 1928.	Ditto . . .	Ditto.
28	Tobacco in Gujarat. Bombay Department of Agriculture Leaflet 1 of 1929.	Ditto . . .	Ditto.
29	Prickly-pear as Fodder. Bombay Department of Agriculture Leaflet 2 of 1929.	Ditto . . .	Ditto.

No.	Title	Author	Where published
GENERAL AGRICULTURE—contd.			
30	Annual Report of the Department of Agriculture in the Bombay Presidency for the year 1927-28. Price, As. 11.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press.
31	Annual Season and Crop Report of the Bombay Presidency for the year 1927-28.	Ditto . . .	Ditto.
32	Quinquennial Review of Demonstration Work carried out in the Nimar District during the period from 1922-27. Price, As. 3.	Issued by the Department of Agriculture, Central Provinces.	Government Press, Central Provinces, Nagpur.
33	Season and Crop Report of Bihar and Orissa, for 1928-29. Price, Rs. 2-4-0.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gularbagh.
34	Agricultural Statistics of the Department of Agriculture, Bihar and Orissa, for 1927-28.	Ditto . . .	Ditto.
35	Combined Farm Reports of the Department of Agriculture, Bihar and Orissa, for 1927-28.	Ditto . . .	Ditto.
36	Suitable implements and better methods of cultivating heavy black soils of South Bihar. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.
37	Well boring notice. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.
38	The care and maintenance of 2½" open borings. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.
39	Improved Paddies for Orissa. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.
40	Varieties of Paddies which have been found suitable for growing in South-East Bihar Range. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.
41	Varieties of Wheat which have been found suitable for growing in South-East Bihar Range. Leaflet of the Department of Agriculture, Bihar and Orissa.	Ditto . . .	Ditto.

No.	Title	Author	Where published
GENERAL AGRICULTURE—contd.			
42	Monthly and Annual Rainfall Table in the province of Bengal for 1928.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt.
43	Season and Crop Report of Bengal for 1928-29. Price, Rs. 2-6 or 4s. 3d.	Ditto	Ditto.
44	Recommendations regarding Crops, Manure and Cattle (in English). Leaflet No. 2 of 1929 of the Department of Agriculture, Bengal.	Ditto	Ditto.
45	Cultivation of Flax (in Bengali). Leaflet No. 5 of 1928 of the Department of Agriculture, Bengal.	Ditto	Ditto.
46	Improvement and Care of Cattle in Bengal (in English). Bengal Department of Agriculture Bulletin No. 2 of 1929.	Ditto	Ditto.
47	Potato Blight (Nepali translation). Leaflet of the Bengal Department of Agriculture.	Ditto	Ditto.
48	Sericulture in Bengal. Bengal Department of Agriculture, Leaflet No. 6 of 1929.	Ditto	Ditto.
49	Orange Cultivation in Assam. Assam Department of Agriculture Bulletin No. 2 of 1928 (in English).	Issued by the Department of Agriculture, Assam.	Government Press, Shillong.
50	Banana Culture. Assam Department of Agriculture Leaflet No. 1 of 1929. (Bengali and Assamese).	Ditto	Ditto.
51	Sweet Potato (in Bengali, Assamese, Khasi). Assam Department of Agriculture Leaflet No. 2 of 1929.	Ditto	Ditto.
52	Report on the Preliminary Agricultural Survey of the Almora District, United Provinces.	S. D. Joshi, B.Sc. . . .	Government Press, Allahabad.
53	Cultivation of Broom Corn . . .	S. S. Nehru, B.Sc., M.A., Ph.D., I.C.S.	Ditto.
54	Lac—a paying crop for the sub-montane tracts. Punjab Department Agriculture Leaflet No. 62.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.

No.	Title	Author	Where published
GENERAL AGRICULTURE—contd.			
55	A simple method of identifying the best laying hens. Punjab Department of Agriculture Leaflet No. 71.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.
56	Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June, 1928, Part II, Vol. II. Price, Rs. 6-12-0.	Ditto	Ditto.
57	Seasonal Notes of the Department of Agriculture, Punjab, for April 1929.	Ditto	Ditto.
58	Punjab Cattle Census Report of 1928.	Ditto	Ditto.
59	Summary of Remarks on the Kharif crop of the North-West Frontier Province for 1928. Price, As. 10 or 1s.	Revenue Commissioner, North-West Frontier Province.	Manager, Government of India Press, N.-W. F. P., Peshawar.
60	Fertilizers for Paddy. Results obtained at the Hmawbi Agricultural Station. Burma Department of Agriculture Bulletin No. 25 of 1928.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
61	The Supply of Plough Cattle in Burma. Burma Department of Agricultural Survey No. 7 of 1928.	Ditto	Ditto.
62	Small Pumping Sets for Irrigation Purposes. Burma Department of Agriculture Leaflet No. 59.	Ditto	Ditto.
63	Varieties of Improved Paddy for Insein, Pegu, Hanthawaddy, etc. Burma Department of Agriculture Leaflet No. 60.	Ditto	Ditto.
64	Drill Sowing of Cotton. Burma Department of Agriculture Leaflet No. 61.	Ditto	Ditto.
65	The Journal of the Mysore Agricultural and Experimental Union (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural and Experimental Union.	Bangalore Press, Bangalore.
66	The Madras Agricultural Journal (Monthly). Annual Subscription, Rs. 4; Single copy, As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
67	The Planters' Chronicle (Weekly) .	United Planters' Association of South India.	Diocesan Press, P. B. 455, Madras.

No.	Title	Author	Where published
GENERAL AGRICULTURE—concl'd.			
68	<i>The Nagpur Agricultural College Magazine</i> (Quarterly). Annual subscription, Rs. 3.	S. M. Ali and N. B. Chincholkar, Editors.	Udyama Desha Press, Nagpur.
69	<i>Poona Agricultural College Magazine</i> (Quarterly). Annual subscription, Rs. 2-8; Single copy, As. 10.	V. G. Deshpande, M.Ag., and S. M. Rao, B.A., Editors.	Aryabhushan Press, Poona City.
70	<i>The Allahabad Farmer</i> (Quarterly). Single copy As. 8 (per year Rs. 2).	W. B. Hayes, E. W. Jeremy and J. N. Shivpur.	The Mission Press, Allahabad.
71	<i>Quarterly Journal of the Indian Tea Association</i> , Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
72	<i>Rural India</i> (Monthly). Single copy, As. 6. Annual subscription, Rs. 3.	A. Swaminatha Aiyer, B.A.	Magazine Press, Chingleput.
73	<i>Kisan</i> . Annual subscription, Rs. 3 or As. 5 per copy.	Sukhsampathrai Bhandari, M.R.A.S., Editor.	Gajanana Printing Works, Indore.
AGRICULTURAL CHEMISTRY			
74	Field Experiments with Calcium Cyanamide as a Nitrogenous Manure for South Indian Soils and Crops (in English). Madras Department of Agriculture Bulletin No. 94.	B. Viswanath, F.I.C., and S. Kasinathan.	Government Press, Madras.
75	A Study of the Soils associated with the deterioration of the Cardamom crop in North Canara. Bombay Department of Agriculture Bulletin No. 157 of 1929. Price, As. 3.	Rao Bahadur D. L. Sahasrabuddho and G. M. Bapat.	Government Press, Bombay.
BOTANY			
76	The Improvement of Dharwar-American Cotton by Hybridization. Pusa Agricultural Research Institute Bulletin No. 189. Price, Rs. 2-2 or 4s.	R. K. Kulkarni, B.Ag., and T. R. Khadilkar, B. Ag.	Government of India Central Publication Branch, Calcutta
MYCOLOGY			
77	Some Diseases of Crops in the Andaman Islands. Pusa Agricultural Research Institute Bulletin No. 195. Price, As. 4 or 5d.	M. Mitra, M.Sc., F.L.S.	Government of India Central Publication Branch, Calcutta.

No.	Title	Author	Where published
MYCOLOGY—concl'd.			
78	Treatment of Smut by Copper Sulphate. Reprint (in Telegu). Madras Department of Agriculture Leaflet No. 26.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
79	Red-rot Disease of Sugarcane (in Telegu, Malayalam and Kanarese). Madras Department of Agriculture Leaflet No. 51.	Ditto . . .	Ditto.
80	Coconut Stem Bleeding Disease (in Telegu, Malayalam and Kanarese). Madras Department of Agriculture Leaflet No. 15.	Ditto . . .	Ditto.
81	Die-Back disease of Citrus trees and its relation to the Soils of Western India. Bombay Department of Agriculture Bulletin No. 155 of 1928. Price, As. 5.	Dr. G. S. Cheema and S. S. Bhat.	Government Press, Bombay.
82	A Note on the Control of Sugarcane Mosaic.	P. K. Dey, M.Sc. . . .	Government Press, Allahabad.
83	Control of the Powdery Mildew of Grape. Bombay Department of Agriculture Leaflet 6 of 1928.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press.
84	Control of the Red Rot of Sugarcane. Bombay Department of Agriculture Leaflet 7 of 1928.	Ditto . . .	Ditto.
ENTOMOLOGY			
85	A List of the Generic Names used for Microlepidoptera. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. XI, Price, Rs. 3 or 5s. 3d.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.	Government of India Central Publication Branch, Calcutta.
86	Life History, Bionomics and Control of <i>Mylocerus maculosus</i> , Desb. (Curculionidae: Coleoptera). Pusa Agricultural Research Institute Bulletin No. 181, Price, As. 14 or 1s. 6d.	Kidar Nath Trihan, M.Sc.	Ditto.
87	The Cultivation of Lac in the Plains of India, <i>Laccifera lacca</i> , Kerr. (Revised). Pusa Agricultural Research Institute Bulletin No. 185. Price Rs. 4 or 6s. 9d.	Rai Bahadur C. S. Misra, B.A.	Ditto.

No.	Title	Author	Where published
ENTOMOLOGY—contd.			
88	Description of a New Species <i>Dipylidium catus</i> n. sp., with a note on the Genus <i>Dipylidium</i> Leuckart, 1863. Pusa Agricultural Research Institute Bulletin No. 190. Price, As. 6 or 8d.	Amarnath Gulati, M.Sc.	Government of India* Central Publication Branch, Calcutta.
89	The Cotton White-Fly (<i>Bemisia gossypiperda</i>) n. sp. Pusa Agricultural Research Institute Bulletin No. 196. Price, As. 10 or 1s.	Rai Bahadur C. S. Misra, B.A., and Karam Singh Lamba, M.Sc.	Ditto.
90	Blue Beetle of Paddy— <i>Leptispa pygmaea</i> —a serious pest of the Paddy crop in Malabar (English and Malayalam). Madras Department of Agriculture Leaflet No. 55.	Issued by the Department of Agriculture, Madras.	Government Madras. Press,
VETERINARY.			
91	Annual Report of the Civil Veterinary Department, Punjab, for 1927-28.	Issued by the Director, Civil Veterinary Depart- ment, Punjab, Lahore.	Government Lahore. Printing,
92	Report of the work performed by the Officer in charge of the Camel Specialist's office, Sohawa, for 1927-28.	Ditto	Ditto.
93	Anthrax. Bulletin of the Burma Civil Veterinary Department.	D. T. Mitchell, M.R.C.V.S.	Government Printing, Burma, Rangoon.
94	Blood Smears. Bulletin of the Burma Civil Veterinary Department.	Ditto	Ditto.
95	Black Quarter. Bulletin of the Burma Civil Veterinary Department.	Ditto	Ditto.
96	Lymphangitis in Horses. Bulletin of the Burma Civil Veterinary Department.	Ditto	Ditto.
97	Parasitic Worms of Domestic Animals. Bulletin of the Burma Civil Veterinary Department.	Ditto	Ditto.
98	The Indian Veterinary Journal (Quarterly). Annual subscription, Rs. 4 for members of All-India Veterinary Association and Students; Rs. 8 for others.	P. Srinavasa Rao, G.M.V.C., Editor.	Methodist Publishing House, Madras.

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