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**A Summary of the Experiments on Rice in
Bihar and Orissa from 1912 to 1919**

BY

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A Summary of the Experiments on Rice in Bihar and Orissa from 1912 to 1919

(Received for publication on 19th January, 1920.)

THE various experiments which are summarised in this paper were carried out in order to discover the best methods of cultivating rice in Bihar and Orissa both from the point of view of outturn and of profit. They were mostly undertaken on land which could be irrigated at least occasionally and are concerned with questions of ploughing, seed selection, sowing, transplanting and manuring. As is usually the case with a summary of experiments which has to be given at a specified date, some of the questions investigated have not yet been sufficiently examined, in others the results are indefinite; nevertheless various conclusions may be drawn.

For the sake of clearness I have divided the paper into four parts.

- A. Introduction.
- B. A summary of the experiments in cultivation.
- C. A summary of the experiments in the use of manures.
- D. Conclusions that, I think, may be drawn.

A. Introduction.

Although experiments were carried out before 1912-13, I have thought it preferable to commence with that date because up to that time there was only one Deputy Director in charge of all the farms in the province (which is roughly the size of France), and it was impossible for him to give the experiments close personal supervision. The consequence was that as the farm staffs were for the most part untrained in experimental work and lacking in the spirit of impartial scientific enquiry many of the results were inaccurate.

I arranged the experiments on the Bankipore and Dumraon Farms up to 1916-17 inclusive, after which they were designed by Mr. Robinson, Assistant Director of Agriculture; on the Cuttack Farm up to 1915-16, after which they were designed by Mr. Sethi, Deputy Director of Agriculture; on the Sabour Farm in 1912-13, after which Mr. McGowan, the Professor of Agriculture, was responsible, though the majority of the rice experiments there were actually carried out by Mr. Sil, the Assistant Professor of Agriculture. In certain experiments I have recorded the results in a different form to that in which they were given in the yearly farm reports, and have sometimes drawn different conclusions from them.

1. EXPLANATION OF THE TABLES.

In the following tables the outturns are given in pounds per acre, the profits in rupees and annas per acre.

A deficit or loss is shown by prefixing a *minus* sign (—).

A *maund* is 82 lb., a *seer* (one-fortieth of a *maund*) is taken as 2 lb.

In all cases where the outturn is entered without the name of the crop, the crop is rice. Unless otherwise stated the rice was some variety of the main crop harvested in December, and was transplanted.

It is important that an experiment should be tested on a variety of plots and for several seasons. In those tables which show the average results, therefore, I have recorded the number of trials (*i.e.*, the total number of plots), the area (*i.e.*, the sum of the area of all the plots) and the number of years during which the trials were carried out. In the same tables the average outturn in pounds per acre produced by each treatment was arrived at as follows:—The records available were usually the average results for each year reduced, for the sake of conformity, to pounds per acre, with a note as to the number and size of the plots; but the number and size of the plots varied from year to year. I have multiplied these recorded results by the area of the plots in their respective years, added the products together and divided by the total area in acres.

When the average results are given in the body of the report the results of each year will be found in the appendix.

In certain cases the profits resulting from an experiment are given, but these should not be regarded as more than an indication of what may be expected. Naturally the results will vary in different circumstances. The figures given were obtained from the farm books and include the cost of the seed, manures, labour (both of men and animals) and so forth on the one side, and on the other the value of the outturn at the then market rates. No allowance has been made for rent, purchase and depreciation of implements, or the wages of the Superintendent or superior farm staff other than the mates (foremen actually in charge of the coolies). For practical purposes these figures seem sufficient. They show that as a result of actual experiments a field, which unmanured or untreated brought in A rupees, after the addition of a manure or special treatment brought in A *plus* or *minus* X rupees when all extra expenses had been deducted. Questions of rent, depreciation *etcetera* do not arise as they are common to the treated and untreated field: the important point is the *plus* or *minus* X rupees. It should however, be remembered that a ryot almost invariably pays less in cultivation charges than a Government farm in the same district and any profit obtained is therefore likely to be larger. And further, at the present

moment (the end of 1919) the value of the crops has increased since the first experiments recorded much more than the price of labour.

2. THE *paira* CROP.

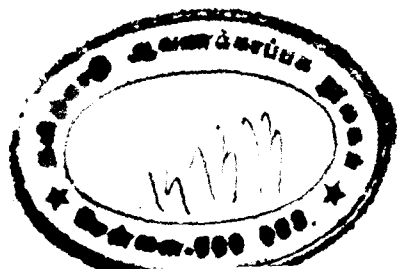
Although the main object of these experiments is to discover their effect upon the rice yet whenever the rice was followed by a *paira* crop, the details of the latter have been included, except in those cases (such as when varying numbers of seedlings were transplanted) in which the treatment applied to the rice could not appreciably influence the *paira*.

The *paira* is a cold weather crop broadcast in the mud amongst the standing paddy in October on the heavier rice lands of most parts of Bihar. No extra cultivation beyond sowing is required and the crop, which owing to the fact that it is then low, is unharmed when the rice is harvested in December is gathered in due course in March. Several crops are grown in this manner but they are nearly always leguminous—perhaps the most common being *khesari*, lentils, small peas, gram and linseed or some mixture of these.

The average profit from 16 unmanured fields during four years on the Bankipore Farm was, from the rice Rs. 22-10 per acre, from the *paira* Rs. 20-1. So that, on suitable land, the *paira* is of almost equal value to the rice. In obtaining this average the whole cost of the cultivation, such as ploughing, puddling and so forth has been charged to the rice, only the cost of the seed, broadcasting and harvesting the *paira* being charged to that crop. But as the ploughing and puddling would have been necessary for the rice in any case, the *paira* can be looked upon as a very valuable bye-product.

As the *paira* is nearly as valuable as the rice, the effects on it of manures applied to the rice ought to be considered, and the *paira* outturns have been included for that reason.

And further, the possibility of introducing a *paira* crop on lands on which it is not at present grown should be carefully considered, for it follows that if by the addition of some simple manurial prescription a good *paira* crop can be grown on such lands the value of the outturn will be nearly doubled at once. Unfortunately up to the present very little attention has been paid to this point. The problem was attacked at Dumraon (see table 33 and the following remarks) and was apparently solved, but the experiments were not completed. It would, I think, be advisable to put down a complete manurial series on every farm containing rice lands on which a *paira* is not grown, and sow a *paira* in each plot with careful notes of the results. If the addition of certain elements enabled the *paira* to grow, it might



be found possible to obtain them in a cheap form. For example, at Dumraon it seems almost certain that potash is required; possibly the same is true as regards Cuttack Farm where the chemical analysis shows that the percentage of potash is low. If it is found that the addition of potash enables a good *paira* crop to be grown in these districts the discovery of potassic salts in Orissa should render the manure available at a comparatively low cost if it prove impossible to supply it cheaply as ashes.

Too much reliance, however, cannot be placed on manurial results as shown in a *paira* crop until the experiments have been made on a large number of plots, as they are subject to more than the usual number of factors likely to mask the effect of the manures; for example, small inequalities in the surface of the rice field made at the time of puddling or otherwise will cause the water to stand longer in certain parts and render the germination of the *paira* uneven.

3. THE FARMS.

Four farms are dealt with in this report, Bankipore, Cuttack, Dumraon and Sabour.

Bankipore Farm. This farm was situated immediately south of Patna Junction Station in Bihar on heavy dark soil typical of a large part of the Patna District and particularly of the low lying area south of the Ganges Bank on which the East Indian Railway main line is built. It was almost entirely rice land.

The following chemical analysis of the soil was made by Mr. Taylor, the Agricultural Chemist to the Government of Bihar and Orissa :—

Particulars.	NORTH OF THE DIS- TRIBUTARY		SOUTH OF THE DIS- TRIBUTARY	
	Surface soil per cent.	Sub-soil per cent.	Surface soil per cent.	Sub-soil per cent.
Insoluble matter	76.96	73.84	75.60	73.85
Potash	0.82	0.82	0.80	0.83
Soda	0.82	0.82	0.50	0.52
Lime	1.89	1.65	0.82	1.32
Magnesia	1.38	1.96	0.73	1.17
Iron aluminium	14.46	17.06	17.24	18.32
Phosphorous pentoxide	0.25	0.30	0.17	0.13
Sulphur trioxide	trace	trace	trace	trace
Carbon dioxide	trace	trace	trace	trace
Combined moisture and organic matter*	3.42	3.55	4.23	3.36
TOTAL	100.00	100.00	100.00	100.00
* Containing nitrogen	0.07	0.055	0.065	0.043

Cuttack Farm. This farm is situated about 6 miles from Cuttack in Orissa on the Taldana Road. The soil is a sandy loam and typical of much of the land in the Cuttack delta. The greater part of the area is rice land.

The following table gives the chemical analysis of the soil.

Particulars.	Surface soil (first 9 inches), per cent.	Sub-soil (second 9 inches), per cent.
Insoluble silicates and sand	86.66	84.33
Ferric oxide	3.74	4.83
Alumina	5.52	6.37
Lime	0.30	0.39
Magnesia	0.59	0.41
Potash	0.24	0.33
Soda	0.03	0.17
Phosphoric acid	0.03	0.03
Sulphuric acid	0.01	0.007
Carbonic acid	0.05	0.06
Organic matter and combined water *	2.83	3.07
TOTAL	100.00	100.00
* Containing nitrogen	0.004	0.004

Dumraon Farm. This farm is situated in Bihar on land lying either side of the East Indian Railway main line just east of Dumraon Station. The soil is a sandy loam. There is very little rice land.

Sabour Farm. This farm is at Sabour about 4 miles east of Bhagalpur in Bihar. The soil of the rice lands on the farm is fairly heavy, the following details are given by Mr. Taylor, the Agricultural Chemist to the Government of Bihar and Orissa and were deduced from 70 samples of soil.

	Per cent.
Nitrogen in its organic form	0.07
Available P_2O_5	0.011
Available K_2O	0.011

B. Cultivation experiments

The experiments have tested to a greater or lesser extent a number of common practices and, speaking broadly, the general result has been to show that the cultivator is right in his methods. This is what one would expect, for, on the face of it, changes in the way of cultivating the crop which increase the yield without adding to the cost or requiring new implements, would almost certainly have been discovered by the cultivators themselves in the course of the many generations during which they have been growing rice. It is not usually wise therefore, to devote too much time or space to this class of enquiry if the first few results show the present practice to be sound. Conversely, it is absolutely necessary to proceed cautiously should it appear that a mere change in the method results in a distinct improvement. The new process should be studied under varying conditions and particularly over a number of seasons, for an initial success may be due simply to the fact that the test was carried out under the best conditions and in a good year.

Of course these remarks do not apply to the introduction of obvious improvements, in vogue in well cultivated areas, to ignorant and backward cultivators such as jungle tribes. In such cases the Agricultural Department has the opportunity of carrying out at once what under modern conditions would take place of itself in a comparatively short space of time historically speaking; but opportunities of this kind are unlikely to occur in the rice tracts of Bihar.

Besides dealing with experiments which tested the value of existing practices, this part also includes experiments designed to compare the results of ordinary methods of cultivation with other methods depending upon facts or implements beyond the knowledge of the cultivator. For example, the use of seed grain that sinks in a saturated salt solution and the case of an improved plough. The average cultivator is not likely to discover for himself that a salt solution will float heavier grain than pure water, and would not willingly incur the expense of an improved plough unless he was sure it would be to his advantage in the end.

1. HOT WEATHER CULTIVATION.

Taking the province as a whole the rice lands are not as a rule cultivated during the hot weather. North of the Ganges they are usually ploughed, and the cultivators there say that this reduces the weeds and improves the yield. South of the river, on the other hand, the ryots more commonly leave them uncultivated from harvest

time until they are puddled preparatory to transplanting, as they maintain that the weeds which grow up during the interval rot, when turned under water, before the rice is transplanted and thus benefit the crop, that is, they prefer to keep the weeds and utilise them as a green manure. On some of the low-lying heavy lands, however, there are certain weeds which do not die when the land is puddled, and these are occasionally checked by ploughing the surface during the hot weather.

TABLE I.

(Bankipore.)

NUMBER OF		Total area in acres	Ploughed in the hot weather with a	AVERAGE INCREASE OVER THE UNPLOWED PLOTS			
Trials	Years			RICE		GRAM	
				Grain	Straw	Grain	Straw
13	4	2.4	Punjab plough . .	113	99	183	161
5	3	0.8	Hindustan plough . .	89	11	219	188
9	4	1.6	Local plough . .	29	43	85	108

TABLE II.

(Cuttack.)

NUMBER OF		Total area in acres	Treatment	AVERAGE	
Trials	Years			Grain	Straw
4	2	0.8	Ploughed in the hot weather.	1,219	1,883
4	2	0.8	Unploughed . .	1,066	1,414

The Bankipore table above shows that hot weather cultivation on land south of the river in Patna distinctly increases the yield of the rice and still more of the *paira* when carried out with a plough having a share and mould board (such as the Punjab or, to a less extent, the Hindustan) though there is only a little extra yield of rice from cultivation with the local plough. It is probable that this last fact explains the ryot's neglect of the practice, especially if the increase in his *paira* was not associated with the hot weather ploughing, as is quite possible.

At Cuttack, in Orissa, hot weather cultivation has increased the yield.

Definite figures from land north of the river would be useful for comparison; while a series is required to show whether the increased yield is maintained over a number of years at the same figure or whether, as is more probable, there is a fall in the proportional increase when the same land is ploughed every year, though not back to the original out-turn from unploughed land.

Still we may say that it certainly pays, and is better farming, in Patna, Cuttack, and probably elsewhere, to invest in a plough such as the Punjab or some similar make and to plough the land at least once with it during the hot weather to aerate the soil and kill the weeds, rather than to leave it unploughed.

2. SEED SELECTION.

TABLE III.

(Cuttack.)

Seed sown	AVERAGE OF DUPLICATE TRIALS IN TWO YEARS	
	Grain	Straw
Seed that did not pass through sieve	1,754	2,583
Corresponding unselected seed	1,743	2,413
Seed that sank in a saturated salt solution	2,011	2,531
Corresponding unselected seed	1,799	2,480

Two simple methods of seed selection were tried, in one case the seed was rubbed over a sieve of such a size that it let through about half the sample—the larger seeds which did not pass through were sown, in the other case the seed was thrown into a saturated solution of salt in water and the seeds which floated were rejected.

It will be seen that seed selected in the former way gave an increased outturn of 0.6 per cent. of grain only, but seed selected by the salt solution produced an increase of 11.8 per cent.; that is selection by weight is much better than selection by size.

Selecting seed in this way is simple and inexpensive and will well repay the cultivator, the rejected seed that floats can be sold and the salt from the brine given to the cattle.

3. TRANSPLANTED AND BROADCAST RICE COMPARED.

It is a well known fact that transplanted rice gives a larger out-turn and is more profitable than broadcast, and the following trials bear this out.

TABLE IV.

(Sabour.)

Cultivation	1915-16	
	Grain	Straw
Transplanted	939	3,466
Broadcast	475	2,388

The experiments were carried out in triplicate on 0.1 acre plots, the figures are the average of the three plots.

TABLE V.

(Cuttack.)

NUMBER OF		Total area in acres	Cultivation	AVERAGE			
Trials	Years			Grain	Straw	Cost	Profit
8	4	1.6	Transplanted	1,545	2,013	R a. 22 5	R a. 27 11
8	4	1.6	Broadcast	1,237	2,004	23 6	16 7

It will be noticed that the expenditure at Cuttack on broadcast rice was Rs. 1-1-0 per acre more than on transplanted. In Bihar the reverse is the case, transplanting costing considerably more than broadcasting. The following examples from non-experimental fields on the Bankipore Farm give definite figures (they were selected by opening the farm books at random).

	Cultivation charges per acre	Grain per acre	Straw per acre
1915-16.			
6.1 acres transplanted	R a. p. 25 0 4	629	672
8.7 acres broadcast	19 1 5	511	907
1916-17.			
5.8 acres transplanted	18 12 3	1,430	1,905
7.4 acres broadcast	14 11 5	562	735

This shows that the cultivation cost in Bihar is Rs. 5 per acre more when the rice is transplanted. The fact that the difference between the yield is less and the cost of broadcasting more in proportion at Cuttack than in Bihar is probably due to the system of cultivating broadcast lands in Orissa, referred to in the next section.

The Bankipore figures given above cannot be considered so reliable as the others when comparing the yields (though as a comparison of the cost of the two methods they are perfectly fair) because the fields were selected by chance from the books instead of being selected as of equal value on the land, and the operations were not necessarily carried out at the same time, nevertheless they have the advantage of being actual figures of comparatively large areas of similar land under field conditions on one farm, and may therefore be taken as approximately correct. With the above proviso, the following is the additional yield from transplanted rice on the three farms.

At Bankipore, Bihar ; 92 per cent. of grain and 57 per cent. of straw.

At Sabour, Bihar ; 98 per cent. of grain and 45 per cent. of straw.

At Cuttack, Orissa ; 25 per cent. of grain and 4 per cent. of straw.

Another point worth considering is the yield in each case from a given weight of seed. The seed rate per acre of broadcast land in Bihar is about 30 lb., in Orissa about 80 lb. The seed rate per acre of seed bed is about 500 lb., and, as one acre of seed bed transplants ten acres of land, the seed rate per acre of land transplanted is about 50 lb. Therefore, from the tables given above it follows that from 1 lb. of seed is obtained—

16 lb. when broadcast, or 19 lb. when transplanted at Sabour.

18 lb. when broadcast, or 21 lb. when transplanted at Bankipore.

15 lb. when broadcast, or 31 lb. when transplanted at Cuttack.

The greater difference between the two at Cuttack is due to the method of growing broadcast rice in Orissa where many seedlings are uprooted. But considering the results in Bihar alone, where no seedlings are destroyed, it appears that although there may be rather better germination in the seed bed than in the field this does not account for the difference, and it follows that the plants benefit from the check of uprooting and transplanting them.

But, it may be asked, if the money return and the yield from transplanted rice is greater, why then do the ryots who, of course, are quite aware of this, broadcast any land at all. They do so for a mixture of reasons. Some lands while too low for dry crops are too high for transplanted rice, which requires more water, and are therefore put down under broadcast rice. Others again are too low, and are liable to be flooded too deep by the heavy rains shortly after transplanting so a rice

is broadcast which has more chance of keeping above water. Also, and more important in the rice tracts, it is usually impossible to transplant the whole area owing to lack of labour. The seed beds are sown at the commencement of the rains and the sowing period cannot be extended for long (see section 5) while if the seedlings are not transplanted within a fairly definite time after they are sown the yield falls off considerably (see section 8), but transplanting is slow and laborious work, about ten labourers being required to transplant an acre in one day, and everyone wants to transplant at nearly the same time. Thus the area that can be commanded is restricted. The cultivators usually transplant as much as they can.

4. BROADCAST RICE IN ORISSA.

(In this section and this section only, the figures of yields refer to broadcast rice.)

The cultivation of broadcast rice is not uniform throughout the Province. In Bihar the land is prepared as for any other crop and sown at the rate of 15 *seers* (30 lb.) of seed per acre, the after cultivation consisting of weeding when necessary. Throughout Orissa and the greater part of Chota Nagpur, on the other hand, the seed rate is very much higher, never less than 30 *seers* (60 lb.) usually 40 *seers* (80 lb.) and even as much as 60 *seers* (120 lb.). The land is not prepared so well, but when the crop is about a month old it is ploughed through with the local plough. The cultivators state that this checks the weeds, thins the crop and loosens the soil; and this is correct as there is a great improvement in the rice after it has been ploughed through. But (as we have seen in section 3) though the yield of broadcast rice in Orissa more nearly approaches that of transplanted rice than it does in Bihar it costs more and the method is proportionally less economical.

The merits of the two systems require careful investigation. Some enquiry has already been made, but not sufficient.

TABLE VI.

(Cuttack)

NUMBER OF		Total area in acres	Seed rate per acre	AVERAGE	
Trials	Years			Grain	Straw
14	6	2.8	40 <i>seers</i> (80 lb.) . .	1,795	2,767
14	6	2.8	30 <i>seers</i> (60 lb.) . .	1,810	2,569
14	6	2.8	20 <i>seers</i> (40 lb.) . .	1,905	2,785

In these experiments the crop was ploughed through according to the local practice, and the results show clearly that the seed rate can be reduced with advantage, thereby effecting a considerable saving in seed grain and also increasing the yield. It occurred to me, however, that this was due to the better preparatory cultivation of the land on the government farm compared to that of the local cultivators, and that the ploughing through could be omitted in the former case. This was tested in the series given below.

TABLE VII.
(Cuttack.)

NUMBER OF		Total area in acres	Seed rate per acre	After treatment	AVERAGE	
Trials	Years				Grain	Straw
4	2	0.8	40 <i>seers</i> (80 lb.)	Ploughed through	1,518	2,157
4	2	0.8	30 <i>seers</i> (60 lb.)	Do.	1,420	1,806
4	2	0.8	20 <i>seers</i> (40 lb.)	Do.	1,551	2,580
4	2	0.8	15 <i>seers</i> (30 lb.)	Not ploughed	1,637	2,777

These experiments as far as they go, show that it would be better to follow the Bihar custom in Cuttack. A further trial was made later.

TABLE VIII.
(Cuttack.)

Seed rate per acre	Preparation before sowing	Treatment after sowing	1917-18			
			Grain	Straw	Cost of cultivation	Profit
35 <i>seers</i> (70 lb.)	Ploughed 5 times.	Ploughed through.	1,650	4,047	R a. 24 13	R a. 24 0
35 <i>seers</i> (70 lb.)	Do.	Not ploughed	1,455	4,405	30 9	14 15
25 <i>seers</i> (50 lb.)	Do.	Do.	1,537	3,946	28 2	17 14
25 <i>seers</i> (50 lb.)	Ploughed 10 times.	Do.	1,778	5,227	31 9	23 11

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

On this occasion a larger yield was obtained with a comparatively low seed rate on the better cultivated land, but the higher seed rate and the local cultivation proved slightly more profitable. It would,

however, have been better as a test of the two methods had the seed rate been reduced, if not to the 15 *seers* of Bihar, at least to the 20 *seers* that have so far proved the best on this farm.

On the whole the evidence available up to date appears to me to be in favour of not ploughing through. But there is another advantage in the Orissa custom, though it is one quite unknown to the local cultivators; that is to utilise the system to apply a green manure to the broadcast rice.

TABLE IX.
(Cuttack.)

NUMBER OF		Total area in acres	Treatment	AVERAGE		
Trials	Years			Grain	Straw	Profit
6	3	1.2	Green manure (<i>dhaincha</i>)	1,710	2,481	R a. 28 10
6	3	1.2	Unmanured	1,456	2,327	22 3

In these experiments 10 lb. of *dhaincha* (*Sesbania aculeata*) per acre were mixed with the rice seed before sowing, and the whole sown together. When the crop was ploughed through a month later most of the *dhaincha* plants were uprooted and those that were not were pulled up and forced into the mud, as are other upstanding weeds, by the gang that goes through the fields after the ploughing through. This proved beneficial and profitable.

The two questions have not yet been examined in conjunction to find out whether it pays better to prepare the land well, reduce the seed rate and not plough through, or to retain the high seed rate, mix in *dhaincha* and plough through. The evidence, though insufficient as yet, is in favour of the latter as it has given a larger increase per cent.

5. LOSS FROM LATE RAINS AND LATE SOWING.

Every one knows that if the rains are late the rice crop is poor, but any information as to the relation between the time of sowing and the decrease of the crop should be of use to those interested in the gross output. Probably the best way of arriving at correct figures would be to transplant the same area for a number of years with seedlings of the same variety sown at the first favourable rainfall, recording the date and the yield. But this would involve other questions, such as the nature of the rainfall each year, and, possibly, variations in the soil, while in any case it would take a long time to arrive at satisfactory figures.

In order to obtain some idea of the loss due to late transplanting only, I arranged a series at Bankipore and Sabour in 1912, in which the seed was sown and the seedlings transplanted at intervals of half a month, thus artificially approximating later and later rains, while the land used could be irrigated when necessary, thus eliminating any difficulties due to breaks in the rains. I have only recorded the dates of transplanting, but the seeds were sown about 5 weeks earlier in each case.

TABLE X.

Transplanted on	BANKIPORE		SABOUR		AVERAGE		LOSS PER CENT	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
July 10th 1912 . . .	1,379	2,793	1,708	6,999	1,543	4,896	0	0
July 25th 1912 . . .	1,107	2,298	1,767	4,048	1,437	3,173	8.87	35.19
August 10th 1912 . . .	1,066	2,246	1,517	3,196	1,291	2,721	16.33	44.42
August 25th 1912 . . .	954	2,052	1,353	3,162	1,153	2,607	25.28	46.75
September 10th 1912 . . .	724	1,537	1,116	2,650	920	2,093	40.38	57.25

Each transplanting was on 6 plots of 0.2 acre each, the figures are the average of 6 plots; the figures in the column of averages are thus based on 2.4 acres each.

These trials show that a delay of a fortnight beyond the usual time (in this case the first sowing was about June 5th) means a loss of nearly 7 per cent. of grain, a delay of a month 16 per cent. loss, while if the rains are delayed until the first week in August the loss is over 40 per cent. The loss of straw is larger in each case.

These figures, of course, can only be taken as approximate.

6. WET AND DRY SEED-BEDS.

Two kinds of seed-beds are sown. In one the seed-bed is puddled under water before sowing and kept wet, in the other the seed is sown in moist land in the same way as other crops.

TABLE XI.

Cultivation	SABOUR	CUTTACK	SABOUR		CUTTACK	
			AVERAGE		AVERAGE	
	NUMBER OF	Total area in acres	Trials	Years	Grain	Straw
Wet seed-bed . . .	16	3	0.4	6	1,372	3,155
	16	3	0.4	6	1,647	2,955

The above trials show an increased yield in favour of a wet and puddled seed-bed of 3.5 per cent. of grain at Sabour and 7.9 per cent. at Cuttack. The cost of cultivation in each case is about the same, the average for the two years 1916-17 and 1917-18 at Cuttack being Rs. 25.5 per acre for a dry and Rs. 25.6 per acre for a wet seed-bed. Therefore a wet seed-bed is more profitable.

The cultivator prefers a wet seed-bed, but he is dependant to a great extent upon the weather. The seed is sown at the commencement of the rains and any undue delay in sowing decreases the outturn very much more than the difference between the two types of seed-bed (section 5). The cultivator, therefore, sows his seed in a dry seed-bed if he cannot obtain sufficient water at sowing time to enable him to puddle it. He can, of course, influence this to some extent by his choice of the position of his seed-beds.

7. SEED RATE IN THE SEED-BED.

TABLE XII.
(Sabour.)

Seed rate per acre of seed-bed	1913-14 Grain
1 maund (82 lb.)	1,120
4 maunds (328 lb.)	1,025
8 maunds (656 lb.)	2,110
16 maunds (1,312 lb.)	1,079

On single 0.1 acre plots.

TABLE XIII.
(Sabour.)

NUMBER OF		Total area in acres	Seed rate per acre of seed- bed	AVERAGE
Trials	Years			Grain
3	3	0.3	2 maunds (164 lb.) . . .	1,195
3	3	0.3	4 maunds (328 lb.) . . .	1,159
3	3	0.3	10 maunds (820 lb.) . . .	1,166

TABLE XIV.

(Bankipore.)

NUMBER OF		Total area in acres	Seed rate per acre of seed-bed	AVERAGE	
Trials	Years			Grain	Straw
12	3	2.7	5 maunds (410 lb.)	747	980
12	3	2.7	7.5 maunds (615 lb.)	636	964

TABLE XV.

(Cuttack.)

NUMBER OF		Total area in acres	Seed rate per acre of seed-bed	AVERAGE	
Trials	Years			Grain	Straw
9	3	1.8	3 maunds (246 lb.) .	1,301	1,846
9	3	1.8	4 maunds (328 lb.) .	1,484	2,028
9	3	1.8	5 maunds (410 lb.) .	1,543	1,879

In every series, while the different plots were transplanted from seed-beds sown with varying quantities of seed, the same number of seedlings were transplanted in each plot.

In the first year's trials at Sabour (table 12) 1 maund gave by far the lowest outturn, 4 and 16 maunds each gave about the same and 8 maunds higher than either; therefore the best weight must be between 4 and 16.

Table 13 shows that the results from 2, 4 and 10 maunds are all about the same. At first sight, from this table alone, it might appear that it would therefore pay best to sow 2 maunds, but the results may equally mean that the optimum rate lies between 4 and 10 maunds, and taking the other tables into consideration this is the correct interpretation.

The Bankipore series (table 14) shows that the best seed rate is below 7.5 maunds.

The Cuttack experiments (table 15) clearly show that 4 *maunds* give a larger yield than 3, and 5 than 4.

Taking the 4 tables together therefore, we find that the best seed rate lies between 5 and 7.5 *maunds*. As a matter of fact the cultivator's usual seed rate is about 5 to 7 *maunds* per acre of seed-bed depending on the soil and local conditions. The experiments show that this is correct and should not be either reduced or increased.

This might have been expected, because the cultivators must have experimented in innumerable trials in past years.

From one point of view, however, the results are surprising. An officer, commenting on the Cuttack series, when he heard that while different seed rates were sown in the seed-beds the same number of seedlings were transplanted in each plot said, "If this is so, it is almost inconceivable that the thinner sown and presumably stouter seedlings would give much the smallest yield per acre." It is curious. Nevertheless the cultivator transplants approximately the same number of seedlings in a given area on each occasion, and it is nearly inconceivable to suppose that if by the simple and economical process of sowing less seed he could increase his yield, he would not do so. It would appear, therefore, that just as we have seen that the yield is increased by the check of transplanting so it is necessary to crowd the seedlings to some extent in the seed-bed probably to check root development before transplanting.

8. TIME AT WHICH TO TRANSPLANT THE SEEDLINGS.

TABLE XVI.

(Cuttack.)

Age of seedlings	1916-17		1917-18		1918-19		AVERAGE	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
20 days old . . .	994	2,121	979	1,845	1,296	2,203	1,090	2,056
30 days old . . .	920	1,588	1,317	2,306	1,397	2,149	1,211	2,014
40 days old . . .	1,045	2,121	1,465	2,716	1,579	2,536	1,363	2,458

Each year the experiments were carried out in duplicate on 0.1 acre plots, the figures are the average of the two plots.

The cultivator usually transplants his seedlings when they are five to six weeks old. The above table shows that at any rate it is unwise to transplant them when they are younger than this.

9. THE NUMBER OF SEEDLINGS TO TRANSPLANT IN EACH HOLE.

TABLE XVII.

(Bankipore.)

NUMBER OF		Total area in acres	Number of seedlings	AVERAGE	
Trials	Years			Grain	Straw
10	3	2.1	1 in each hole . .	746	1,209
46	7	9.8	2 in each hole . .	994	1,824
46	7	9.8	4 in each hole . .	1,070	1,916
46	7	9.8	8 in each hole . .	1,187	2,161

TABLE XVIII.

(Cuttack.)

NUMBER OF		Total area in acres	Number of seedlings	AVERAGE	
Trials	Years			Grain	Straw
10	5	2	1 in each hole . .	1,873	3,169
10	5	2	2 in each hole . .	1,964	3,156
10	5	2	4 in each hole . .	2,003	3,501
10	5	2	8 in each hole . .	1,913	3,705

TABLE XIX.

(Sabour.)

NUMBER OF		Total area in acres	Number of seedlings	AVERAGE	
Trials	Years			Grain	Straw
161	5	4.1	1 to 2 in each hole .	1,414	...
161	5	4.1	4 to 6 in each hole .	1,577	...

In certain parts of India, particularly Madras, a large saving has been effected by transplanting single seedlings instead of bunches as was the local practice, and a number of experiments have been carried out at Bankipore, Cuttack and Sabour to ascertain whether a similar saving was possible in this province. From the results recorded above it is obvious that it is not possible in Bihar. The fact that two seedlings have given a slightly better result than eight, and four than both at Cuttack show that a small number of seedlings may possibly succeed in Orissa, but further investigation is advisable as the number of trials and the total area of the experiments at Cuttack were less than on the other farms.

At Sabour, where Mr. Sil, the Assistant Professor of Agriculture, carried out many series, and to a less extent at Bankipore, the possibility of succeeding with one or two seedlings under special conditions was carefully examined. Trials were made with early and late sowings, with thickly and thinly sown seed-beds, from wet and dry seed-beds, in heavily manured and unmanured land, etc., but I have not burdened this report by recording all these experiments in detail as they led to no definite results, the total outturn varied as might be expected but the largest number of seedlings gave the highest yield.

On the other hand the average cultivator can probably effect a certain saving if he takes the trouble to plant bunches more regular in number, at present though he hardly ever puts less than eight into a hole frequently bunches of over 20 can be found. No experiments, however, have been made as yet to ascertain the number at which the yield begins to fall off again.

10. THE DISTANCE APART AT WHICH TO TRANSPLANT THE SEEDLINGS.

TABLE XX.

(Sabour.)

NUMBER OF		Total area in acres	Distance apart	AVERAGE	
Trials	Years			Grain	Straw
3	3	0.15	6 inches . . .	1,146	4,162
3	3	0.15	9 inches . . .	1,186	3,595
3	3	0.15	12 inches . . .	919	2,768
3	3	0.15	18 inches . . .	454	2,125

The cultivator usually transplants his seedlings from six to nine inches apart, and the above table shows that this is correct.

11. NIGAR.

Nigar means literally "putting off." It is used by the cultivators in Bihar in connection with running water off the fields; e.g., the process of running the water out of the *ahars* to dry them preparatory to *rabi* cultivation, or the draining of the rice fields.

The water is usually run out of the rice fields twice, shortly after transplanting and again in the *utra nichchattra* which usually falls between the 12th and 24th of September. This section is concerned with this last *nigar* which is of importance on the area irrigated by the Sone Canals.

If the fields are dried shortly after transplanting no particular strain falls on the canal for two reasons, firstly because the fields are not all

drained at the same time but more or less in rotation as they are transplanted, secondly because less water is generally required to fill them up again as the time is usually one of heavy rainfall. The *utra nigar*, however, is different. It is done by rule at the beginning of the *utra* and is applied to all rice, transplanted and broadcast, early and late. The land is left to dry throughout the *nichchattra*, and at the commencement of the next *nichchattra*, the *hathia*, every field is filled up again. It is this that throws a strain on the canal. As the canal authorities point out, if the practice could be done away with, or even if it could be modified, the use of the canal would not be limited by the necessity of delivering a maximum supply on a given date and it could, therefore, irrigate a larger area of the country.

After discussions with various Public Works Officers, a series of experiments were drawn up to commence in 1916 and to be carried out on canal lands under the supervision of the Irrigation and Agricultural Departments, officers of both departments being present at and reporting on each operation. Before describing these I will recapitulate the questions involved as they appeared to me.

It may be assumed that *nigar* is beneficial for at least four reasons. (1) Theoretically it is probably advantageous to dry and aerate the soil. (2) It is the custom, not only on the canal irrigated lands, but also in those parts of Gaya and Patna irrigated by the indigenous system of pines and *ahars*,* except when there is so little reserve water that there is a danger that the fields cannot be refilled. (3) Even on the canal lands, where water is assured, the practice involves a certain amount of work in opening and closing the fields, and no one does unnecessary work. (4) Both the Irrigation and the Agricultural Departments had carried out experiments previously which showed that *nigar* was beneficial.

On the other hand it is probably not necessary to *nigar* on a given date. The cultivator has no doubt found that the *utra* is about the best time for the majority of his rice, the main crop harvested in December, but besides this his rice includes varieties such as *sirhanti* harvested in October and *kartika* harvested in November. If nigarring them at this time did harm they would be nigarrered earlier, and conversely if it did them good the nigarring time of the main crop could be varied without doing much damage.

Thus the series should at least include main crop varieties nigarrered at different times and *kartika* nigarrered a month earlier than the usual time. (I find that unfortunately in the experiments the *kartika*

* See the author's paper "Indigenous Irrigation Works in Bihar and their improvement" in the *Agricultural Journal of India*, Vol. XI, Part II.

was nigarred a month later than usual instead of a month earlier, and as this is tantamount to no niggarring, I have excluded the result. The mistake was possibly due to my giving insufficient instructions as I was unaware at the time that I should be unable to supervise the experiments personally.

If it could be proved that small variations in the time of niggarring caused no appreciable loss, the canal authorities would be justified in insisting on different blocks of the canal irrigated land being nigarred and filled up again on different dates, and they would then have extra water to supply further areas.

Definite knowledge could not be obtained in one year even if the experiments were carried out over a large area, for variations in the rainfall must influence the result. It was necessary, therefore, to continue the experiments for a sufficient number of years to represent a fair average.

This has not yet been done, but the results of three seasons given below are very encouraging.

TABLE XXI.

NUMBER OF		Total area in acres (about)	Kind of rice	Treatment	AVERAGE	
Trials	Years				Grain	Straw
16	3	3	Main crop harvested in Decem- ber	Nigarred at the usual time . . .	1,422	1,950
				Not nigarred	1,373	1,901
				Nigarred at the usual time <i>khari</i> salt . .	1,460	1,884
				Not nigarred <i>khari</i> salt	1,519	2,080
				Nigarred at the usual time but not allowed to dry enough to crack the soil.	1,325	1,070
				Nigarred on September 1st	1,302	1,739
				Nigarred on September 15th	1,181	1,612
				Nigarred on October 1st	1,110	1,599
				Nigarred on October 15th	1,268	1,909
				Ngarred at any time the weather permits from September 1st to October 15th.	1,275	1,773
10	3	1.8	<i>Kartika</i> harvested in Novem- ber.	Nigarred at any time the weather permits from September 1st to October 15th but not allowed to dry enough to crack the soil.	1,310	1,897
				Nigarred at the usual time	1,353	1,645
				Not nigarred	1,341	1,768

There was a heavy fall of rain during the niggarring period of 1917 and the plots did not dry. This has a considerable effect on the figures which are the average of three years only. Of course, such years should be included, but they should not form one-third of the whole.

The first two experiments show that *nigar* is beneficial, though the increase is only 3.6 per cent. It will probably be found to be larger when the average of a number of years is taken.

In the last two niggarring is shown to benefit *kartika* rice also but to a less extent. The increase in this case is almost negligible being only .9 per cent. Here again the percentage of gain should be larger after a longer trial including a smaller proportion of unfavourable years, but it is improbable that *kartika* when nigarred at the same time as the main crop varieties will derive as much benefit from the process as they do.

The third and fourth experiments were included to test the action of *khari* salt, which was added to both just after the water was run out of the niggared plot. From table 21 it appears that the addition of this salt has more than made good the loss due to not niggarring but a reference to table P in the appendix shows that this is due to the extraordinary (and probably incorrect) figures of the first series at Ageon in 1918. If these are omitted *khari* salt is found to have no effect.

Comparing number five with number one it appears, as would be expected, that it is better to dry the soil completely; but this result is contradicted in numbers ten and eleven. This would, naturally, take longer to decide than the other points, as it is more dependent on the weather.

The most important plots in the series are numbers six to nine, where the period of *nigar* is varied from September 1st to October 15th. Of these September 15th is practically the customary time. Up to the present they show that no harm results if the water is run off at any time between these dates and run in again after the usual interval. In other words they justify the canal authorities in dividing up the area into blocks to be nigarred on varying days between these dates, and thereby conserving water for irrigating land at present outside the canals.

C. Manurial experiments.

I have divided this part into chemical manures and simple manures for convenience in reference. But, while as a rule the section on chemical manures contains those manures which are relatively expensive and difficult to obtain, and that on simple manures describes those which are usually cheaper and more easily available, no definite line can be drawn between the two. The value of the manures in each case depends upon their power of supplying the plants with the same elements, and some manures (for example, saltpetre and bonemeal) though included among the chemical manures are easily obtained in certain tracts.

1. CHEMICAL MANURES

TABLE XXII.

(Bankipore.)

Manure applied per acre	1915-16						RESIDUAL RESULTS IN 1916-17					
	RICE			GRAM			RICE			KERAO		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
160 lb. of ammonium sulphate	1,648	2,788	Rs. A. 17 8	351	276	Rs. A. 8 14	1,497	1,905	Rs. A. 28 1	795	758	Rs. A. 28 1
120 lb. of superphosphate	1,585	2,808	31 0	433	322	12 11	817	1,260	5 4	894	751	30 7
100 lb. of muriate of potash.	1,374	2,019	13 1	484	350	15 6	295	627	12 0	575	430	17 6
160 lb. of ammonium sulphate + 100 lb. of muriate of potash.	1,876	3,024	12 11	633	491	22 5	1,372	1,652	21 10	972	703	33 1
160 lb. of ammonium sulphate + 120 lb. of superphosphate	1,886	3,372	23 2	402	308	11 4	1,667	2,090	34 2	1,001	892	35 6
120 lb. of superphosphate + 100 lb. of muriate of potash.	1,420	2,422	10 11	482	360	15 4	792	1,092	5 5	754	688	25 9
Unmanured	1,028	1,545	12 5	413	336	12 3	205	435	16 4	682	587	21 14
												5 10

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE XXIII.

(Bankipore.)

Manures applied per acre	1918-19		
	RICE		
	Grain	Straw	Profit
164 lb. of superphosphate	1,165	2,120	Rs. A. 28 3
410 lb. of bonemeal	1,360	2,485	29 10
Unmanured	1,330	2,965	51 11

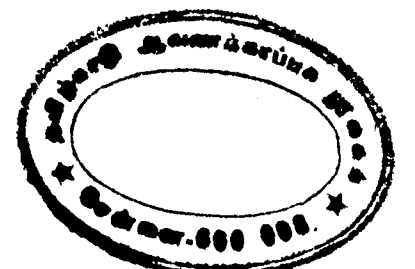
The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

Table 22 is interesting in that all the manures paid for themselves in the year of their application, if both crops are taken into account, notwithstanding their relatively high price in 1915.

While the series was only carried out in duplicate and for one year and is therefore not so reliable as would be a number of trials spread over several years, yet certain deductions can be made as to the value of the three classes of manures on this soil, and these deductions have much more weight if borne out not only by a comparison of two plots with two plots but by combining the results of the whole series of 14 plots into two groups for each manure.

Ammonia is clearly shown to be a valuable manure for rice. The two plots treated with ammonium sulphate have given a large increase over the unmanured plots. Again, when the six plots that received ammonium sulphate are compared with the eight plots that did not, the manure is shown to have given an increase of 33 per cent. of grain and 39 per cent. of straw. A small part of this increase is due to the sulphur as we shall see when discussing *khari* salt in the next section.

At first sight its residual effects on the rice (in 1916-17) appear extraordinary, the plots manured with ammonia the previous year giving an increase over the others of 187 per cent. of grain and 121 per cent. of straw. But, while this manure has a considerable residual effect, this enormous increase is only indirectly due to it. The plots were



flooded for a short time in 1916 and the impetus given to the plants by the nitrogenous dressing, besides making them stronger, made them slightly taller, so that they were both able to stand the immersion better and were under water for a shorter time. Nevertheless, although the actual increase in this case is largely a matter of luck, there is the other side of the question, had the plants not been given this extra help they would not have been taller and stouter and would not have received less damage than the rest—while short floods are frequent in this low-lying rice tract.

The *paira*, a leguminous crop, is not likely to be affected by a nitrogenous manure, and the outturn of the gram on the six plots manured with ammonium sulphate was the same as that on the eight plots that were not; the average figures are 455 lb. of grain per acre in the former case and 453 lb. in the latter.

Superphosphate has given good results, its application producing a large increase of rice over the unmanured plots. A comparison of the six plots treated with superphosphate with the eight plots not so treated shows an increase due to this manure of 10 per cent. of grain and 22 per cent. of straw.

Its residual results are also considerable. The six plots to which superphosphate was added in the previous year giving an average increase over the eight to which it was not added of 30 per cent. of grain and 28 per cent. of straw. Here again, as in the case of the ammonium sulphate described above, the effect may have been exaggerated by the unfortunate year, nevertheless the residual value in the second year, must be considerable.

(In the 1918-19 series given in table 23 the addition of phosphate manures would seem to have given a negative result, but it appears certain that the unmanured plots were in some way better than the others.)

Superphosphate has apparently had no effect on the *paira* in the first year, the figures obtained by a comparison of all the plots showing a slight decrease; but similar figures for the second year show an increase from this manure of 16 per cent. of grain and 21 per cent. of straw in the *kerao*. In view of the warning already given (in the introduction) against too hasty a judgment of the effects of a manure on the *paira* crop I am inclined to think that the results must have been masked in some way the first year, even if it is equally likely that they have been somewhat exaggerated the second year.

The figures obtained by a comparison of the plots manured with potash with those not so manured show an average increase of 20 lb.

per acre of rice grain the first year, which is negligible, and a loss of 22 per cent. the second, which is of course only the compliment of the lucky gain made by the ammonium sulphate plots explained above, and is therefore of no consequence. It appears then that this manure has no effect on the rice in this soil.

Its influence on the *paira* crop is not definite. A comparison as above of all the plots of the first year shows an increase due to potash of 35 per cent. of grain and 29 per cent. of straw, but the residual results are *nil*.

TABLE XXIV.

(Cuttack.)

NUMBER OF		Total area in acres	Manure applied per acre	Grain	AVERAGE Straw
Trials	Years				
6	3	1.2	160 lb. of sulphate of ammonia + 120 lb. of superphosphate + 100 lb. of muriate of potash.	2,273	4,600
6	3	1.2	160 lb. of sulphate of ammonia + 120 lb. of superphosphate.	2,286	4,757
6	3	1.2	160 lb. of sulphate of ammonia + 100 lb. of muriate of potash.	2,318	4,733
6	3	1.2	120 lb. of superphosphate + 100 lb. of muriate of potash.	1,946	3,321
6	3	1.2	Unmanured	1,782	3,145

None of these manures paid for their application in any of the three years, and the series was discontinued owing to the steady rise in their price. Nevertheless, while bearing this in mind, the results are of value in that they show the class of manures that will benefit the rice on this soil.

Ammonia is obviously beneficial. Comparing the 18 plots which received ammonium sulphate with the 12 which did not we arrive at an increase due to this manure of 23 per cent. of grain and 45 per cent. of straw.

Phosphatic manures gave a small increase, a comparison in the same way of the plots manured with superphosphate with those that were not showing an increase in the former of 6 per cent. of grain and 7 per cent. of straw.

Potash also gave an average increase of 7 per cent. each of grain and straw.

TABLE XXV.

(Sabour.)

Manure applied per acre	1913-14		1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Unmanured . . .	786	1,778	625	1,230	1,240	2,540	1,365	2,108
5 maunds (410 lb.) of bonemeal in 1913-14.	890	1,640	1,120	2,090	1,195	2,755	1,330	3,121
3 maunds (246 lb.) of bonemeal in 1913-14 and 1915-16.	685	1,460	1,190	2,402	870	1,525	1,665	2,455
1 maund (82 lb.) of bonemeal + 1 maund (41 lb.) of saltpetre each year.	910	1,675	840	1,640	1,115	3,085	1,625	2,730

The experiments were in duplicate on 0.1 acre plots, the plots being the same each year; the figures are the average of the two plots.

Deductions from this series must be somewhat indeterminate, particularly as all the manures have given a negative result in 1915-16, when it would seem that something must have happened to increase the relative yield of the unmanured plot.

The bonemeal and saltpetre has given an average increase of 118 lb. of grain per acre per annum during the four years.

It is noteworthy that in each case the addition of bonemeal has given a substantial increase, not in the year of its application but in the succeeding year. Thus the bonemeal applied in 1913-14 has given no definite results that year, the gain in one case being counterbalanced by the loss in the other, but in the next year the 5 maunds have produced an increase of 79 per cent. of grain over the unmanured plot, and the 3 maunds an increase of 90 per cent. Again the addition of 3 maunds in 1915-16 has produced no result in that year but has resulted in an increase of 22 per cent. of grain the next year.

The single application of 5 maunds of bonemeal in the first year has produced slightly more during the four years than have the two applications of 3 maunds each.

TABLE XXVI.

(Sabour.)

Manure applied per acre	1914-15		1915-16		1916-17		1917-18	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Green manure (<i>sannai</i>) each year.	1,120	1,919	1,947	6,570	935	6,072	665	5,547
Green manure (<i>sannai</i>) + 5 maunds (410 lb.) of bonemeal each year.	1,080	2,007	2,390	6,620	1,050	6,320	1,075	6,490
Green manure (<i>sannai</i>) + 5 maunds (410 lb.) of bonemeal in 1915-16 and 1917-18.	785	1,543	1,982	6,048	822	6,690	505	6,840
Green manure (<i>sannai</i>) + 10 maunds (820 lb.) of bonemeal in 1915-16 and 1917-18.	995	2,030	1,980	5,915	620	6,780	635	6,962

The experiments were in duplicate on 0.05 acre plots, the plots being the same each year, the figures are the average of the two plots.

The results in this series are not definite.

Comparing the plots which received green manure and bonemeal each year with those that received green manure alone, it appears that the bonemeal had no effect the first year (the yields being practically the same) but produced an increase of 23 per cent. the next year, followed by increases of 12 per cent. and 62 per cent. in the two following years. That is, the bonemeal acted as in the previous table.

In the next two cases, however, the effect of the bonemeal is by no means clear. In 1915-16 we may conclude that the green-manure caused the increase, as the outturns are the same as that of the plots manured with green manure alone, but the bonemeal seems to have had no effect in the next year either. It is possible that the whole series has been upset by an uneven growth of the *sannai*, always a danger when the results are dependent upon a green-manure as a constant factor.

TABLE XXVII.

(Bankipore.)

NUMBER OF Trials	Years	Total area in acres	Manure applied per acre	RICE		GRAM		Year's Profit
				Grain	Straw	Grain	Straw	
4	2	0.8	300 lb. of basic slag	1,501	2,254	421	361	Rs. A. 16 1 34 14
4	2	0.8	1,640 lb. of lime	1,533	2,402	480	454	18 7 15 8
4	2	0.8	Unmanured	1,497	2,198	533	454	21 8 53 9

TABLE XXVIII.

(Sabour.)

Manure applied per acre	1914-15		1915-16		1916-17		1917-18		AVERAGE	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Green manure (<i>sannat</i>) + 820 lb. of lime	1,165	2,400	2,315	7,785	820	5,745	840	5,885	1,285	5,454
Green manure (<i>sannat</i>)	1,120	1,919	1,947	6,570	935	6,072	665	5,547	1,167	5,027

The experiments were in duplicate on 0.05 acre plots, the same plots receiving the manure each year, the figures are the average of the two plots.

TABLE XXIX.

(Cutlack.)

Manure applied per acre	1913-14		
	Grain	Straw	Profit
50 lb. of basic slag	1,855	2,742	Rs. A. 31 4
1,640 lb. of lime	1,722	2,691	34 14
Unmanured	1,495	2,511	42 0

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE XXX.

(Cutlack.)

Manure applied per acre	1913-14		
	Grain	Straw	Profit
100 lb. of basic slag	1,978	2,870	Rs. A. 33 6
1,640 lb. of lime	2,258	3,280	43 3
Unmanured	1,906	3,068	42 11

The experiments were on 0.2 acre plots on broadcast rice.

TABLE XXXI.

(Cutlack.)

Manure applied per acre	1912-13	
	Grain	Straw
Green manure + 246 lb. of lime	2,367	3,777
Green manure (<i>dhaincha</i>)	2,434	3,938

The experiments were on four plots of 0.2 acre each, the figures are the average of the four plots.

TABLE XXXII.
(Cuttack.)

NUMBER OF		Total area in acres	Manure applied per acro	AVERAGE	
Trials	Years			Grain	Straw
6	3	1-2	Green manure + 1,230 lb. of lime.	2,134	3,177
6	3	1-2	Green manure (dhaincha)	2,131	3,417

In the above trials lime gave a 2 per cent. addition of grain at Bankipore, where it did not pay for its application, and 10 per cent. at Sabour. Its action at Cuttack varied, it gave no increase in six trials, 2 per cent. in four trials, 15 per cent. in two trials and 18 per cent. in one; but in only one case did it pay for its cost.

Lime, therefore, is not a profitable manure for Bankipore or Cuttack and, though it appears more likely to do good at Sabour, this is not yet certain for the comparison (table 28) was a green-manured with a green-manured and limed area, and, depending as it does upon the growth of a crop, green manure is not necessarily a constant factor.

2. SIMPLE MANURES.

By simple manures are meant manures which the ryot can obtain without much difficulty.

TABLE XXXIII.
(Dumraon.)

Manure applied per acre	1908-09		1909-10		1910-11 23		1911-12		1912-13	
	RICE		RICE		RICE		RICE		RICE	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
50 maunds of cowdung .	2,624	4,920	2,972	9,020	2,613	6,713	2,665	4,715	1,906	3,044
100 maunds of cowdung	2,152	3,854	2,972	8,610	2,644	4,423	1,896	3,792	1,588	5,382
84 maunds of cowdung + 3.75 maunds of castor cake.	3,075	2,665	3,321	9,840	2,572	4,920	2,685	4,920	2,285	5,032
Green manure (sannal) .	2,378	4,715	2,608	9,020	2,142	3,587	1,640	2,972	1,168	2,480
Green manure (dhaincha)	2,650	3,936	2,768	10,250	2,972	5,863	2,337	5,330	1,127	2,562
3 maunds of bonemeal + 1 maund of salt- petre.	2,255	4,612	2,829	7,380	2,767	5,227	2,347	3,997	1,691	3,761
Unmanured .	1,845	2,542	1,742	5,330	1,640	3,772	1,271	2,306	789	1,804

Manure applied per acre	1912-13						1913-14					
	GRAM.			RICE.			GRAM.			RICE.		
	Grain.	Straw.	Profit.	Year's profit.	Grain.	Straw.	Profit.	Grain.	Straw.	Profit.	Year's profit.	Year's profit.
50 maunds of cowdung	887	1,209	Rs. A. 26 14	Rs. A. 51 12	1,886	4,869	Rs. A. 48 15	656	594	Rs. A. 21 0	Rs. A. 69 15	Rs. A. 69 15
100 maunds of cowdung	461	481	10 0	21 6	1,722	3,844	39 6	676	574	21 10	61 0	61 0
34 maunds of cowdung + 3.75 maunds of castor cake	615	635	15 11	51 3	2,132	4,397	51 4	451	410	13 0	4 4	4 4
Green manure (sannai)	615	512	14 8	23 9	1,578	3,382	30 11	533	471	16 7	47 2	47 2
Green manure (dhaincha)	512	779	13 9	20 5	1,865	4,264	44 3	328	284	6 8	50 11	50 11
8 maunds of bonemeal + 1 maund of salt-petre.	471	594	11 1	17 12	1,322	2,972	8 8	348	225	8 3	16 11	16 11
Unmanured	287	348	3 8	4 1	1,250	2,665	24 9	134	123	1 3	25 12	25 12
Manure applied per acre.	1914-15.						1915-16.					
	RICE.			GRAM.			RICE.			GRAM.		
	Grain.	Straw.	Profit.	Grain.	Straw.	Year's profit.	Grain.	Straw.	Profit.	Grain.	Straw.	Year's profit.
50 maunds of cowdung	1,619	3,936	Rs. A. 54 12	205	205	Rs. A. 57 10	2,132	3,690	Rs. A. 47 9	1,931	4,202	Rs. A. 41 0
100 maunds of cowdung	1,650	3,116	50 7	154	154	50 13	1,998	3,484	38 12	1,449	3,484	28 10
34 maunds of cowdung + 3.75 maunds of castor cake.	2,081	3,403	58 10	102	123	56 11	2,065	3,740	38 4	1,586	2,310	10 11
Green manure (sannai)	2,152	3,639	66 7	143	154	66 7	1,931	4,202	41 0	1,009	2,356	8 4
Green manure (dhaincha)	1,127	3,649	16 13	82	102	13 14	1,449	3,484	28 10	1,009	2,356	8 4
3 maunds of bonemeal + 1 maund of salt-petre	1,250	2,378	5 3	113	102	3 9	1,586	2,310	10 11	1,009	2,356	8 4
Unmanured	635	1,640	8 3	82	102	5 4	1,009	2,356	8 4	1,009	2,356	8 4

The experiments were on 0.2 acre plots, each plot receiving the same manure yearly.

This interesting series was started by my predecessor before the formation of the province. Unfortunately it could not be laid out in duplicate as there are not sufficient suitable rice plots at Dumraon. After a careful study of the plots (which I was better able to make after my transfer to Bankipore when this became my nearest outlying farm as opposed to his furthest from Calcutta), I found that the plot manured with 34 *maunds* of cowdung and 3.75 *maunds* of castor cake was lower, and therefore usually better, than the rest, which discounts to some extent the comparatively large yields from this manure. The plot manured with 50 *maunds* of cowdung was just lower than the others. Thus, as is generally the case with a single series, certain reservations are necessary when comparing the outturns plot with plot.

Nevertheless the accumulated benefit derived by applying these manures yearly and the profit that would accrue where such a practice common is most plain, and, if necessary, leaves a large margin for any error that might be due to variations in the plots. Thus if we omit the suspect plot manured with 34 *maunds* of cowdung and 3.75 of cake and, further, reduce the outturns from the plot manured with 50 *maunds* of cowdung to the same as those from the plot manured with 100 *maunds* (which would more or less agree with the experience on other farms, as is shown later), we find that had a man owning 5 acres of similar rice land manured each acre yearly with one of these five manures for eight years he would have increased his rice grain receipts by an additional 29,693 lb. Thus :—

From his acre manured with—	lb.
50 <i>maunds</i> of cowdung	6,441
100 <i>maunds</i> of cowdung	6,441
Sannai green manure	5,411
Dhaincha green manure	5,534
3 <i>maunds</i> bonemeal + 1 <i>maund</i> saltpetre	5,866
TOTAL	29,693

His extra receipts in money during the last five years alone, and only counting the rice, would have been, according to the farm accounts which naturally show less profit than a cultivator would make, Rs. 442. (As a matter of fact, they would have been more, for an Indian cultivator wise enough to apply such a series of manures would not only save over labour and incidental expenses, but would notice when his bone-meal and saltpetre plot was being run at a loss owing to the rise in price of these manures, and would have abandoned this dressing.)

But there is another way of examining the results which is not open to the same objections due to the series being on a single line of plots, that is a comparison of the relative returns of the plots. Whatever the initial difference between the outturn of the plots, any increase or decrease of this difference must be due to the treatment of the plot, and a steady advance must be due to the accumulated effect of the manure. In practice, of course, dealing with living plants and a complicated soil one cannot expect an arithmetical progression, but only an indication.

If the increase over the unmanured plot in the first year in each case is taken as 1 and the increase in the other years reduced proportionally, we get the following figures :—

TABLE XXXIV.

Manures per acre.	1908-9	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
50 maunds of cowdung .	1	1.579	1.249	1.789	1.434	0.816	1.263	1.442
100 maunds of cowdung .	1	4.007	3.27	2.036	2.603	1.537	3.306	3.222
34 maunds of cowdung + 3.75 maunds of castor cake.	1	1.284	0.758	1.15	1.216	0.717	1.176	0.883
Green manure (<i>sannai</i>) .	1	1.615	0.942	0.692	0.711	0.615	2.846	1.73
Green manure (<i>dhaincha</i>) .	1	5.102	6.498	5.2	1.649	3	2.4	2.146
3 maunds of bonemeal + 1 maund of saltpetre.	1	2.651	2.749	2.624	2.2	0.176	1.5	1.407

Several deductions can be made from this table. In the first place none of the manures has proved harmful after a number of years, all have given an increase over the unmanured plot in the first year, and added to this in most of the succeeding years. Had the accumulated effects been harmful, the figures would have shown a gradual or rapid decline. These particular manures are not likely to cause harm, but I mention the fact because I have occasionally heard the opinion expressed that continuous green-manuring causes a decrease. That the *dhaincha* (*Sesbania aculeata*) has not done this is obvious. At first sight the case for *sannai* (*Crotalaria juncea*) may not seem so certain but applying a green manure is not the same thing as adding a definite quantity of manurial matter. The amount is dependent upon the growth of the plants to be ploughed in and these, like all plants, will vary from season to season, and therefore the fall to less than the original increase during three years is only due to faulty growth of the crop. Were it due

to any harmful action of the manure it would not have been followed by a rise to nearly three times in the seventh and over one and a half times in the eighth year.

From an examination of table 34 up to and including the year 1912-13, where it is divided by a vertical line, it appears that both the plot manured with 100 maunds of cowdung and that manured with 3 maunds of bone-meal and 1 maund of saltpetre have reached a level. That is to say the accumulated effect in both these manures does not seem to be raising the outturn any further. This implies that in each case the quantity applied yearly could have been reduced in future without lowering the outturn had the series been carried on as before, but at this point I introduced a *paira* crop.

This *paira* crop raised questions which have not yet been solved though perhaps the solution can be indicated. The cultivators of the neighbourhood do not grow a *paira* on light soils of this nature as a rule, and the wisdom of this is shown in these experiments where though the unmanured plot gave a small return the first year this fell to little more than half in the second, less than a third in the third (when the outturn did not even pay the small expenses incurred) and failed entirely in the fourth year. This looks as if some essential plant food was lacking in the soil. It is not nitrogen, firstly because a leguminous crop like gram would certainly obtain enough of this element on a soil that supported rice, secondly because in that case the *paira* crop on the bonemeal and saltpetre plot would stand out from the rest. It could hardly be phosphorous, for then also the bonemeal plot should have beaten the others. Therefore it is probably potash, and this is further borne out by a comparison of the plots; the best returns on the whole in each year were obtained from the plots manured with farm-yard manure, which contains a certain amount of potash but did not supply enough. (In the fourth year when the *paira* was not harvested, there was probably enough on the cowdung plots to produce a small profit though, owing to a misunderstanding, this was discarded with the rest.

Now, if a good *paira* crop could be grown on these lands it would almost double the yearly returns, as shown in the introduction to this paper when discussing the *paira* at Bankipore, and it would seem as if this might be obtained, and the yield of rice increased as well, by a simple and cheap manurial dressing containing potash. Before it can be recommended definitely, however, trials should be made on the Dumraon Farm; I was unable to do so as I had to wait for suitable plots and left before these could be obtained.

TABLE XXXV.

Dumraon.

Manure applied per acre	1916-17		
	Grain	Straw	Profit
50 maunds of cowdung	1,742	2,435	Rs. A. 20 10
Green manure (dhaincha)	1,886	2,502	22 4
5 maunds of castor cake	1,993	2,914	13 5
Unmanured	1,698	2,726	20 10

The experiments were carried out on 0.2 acre plots.

This series, though of little value by itself, shows nothing to contradict the deductions made above. Dhaincha, though it has not given the largest yield, has proved the most profitable. Castor cake which has produced the largest outturn, has not paid for itself.

TABLE XXXVI.
(Bankipore.)

NUMBER OF		Total area in acres	Manure applied per acre	AVERAGE INCREASE OVER THE UNMANURED PLOT						
				RICE			GRAM			Year's profit
Trials	Years			Grain	Straw	Profit	Grain	Straw	Profit	
4	2	0.8	100 maunds of cowdung	340	574	Rs. A. —0 12	70	17	Rs. A. 4 8	Rs. A. 3 12
4	2	0.8	50 maunds of cowdung	240	291	0 6	81	99	4 12	5 2
6	3	1.2	5 maunds of castor cake	150	137	—11 3	—90	—85	—4 11	—15 14
2	1	0.4	5 maunds of mustard cake	—45	—570	—13 14	..	..	..	..
14	5	3	2 maunds of khari salt	270	112	6 13	44	32	1 2	7 15
4	2	0.8	2 maunds of sulphate of magnesia	224	384	—7 10	—137	—126	—6 14	—14 8
8	4	1.8	Green manure (<i>dhaincha</i>)	—25	—97	—3 1	18	12	1 9	—1 8
4	2	0.8	Green manure (<i>kenna</i>)	163	154	1 5	18	23	1 1	2 6

TABLE XXXVII.

(Bankipore.)

Manure applied per acre in 1915-16	RESIDUAL RESULTS IN 1916-17 OF THE MANURES APPLIED IN 1915-16		
	Grain	Straw	Profit
100 maunds of cowdung	2,050	3,842	Rs. A. 61 7
50 maunds of cowdung	1,575	3,080	42 6
5 maunds of castor cake	1,807	2,520	44 2
2 maunds of khari salt	2,315	3,847	66 3
2 maunds of sulphate of magnesia	2,062	2,317	55 6
Green manure (<i>dhaincha</i>)	1,602	3,300	44 4
Green manure (<i>sannai</i>)	1,737	3,465	48 3
Unmanured	1,605	3,280	44 5

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

The majority of the manures in table 36 have not yet been tried a sufficient number of times to insure certainty in any recommendations for this soil but nevertheless it is advisable to record the results partly because by the accumulation of such records the effects of the manures will become definitely known, and partly because even a few trials, provided they are given no more weight than they deserve, give an indication of the value of the manures.

Well-preserved farm-yard manure, as might be expected, has given an increase, a dressing of 100 maunds per acre showing a higher additional yield of rice than any other of the manures considered. This extra yield, however, has not paid the cost at farm rates of the manure (valued at 2 annas a maund) and of carting and spreading it though when the additional yield of the *paira* crop is included a profit is shown. Manuring with 50 maunds of cowdung resulted in less rice but a larger profit. But the residual value must also be considered. There are figures for one year only on the rice alone in table 37. Taking the average yields of four trials in two years from table 36 and combining them with the residual results of two of these trials in one year from table 37, we find that after three crops the additional profits per acre are, from 100 maunds of cowdung Rs. 20-14, from 50 maunds Rs. 3-3 or Rs. 17-11 in favour of the larger amount.

A further series was laid down to compare the value of 100 maunds of cowdung with 50 maunds, the results of which are shown in the following table.

TABLE XXXVIII.
(Bankipore.)

(Dumraopore.)

Manure applied per acre	1914-15				RESIDUAL RESULTS IN 1915-16						Year's profit		
	RICE		GRAM		RICE		GRAM		Year's profit				
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw					
100 maunds of cowdung	1,659	4,710	Rs. A. 45 3	1,014	1,150	Rs. A. 56 10	1,737	3,075	Rs. A. 44 14	877	552	Rs. A. 34 0	Rs. A. 78 14
50 maunds of cowdung	1,654	4,265	48 15	946	1,088	50 10	1,604	2,710	38 12	640	460	23 6	62 2

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

In this case the larger dressing proved as usual less profitable on the rice than the smaller in the first year but at the end of two years had given an extra yield per acre of 138 lb. of grain and 810 lb. of straw of rice with an increased profit of Rs. 2-6 and 305 lb. of grain and 156 lb. of straw of gram with an increased profit of Rs. 16-10, or a total additional profit of Rs. 19.

It may be concluded therefore, that when a single dressing is given at intervals it is better to apply 100 rather than 50 *maunds* of cowdung.

Returning to table 36; oil-seed cakes, though usually raising the yield, have not proved profitable manures at Bankipore.

Khari salt (hide salt) has given the highest average yield of rice grain of any of these manures except one, and the largest money return while its residual value is also considerable in the one year shown in table 37. Sulphur and chlorine are both deficient in this soil. Magnesium sulphate produces nearly as great an effect as *khari* salt, and the figures have been included for comparison, but its greater cost puts it out of the running as a rival. Common salt also increases the yield of rice, the addition of 2 *maunds* (164 lb.) per acre to broadcast rice in 1917-18 resulted in an increase of 229 lb. of grain, but the manure did not pay for itself. *Khari* salt is an impure sodium sulphate containing chloride and owing to its very impurities, provides both sulphur and chlorine at a lower cost in each case than if they were added separately.

Green-manuring with *sannai* has shown a profit. The negative results with *dhaincha* are surprising and contrary to the experience on other farms, but a reference to tables T and U in the appendix show that this manure gave a profit over the unmanured plots in three years out of the four and it is probable that there was some unrecorded adverse factor in the fourth. This view is strengthened by the fact that the average increase of the *païra* is the same for both the manures.

TABLE XXXIX.

(Cuttack).

NUMBER OF		Total area in acres	Manure applied per acre	AVERAGE INCREASE OVER THE UNMANURED PLOTS		
Trials	Year			Grain	Straw	Profit
14	10	2-77	Green manure (<i>dhaincha</i>)	327	495	Rs. A. 8 2
9	5	1-73	50 <i>maunds</i> of cowdung	166	112	2 3
7	4	1-4	50 <i>maunds</i> of village <i>khatto</i>	34	4	-0 14
2	1	0-33	5 <i>maunds</i> of gingelly cake	2	-102	-11 8

The profit of the green manure is based on ten trials only.

Green-manuring with *dhaincha* (*Sesbania aculeata*) has given the best results of the manures tried on the Cuttack Farm. The advantage of green-manuring is its low cost, and it is well worth recommending in the neighbourhood.

Fifty *maunds* of cowdung, although so far not producing so much increase in the yield of rice on this soil as at Bankipore, has proved a profitable manure.

The comparison of cowdung with an equal quantity of village *khatto* shown in this table emphasises two useful points. *Khatto* is a dry mixture of cowdung and ashes used as a manure by the local cultivators, and may be taken as their farm-yard manure. But farm-yard manure of the ordinary type preserved under cover on the farm is shown to be nearly five times as effective. Again the use of *khatto* resulted in a small loss on the farm (14 annas per acre) the slight extra yield not paying for the extra labour and cost of the manure. This helps to prove the contention several times repeated in this report that any manures which pay on the farms will pay the cultivators still more as his expenses are lower; for in this instance *khatto* manure must pay the cultivators or they would not apply it.

The trials of cake are too few for certainty in themselves, but here again this type of manure has not been found profitable.

TABLE XL.

(Sabour.)

Manure applied per acre		1912-13	
Green manure (<i>dhaincha</i>)	.	Grain	Straw
Unmanured	.	1,687	3,276
	.	1,499	3,227

The experiments were in triplicate in 0.1 acre plots, the figures are the average of the three plots.

Green-manuring with *dhaincha* has given an increase of 188 lb. per acre in this case, or 12.5 per cent.

D. Conclusions.

Various details of rice cultivation in Bihar have been examined in part B, and the results so far obtained appear to me to warrant the following conclusions.

It pays to plough those rice lands of Patna and Cuttack which are not at present cultivated during the hot weather, if a Punjab or some similar plough is used—and it would probably pay to do so elsewhere. (Section 1.)

Seed selection by the simple salt water method pays, and should be adopted by the cultivators. (Section 2.)

Transplanted rice produces more grain and pays better than broadcast rice. (Section 3.)

The method of cultivating broadcast rice in vogue in Orissa and Chota Nagpur, while probably in itself inferior to that of Bihar, is capable of a simple combination with green manure that has given an increase of 17 per cent. of grain. (Section 4.)

Sowings should take place as early as possible, as a delay results in a considerable loss that increases rapidly the longer the sowing is put off. (Section 5.)

A wet seed-bed pays better than a dry seed-bed. (Section 6.)

The usual seed rate is correct under present conditions. (Section 7.)

The time the seedlings are kept in the seed-bed before transplantation is probably correct, at any rate it cannot be reduced. (Section 8.)

The number of seedlings transplanted in each bunch cannot with safety be reduced below eight in Bihar. (Section 9.)

The distance apart at which the seedlings are transplanted is probably correct, at any rate it cannot be increased. (Section 10.)

The results of three years' experiments support the contention that the authorities of the Sone Canals would be justified in insisting on different blocks of the canal-irrigated lands being nigarred on varying dates between September 1st and October 15th, as this would not lower the yield of rice and would enable the canal to supply a larger area. During these three years no harm has resulted through varying the *nigar* between these dates, and, while there is no harm in continuing the experiments up to the five to seven years I originally suggested, it is unlikely, from every point of view, that so small a variation in the time of *nigar* would cause a loss, certainly not one equal to the gain that would result from the larger crops, and greater insurance of crops, on the extra land that could be irrigated. (Section 11.)

The examination of manures in part C cannot be summarised so easily. The primary object of the experiments with chemical manures (section 1) is to ascertain what class of manure is required, and of those in section 2 to find cheap manures that will pay: naturally the enquiries overlap. The answer in each case depends chiefly upon the nature of the soil and varies from place to place; general deductions, therefore, are not of much value.

Expensive chemical manures are not likely to pay under existing conditions on rice alone, although they may more than pay their way where a good *paira* crop can be grown in addition, as we have seen at Bankipore. A possible exception is ammonium sulphate for, as might be expected with a gramineous crop such as rice, this manure has given a large increase, 23 per cent. of grain at Cuttack and 33 per cent. at Bankipore. (The difference in favour of Bankipore is probably due to the sulphur in the manure, an element that is deficient on that farm.)

On the other hand special cases may occur where it will pay to import manures for a definite purpose; a case in point is Dumraon, and possibly Cuttack, where it seems likely that potash may enable a good *paira* to be grown and thus nearly double the proceeds from the land. (Introduction and part C, section 2, table 33.) The possibility of introducing a *paira* crop should be carefully considered on all rice lands on which it is not now grown.

Several local manures have been proved to pay.

Of these the most important under present conditions is green manure, because of its low cost and the ease with which it can be applied. Green manure is obtained by sowing 30 lb. per acre of *dhaincha* (*Sesbania aculeata*) or 60 lb. of *sannai* (*Crotalaria juncea*) on the rice fields at the first rain and ploughing it in when the land is puddled before transplanting. The cultivator can grow the seed on any unused land, and its application only requires a little extra work, a rough ploughing or two at sowing time and one or two extra when puddling.

A reference to the tables shows that *dhaincha* gave an increase of 19.8 per cent. of grain and Rs. 8.2 per acre of profit at Cuttack, 11 per cent. of grain and Rs. 1.10 per acre of profit at Dumraon, 12 per cent. of grain at Sabour. The average result at Bankipore was a decrease, but the manure resulted in an increase of grain and profit in three out of the four years and was probably masked in the fourth by some unexplained error; more particularly as the average increase in the *paira* was the same as that from *sannai*. *Sannai* gave an increase of 14 per cent. of grain and Rs. 1.5 per acre of profit at Bankipore, the only farm on which it was tried. (I have not included table 33 at Dumraon, where both did well, as the series is single and accumulative.)

Well-preserved farm-yard manure is also profitable. The average increase at Bankipore from a dressing of 100 *maunds* was 29.2 per cent. of rice and 13.6 per cent. of *paira* grain. The addition of 50 *maunds* produced an increase of 20.6 per cent. of rice and 15.9 per cent. of *paira* grain at Bankipore, 8.8 per cent. of rice grain at Cuttack and 2.6 per cent. at Dumraon (again ignoring table 33). When a single application is made at intervals 100 *maunds* are more profitable than half that amount. Well-preserved farm-yard manure proved five times as valuable as the local substitute at Cuttack.

Khari salt is a profitable manure on soils, such as that at Bankipore which are deficient in sulphur and chlorine. It gave an average increase of 19 per cent. of rice grain, 9 per cent. of *paira* grain, and Rs. 7.15 per acre of profit. When tried at Cuttack, where the chemical analysis shows there is more sulphur, it did not pay for itself. (Table W in the appendix.)

TABLE B.

(Cuttack.)

Treatment	1915-16		1916-17	
	Grain	Straw	Grain	Straw
Ploughed in the hot weather	1,353	1,706	1,086	2,060
Unploughed	1,107	1,537	1,025	1,291

Each year the experiments were in duplicate on 0.2 acre plots. The figures are the average of the two plots.

(2) Seed Selection.

TABLE C.

(Cuttack.)

Seed sown	1914-15		1915-16	
	Grain	Straw	Grain	Straw
Seed that did not pass through sieve . .	1,871	2,870	1,638	2,296
Corresponding unselected seed	1,842	2,767	1,645	2,060
Seed that sank in a saturated salt solution.	1,826	2,829	2,196	2,234
Corresponding unselected seed	1,771	2,562	1,827	2,398

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

(3) Transplanted and broadcast rice compared.

TABLE D.

(Cuttack.)

Cultivation	1915-16		1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Transplanted	1,927	2,362	1,491	1,588	1,571	2,255	1,189	1,845
Broadcast	1,684	1,942	1,247	1,435	1,368	3,023	650	1,614

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

(4) Broadcast rice in Orissa.

TABLE E.

(Cuttack.)

Seed rate per acre	1912-13		1913-14		1914-15		1914-15		1915-16		1916-17		1917-18	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
40 seers (60 lb.)	2,213	4,125	2,094	2,624	1,604	3,101	1,481	2,470	1,555	1,845	1,578	2,203	2,039	2,998
30 seers (60 lb.)	2,554	4,258	2,149	2,709	1,174	1,994	1,317	2,255	1,524	1,538	1,720	2,562	2,234	2,665
20 seers (40 lb.)	2,689	4,438	2,156	2,672	1,404	2,896	1,532	3,270	1,570	1,891	1,920	2,229	2,167	2,076

E

Each series was in duplicate on 0.2 acre plots; the figures are the average of the two plots.

TABLE F.

(Cutlack.)

Seed rate per acre	After treatment	1914-15		1915-16	
		Grain	Straw	Grain	Straw
40 seers (80 lb.)	Ploughed through	1,481	2,470	1,555	1,845
30 seers (60 lb.)	Do. . .	1,317	2,255	1,524	1,538
20 seers (40 lb.)	Do. . .	1,532	2,270	1,570	1,891
15 seers (30 lb.)	Not ploughed	1,783	3,198	1,491	2,357

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE G.

(Cutlack.)

Treatment	1915-16			1916-17			1917-18		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
(1) From manure (dhaiacha)	2,328	3,088	50 3	1,214	1,740	17 3	1,589	2,614	18 8
Unmanured	2,182	2,702	45 6	850	1,563	8 9	1,335	2,716	12 10

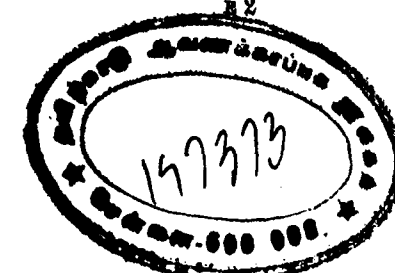
Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

(6) Wet and dry seed beds.

TABLE H.

Cultivation	SABOUR						CUTTACK			
	1913-14		1914-15		1916-17		1916-17		1917-18	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Wet seed-bed	2,260	..	762	..	205	497	1,711	3,162	1,855	3,357
Dry seed-bed	2,160	..	686	..	295	1,030	1,701	3,049	1,507	3,229
									1,788	2,947
									1,732	2,538

At Sabour the first year each experiment was on 8 plots of 0.025 acre, and in the two following years on 4 plots of 0.025 acre; at Cutlack each year the experiments were in duplicate on 0.2 acre plots; in all cases the figures are the average of the plots.



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(7) Seed rate in seed bed.

TABLE I.

(Sabour.)

Seed sown per acre of seed bed	1914-15	1915-16	1916-17
	Grain	Grain	Grain
2 maunds (164 lb.)	1,351	1,096	1,137
4 maunds (328 lb.)	1,359	1,058	1,061
10 maunds (820 lb.)	1,149	1,163	1,186

Each year the experiments were on 0.1 acre plots.

TABLE J.

(Bankipore.)

Seed sown per acre of seed bed	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
5 maunds (410 lb.)	815	981	887	1,244	499	713
7.5 maunds (615 lb.)	697	946	541	1,107	635	848

Each experiment was on 6 plots of 0.2 acres in 1914-15 and on 3 plots of 0.25 acre in each of the two following years ; the figures are the averages of the plots.

TABLE K.

(Cuttack.)

Seed sown per acre of seed bed	1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw
3 maunds (246 lb.)	1,547	1,947	1,300	2,532	1,055	1,058
4 maunds (328 lb.)	1,886	2,306	1,309	2,460	1,257	1,319
5 maunds (410 lb.)	1,845	1,742	1,555	2,460	1,230	1,435

Each year the experiments were in triplicate on 0.2 acre plots ; the figures are the average of the three plots.

(9) The number of seedlings to transplant in each hole.

TABLE L.

(Bankipore.)

Number of seedlings	1912-13		1913-14		1914-15		1915-16		1917-18.		1918-19.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole	..	..	788	1,276	919	1,297	..	401	..	..	..	..
2 in each hole	1,128	2,371	1,005	1,325	785	1,102	734	365	912	365	574	1,092
4 in each hole	1,205	2,428	979	1,450	867	1,350	730	407	894	865	711	1,212
8 in each hole	1,816	2,668	1,150	1,799	1,081	1,830	805	574	1,035	1,167	859	1,222
Number of seedlings	1916-17		1917-18.		1918-19.		1917-18.		1918-19.		1918-19.	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole	..	..	..	..	..	..	..	..	..	..	..	..
2 in each hole	1,676	2,492	470	692	..	692	1,449	2,869	415	980	415	980
4 in each hole	1,829	2,559	644	742	..	742	1,539	3,152	505	985	505	985
8 in each hole	1,898	2,897	585	908	..	908	1,539	2,990	875	1,680	875	1,680

Each experiment was on 20 plots of 0.2 acre each in 1912-13 ; on 4 plots of 0.2 acre each in 1913-14 and 1914-15 (both series) ; on 2 plots of 0.25 acre each in 1915-16 (both series) ; the first series on three and the second on 2 plots of 0.25 acre each in 1916-17 ; on 3 plots of 0.25 acre each in 1917-18 ; on 2 plots of 0.2 acre each in 1918-19. The figures are the average of the various plots.

TABLE M.

(Cuttack.)

Number of seedlings	1912-13		1913-14		1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1 in each hole . . .	2,097	3,895	2,296	2,870	2,076	3,546	1,660	2,678	1,238	2,858
2 in each hole . . .	2,189	4,147	2,852	2,716	1,932	3,290	1,545	2,644	1,300	2,985
4 in each hole . . .	2,261	4,762	2,665	3,280	2,132	3,921	1,746	2,572	1,210	2,972
8 in each hole . . .	2,132	4,946	2,465	3,408	2,199	4,095	1,727	3,080	1,040	2,998

Each year the experiments were in duplicate on 0.2 acre plots; the figures are the average of the two plots.

TABLE N.

(Sabour.)

Number of seedlings	1912-13		1913-14	1914-15		1915-16	1916-17	
	Grain	Straw	Grain	Grain	Grain	Straw	Grain	Straw
1 to 2 in each hole . . .	2,005	4,261	2,001	992	976	2,776	1,028	2,091
4 to 6 in each hole . . .	2,469	4,580	2,878	1,152	1,192	3,309	1,195	2,415

The first year the experiments were on single plots of 0.1 acre each, and in the following years on 40 plots of 0.025 acre each, the figures are the average of the 40 plots.

(10) The distance apart at which to transplant the seedlings.

TABLE O.

(Sabour.)

Distance apart	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
6 inches . . .	1,252	...	1,616	4,787	1,479	3,537
9 inches . . .	942	...	1,160	4,200	1,485	2,990
12 inches . . .	667	...	877	3,282	1,212	2,255
16 inches . . .	442	...	660	2,605	560	1,645

Each year the experiments were on 0.05 acre plots.

(ii) Nigar.
TABLE P.

Kind of rice	Treatment	SOHARA.						AGEON.					
		1916		1917		1918		1916		1917		1918	
		Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
Main crop, harvested in December.	Nigarred at the usual time .	1,570	1,578	1,761	3,083	1,912	2,273	1,365	2,269	662	1,377	1,556	1,912
	Not nigarred	1,306	1,399	1,672	2,437	1,860	1,897	1,358	2,286	908	1,770	1,804	2,383
	Nigarred at the usual time+ <i>khari</i> salt.	1,797	2,026	1,638	1,652	1,872	2,082	1,424	2,206	1,027	1,512	1,707	2,081
	Not nigarred+ <i>khari</i> salt .	1,463	1,505	1,748	2,753	1,994	2,019	1,556	2,432	1,058	1,815	1,610	2,147
	Nigarred at the usual time but not allowed to dry enough to crack the soil.	1,760	1,645	1,843	2,826	1,865	1,533	1,481	2,465	841	1,512	1,073	1,355
	Nigarred on September 1st .	1,046	1,018	1,859	2,213	1,759	2,158	1,207	2,066	980	1,328	1,584	1,928
	Nigarred on September 15th .	1,153	1,069	1,422	2,098	1,866	2,180	821	1,776	768	1,045	1,547	1,903
	Nigarred on October 1st .	1,452	1,474	1,459	2,342	1,640	1,854	703	1,570	546	996	1,520	1,808
	Nigarred on October 15th .	1,325	1,377	1,768	2,361	1,700	2,232	1,443	2,687	907	1,500	1,225	1,762
	Nigarred at any time the weather permits from September 1st to October 15th	1,801	1,302	1,598	2,294	1,867	2,178	1,501	2,459	861	1,697	1,141	1,507
<i>Korika</i> , harvested in November.	Nigarred at any time the weather permits from September 1st to October 15th	1,512	1,447	1,667	3,101	1,943	2,377	1,370	2,306	781	1,512	1,395	1,746
	Nigarred at any time the weather permits from September 1st to October 15th but not allowed to dry enough to crack the soil.	1,746	1,676	1,950	2,095	1,610	2,113	..	..	854	1,476	..	..
	Nigarred at the usual time .	1,500	1,438	1,809	2,497	2,064	2,452	..	..	603	1,476	..	..
Not nigarred												607	860
												698	977

Each series was in duplicate. The area of the plots varied slightly in each series, at Sohara they were about 0.22 of an acre, at Ageon in one series 0.08 of an acre and in the other from about 0.2 to and 0.3 of an acre. The figures are the average of the two plots and are calculated on the exact area of the respective plots.

C. MANURIAL EXPERIMENTS.

1. Chemical manures.

TABLE Q.

(Cutlack.)

Manure applied per acre	1914-15		1915-16		1916-17	
	Grain	Straw	Grain	Straw	Grain	Straw
160 lb. of sulphate of ammonia + 120 lb. of superphosphate + 100 lb. of muriate of potash.	2,406	6,662	2,577	3,193	1,837	3,946
160 lb. of sulphate of ammonia + 120 lb. of superphosphate.	2,470	6,995	2,470	4,150	1,919	3,125
160 lb. of sulphate of ammonia + 100 lb. of muriate of potash.	2,388	6,611	2,542	4,130	2,024	3,459
120 lb. of superphosphate + 100 lb. of muriate of potash	1,999	4,546	2,031	2,649	1,809	2,767
Unmanured	1,947	4,433	1,901	2,008	1,498	2,995

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

(Bankipore.)

Manure applied per acre	1914-15						1915-16									
	RICE			GRAM			Year's profit	RICE			GRAM			Year's profit		
	Grain	Straw	Profit	Grain	Straw	Profit		Grain	Straw	Profit	Grain	Straw	Profit			
300 lb. of basic slag . . .	1,558	2,295	R a. 29 2		345	323	R a. 15 12	44 14	1,444	2,234	R a. 8 8		497	400	R a. 16 7	24 15
1,640 lb. of lime . . .	1,403	2,096	22 6		424	338	16 1	38 7	1,664	2,709	-28 14		536	570	20 13	-8 1
Unmanured . . .	1,501	2,106	37 15		400	300	15 11	53 10	1,494	2,291	26 4		717	609	27 6	33 10

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE S.

(Cuttack.)

Manure applied per acre	1916-17		1917-18		1918-19	
	Grain	Straw	Grain	Straw	Grain	Straw
Green manure + 1,230 lb. of lime.	2,425	3,305	2,204	3,229	1,773	2,998
Green manure (<i>dhaincha</i>) .	2,395	3,408	2,239	3,280	1,760	3,562

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

SUMMARY OF EXPERIMENTS ON RICE IN

2. Simple Manures.

TABLE T.
(Bankipore.)

Manure applied per acre	1914-15						1915-16					
	RICE			GRAM			RICE			GRAM		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
100 maunds of cowdung .	1,274	2,172	20 5	438	504	20 6	1,730	2,850	19 2	718	505	29 0
50 maunds of cowdung .	1,222	2,024	24 12	495	561	24 7	1,582	2,432	16 14	684	612	25 6
5 maunds of castor cake .	1,218	1,968	15 12	363	425	15 8	1,570	2,542	8 11	475	382	15 9
2 maunds of khari salt .	1,187	2,203	27 9	250	307	9 13	1,673	2,543	26 8	433	379	14 0
Green manure (dhaincha) .	1,139	1,973	26 0	568	562	27 12	1,550	2,306	23 2	686	614	26 11
Green manure (sanna) .	1,187	1,993	26 11	532	641	25 5	1,464	2,190	16 15	520	331	17 4
Unmanured .	933	1,717	20 1	379	439	16 11	1,391	2,158	20 14	638	537	23 11

Each year the experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE U.
(Bankipore.)

Manure applied per acre	1916-17.						1917-18.					
	RICE			GRAM			RICE			GRAM		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
2 maunds of khari salt .	2,436	3,000	60 13	484	400	14 1	1,830	2,823	31 5	550	507	16 0
Green manure (dhaincha) .	2,144	2,768	52 1	508	428	15 2	1,486	2,898	26 13	507	455	13 15
Unmanured .	1,980	2,370	49 10	538	440	16 1	2,032	3,968	46 12	600	576	18 11
2 maunds of khari salt .	1,730	2,560	31 3	1,112	1,032	37 10	2,026	2,178	30 5	1,003	848	30 5
Unmanured .	1,067	1,612	10 6	745	722	22 6	1,525	2,031	21 3	648	545	15 13

Each year the first three (those above the blank line) were in duplicate on 0.25 acre plots, the last two (those below the blank line) in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE V.
(Bankipore.)

Manure applied per acre	Grain	1918-19	
		Straw	Profit
			R a.
5 maunds of mustard cake	1,285	2,395	37 13
5 maunds of castor cake	1,315	2,765	34 9
55 maunds of cowdung	1,155	2,215	31 4
2 maunds of khari salt	1,335	2,480	64 15
Unmanured	1,330	2,965	51 11

The experiments were in duplicate on 0.2 acre plots, the figures are the average of the two plots.

TABLE W.
(Outtock.)

Manure applied per acre	1907-08			1908-09			1909-10			1910-11			1911-12		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
Unmanured	1,845	5,002	58 12	2,460	5,371	1,568	4,715	1,824	3,862	2,398	4,602	R a. 64 3	2,398	4,602	R a. 64 3
Green manure (dhaincha)	2,378	6,166	56 0	2,911	5,801	2,132	5,022	2,419	4,305	2,542	5,504	68 15	2,542	5,504	68 15
50 maunds of cowdung	..	..	60 15	..	..	..	..	..	..	2,439	4,940	62 6	2,439	4,940	62 6
50 maunds of village khatto	..	..	51 13	..	..	..	..	..	..	2,429	5,053	64 1	2,429	5,053	64 1
5 maunds of gingelly cake	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
100 maunds of cowdung	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3 maunds of khari salt	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Manure applied per acre	1912-13			1913-14			1913-14			1913-14		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
Unmanured	2,517	3,782	R a. 58 12	1,445	1,907	30 7	1,906	3,068	42 11	1,495	2,511	R a. 42 0
Green manure (dhaincha)	2,434	3,938	56 0	1,784	2,081	38 11	..	..	..	..	..	..
50 maunds of cowdung	2,690	3,870	60 15	1,464	1,907	26 10	2,260	2,808	46 11	..	..	..
50 maunds of village khatto	2,373	3,354	51 13	..	..	..	..	..	..	..	..	..
5 maunds of gingelly cake	..	..	..	1,451	1,722	19 7	1,876	2,870	30 11	..	..	..
100 maunds of cowdung	..	..	..	..	..	..	2,122	3,177	43 2	..	..	..
3 maunds of khari salt	..	..	..	..	..	..	..	..	..	1,702	3,023	R a. 35 3

(Cutback)—concl.

Manure applied per acre	1915-16			1916-17			1917-18		
	Grain	Straw	Profit	Grain	Straw	Profit	Grain	Straw	Profit
Unmanured	1,505	2,229	R a. 48 4	1,368	2,808	R a. 43 5	1,492	2,306	R a. 39 6
Green manure (<i>dhatncha</i>)	1,957	2,721	65 6	1,563	3,063	47 1	1,896	3,382	55 5
50 <i>maunds</i> of cowdung	1,763	2,654	56 5	1,470	2,716	48 6	..	..	..
50 <i>maunds</i> of village <i>khatto</i>	1,698	2,562	54 5	1,424	2,690	41 4	..	..	..
5 <i>maunds</i> of gingelly cake	..	..	..	..	..	..	..	..	..
100 <i>maunds</i> of cowdung	..	..	..	..	..	..	..	..	..
3 <i>maunds</i> of <i>khari</i> salt	..	..	..	..	..	..	..	..	..

From 1907-08 to 1911-12 inclusive the experiments were on 0.2 acre plots, the first two series of 1913-14 were on 0.16 acre plots, all the remainder were in duplicate on 0.2 acre plots, the figures in these cases being the average of the two plots. The second series in 1913-14 were on broadcast rice, the others as usual on transplanted rice.

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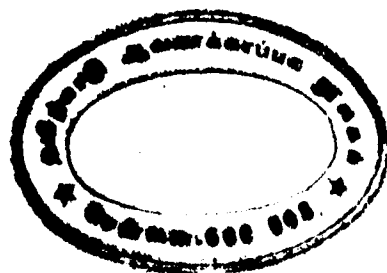
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