ulletin No. 157 1925

Agricultural Research Institute, Pusa

The Experimental Sullage Farm, Lyallpur

BY

P. E. LANDER, M.A., D.Sc., A.I.C.,
Agricultural Chemist to Government, Punjab.

CALCUTTA: GOVERNMENT OF INDIA
CENTRAL PUBLICATION BRANCH
1925

Government of India Publications are obtainable from the Government of India Central Publication Branch, 8, Hastings Street, Calcutta, and from the following Agents :—

EUROPE.

OFFICE OF THE HIGH COMMISSIONER FOR INDIA,
42, GROSVENOR GARDENS, LONDON, S.W. 1.

Ernest Leroux, 28, Rue Bonaparte, Paris.
Martinus Nijhoff, The Hague, Holland.
Otto Harrassowitz, Leipzig.
Friedländer und Sohn, Berlin.
and all Book-sellers in the United Kingdom.

INDIA AND CEYLON.

Provincial Book Depôts :

MADRAS :—Office of the Superintendent, Government Press, Mount Road, Madras.
BOMBAY :—Office of the Manager, Government Central Press, Bombay.
SIND :—Library attached to the Office of the Commissioner in Sind, Karachi.
BENGAL :—Office of the Bengal Secretariat Book Depôt, Writers' Buildings, Room No. 1, Ground Floor, Calcutta.
UNITED PROVINCES OF AGRA AND OUDH :—Office of the Superintendent of Government Press, United Provinces of Agra and Oudh, Allahabad.
PUNJAB :—Office of the Government of Punjab, Lahore.
BURMA :—Office of the Superintendent, Government Printing, Burma, Rangoon.
CENTRAL PROVINCES AND BERAR :—Office of the Central Provinces Secretariat, Nagpur.
ASSAM :—Office of the Superintendent, Assam Secretariat Press.
BIHAR AND ORISSA :—Office of the Superintendent, Government Printing, Bihar and Orissa, P. O. Gulzarbagh, Patna.
COORG :—Office of the Chief Commissioner of Coorg, Bangalore.
NORTH-WEST FRONTIER PROVINCE :—Government Press, Peshawar.

Thacker, Spink & Co., Calcutta and Simla.
W. Newman & Co., Ltd., Calcutta.
R. Cambray & Co., Calcutta.
S. K. Lahiri & Co., Calcutta.
The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.
Butterworth & Co. (India), Ltd., Calcutta.
Rai M. C. Sarcar Bahadur & Sons, 90-2A, Harrison Road, Calcutta.
The Weldon Library, 17, Park Street, Calcutta.
Standard Literature Company, Limited, Calcutta.
Association Press, Calcutta.
Chukerverrity, Chatterjee & Co., Ltd., 13, College Square, Calcutta.
Higginbotham & Co., Madras.
V. Kalyanarama Iyer & Co., Madras.
P. R. Rama Iyer & Co., Madras.
Rochouse and Sons, Madras.
Bright & Co., Trivandrum.
V. S. Swaminathan, Bookseller, West Tower Street, Madura.
Thacker & Co., Ltd., Bombay.
D. B. Taraporevala, Sons & Co., Bombay.
Sunder Pandurang, Bombay.
Ram Chandra Govind & Sons, Kalbadevi, Bombay.
N. M. Tripathi & Co., Booksellers, Princess Street, Kalbadevi Road, Bombay.
Proprietor, New Kitabkhana, Poona.
The Manager, Oriental Book Supplying Agency, 15, Shukrawar, Poona City.
R. S. Gondhalekar's Book Depôt, Publisher and Bookseller, Budhwar Chawk, Poona City.
Managing Director, Co-operative Bookstall, Booksellers and Publishers, Poona City.
The Standard Bookstall, Karachi, Rawalpindi, Murree, Lahore, Peshawar and Quetta.
e Book Company, Calcutta,

Burma Book Club Ltd., Rangoon.
Karsandas Narandas & Sons, Surat.
A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.
N. B. Mathur, Supdt., Nazir Kanun Hind Press, Allahabad.
The North India Christian Tract and Book Society, 18, Clive Road, Allahabad.
Ram Dayal Agarwala, 184, Katra, Allahabad.
Manager, Newal Kishore Press, Lucknow.
The Upper India Publishing House, Ltd., 41, Aminabad Park, Lucknow.
Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhi, Cawnpore.
Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allahabad.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
Puri Brothers, Booksellers and Publishers, Katcheri Road, Lahore.
Manager of the Imperial Book Depôt, 63, Chandney Chawk Street, Delhi.
Oxford Book and Stationery Company, Delhi.
Supdt., American Baptist Mission Press, Rangoon.
Proprietor, Rangoon Times Press, Rangoon.
The Modern Publishing House, Ltd., 30, Phayre Street, Rangoon.
The International Buddhist Book Depôt, Post Box No. 971, Rangoon.
Manager, the "Hitavada," Nagpur.
S. C. Talukdar, Proprietor, Students & Co., Cooch Behar.
Times of Ceylon Co., Ltd.
The Manager, Ceylon Observer, Colombo.
The Manager, The Indian Book Shop, Benares City.
B. C. Basak, Esq., Proprietor, Albert Library, Dacca;

PREFACE.

The following paper is an account of the operations carried on at the Experimental Sullage Farm at Lyallpur from the time of their commencement at the end of 1917, by Mr. Wilsdon, the then Agricultural Chemist, upto June 1924.

Full agricultural data and chemical data is given together with criticisms, and finally conclusions are given which have been arrived at after six and a half years' work. The agricultural operations have been conducted with the assistance of the Professor of Agriculture, Mr. H. R. Stewart, and the late Professor of Agriculture, Mr. Roberts.

P. E. LANDER.

The Experimental Sullage Farm, Lyallpur.

(*Received for publication on 1st September 1924.*)

The Experimental Sullage Farm at Lyallpur owes its origin to the fact that the town drainage system is situated so close to the Lyallpur Agricultural College that considerable nuisance from smell is experienced. In 1917, proposals were considered for removing the sullage water from the city to a greater distance both from the city and college, and it was decided, amongst the Director of Agriculture, the Agricultural Chemist and the Sanitary Engineer to Government, that the Agricultural Department should undertake experimental cultivation with sullage diluted with canal water with the object of obtaining results which might be useful not only in designing the Lyallpur drainage extensions but also have application to other towns. It was hoped to obtain knowledge of the most economical dilution for the application of sullage to agricultural lands. With a clearer knowledge of the factors influencing this figure it should be possible to decide the most suitable area per thousand of population which should be taken up for sullage disposal. It might also be possible to state the most profitable conditions of working where a municipality can supply continuous demand for irrigation water charged with sullage either from its own pumping installations, or by arrangement with the Irrigation Department. Besides the gaining of knowledge of these practical aspects, it was hoped to obtain valuable scientific data on the influence of concentration on the biological processes involved in the nitrification of the organic substances contained in sullage. Unfortunately certain factors which will be pointed out later have seriously mitigated the possibility of deducing accurate quantitative results, and only generalizations have been possible owing to the varying strengths of the sullage water from time to time.

Some very interesting results have nevertheless been obtained, and further light thrown on the important subject of nitrification. The Lyallpur Municipality agreed to place about two acres of uncultivated land at the disposal of the Agricultural Department for the purpose, but it was soon discovered that this land had certain serious drawbacks owing to its great unevenness in fertility. This was in some measure due to the fact that a part of the land was the site of an old slaughter

house, which would naturally give a higher fertility in its immediate neighbourhood. In work of this kind a fairly even "base line" of uniform fertility is to be desired if accurate conclusions are to be drawn from the agricultural and chemical data obtained.

However, on the 29th November, 1917, the Sanitary Board gave a grant of Rs. 1,350. A pair of tanks was constructed by the Agricultural Chemist, the plan of which is shown in the accompanying Fig. I. The tanks A and B were constructed as pair, each with

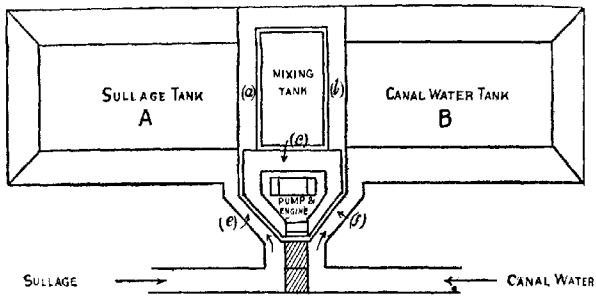

FIG. I. Sullage Tanks at Lyallpur.

splayed brick pitched floor and sides. A brickwork mixing sump with vertical walls was built between the tanks and connected to them by pipes controlled by valves. Sullage water was run into tank A and canal water into tank B, and the two liquids were run into the mixing tank in the proportions desired. Some trouble was experienced from the leakage of liquid from one tank to the other, tending to vitiate the experimental value of work.

To lift the sullage from the tanks a hand-power chain-pump, made by the Empire Engineering Company of Cawnpore, was fitted. With this apparatus 7,000 cu. ft. were lifted an average height of 6 ft. in 19 net working hours by four men. Including stoppages and rest for men employed, the gross working period was $3\frac{1}{2}$ days. While working, the pump lifted 5·9 cu. ft. per minute. Two men at a time were required to work the pump. The area irrigated in this manner was 0·45 acre and the pump men were paid one rupee a day, so the cost of irrigation worked at $4 \times 3\frac{1}{2} \times 1 \div 0{\cdot}45 =$ Rs. 31 per acre for one watering about 4 inches deep.

As the working of the chain-pump proved laborious, expensive and slow, it was removed, and a second-hand direct-coupled Crossley petrol

engine and centrifugal pump was fitted up in a shed by the Sanitary Board in 1920 at a cost of Rs. 224-8.

This plant worked for about a year when it had to be discarded as worn out, it was obsolete in design and spare parts were unobtainable. It was sold by public auction for Rs. 151 and was replaced in 1921 by 5 B.H.P. Petter Junior kerosine oil engine with belt drive to a 3" "Standard" unchokable centrifugal pump, output 130 gallons per minute at 1,350 revolutions per minute.

The Sanitary Board gave a grant of Rs. 3,461 for this work.

The pump when first put to work gave a discharge of 196 gallons per minute instead of only 130. Rs. 3,063 were actually spent on the pumping plant, and the balance was utilized by the Agricultural Chemist in the purchase of seed.

By the aid of this installation the effect of various methods of application could be tested by cropping and at the same time some degree of control exercised over the biological and chemical reactions taking place in the soil by methods already worked out.

The original laying out of the land is shown in Fig. II with 29 plots. The work was started at the end of 1917 and owing to the very uneven fertility of the land three crops were grown on it, in order, if possible, to reduce the margin of unevenness. Table I shows the yields from each crop from which it will be seen that the land was still by no means of even fertility. The variation of the yields is indicated for each plot, with fertility contours drawn in as shown on the diagram. It will be seen that the fertility rises to an extraordinary extent in the direction of the old slaughter house, at the spot marked "X".

It did not appear possible at this time to level up the fertility of the ground by exhaustive cropping, and consequently the experiments were started in the *rabi* of 1919 with the application of sullage in various stages of dilution. It has since transpired that there are some errors in Table I giving average yields and in the contours of average cropping power of the plots. The area of plots Nos. 25 to 29 should have been 0·15 acre instead of 0·2274 acre, and in the contour map the figures for plots 11 and 28 should have been 1·76 and 1·13 instead of 1·70 and 1·47 respectively even when the correction for the area of plots 25 to 29 is not applied. The general trend of contours, however, remains unaltered after the correction of error for area. It has been considered best to give the original table as it has appeared in the annual report for the year in question (1918-19) and also to recalculate the table for the correction mentioned. Table II (revised) also shows the rearrangement of the plots from 1 to 24 which were originally too small for carrying on

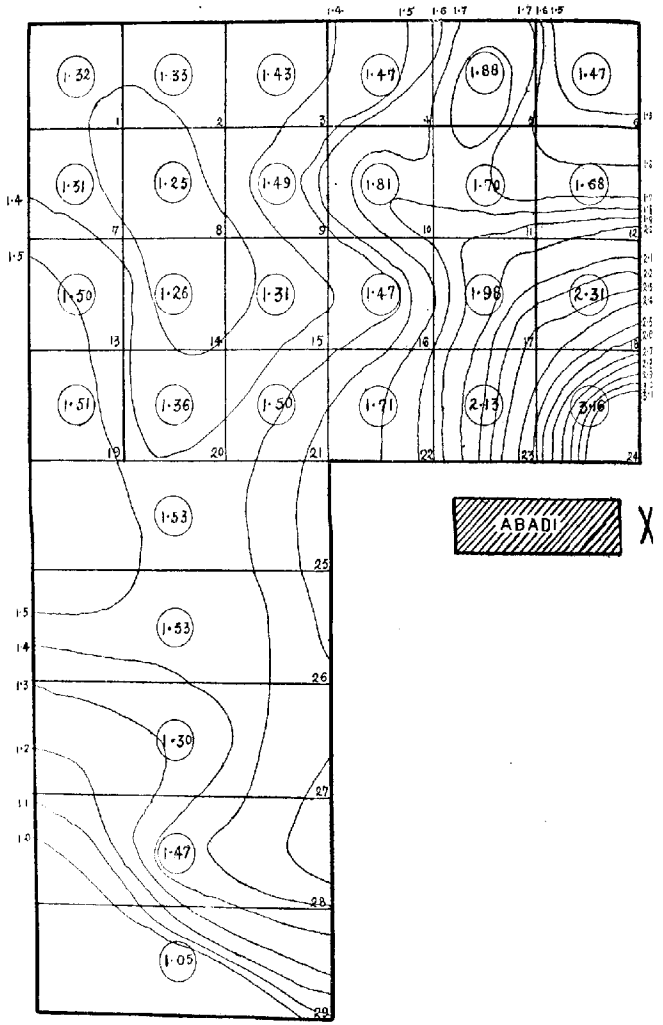

FIG. II Sullage Farm contours of average cropping power.

the agricultural operations, as well as introducing an error due to percolation. The rearrangement was made in the beginning of 1922 (Fig. III).

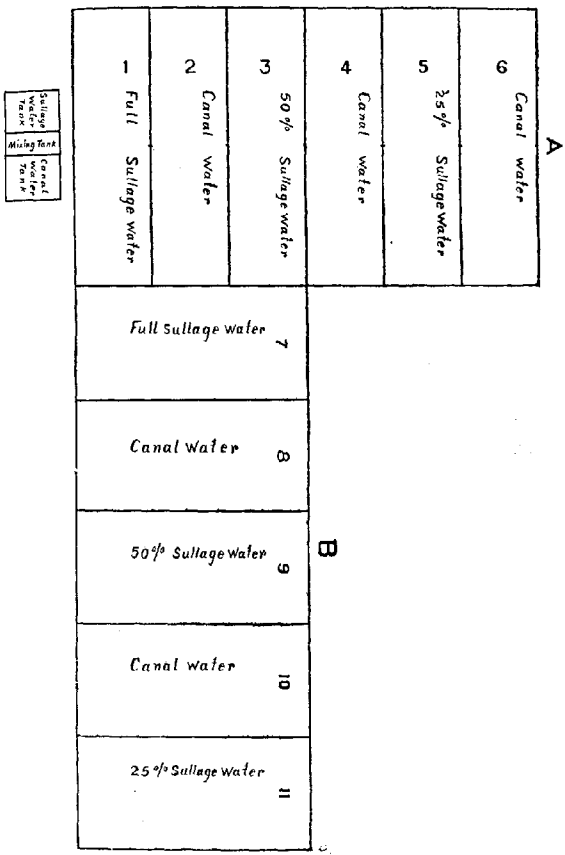

Fig. III. The Lyallpur Sullage Farm.

Table II thus shows us the particulars of the old plots, with their relative fertilities and the manner in which they were rearranged for the new series.

It may be permitted to anticipate here and refer to Table VIII compiled as a result of growing a wheat crop under canal water alone in the years 1923-24, in which the fertilities of these same plots are calculated from the relative yields of total grain and straw of the crop after several years' treatment, and can readily be compared with the originals. Comment will be made on these later.

Inspite of the aforesaid irregularities, work was started in accordance with the original *raison d'etre* of the farm. Wheat was sown on all the plots in October 1919 and the application of sullage was commenced in various stages of dilution with the canal water. The crop suffered considerably from lodging especially in smaller plots with full sullage and this tended to make the results of the yields less satisfactory. Wheat treated with sullage of any marked strength seems particularly prone to lodging, although there was no particular correlation between the degree of lodging and the treatment received.

The total nitrogen so added has been recorded and the changes of total and available nitrogen in the soil periodically examined. Three concentrations of sullage were employed, *viz.*, "full" 50 per cent. and 25 per cent. on one set of plots in addition to the canal water used on the control plots and on the other 75 per cent. sullage was applied also. Tables III and III(*a*) show the yields of wheat obtained, which have been compared with those obtained in the last season. It will be seen that there is no marked difference in the yields so far, and the land is still far from even. The amounts of the yields in the similarly treated plots compared with those obtained in the previous year afford some indication of the results of the treatment of sullage. This is shown in Table III (*a*) from which it will be seen that the lowest yields are obtained in all cases from the plots treated with full sullage. The figures were not sufficiently reliable to justify us in forming any opinion of the most effective concentration of sullage so far, but the results indicate that a concentration of 75 per cent. sullage gives the best results.

Table IV gives the results for the fluctuations in nitrogen and these are reproduced graphically in Figs. IV and V.

The explanation of the diagrams is as follows:—The nitrous and nitric-nitrogen curves show the absolute amount in lb. per acre in the top 18 inches at any particular date, while the thick black total nitrogen difference curve is the excess of total nitrogen over the minimum figure in any month and simply shows the fluctuation of total nitrogen. The

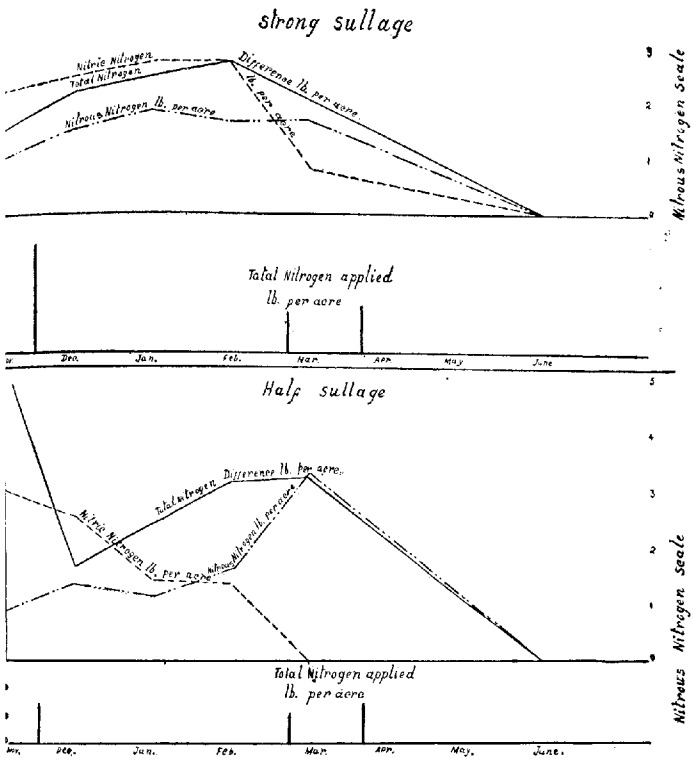

FIG. IV.

total nitrogen applied to the plots calculated on an acre works out as follows :—

Full sewage	. . . . .	74·36 lb.	per acre.
Half sewage	. . . . .	41·65 „	„ „
Quarter sewage	. . . . .	29·59 „	„ „
Canal	. . . . .	7·54 „	„ „

25 % sullage.

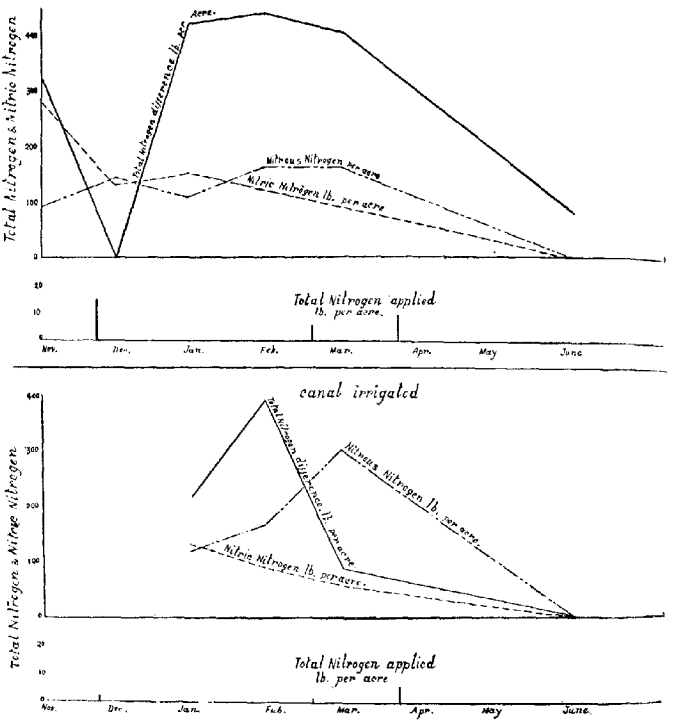

FIG. V.

In the same table is given the concentration of total nitrogen in mg. per 100 grm. of soil. It will be seen that there is no corresponding increase in the total nitrogen in those plots which receive the heaviest applications of sullage. The figures for available nitrogen are, however, more instructive. It will be seen from the diagram that after the point where a second application of manure was given in February rapid denitrification has taken place, this being most rapid in the

plots receiving full and half sullage. There is no corresponding fall in the nitric-nitrogen in the plots treated with weaker solutions. It appears probable therefore that the excess of organic matter applied with sullage at this point in the growth of the crop brings about denitrification which is probably responsible for the diminished yields.

The wheat crop from which these conclusions were drawn was followed by cane sown in March 1921. Sugarcane was selected because cane takes a greater number of waterings than wheat and thus was expected to bring into prominence the difference in the effect of sullage and its dilution. But the engine and the water lifting pump broke down in May thus preventing any mixing operations, and consequently only canal water was able to be applied to the crop, which was therefore a non-experimental one. At this period also the supply of canal water to the experimental farm was most unsatisfactory, just at the dry and hot period when it required it most, and the crop suffered severely on that account. No attempt was therefore made to tabulate data and the crop was handed over to the Professor of Agriculture in November.

A cropping scheme was now drawn up which would ensure an alternation of crops and also enable the land to lie fallow for certain periods. Fig. VIII shows the actual sequence followed.

We may now proceed to consider the results from these crops, which followed on the installation of the new pumping engine. Dealing first with the crops in the first half of the scheme taking us up to the end of June 1923, full details as to yields and waterings are shown in Table V, and Figs. VI and VII show the details of the total nitrogen in the soil during the course of the trials, the nitrogen of the canal and sullage irrigations, the nitric-nitrogen in the soil and the yield of green fodder in maunds per acre. From this table we note that the highest yields are given by plots receiving full sullage water, after taking into consideration the relative fertilities of the plots. It will be noted that the relative fertility rises from plot 1 to 6, but the yields, nevertheless, run in the opposite direction in the order of the strength of the sullage water. Plot 6 was non-experimental.

In the second crop grown in Block A the 50 per cent. sullage, however, did not give so high a yield as the 25 per cent. This may be explained by the varying strength of the sullage from time to time, as we note that the total nitrogen added to the soil in the case of first crop was at the rate of 24 lb. per acre with the 50 per cent. sullage and 13·63 with the 25 per cent., whereas with the second crop the corresponding figures are 27·1 and 22·7 although the actual yields do not run strictly parallel with these figures. On the whole the various yields in the second were lower than in the first, in spite of a somewhat greater total

nitrogen content in the irrigations with the exception of the full sullage.

It is interesting in this connection to note, however, that the total nitrogen content of the soil steadily rises from August to September as seen in Figs. VI and VII.

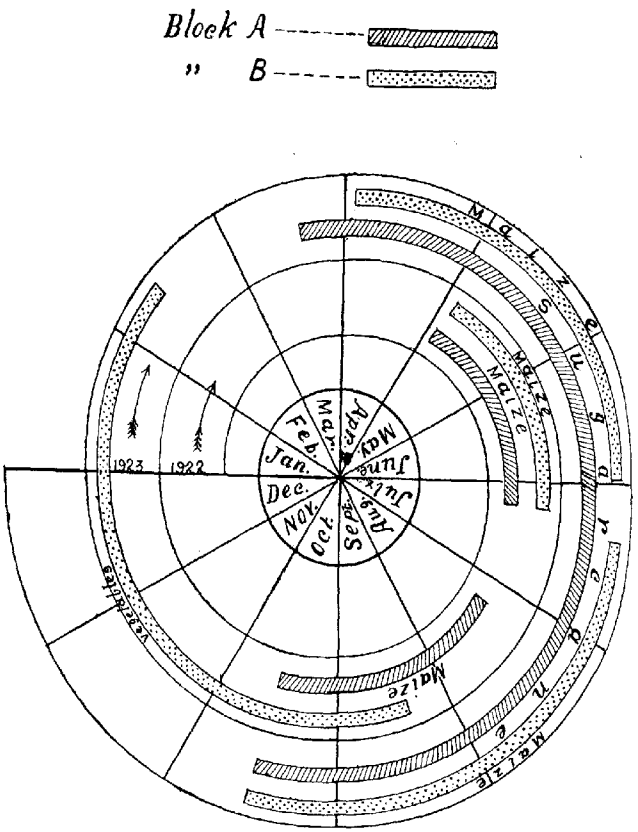

FIG. VIII Showing sequence of crops, May 1922 to October 1923.

These nitrogen content curves are very interesting as showing in all the plots a certain uniformity of rise and fall as the season progresses, and it is instructive to note that the increase or decrease of the total nitrogen content of the soil is out of all proportion to that contained in the irrigation water, there being fluctuations in the total nitrogen content of the soil from 650 to 1,300 lb. per acre. A reference to the curves also shows that the lowest figure for the total nitrogen is proportionately higher on these plots which had received sullage and the difference runs more or less parallel to the concentrations. In view of these wide variations in the natural fluctuations of the nitrogen in the soil, it is extremely difficult to definitely correlate yields with the concentration of the sullage itself which varies within such wide limits. It would appear that conclusions as to the use of sullage water can best be drawn from the yields of much larger plots, and of a greater degree of uniformity than this land presents, but the general indication from the maize fodder crops is that full sullage is best in this case.

As this crop, however, is a short time crop, and is ready for use after about 2 months after only three irrigations, a too hasty conclusion must not be drawn.

Block B. Maize and vegetables. A maize crop was sown on this plot on 3rd May and was gathered on 6th July, 1922. Full details are given in Table V and Figs. VI and VII.

In this case the full sullage was given to the richest plot, being the reverse of the applications in Block A, where the full sullage was given to the plots of lowest fertility, and we still find that the yields run parallel with the strength of the sullage added. The curves show much the same general features, with the exception of the fact that, while in plots 7, 8 and 10 the total nitrogen in the soil rises in August and falls in September, the reverse occurs in plots 9 and 11. It is difficult to explain this anomaly, and again the natural fluctuation of the total nitrogen content of the soil is out of all proportion to that added in the irrigation water. In trials on other Lyallpur soils the same fluctuations in the total nitrogen content have also been noted from month to month, and at Rothamsted extremely large fluctuations have also been noted from day to day and even from hour to hour.

These variations hence render an accurate interpretation of the effect of sullage water a matter of great difficulty.

Trials on vegetables. After this maize crop was gathered, the land was prepared for vegetables which were sown early in September.

The vegetables grown were :—Cauliflower, turnips, raddishes, spinach and carrots.

It is not easy to compile accurate results from small pieces of land of the yield of such crops as these, especially as they are not all gathered at the same time. As far as has been possible, however, Table VI shows the results calculated to the acre, in yields, relative fertility and total nitrogen added.

It is practically impossible to draw any conclusions or correlation between the yields and the analytical figures for the added nitrogen. It was noted, however, that full sullage water was detrimental to carrots and turnips, causing them to rot, burst and acquire a bitter taste. Full sullage water appeared to suit the other vegetables quite well.

The curves of nitrogen contents are shown in Figs. VI and VIII (September to November) and the same remarks hold good as were mentioned for the maize crop.

We have seen that maize is a crop which is perhaps best suited to receive applications of full sullage water, and it would be interesting at this point to consider, from the number of waterings and the amount applied at each irrigation, the volume of sullage water required per acre of maize, and also, basing our figures on those obtained from the Lyallpur water, to calculate the total nitrogen figure.

In our experiments the number of waterings given per maize fodder crop was four representing 189,699 gallons per acre, spread over two months, and in this sullage water the concentration of total nitrogen varied from 0·019 grm. of total nitrogen to 0·059 grm. per 1,000 c.c. of water, giving us a manurial value of from 9 to 28 lb. of nitrogen per acre per irrigation in the case of the maize crop, these being the average figures obtained from the Lyallpur full sullage.

For wheat this is too high a concentration as lodging is the result, and the best concentration as far as one has been able to judge is one-quarter of the above figures calculated on three or four waterings.

In the case of vegetables full sullage was beneficial to cauliflower and spinach which received eight waterings and consequently double the above figures apply in this case.

For underground vegetables full sullage is not suitable in the strengths as recorded, and 25 per cent. appears to produce the best results.

It is regretted that no reliable figures have yet been obtained from cane owing to the failure of the crop about which further comment will be made later.

Following the vegetable crop on Block B, another maize crop was sown in April and gathered in June 1923. The results showing the calculated yield per acre and amount of nitrogen added in the various applications of sullage are shown in Table VII. We note that the plot

receiving full sullage water gives by far the greatest yield, thus confirming previous observations. The total nitrogen added during the course of the trial corresponded to 89·05 lb. per acre. The figures for the nitrogen added to the two canal water plots are considerably lower, but the yields from the control plots show no consistency with the yields from 25 per cent. and 50 per cent. sullage water plots where nitrogen added works out to 31·28 and 47·18 lb. per acre respectively. These facts, as pointed out before, render a quantitative interpretation very difficult, and almost prohibit conclusions being drawn. Having dealt with the crops on the first half of the scheme as above mentioned during which sullage water was applied, the second half deals with a cane crop sown on Block A in March 1923 and gathered in October 1923, and a succeeding wheat crop sown in November 1923 and gathered in May 1924. This latter crop was grown on the whole farm. In Block B one maize crop preceded wheat but was spoiled by heavy rains and declared non-experimental.

The cane crop unfortunately did not germinate well and later on was badly attacked by white ants, vitiating the crop trials from an experimental point of view to such an extent that it was not considered worth while to keep any records. The crop was accordingly handed over to the Professor of Agriculture to be fed as fodder.

The wheat crop. Only canal water was applied, as at this stage it was thought advisable to obtain some knowledge of the state of the relative fertilities of the various plots, after their treatment with sullage. Full details are given in Table VIII which gives the calculated yields per acre from the various plots both for grain, straw and total produce. If we examine this table the residual effect of previous applications of full sullage does not manifest itself in a pronounced increase of grain. The highest yield of grain shows itself on the 25 per cent. and 50 per cent. plots, the full sullage plots come next, while those plots which had received canal water throughout come lowest with an average yield of from 18 to 20 mds. per acre. Turning to the yields of straw the highest yields are again given by the 50 per cent. and 25 per cent. plots in Block A, but by full sullage plot in Block B, where the richest plot had been receiving the full sullage. The canal water plots come last.

The conclusion that might possibly be drawn from these figures, taking into consideration the previous lodging effects noticed with full sullage water and considering that these figures are the result of the residual effect of previous applications, is that 25 per cent. or at most 50 per cent. sullage as represented by the concentrations of the Lyallpur water should be applied to a wheat crop.

Fertility figures. On the basis of these yields an attempt has been made to plot the relative fertilities of the various plots, and compare them with those given for the plots before the experiment was started. In Table IX are given the old and new fertilities of the plots derived from the yield of grain and straw combined and for grain and straw separately. Taking the plots which have throughout received canal water only, there is a general tendency for the land to become poorer with the exception of two cases, but it must be remembered that no manure of any sort has been applied to these plots during the course of the experiment.

The two plots which have received full sullage water show opposite results similarly the two 50 per cent. plots. The two 25 per cent. plots show a slight increase of fertility in each case, but it will be obvious that the figures are of such a nature as to preclude the possibility of drawing any hard and fast conclusions.

Conclusions.

For reasons which have been recounted, the present sullage farm is not entirely satisfactory, its uneven fertility and small size tending to militate against obtaining as accurate results as might be wished.

Some very interesting results have, nevertheless, been obtained on crop results, and also in connection with the phenomenon of nitrogen fixation. It has been found that the natural fluctuations in the total nitrogen content of the soil even over short periods of time are out of all proportion to the nitrogen which has been applied in the sullage water. Improved crop yields would, therefore, not appear to be the result merely of an increased application of nitrogen over that contained in the canal water, but might also be considered to depend on certain accessory factors which the sullage water furnishes and which with a little stretch of the imagination could be placed in the same category as the well-known accessory food factors so important to animal life. So far no detailed investigations have been made on the micro-organisms of the soil of the sullage *versus* canal water treatment, but it is hoped with the extension of the Bacteriological Department that work in this connection may be carried out.

Wheat appears to be unsuited for treatment with sullage owing to its great tendency to lodge when growth is forced, as the sullage water always tends to increase vegetative growth, and is thus most suitable for those crops where a heavy vegetative growth is required, such as in fodder crops. Whenever heavy dressings of manure, both artificial and oilcakes, are applied to wheat the crop generally lodges and

yields are accordingly lowered, and only very weak applications of sullage can be applied without producing this effect.

The crops best suited for treatment with sullage are green fodders, vegetables and sugarcane, where a forced vegetative growth is required.

Maize does very well and can occupy the ground from April till October during which time three heavy crops can be obtained. It can then be followed by winter oats. This would appear to be one of the best rotations for the use of sullage water.

Underground vegetables tend to crack and burst when grown on too rich a soil, or with too heavy an application of manure, and this effect is brought about with sullage water except when in great dilution. This was particularly noticed in carrots and turnips, which moreover acquired a somewhat unpleasant taste. On the other hand, those vegetables such as cauliflower and spinach whose edible portion is above ground are improved both in condition and yield by sullage water.

Thick sugarcane has not so far done well on the farm, one of the main difficulties being that this crop must be grown where a plenty supply of water is available in order to apply water every six days or so which is not practicable on the present site except for the full sullage, but with care and attention there is no reason why it should not be grown successfully. Very good crops are grown on sullage at Amritsar. It requires heavy manurial treatment and frequent waterings, and further trials are being carried out with full sullage water.

The sequence of rotation which is being followed at the present time is maize, oats and thick cane. These are always in great demand in the neighbourhood of large towns and are good paying crops.

In conclusion, I would record my appreciation of the valuable advice and assistance given by Mr. Stewart who has been in charge of the agricultural part of the work and to Pandit Lal Chand Dharmani who has been largely responsible for the chemical part.

TABLE I.

Plot	Area	Yield in sr.	Treatment of crop	Yield in sr.	Treatment of crop	Yield in sr.	Treatment of crop	Yield (in sr.) if area were 0·05 acre			Relative yields			Average relative yields
								Chari	*Swank* and Maize	Wheat and *Bhusa*	Chari	Maize	Wheat.	
1	0·05	160	Chari sown 17th April 1918. Harvested 21st June 1918. Irrigated 26th April 1918, etc.	162	Mixture of Swank and Maize sown 17th August 1918. Irrigated 19th September 1918 and 28th September 1918. Harvested 25th October 1918.	61	Wheat sown 4th December 1918. Irrigated 25th January, 28th February and 2nd April 1919. Harvested 29th April 1919.	160	162	61	1·12	1·59	1·24	1·32
2	0·05	184		165		53		184	165	53	1·29	1·61	1·08	1·33
3	0·05	207		165		60		207	165	60	1·45	1·61	1·22	1·43
4	0·05	225		161		62		225	161	62	1·58	1·58	1·26	1·47
5	0·05	297		195		80		297	195	80	2·09	1·91	1·63	1·88
6	0·05	218		178		57		218	178	57	1·53	1·74	1·16	1·47
7	0·0425	158		120		51		186	141	60	1·32	1·38	1·22	1·31
8	0·05	169		146		55		169	146	55	1·19	1·43	1·12	1·25
9	0·05	195		159		75		195	159	75	1·37	1·56	1·53	1·49
10	0·05	269		215		70		269	215	70	1·89	2·11	1·42	1·81
11	0·05	305		193		62		305	193	62	2·14	1·89	1·26	1·80
12	0·05	243		163		86		243	163	86	1·71	1·59	1·75	1·68
13	0·0425	186		142		56		219	167	66	1·54	1·63	1·34	1·50
14	0·05	150		166		54		150	166	54	1·05	1·62	1·10	1·26
15	0·05	149		177		57		149	177	57	1·05	1·73	1·16	1·31
16	0·05	220		171		59		220	171	59	1·54	1·67	1·20	1·47
17	0·05	295		197		95		295	197	95	2·07	1·93	1·94	1·98
18	0·05	281		232		132		281	232	132	1·97	2·27	2·69	2·31
19	0·05	205		180		65		205	180	65	1·44	1·76	1·32	1·51
20	0·05	192		164		56		192	164	56	1·35	1·60	1·14	1·36
21	0·05	142		174		89		142	174	89	1·00	1·70	1·81	1·50
22	0·05	185		195		94		185	195	94	1·30	1·91	1·91	1·71
23	0·05	287		187		124		287	187	124	2·02	1·83	2·53	2·13
24	0·05	365		318		188		365	318	188	2·57	3·11	3·81	3·16
25	0·2274	770		715		416		169	157	91	1·19	1·54	1·85	1·53
26	0·2274	751		815		372		165	179	82	1·16	1·75	1·67	1·53
27	0·2274	690		617		330		152	136	73	1·07	1·33	1·49	1·30
28	0·2274	792		552		224		174	121	49	1·22	1·18	1·00	1·13
29	0·2274	702		464		238		154	102	52	1·08	1·00	1·06	1·05

TABLE II.

Table showing average relative yields of plots after application of correction for areas of plots 25—29, and after rearrangement of plots.

Plots	Area as given in old table	Corrected area •	Yield (in ar.) if area were 0·05 acre			Relative yields			Average relative yields	Plots	Average relative yields	Plot No. after rearrangement	Average of yields after correction of plots	Average relative yields
			Chari	*Swank* and Maize	Wheat and *Bhusa*	*Chari*	*Swank* and Maize	Wheat and *Bhusa*						
1	0·05	0·05	160	162	61	1·12	1·15	1·15	1·14	1	1·14	1+ 7+13+19	1·28	1·09
2	0·05	0·05	184	165	53	1·29	1·17	1·00	1·15	7	1·15			
3	0·05	0·05	207	165	60	1·45	1·17	1·13	1·25	13	1·32	1		
4	0·05	0·05	225	161	62	1·58	1·14	1·17	1·30	19	1·32			
5	0·05	0·05	297	195	80	2·09	1·38	1·51	1·66	2	1·15	2+ 8+14+20	1·13	1·00
6	0·05	0·05	218	178	57	1·53	1·26	1·08	1·29	8	1·09			
7	0·0425	0·0425	186	141	60	1·32	1·00	1·13	1·15	14	1·08	2		
8	0·05	0·05	169	146	55	1·19	1·04	1·04	1·09	20	1·19			
9	0·05	0·05	195	159	75	1·37	1·13	1·42	1·31	3	1·25	3+ 9+15+21	1·25	1·11
10	0·05	0·05	269	215	70	1·89	1·53	1·32	1·58	9	1·31			
11	0·05	0·05	305	193	62	2·14	1·37	1·17	1·56	15	1·13	3		
12	0·05	0·05	243	163	86	1·71	1·16	1·62	1·50	21	1·30			
13	0·0425	0·0425	219	167	66	1·54	1·18	1·25	1·32	4	1·30	4+10+16+22	1·41	1·25
14	0·05	0·05	150	166	54	1·05	1·18	1·02	1·08	10	1·58			
15	0·05	0·05	149	177	57	1·05	1·26	1·08	1·13	16	1·29	4		
16	0·05	0·05	220	171	59	1·54	1·21	1·11	1·29	22	1·48			
17	0·05	0·05	295	197	95	2·07	1·40	1·79	1·75	5	1·66	5+11+17+23	1·72	1·52
18	0·05	0·05	281	232	132	1·97	1·65	2·49	2·04	11	1·56			
19	0·05	0·05	205	180	65	1·44	1·28	1·23	1·32	17	1·75	5		
20	0·05	0·05	192	164	56	1·35	1·16	1·06	1·19	23	1·89			
21	0·05	0·05	142	174	89	1·00	1·23	1·68	1·30	6	1·29	6+12+18+24	1·91	1·69
22	0·05	0·05	185	195	94	1·30	1·38	1·77	1·48	12	1·50			
23	0·05	0·05	287	187	124	2·02	1·33	2·34	1·89	18	2·04			
24	0·05	0·05	365	318	188	2·57	2·26	3·55	2·78	24	2·79	6		
25	0·2274	0·15	257	238	139	1·81	1·69	2·62	2·04	25	2·04	7	2·04	1·81
26	0·2274	0·15	250	272	124	1·76	1·93	2·34	2·01	26	2·01	8	2·01	1·78
27	0·2274	0·15	230	206	110	1·62	1·46	2·08	1·72	27	1·72	9	1·72	1·52
28	0·2274	0·15	204	184	75	1·86	1·31	1·42	1·53	28	1·53	10	1·53	1·35
29	0·2274	0·15	234	155	79	1·65	1·10	1·49	1·41	29	1·41	11	1·41	1·25

TABLE III.

Comparison of this year's yield with last year's produce.

No. of Plot	Treatment	Area in acres	Yield in sr. This year's 1919-20	Yield in sr. Last year's 1918-19	Increase or decrease	Per cent. increase or decrease	Ratio	REMARKS
1	Canal only.	0·05	160	64	+108	+177	2·77	
2	,,	0·05	210	53	+157	+296·2	3·96	
3	,,	0·05	211·5	60	+151·5	+252·5	3·53	
4	,,	0·05	189	62	+127	+204·8	3·05	
5	,,	0·05	186·5	80	+106·5	+133·1	2·33	
6	,,	0·05	181	57	+84	+147·4	2·47	
7	¼ Sewage, ¾ Canal.	0·0425	175·25	60	+115·25	+192·1	2·92	
8	,, ,,	0·05	184	55	+129	+234·6	3·35	
9	,, ,,	0·05	220	75	+145	+193·4	2·93	
10	,, ,,	0·05	230	70	+160	+228·6	3·29	
11	,, ,,	0·05	217	62	+155	+250	3·5	
12	,, ,,	0·05	165·5	86	+ 79·5	+ 92·5	1·92	
13	½ Sewage, ½ Canal.	0·0425	188·2	66	+122·2	+185·2	2·85	
14	,, ,,	0·05	210	54	+156	+288·9	3·89	
15	,, ,,	0·05	222	57	+165	+288·5	3·89	
16	,, ,,	0·05	234	59	+175	+296·6	3·97	
17	,, ,,	0·05	252	95	+157	+165·3	2·65	
18	,, ,,	0·05	217	132	+ 85	+ 64·4	1·64	
19	Sewage only.	0·05	171	65	+106	+163·1	2·63	
20	,, ,,	0·05	206	56	+150	+267·9	3·68	
21	,, ,,	0·05	222	89	+133	+149·5	2·49	
22	,, ,,	0·05	196	94	+102	+108·5	2·09	
23	,, ,,	0·05	213	124	+ 89	+ 71·8	1·72	
24	,, ,,	0·05	177	188	— 11	— 5·8	0·94	

TABLE III (*a*).

Treatment	Yield (in sr.) if area were 0·05 acre: Grain and straw	Grain	Straw	Relative yields: Grain and straw	Grain	Straw	Comparison with last year's crop: Ratio	Per cent. increase or decrease	REMARKS
Small plots:—Canal irrigated.	184·5	63·3	121·16	1·03	1	1·08	3·02	+201·95	
¼ Canal+¾ Sewage.	196·62	63·9	134·78	1·00	1·009	1·2	2·97	+196·53	
½ Canal+½ Sewage.	220·3	64·5	156·0	1·21	1·019	1·4	3·15	+214·08	
Sewage only	197·5	57·21	140·29	1·085	0·9	1·24	2·26	+125·8	
Big plots:—Canal irrigated.	187·68	65·5	122·18	1·03	1·034	1·09	2·205	+100·3	
¾ Canal+¼ Sewage.	193·5	75·75	117·75	1·06	1·19	1·05	1·45	+145·0	
½ Canal+½ Sewage.	182·0	69·5	112·5	1	1·09	1	1·65	+65·5	
Sewage only	**198·25**	**72·0**	**126·25**	**1·09**	**1·14**	**1·12**	**1·43**	**+42·8**	

TABLE IV.

No. of plot	Treatment	Area in acres	Yield in sr.			Yield (in sr.) if area were 0·05 acre			Relative yields			Total nitrogen supplied lb.
			Grain and straw	Grain	Straw	Grain and straw	Grain	Straw	Grain and straw	Grain	Straw	
25	Sewage only . .	0·15	595	214·75	380·25	198·25	72	126·25	1·4	1·57	1·35	11·15
26	Canal only . . .	0·15	568	204·0	365·0	189·25	67·25	122	1·34	1·49	1·29	1·13
27	Half-sewage . .	0·15	546	208·5	337·5	182·0	69·5	112·5	1·29	1·53	1·2	6·25
28	Canal only . . .	0·15	558	191·5	366·5	186·0	63·75	122·25	1·32	1·40	1·3	1·13
	½ Sewage . . .	0·15	581	227·5	353·5	193·5	76·75	117·73	1·37	1·67	1·26	4·44

TABLE IV—*concld.*

No. of plot	Treatment	Area in acres	Nitrogen contents of the soil (mg. per 100 grm. of soil)											
			November			December			January			February		
			Total N	Nitrous N	Nitric N	Total N	Nitrous N	Nitric N	Total N	Nitrous N	Nitric N	Total N	Nitrous N	Nitric N
25	Sewage only	0·15	47·23	0·022	4·4	48·50	0·03	4·8	48·99	0·036	5·3	49·53	0·032	5·3
26	Canal only	0·15	..	..	..	..	..	..	48·19	0·024	3·0	52·68	0·034	2·0
27	Half sewage	0·15	52·0	0·018	6·2	44·29	0·028	5·2	45·74	0·024	3·0	47·91	0·034	2·8
28	Canal only	0·15	..	..	..	..	..	..	50·09	0·024	2·2	50·23	0·032	1·6
29	¼ Sewage	0·15	50·98	0·018	5·5	44·4	0·028	2·6	53·02	0·022	3·0	53·22	0·032	2·4

No. of plot	Treatment	Area in acres	Nitrogen contents of the soil (mg. per 100 grm. of soil)						Comparison with last year's crop.				
			March			June			This year's yield 1919-20	Last year's yield 1918-19	Increase or decrease	Per cent. increase or decrease	Ratio
			Total N	Nitrous N	Nitric N	Total N	Nitrous N	Nitric N					
25	Sewage only	0·15	48·31	0·032	1·6	44·3	nil	nil	198·5	139	+59·5	+42·8	1·43
26	Canal only	0·15	41·45	0·076	1·2	43·85	nil	nil	139·25	124	+65·25	+52·26	1·53
27	Half sewage	0·15	48·05	0·068	nil	41·07	nil	nil	182	110	+72	+65·5	1·65
28	Canal only	0·15	50·02	0·044	1·2	43·65	nil	nil	186	75	+111	+148	2·48
29	¼ Sewage	0·15	52·55	0·032	1·8	46·05	nil	nil	193·5	79	+114·5	+145	2·45

TABLE V.

Showing the effect of different dilutions of sullage on maize (fodder crop).

No. of plot	Treatment	Relative fertility of plots before the application of sullage water. A. C.'s report 1918-19	I. Maize fodder crop. Sown 3-V-22. Gathered 6-VII-22.			II. Maize fodder crop. Grown 6-VIII-22. Gathered 15-X-22.		
			Yield of green fodder in md. per acre	Total nitrogen in each of the 3 irrigations given and total nitrogen added in lb. per acre	Total nitrogen removed by the crop lb. per acre	Yield of green fodder in md. per acre	Total nitrogen in each of the 3 irrigations given and total nitrogen added in lb. per acre	Total nitrogen removed by the crop lb. per acre
1	Full sullage . .	1·09	210	1. 18·7 2. 28·1 3. 9·13 } 55·93	24·9	146	1. 17·8 2. 13·5 3. 14·2 } 45·5	31·56
2	Canal . . .	1·0	190	1. 0·54 2. 0·87 } 1·41	22·6	117	1. 0·75 2. 1·90 3. 1·70 } 4·35	22·56
3	50 per cent. sullage	1·11	199	1. 4·01 2. 14·2 3. 6·03 } 24·24	23·7	129	1. 9·3 2. 8·1 3. 9·7 } 27·1	25·43
4	Canal . . .	1·25	172	1. 0·54 2. 0·87 } 1·41	20·4	128	1. 0·75 2. 1·90 3. 1·70 } 4·35	21·13
5	25 per cent. sullage	1·51	192	1. 2·68 2. 8·02 3. 2·93 } 13·63	22·8	131	1. 8·5 2. 6·4 3. 7·8 } 22·7	23·42

TABLE V—*concld.*

Showing the effect of different dilutions of sullage on maize (fodder crop).

No. of plot	Treatment	Relative fertility of plots before the application of sullage water. A. C.'s report 1918-19	I. Maize fodder crop. Sown 3-V-22. Gathered 6-VII-22.			II. Maize fodder crop. Grown 6-VIII-22. Gathered 15-X-22.		
			Yield of green fodder in md. per acre	Total nitrogen in each of the 3 irrigations given and total nitrogen added in lb. per acre	Total nitrogen removed by the crop lb. per acre	Yield of green fodder in md. per acre	Total nitrogen in each of the 3 irrigations given and total nitrogen added in lb. per acre	Total nitrogen removed by the crop lb. per acre
7	Full sullage . . .	1·81	244	1. 25·0 2. 37·4 3. 12·2 } 74·6	29·0	Winter vegetables sown September 1922—February 1923	1. 24·5 2. 22·9 3. 26·2 } 73·6	Not Estimated.
8	Canal . . .	1·78	142	1. 0·71 2. 1·17 } 1·88	16·8		1. 1·30 2. 2·05 3. 1·06 } 4·41	
9	50 per cent. sullage	1·52	167	1. 5·35 2. 18·90 3. 8·04 } 32·29	19·8		1. 12·2 2. 14·0 3. 12·4 } 38·6	
10	Canal . . .	1·35	131	1. 0·71 2. 1·17 } 1·88	15·6		1. 1·30 2. 2·05 3. 1·06 } 4·41	
11	25 per cent. sullage	1·25	128·5	1. 3·57 2. 10·70 3. 3·91 } 18·18	15·3		1. 6·45 2. 6·46 3. 6·40 } 19·31	

TABLE VI.

Vegetables (September 1922—February 1923).

No. of plots	Treatment	Relative fertility of plots before the application of sullage water. A. C.'s report 1918-19	Cauliflower yield per acre in md.	Raddish and turnips yield per acre in md.	Carrots yield per acre in md.	Spinach yield per acre in md.	Total nitrogen in each of the three irrigations given and total nitrogen added in lb. per acre
			Md. sr. ch.	Md. sr. ch.	Md. sr. ch.	Md. sr. ch.	
7	Full sullage	1·81	14 24 7	33 2 11	22 28 13	28 20 0	1. 24·5 2. 22·9 3. 26·2 } 73·6
8	Canal	1·78	7 26 11	31 18 11	22 38 6	18 24 0	1. 1·30 2. 2·05 3. 1·06 } 4·41
9	50 per cent. sullage	1·52	9 24 7	25 13 5	36 12 13	22 0 0	1. 12·2 2. 14·0 3. 12·4 } 38·6
10	Canal	1·35	5 20 0	16 0 0	40 0 0	20 8 0	1. 1·30 2. 2·05 3. 1·06 } 4·41
11	25 per cent. sullage	1·25	9 0 0	39 10 11	34 9 10	30 12 0	1. 6·45 2. 6·46 3. 6·40 } 19·31

TABLE VII.

Maize fodder crop sown on 4th April and gathered on 19-28th June, 1923.

No. of plots	Treatment	Yield of green fodder per acre	Total nitrogen added in irrigation water lb. per acre	REMARKS
		Md. sr. ch.		
7	Full sullage . .	283 26 11	24-4-23 :— 1·62 2-5-23 :—28·87 20-5-23 :—29·96 8-6-23 :—28·60 89·05	
8	Canal . .	194 23 5	24-4-23 :— 1·62 2-5-23 :— 1·38 20-5-23 :— 1·86 8-6-23 :— 1·62 6·48	
9	50 per cent. sullage .	158 23 5	24-4-23 :— 1·62 2-5-23 :—16·04 20-5-23 :—10·25 8-6-23 :—19·27 47·18	
10	Canal . . .	125 20 0	24-4-23 :— 1·62 2-5-23 :— 1·38 20-5-23 :— 1·86 8-6-23 :— 1·62 6·48	
11	25 per cent. sullage .	157 16 11	24-4-23 :— 1·62 2-5-23 :—11·90 29-5-23 :—10·71 8-6-23 :— 7·05 31·28	

TABLE VIII.

Wheat 1923-24—grown on canal water. Yields per acre.

No. of Plots	Area of each plot in acres	Treatment	Weight of bundles, straw and grain	Weight of grain	Weight of straw	REMARKS
			Md. sr. ch.	Md. sr. ch.	Md. sr. ch.	Figures in italics show the relative yields in each column. The crop was grown on canal water alone. Wheat sown on 16th Nov. 1923 in plots 7-11. Wheat sown on 21st Nov. 1923 in plots 1-6. Wheat harvested in the 1st week of May 1924 in plots 1-11. Irrigation given on 15th January 1924, 17th March 1924, and 8th April 1924.
1	0·2	Full . .	75 37 8 *1·44*	24 12 8 *1·28*	51 25 0 *1·55*	
2	0·2	Canal . .	70 37 8 *1·35*	22 25 8 *1·19*	48 12 0 *1·45*	
3	0·2	50 per cent. .	85 5 0 *1·62*	29 0 0 *1·53*	56 5 0 *1·68*	
4	0·2	Canal . .	74 30 0 *1·42*	22 35 0 *1·21*	51 35 0 *1·55*	
5	0·2	25 per cent. .	89 17 8 *1·70*	28 35 0 *1·52*	60 22 8 *1·81*	
6	0·2	Canal . .	67 37 8 *1·29*	18 38 12 *1·00*	48 38 12 *1·47*	
7	0·15	Full . .	73 36 11 *1·40*	23 0 0 *1·21*	50 36 11 *1·52*	
8	0·15	Canal . .	52 26 11 *1·00*	19 10 0 *1·02*	33 16 11 *1·00*	
9	0·15	50 per cent. .	72 20 0 *1·38*	24 36 11 *1·31*	47 23 5 *1·42*	
10	0·15	Canal . .	55 23 5 *1·06*	19 16 11 *1·02*	36 6 11 *1·08*	
11	0·15	25 per cent. .	70 20 0 *1·34*	24 35 0 *1·31*	45 25 0 *1·37*	

TABLE IX.

Comparison of the relative yields of wheat crop 1923-24 from different plots with original relative fertility yields of the plots.

No. of plots	Treatment	Original relative yields 1918-19 (grain and straw) average of 3 crops	Relative yield of wheat 1923-24 crop		
			Total crop	Grain	Bhusa
1	Full . .	1·09	1·44	1·28	1·55
2	Canal . .	1·00	1·35	1·19	1·45
3	50 per cent. .	1·11	1·62	1·53	1·68
4	Canal . .	1·25	1·42	1·21	1·55
5	25 per cent. .	1·52	1·70	1·52	1·81
6	Canal . .	1·69	1·29	1·00	1·47
7	Full . .	1·81	1·40	1·21	1·52
8	Canal . .	1·78	1·00	1·02	1·00
9	50 per cent. .	1·52	1·38	1·31	1·42
10	Canal . .	1·35	1·06	1·02	1·08
11	25 per cent. .	1·25	1·34	1·31	1·37

PUBLICATIONS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

TO BE HAD FROM

THE MANAGER, GOVERNMENT OF INDIA CENTRAL PUBLICATION BRANCH, 8, HASTINGS STREET, CALCUTTA;

THE OFFICE OF THE AGRICULTURAL ADVISER TO THE GOVERNMENT OF INDIA, PUSA, BIHAR;

AND

ALL AGENTS FOR SALE OF GOVERNMENT PUBLICATIONS.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the above-mentioned.

These publications are :—

1. The *Agricultural Journal of India.* A Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription*, Rs. 6 or 9*s.* 6*d.*, including postage. Single copy, R. 1-8 or 2*s.*
2. Scientific Reports of the Agricultural Research Institute, Pusa.
3. Annual Review of Agricultural Operations in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India.
   - (*a*) Botanical Series.
   - (*b*) Chemical Series.
   - (*c*) Entomological Series.
   - (*d*) Bacteriological Series.
   - (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Indigo Publications.
9. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and Secretary, Sugar Bureau), for the year 1922-23. Price, R. 1.

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, the Physiological Chemist, and Secretary, Sugar Bureau), for the year 1923-24. Price, R. 1 or 1*s.* 8*d.*

Review of Agricultural Operations in India, 1921-22. Price, R. 1-4.

Review of Agricultural Operations in India, 1922-23. Price, R. 1-10.

Proceedings of the Board of Agriculture in India, held at Bangalore on 21st January, 1924, and following days (with appendices). Price, R. 1.

Proceedings of the Cattle Conference, held at Bangalore on 22nd and 23rd January, 1924 (with appendices). Price, As. 9.

Report of the Proceedings of the Fifth Entomological Meeting, held at Pusa, 5th to 10th February, 1923. Price, Rs. 9-8.

Proceedings of the Second Meeting of Veterinary Officers in India, held at Calcutta from 26th February to 2nd March, 1923 (with appendices). Price, R. 1-12.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

Botanical Series.

Vol. XII, No. II. I—History of the operations against Bud-Rot of Palms in South India. II—Inoculation Experiments with *Phytophthora palmivora* Butl. on *Borassus flabellifer* Linn. and *Cocos nucifera* Linn., by W. McRae, M.A., B.Sc. Price, R. 1-4 or 2*s*.

Vol. XII, No. III. Studies in Inheritance in Cotton, I. History of a cross between *G. herbaceum* and *G. Neglectum*, by G. L. Kottur, M.Ag. Price, R. 1-4 or 1*s*. 9*d*.

Vol. XII, No. IV. Studies in Indian Oil Seeds. No. 2. Linseed, by Gabrielle L. C. Howard, M.A., and Abdur Rahman Khan. Price, R. 1-4 or 2*s*.

Vol. XII, No. V. Studies in Gujarat Cottons, Part II, by Maganlal L. Patel, B.Ag. Price, R. 1-12 or 3*s*.

Vol. XIII, No. I. Studies in Indian Tobaccos. No. 4.—Parthenocarpy and Parthenogenesis in the varieties of *Nicotiana Tabacum* L. var. *Cuba* and var. *Mirodato*, by Gabrielle L. C. Howard, M.A., and Kashi Ram. No. 5.—The Inheritance of Characters in *Nicotiana rustica* L., by Gabrielle L. C. Howrad, M.A. Price, Rs. 2-2 or 2*s*. 9*d*.

Vol. XIII, No. II. The Wilt Disease of Safflower, by S. D. Joshi, B.Sc. Price, R. 1 or 1*s*. 6*d*.

Vol. XIII, No. III. Studies in Indian Fibre Plants. No. 3. On the Inheritance of Characters in *Hibiscus Sabdariffa* L., by Albert Howard, C.I.E., and Gabrielle L. C. Howard, M.A. Price, Rs. 2 or 3*s*.

Vol. XIII, No. IV. The Mahali Disease of Coconuts in Malabar, by S. Sundararaman, M.A., and T. S. Ramakrishnan, B.A. Price, As. 12 or 1*s*.

Vol. XIII, No V. The Eradication of *Cyperus rotundus* L.: A Study in Pure and Applied Botany, by S. B. Ranade, B.Sc., and arranged and written by W. Burns, D.Sc. (*In the press.*)

Vol. XIII, No. VI. Studies in Diseases of the Jute Plant. (2) *Macrophoma Corchori* Saw., by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. Price, As. 8 or 9*d*.

Chemical Series.

Vol. VI, No. VII. Chemical Studies on Safflower Seed and its Germination, by V. A. Tamhane, M.Sc., M.Ag. Price, As. 10 or 1*s*.

Vol. VI, No. VIII. Note on the Permanent Manurial Plots, Coimbatore, by Roland V. Norris, D.Sc. Price, R. 1-4 or 1*s*. 9*d*.

Vol. VII, No. I. A Note on Hydrocyanic Acid in the Burma Bean (*Phaseolus lunatus*, spd.), by F. J. Warth, M.Sc., B.Sc. Price, As. 12 or 1*s*.

Vol. VII, No. II. Studies of an Acid Soil in Assam, II, by A. A. Meggitt, B.Sc. Price, As. 12 or 1*s*.

Vol. VII, No. III. A Preliminary Note on the Decomposition of Calcium Cyanamide in South Indian Soils, by Roland V. Norris, D.Sc., F.I.C., B. Viswanath and C. V. Ramaswami Ayyar, L.Ag. Price, As. 12 or 1*s*.

Vol. VII, No. IV. Some Digestibility Trials on Indian Feeding Stuffs, by P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.Ag. Price, As. 12 or 1*s*.

Vol. VII, No V. The Buffer Action of Some Burma Soils, by J. Charlton, M.Sc. Price, As. 12 or 1*s*.

Vol. VII, No. VI. Studies in the Chemistry of Sugarcane, II. Some Factors that determine the ripeness of Sugarcane, by B. Viswanath, F.I.C., and S. Kasiinatha Ayyar, B.A. Price, As. 8 or 9*d*.

Vol. VII, No VII. The Phosphatic Nodules of Trichinopoly and the availability of Flour Phosphate as a Manure for Paddy, by Rao Sahib M. R. Ramaswami Sivan, B.A., Dip. Agr. (*In the press.*)

Entomological Series.

l. VII, No. XI. Studies in Indian Dermaptera, by MORGAN HEBARD. Price, R. 1-4 or 1*s.* 9*d.*
l. VII, No. XII. Further Notes on *Pempheres affinis*, Fst. (The Cotton Stem Weevil), by E. BALLARD, B.A., F.E.S. Price, R. 1 or 1*s.* 4*d.*
l. VII, No. XIII. An Account of Experiments on the Control of *Siya* (*Schœnobius*) *incertellus* in the Godavari Delta, by E. BALLARD, B.A., F.E.S. Price, As. 14 or 1*s.* 4*d.*
l. VIII, Nos. I, II & III. *Hydrophilidæ* of India, by A. D'ORCHYMONT; An Annotated List of Ichneumonidæ in the Pusa Collection, by G. R. DUTT, B.A.; A Second Note on Odonata in the Pusa Collection, by MAJOR F. C. FRASER. Price, R. 1 or 1*s.* 6*d.*
l. VIII, No. IV. Notes on Indian Muscidæ, by R. SENIOR-WHITE, F.E.S. Price, As. 12 or 1*s.*
l. VIII, Nos. V—IX. Papers on Indian Tabanidæ, by P. V. ISAAC, B.A., D.I.C., M.SC., F.E.S.; Two Drosophilidæ, from Coimbatore and a New Aphidiphagous Fly, by J. R. MALLOCH; Notes on Indian Odonata in the Pusa Collection, by MAJOR F. C. FRASER, I.M.S.; On New and Old Oriental Cicindelidæ, by Dr. WALTHER HORN. Price, R. 1-4 or 2*s.*
l. VIII, Nos. X & XI. Papers on Indian Tabanidæ, by P. V. ISAAC, B.A., D.I.C., M.SC., F.E.S.; and Some Indian Species of the Dipterous Genus *Atherigona*, Rondani, by J. R. MALLOCH. (*In the press.*)
l. VIII, No. XII. The Nim Mealy Scale (*Pulvinaria maxima*, Green), by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S. (*In the press.*)

Bacteriological Series.

ol. II, No. I. Nitrogen Fixation in the Punjab, by P. E. LANDER, M.A., D.SC., A.I.C., and BARKAT ALI, L.AG. Price As. 8 or 10*d.*

Veterinary Series.

ol. III, No. VI. Nasal Granuloma in Cattle, by V. KRISHNAMURTI AYYAR, L.V.S. (*In the press.*)

Bulletins issued by the Agricultural Research Institute, Pusa.

No. 141. Comparative Manurial Value of the whole plants and the different parts of Green Manures, by N. V. JOSHI, B.A., M.SC., L.AG. Price, As. 6.
No. 142. The Cultivation of Lac in the Plains of India, by C. S. MISRA, B.A. Price, R. 1-8.
No. 143. Ber (*Zizyphus jujuba*) Fruit and its Fly Pest, by J. L. KHARE, F.E.S. Price, As. 6.
No. 144. Observations on the Morphology and Life-cycle of *Filaria recondita* Grassi, by M. ANANT NARAYAN RAO. Price, As. 6.
No. 145. Some Observations on the Barren Soils of Lower Bari Doab Colony in the Punjab, by S. M. NASIR. Price, As. 3.
No. 146. The Prevention of Nuisances caused by the Parboiling of Paddy, by J. CHARLTON, B.SC., A.I.C. Price, As. 5.
No. 147. List of Publications on Indian Entomology, 1922 (compiled by the Imperial Entomologist). Price, As. 7.
No. 148. The Relative Responsibility of Physical Heat and Micro-organisms for the Hot Weather Rotting of Potatoes in Western India, by S. L. AJREKAR, B.A., and J. D. RANADIVE, B.AG. Price, As. 5.
No. 149. A Study of the Factors Operative in the value of Green Manure, by B. H. WILSDON, B.A., I.E.S., P. E. LANDER, M.A., D.SC., A.I.C., and M. MUKAND LAL, L. AG. Price, As. 5.
No. 150. The Improvement of Fodder and Forage in India (Papers read before a Joint Meeting of the Sections of Agriculture and Botany, Indian Science Congress, Lucknow, 1923), edited by GABRIELLE L. C. HOWARD, M.A. Price, As. 6.
No. 151. A method for the Accurate Determination of Carbonic Acid present as Carbonate in Soils, by PHANI BHUSAN SANYAL, M.SC. Price, As. 2.
No. 152. The External Morphology and Bionomics of the Commonest Indian Tick (*Hyalomma aegyptium*), by MOHAMMAD SHARIF, M.A., F.R.M.S. Price, R. 1.
No. 153. Tamarind as a source of Alcohol and Tartaric Acid, by H. N. BATHAM, M.A., and L. S. NIGAM, L.AG. Price, As. 3 or 4*d.*

Bulletins issued by the Agricultural Research Institute, Pusa—*concld.*

No. 154. The Bionomics of the Sarcopic Mange Parasite of the Buffalo with some observations co cerning the relative power of resistance to adverse conditions of the different stages the Acarus and of its egg, by T. M. TIMONEY, M.R.C.V.S. Price, As. 2.

No. 155. List of Publications on Indian Entomology, 1923 (compiled by the Imperial Entomologi Price, As. 11 or 1*s.*

No. 156. Bud and Boll Shedding in Cotton, by G. R. HILSON, B.Sc., V. RAMANATHA AYYAR, L.Ag and R. CHOKKALINGAM PILLAI, L.Ag. Price As. 14 or 1*s.* 6*d.*

No. 157. The Experimental Sullage Farm, Lyallpur, by P. E. LANDER, M.A., D.SC., A.I Price As. 12 or 1*s.* 3*d.*

No. 158. A New Fodder (Siloed *Shisham* Leaves) for Dairy Cows, by P. E. LANDER, M.A., D.Sc., A.I and LAL CHAND DHARMANI, L.Ag. Price, As. 6 or 8*d.*

Indigo Publication.

No. 12. Indigo Experiments, 1922. (1) The effect on produce when vatliquor is allowed to stan in the beating vat and beating is delayed; (2) The effect of neutralizing the liquor wi caustic soda before beating by J. H. WALTON, M.A., M.Sc. Price, As. 4.

Books.

Wheat in India, by ALBERT HOWARD, M.A., A.R.C.S., F.L.S., and GABRIELLE L. C. HOWARD, M.A. Pric Rs. 5 or 7*s.* 6*d.*

A Description of the Imperial Bacteriological Laboratory, Muktesar; Its Work and Products, by MAJ J. D. E. HOLMES, M.A., D.Sc., M.R.C.V.S. Price, As. 8 or 9*d.*

Agriculture in India, by JAMES MACKENNA, M.A., I.C.S. Price, As. 4 or 5*d.*

Some Diseases of Cattle in India. A Handbook for Stock-owners. Price, As. 8 or 9*d.*

Report on the Diseases of Silkworms in India, by A. PRINGLE JAMESON, D.Sc. Price, Rs. 3.

Notice.

All new publications are included in the above list and are regularly posted to all on the mailing li as soon as issued. Unless complaints of non-receipt of any publication are received by the Manage Government of India Central Publication Branch, 8, Hastings Street, Calcutta, within six month of the date of issue, duplicate copies can be supplied only on payment of cost and postage.

G1PC—M—IV-2-76—11-6 25—750