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PROCEEDINGS

OF THE

oard of Agriculture in India

Held at Pusa on the 9th December, 1929
and following days

WITH APPENDICES



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The Fifteenth Meeting of the Board of Agriculture in India.

INTRODUCTORY.

The Fifteenth Meeting of the Board of Agriculture in India was held on the 9th December 1929 and following days under the presidency of Dewan Bahadur Sir T. Vijayaraghavachariar, Vice-Chairman of the Imperial Council of Agricultural Research.

MEMBERS.

The members present were :—

1. Dewan Bahadur Sir T. Vijayaraghavachariar, K.B.E., Vice-Chairman, Imperial Council of Agricultural Research. (*Ex-officio President.*)
2. J. H. Ritchie, M.A., B.Sc., Secretary, Indian Central Cotton Committee. (*Secretary.*)
3. B. C. Burt, C.I.E., M.B.E., B.Sc., F.C.S., Agricultural Expert, Imperial Council of Agricultural Research.
4. M. S. A. Hydari, I.C.S., Secretary, Imperial Council of Agricultural Research.
5. W. H. Harrison, D.Sc., Officiating Director, Imperial Institute of Agricultural Research, Pusa.
6. F. Ware, F.R.C.V.S., Officiating Director, Imperial Institute of Veterinary Research, Muktesar.
7. W. McRae, M.A., D.Sc., F.L.S., Officiating Joint Director and Imperial Mycologist, Imperial Institute of Agricultural Research, Pusa.
8. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., Imperial Economic Botanist, Imperial Institute of Agricultural Research, Pusa.
9. T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, Imperial Institute of Agricultural Research, Pusa.
10. J. H. Walton, M.A., M.Sc., Imperial Agricultural Bacteriologist, Imperial Institute of Agricultural Research, Pusa.

11. J. Sen, M.A., PH.D., Officiating Imperial Agricultural Chemist, Imperial Institute of Agricultural Research, Pusa.
12. M. Wynne Sayer, B.A., Officiating Imperial Agriculturist, Imperial Institute of Agricultural Research, Pusa.
13. W. Smith, Imperial Dairy Expert, Imperial Institute of Animal Husbandry and Dairying, Bangalore.
14. F. J. Warth, M.Sc., Physiological Chemist, Imperial Institute of Animal Husbandry and Dairying, Bangalore.
15. G. P. Hector, M.A., D.Sc., Officiating Director of Agriculture, Bengal.
16. K. McLean, B.Sc., Assistant Director of Agriculture, Bengal.
17. F. J. Gossip, Livestock Expert, Bengal.
18. P. J. Kerr, M.R.C.V.S., Director, Civil Veterinary Department, and Veterinary Adviser to Government of Bengal.
19. W. Burns, D.Sc., Officiating Director of Agriculture, Bombay Presidency.
20. Rao Saheb B. P. Vagholkar, Deputy Director of Agriculture, South Central Division, Bombay Presidency.
21. Ali Muhammad Ulvi, B.AG., Acting Livestock Expert to Government, Bombay Presidency.
22. K. Hewlett, O.B.E., M.R.C.V.S., Principal, Bombay Veterinary College, Bombay.
23. G. R. Hilson, B.Sc., Officiating Director of Agriculture, Madras.
24. R. W. Littlewood, N.D.A., Deputy Director of Agriculture, Livestock, Madras.
25. Rao Bahadur B. Viswanath Garu, F.I.C., F.C.S., Government Agricultural Chemist, Madras.
26. P. T. Saunders, O.B.E., M.R.C.V.S., Officiating Director of Veterinary Services, Madras.
27. G. S. Henderson, N.D.A., N.D.D., Director of Agriculture, Bihar and Orissa.
28. D. R. Sethi, M.A., B.Sc., Deputy Director of Agriculture, Bihar and Orissa.

29. C. A. Maclean, M.B.E., M.C., M.A., B.Sc., Deputy Director of Agriculture, Bihar and Orissa.
30. P. B. Riley, M.R.C.V.S., Officiating Director, Civil Veterinary Department, and Veterinary Adviser to Government, Bihar and Orissa.
31. P. B. Richards, A.R.C.S., F.E.S., Entomologist to Government, United Provinces.
32. C. Mayadas, M.A., B.Sc., Principal and Professor of Agriculture, Agricultural College, Cawnpore.
33. D. Milne, C.I.E., B.Sc., Director of Agriculture, Punjab.
34. D. P. Johnston, A.R.C.Sc.I., N.D.A., Professor of Agriculture, Agricultural College, Punjab.
35. Muhammad Afzal Hussain, M.Sc., M.A., Entomologist to Government, Punjab.
36. T. F. Quirke, M.R.C.V.S., Director of Veterinary Services, Punjab.
37. F. J. Plymen, C.I.E., A.C.G.I., Director of Agriculture, Central Provinces.
38. E. A. H. Churchill, B.Sc., Deputy Director of Agriculture, Central Provinces.
39. A. McKerral, M.A., B.Sc., Director of Agriculture, Burma.
40. F. D. Odell, M.A., Deputy Director of Agriculture, Burma.
41. J. N. Chakravarty, B.A., M.S.A., M.R.A.S., Deputy Director of Agriculture, Assam.
42. R. C. Woodford, Livestock Expert, Assam.
43. W. Harris, M.R.C.V.S., Superintendent, Civil Veterinary Department, Assam.
44. W. Robertson Brown, Agricultural Officer, North-West Frontier Province.
45. S. M. A. Shah, B.Sc., M.R.C.V.S., Superintendent, Civil Veterinary Department, North-West Frontier Province.
46. P. H. Carpenter, F.I.C., F.C.S., Chief Scientific Officer, Indian Tea Association.
47. L. C. Coleman, M.A., PH.D., Director of Agriculture, Mysore State.
48. C. V. Sane, M.Sc., B.AG., Director of Agriculture, Baroda State.

49. Charan Singh, Director of Agriculture and Horticulture, Jammu and Kashmir State.
50. Harchand Singh, L.Ag., Director of Agriculture, Patiala State.
51. H. H. Pandya, M.Sc., L.Ag., Administrative Officer, Department of Agriculture, Gwalior State.

In addition, the following attended as visitors :—

1. The Hon'ble Sir Saiyid Muhammad Fakhr-ud-din, Khan Bahadur, Kt., Minister in charge of Agriculture, Bihar and Orissa.
2. Sir Frank Noyce, Kt., C.S.I., C.B.E., I.C.S., Secretary to the Government of India, Department of Education, Health and Lands.
3. B. K. Gokhale, I.C.S., Secretary to the Government of Bihar and Orissa, Education and Development Department.
4. Lt.-Col. G. F. Mellor, Director of Farms, Army Headquarters, Simla.
5. Lt.-Col. J. Matson, O.B.E., Assistant Controller, Military Dairy Farms, Southern Circle, Jubbulpore.
6. G. K. Devadhar, M.A., C.I.E., President, Servants of India Society, Poona.
7. W. Roberts, B.Sc., of the British Cotton Growing Association, Khanewal, Punjab.
8. C. M. Hutchinson, C.I.E., of the Imperial Chemical Industries, Ltd., Calcutta.
9. S. Higginbottom, M.A., M.Sc., Principal, Agricultural Institute, Allahabad.
10. P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), Pusa.
11. Zal R. Kothawala, B.Ag., B.Sc., N.D.D., Assistant to the Imperial Dairy Expert, Bangalore (*Joint Secretary*).
12. J. S. Garewal, M.R.C.V.S., Livestock Officer to Government, Punjab.
13. A. P. Cliff, B.A., Dip. Agri. Deputy Director of Agriculture, Bihar and Orissa.
14. N. N. Bose, Superintendent, Co-operative Milk Societies, Calcutta.

15. A. K. B. Cazi, Lecturer in Entomology, Agricultural College, Poona.

16. P. G. Malkani, B.Sc., M.R.C.V.S., Temporary Veterinary Research Officer, Imperial Institute of Veterinary Research, Muktesar.

Agenda.

I. To review the progress made in developing cattle-breeding and dairying and to make recommendations on :—

(i) the standardisation of records which should be maintained at cattle-breeding farms with a view to determine correctly the progress in the improvement of cattle.

(ii) The possibilities of organising the dairy industry on a co-operative basis by the Co-operative Departments in India.

(iii) The position of grassland in the improvement of cattle and the possibility of improving such grassland.

II. To review the work done up-to-date on animal nutrition in India ; what steps should be taken to develop and extend this work and in what way the Provincial Departments can best co-operate with the Physiological Chemist in work on this subject.

III. Locust problem in India—to discuss the question of investigating the biology of the insect and to make suggestions for control measures.

IV. The desirability of discussing the subject of the best means of bringing improved methods of agriculture to the notice of cultivators, at future meetings of the Board.

V.A. To review the present position of mechanical cultivation in India : A discussion on (*a*) the possibility of introducing tractor cultivation, (*b*) special kinds of cultivation for which it is suited, (*c*) the best kind of machine and (*d*) the pooling of knowledge obtained in other Provinces.

B. Investigations into the best method of determining the draught of bullock-drawn implements preferably at one centre for the whole of India.

VI. Collection and publication of work on soils in India.

VII. Water requirements of crops – to discuss the question of accurately measuring the amount of water required for various kinds of crops, especially the more valuable kinds, and the period during which waterings should take place to give optimum results.

VIII. To consider recommendation 27 of Chapter XIV of the Report of the Royal Commission on Agriculture, to make recommendations and to suggest suitable problems for economic enquiry.

IX. To consider the need for mathematical assistance in the study of agricultural genetics and economic problems and how this need should be met.

X. To select a place and date for the next Cattle Conference and to discuss the advisability of combining this with Sectional Meetings of Officers representing veterinary, medicine, animal nutrition and animal genetics.

XI. Protection of crops from depredations of wild animals—to discuss the question in the light of experience gained since 1925.

XII. To review the results of the permanent experimental plots at Pusa and to make proposals for this line of work in future.

PROCEEDINGS.

FIRST DAY.

The Fifteenth Meeting of the Board of Agriculture in India was opened at Pusa on Monday, the 9th December, 1929, by Dewan Bahadur Sir T. Vijayaraghavachariar, Vice-Chairman of the Imperial Council of Agricultural Research.

The Hon'ble Sir Saiyid Muhammad Fakhr-ud-din, Minister of Agriculture for Bihar and Orissa, Sir Frank Noyce, Secretary to the Government of India, Department of Education, Health and Lands, and several other distinguished gentlemen were present.

Sir T. Vijayaraghavachariar in his opening address said :—

GENTLEMEN,—I am very pleased to welcome you from all parts of India to this meeting of the Board of Agriculture. I should like to make special mention of two distinguished visitors, the first being Sir Saiyid Muhammad Fakhr-ud-din who holds the record, unequalled in India, of being Minister continuously from the commencement of the Reforms ; the second is to Sir Frank Noyce whom I have known as a personal friend for nearly 25 years. I knew him first as an Assistant Special Settlement Officer in the Madras Presidency ; no other officer in the whole of India has such a working knowledge of Commissions and Committees. By reason of the intimate knowledge he has acquired of agricultural subjects, Sir Frank, though born a layman, can now be said to have been admitted into the company of the elect.

It is usual to refer, at meetings of the Board, to prominent and outstanding facts connected with agriculture that have occurred since the previous meeting. The last meeting of the Board was held four years ago since which time the Board has come of age. There is always trouble when an individual passes from boyhood to manhood and I think this can also be said of the Board of Agriculture, but there is no doubt that the future of the Board is now assured. The most outstanding fact since the last meeting has been the visit of the Royal Commission on Agriculture and its Report which is now the official Bible of all the Departments of Agriculture in India. The Royal Commission recommended the formation of an Imperial Council of Agricultural Research and this was inaugurated last June by His Excellency the Viceroy.

I wish to refer very briefly to the constitution of this Council which met last week at Pusa. It consists of two parts—a Governing Body and an Advisory Board. The Advisory Board consists, roughly speaking, of experts, and the Governing Body, again roughly speaking, of non-experts. The Governing Body gets advice from the Advisory Body and its chief business is to sanction funds for the research schemes put forward by the Advisory Board.

It was decided at the recent meeting of the Imperial Council of Agricultural Research that the Board of Agriculture should now be called "THE BOARD OF AGRICULTURE AND ANIMAL HUSBANDRY". The Board is to consist of two wings, one to deal with soils and crops and the other with animal husbandry and animal health. This settles a long standing grievance. It has also been decided to have a meeting of the two wings in alternate years. It has been recommended that all the work connected with the Board should be transferred from the Government of India to the Imperial Council of Agricultural Research and that the Secretary of the Imperial Council should also be the Secretary to the Board but assisted for each meeting by two experts from each wing. The constitution of both the wings has been enlarged and though an attempt was made to get an equal number, it was found that the Agriculture wing would out-number the Animal Husbandry wing by one member. In future the membership will consist of 101 members for Agriculture and 100 for Animal Husbandry. The chief reason for the increase in members is due to the demand of Local Governments to include non-official members. The membership now includes 20 non-officials elected by the Provinces and five representatives from the Universities. The official representation has not been reduced. I think it was a very good idea to bring the Universities into touch with the work carried on by this Board. I trust that the composition of the Board will meet with the approval of this meeting.

I wish to mention a few other items of interest to us settled at the meeting of the Imperial Council. In future there will be three kinds of Journals, two scientific—one on agricultural matters and one on animal husbandry—and, in addition, a popular Journal in continuation of the present Agricultural Journal of India. The publication work has been transferred to the Council,—to the charge of the Vice-Chairman, the two Experts and the Secretary,—assisted by two Experts eminent in Agriculture and Animal Husbandry. The scientific Journals will be divided into two parts, the first consisting of original articles and the second of abstracts of work done in the Provinces and selected abstracts of work done in foreign

countries. In order to keep the Provincial abstracts up to date correspondents will be appointed in the Provinces who will be remunerated for their services.

A Sugar Committee has been appointed which has held its first session and submitted an interim report. One of the main recommendations of this Committee is that, during the period of agricultural reconstruction now in progress in India, protection should be given to the industry. The Council has recommended that the Tariff Board should investigate this question. They have also recommended that the present *ad valorem* duty on low grade sugar should be changed to a specific duty. A grant of Rs. 6,000 has been sanctioned to Shahjahanpur to carry on the work of testing new seedlings. A sum of Rs. 8,000 has been allotted to each of the three big sugar producing Provinces, for evolving an approved type of small sugar crushing mill, and it has also been decided to give a prize of Rs. 20,000 to the person who invents the best mill. No restriction has been placed on the status of the inventor, and Government servants will be eligible to compete. A large grant is also proposed for enlarging the Harcourt Butler Technological Institute in the United Provinces to enable it to carry out more work on sugar and expand into an all-India institution.

The inauguration of the Imperial Council of Agricultural Research was a step which appeared to be full of promise in possible results. The Council has not attempted to interfere in any way with Provincial Departments of Agriculture or the control of these Departments. All that the Council wishes to do is to supplement the efforts made in the Provinces. Its grants are as open to the Provinces as to Imperial institutions. Both are engaged in a common task and the intention is to supply a co-ordinating link which has hitherto been lacking. In the past many of the recommendations of the Board of Agriculture suffered through lack of funds to carry them out even though the Imperial and Local Governments were willing to accept them. The Council has been provided with funds though, if the work expands at the rate now anticipated, it will probably be found necessary to augment them. I think we are living in spacious times; the old era of depression is disappearing and it is up to all of us to put up promising schemes of improvement now that we can get the necessary funds for carrying them out. Personally, I feel that in the time to come, whatever political changes may come about, our work will be, if anything, more important than before. The sphere of usefulness of agricultural officers is being enlarged, and at the hands of Ministers they will get as enthusiastic support as under the old form of Gov-

ernment. To advance the cause of agriculture and animal husbandry is the chief aim of all experts. Though I cannot claim to be an expert as my qualification is ignorance of both branches of the subject, as a landholder I know where the shoe pinches. I have come to this Board with an open mind and, though a layman, I trust I shall be adopted by you as one of yourselves.

The Hon'ble Sir Muhammad Fakhr-ud-din said it was his duty to thank the President for the very kind references that had been made about him. When he first met Sir Vijaya he thought he was an industrialist, and he was not long in discovering that Sir Vijaya was also a great organiser. From the way he talked of industry, and from the way he advised the Legislative Council at an informal conference, he thought Sir Vijaya knew more of industries than he himself did. When he heard that Sir Vijaya had been appointed Vice-Chairman of the Imperial Council of Agricultural Research he thought Sir Vijaya had changed from an industrialist to an agriculturist. He was sure the deliberations of the Board of Agriculture would be greatly helped by his Presidentship. Sir Vijaya had enumerated many of the activities of the Research Council, but he had forgotten, in his modesty, to mention his own activities as Vice-Chairman and Chairman. Bihar and Orissa had a great grievance with the Imperial Council of Agricultural Research. After looking about for a capable Director of Agriculture for some years, he had at last found one but no sooner had he done so, then the Research Council took him away. He felt that was a great loss to the Province because he was sure that, had Mr. Burt remained, the Agricultural Department would have been a different body within two years. However, he was gratified to inform the Board that he had obtained the services of another good man in Mr. Henderson. He was not an agriculturist himself and, in discharging his duties, he was dependent on expert advice, and he had to admit that he did not consider he had discharged his duties sufficiently well. He hoped this would now be changed because he had a good man to advise him. Bihar and Orissa was also a poor Province and there was not enough money for agricultural improvement. He at first thought the Board of Agriculture would not be necessary but after consideration he thought the enlargement of its constitution and the division into two wings would give much more useful results than in the past and the decisions would be respected by most laymen.

Sir Frank Noyce thanked the President for the kind reference made to him. He was the only person in the room who had been intimately connected with the work of the Royal Commission on

Agriculture. He had been in frequent communication with the Chairman of the Commission since it concluded its work, and he was glad to be in a position to give the meeting Lord Linlithgow's best wishes for the success of the Board. The Council, as at present constituted, was not quite what the Royal Commission had suggested, but it had come as a very pleasant surprise to its members to know that the Ministers of the Provinces desired to participate in the work of the Council and become permanent members of its Governing Body. There was one remark made by Sir Muhammad Fakhr-ud-din regarding Mr. Burt on which he would like to comment. Sir Muhammad's protests had not been so long and loud as Sir Muhammad had led the Board to believe, for Sir Muhammad had taken a statesmanlike view and agreed, though at great inconvenience to his Province, to let the Council have the benefit of Mr. Burt's experience and expert advice. He (Sir Frank Noyce) had been connected with Agricultural Departments for twenty years. In his new sphere he would continue to keep a keen interest in its work, and the Vice-Chairman could rely on his willing help and support.

The Board then proceeded to appoint Committees to deal with Subjects 1, 2, 3, 5, 6, 7, 9, 11, and 12 on the Agenda.

The Board then took up the discussion of those subjects for which Committees had not been appointed.

Subject IV.—The desirability of discussing the subject of the best means of bringing improved methods of agriculture to the notice of the cultivators, at future meetings of the Board.

The President asked Mr. Milne to open the discussion.

Mr. Milne said that most Provinces had the same general methods of getting into touch with the grower. In the Punjab, farmers' weeks were held during which farmers were shown round the College and Farm and also special courses were held, for example, in fruit growing. Again, ordinary demonstrations were given at fairs and in villages. Ploughing matches were organised and bands of small boys attended fairs and sang songs explaining the advantages of some activity of the Department. Agricultural literature, posters, leaflets, etc., were also employed. Demonstration plots were run both departmentally and in cultivators' fields, and lectures were delivered by the Departmental staff. Another phase of the work in the Punjab was "concentration work" in certain villages where all the improvements that are being

demonstrated by the Department were concentrated with the object of showing what can be achieved when a whole community adopts improved methods. In this scheme the aid of the Public Health and Co-operative Departments have been enlisted. The Department has, however, received some complaints from neighbouring villages that they were being neglected. This really was a very good omen. Again, Government has started better farming societies, the members of which pledge themselves to follow the advice of the Agricultural Department. If the members own or cultivate a minimum of 2,000 acres situated within five adjacent villages, Government posts a *mukaddam* or overseer for three years to work in that locality. If, in addition to the 2,000 acres, there happens to be a 30-acre co-operative farm, Government gives a grant-in-aid for three years to the society equal to the pay of the *mukaddam* to be employed on the farm and posts another *mukaddam* to the villages in question. The first is the servant of the society but not the second. If three of these co-operative farms exist in two adjacent "*Zails*", Government posts an Agricultural Assistant for three years to the Tahsil, whose chief work will be in the two "*Zails*" concerned. Altogether there are 20 of these better farming societies in the Punjab. The Punjab has also a demonstration train, and a certain amount of press propaganda is carried on through the Bureau of the Director of Information. In addition, Agricultural Associations have been formed at most district headquarters. There are 25 Associations for the 29 districts comprising the Punjab. The membership consists of from 50-300 prominent farmers and the Deputy Commissioner is usually the Chairman and the local Agricultural Assistant the Agricultural Adviser and Secretary. These Associations he found most useful, so much so that now-a-days the growers were coming forward to inform the Department of their difficulties and asking for a solution.

Another new scheme recently started in the Punjab was the Agricultural Stall near the Lyallpur Grain Mandi. In it the Department exhibits the best seeds, charts and show cases giving the life-histories of insect and fungal pests, implements, etc. A whole time Agricultural Assistant is in charge who gives advice to visitors. The Agricultural Assistant is provided with beam scales and certified weights with which he can verify the weights of the produce of any farmer who may wish him to do so. This new method of propaganda is becoming popular and though it is somewhat expensive, the average monthly number of visitors is about 2,700 and seems to have great possibilities. Certain people have pressed the Agricultural Department in the Punjab to farm

holdings but if paid labour is substituted for the farmer, his wife and children, the whole experiment loses the driving force of self-interest. The Department has now laid out in most of its 100-acre district farms representative holdings which are farmed by tenants on the "*Batai*" system. Careful accounts of income and expenditure are kept and the farmer has to carry out the instructions of the Department. It is hoped to be able to demonstrate that this farmer makes much more than he would in the ordinary way.

The President asked Mr. Milne if he would like the practice of discussing the subject of the best means of bringing improved methods of agriculture to the notice of cultivators brought on the Agenda at future meetings of the Board.

Mr. Milne said he certainly would.

Mr. Vagholkar said that in the Bombay Presidency the line of working had been changed since 1921 with the development of the Taluka Development Societies. These societies had adopted all the departmental improvements and were carrying on intensive propaganda in the districts. Each Association arranged for demonstration in 30-40 centres and these had proved very successful. Honorary workers were now coming forward to help. In addition to this line of work, the Department sends seeds to Credit and Non-credit Societies so that these organisations were responsible for the distribution of very large quantities of seed of improved varieties. The Department also had demonstration plots and also small plots in cultivators' fields. Shows were also held so that the improvement was reaching a very large percentage of the growers. The Department had also arranged ten-day classes at the College and the farms where one special line of study was taken up, and it was interesting to find that cultivators of 40-50 years of age were attending and were becoming very enthusiastic. District Boards had also come forward to help propaganda in the districts. The District Boards were financing various Development Societies and Government gave an equal subsidy. Implement Societies were also very good agents to conduct propaganda work. One Society with a share capital of only Rs. 3,000 got Rs. 2,000 a year on hire and came in contact with 1,200 growers. It was found that no one organisation was successful for the whole Bombay Presidency, but each locality had to have one suitable to its own needs.

Mr. Devadhar considered there was great scope for improvement in the methods of propaganda. He found that in the past Agricultural Departments had not created a sufficient amount of

enthusiasm. He suggested that something of a pictorial and entertaining nature should be employed instead of the methods adopted in the past and now being employed. Music appealed to all people, and he therefore suggested that some suitable drama should be written to include the results of the Agricultural Department's work. He had seen in the Karnatak an agricultural drama enacted by members of a Co-operative Society for five hours and he had also seen one in Malabar, and he found that the method had been very useful in attracting people. He would not burden the Department of Agriculture with the organisation of the drama, but he suggested that a prize should be given for suitable plays. He also suggested that the issue of the present type of circulars and leaflets should be discontinued and in their place some kind of coloured pictorial representation should be given. He had acquired his experience as a result of work with the Bombay Presidency Baby Week, and he found a great deal of interest being taken in small plays and in coloured posters. It was necessary to attract the attention of the people and there was no doubt that the present methods had not the desired effect.

Mr. Milne said that he had omitted to say that dramas and coloured posters had been tried in the Punjab but without much success.

Mr. Hilson said that Directors of Agriculture, who were responsible for the propaganda work in the Provinces, would meet on the Advisory Board and would discuss this particular subject. He at first thought therefore it would be waste of time to discuss this question at Board meetings. He had however heard it said that as the discussion at meetings of the Board of Agriculture would be circulated and would likely get into the hands of members of Legislative Councils, it might carry great weight in getting extra money for the Agricultural Departments from the Legislative Councils. In this case he thought it very desirable that the subject should be put on the Agenda.

Sir Frank Noyce said he would like to move a formal resolution :—

"That a review of the organisation for all methods of agricultural propaganda and other extension work should find a place in the Agenda of this Board at its future meetings."

The resolution was seconded by Mr. Devadhar.

Sir Frank Noyce said that the evidence given to the Royal Commission on Agriculture had showed that there was a great

deal of ignorance regarding the propaganda work carried out by the Agricultural Department. They were told that the research work was not brought home to the cultivators, and he still found some members of the Legislative Assembly and others reiterating the same complaint. The Board of Agriculture knew what was being done by the Agricultural Departments in the Provinces. If a review of the propaganda carried out by the Departments found a place in its agenda, this would go far to dispel the idea that nothing was being done. It would also give an opportunity for officers to learn what measures were being taken in other Provinces. He certainly thought that this item should figure in the agenda at future meetings.

Mr. Sane said that though the Indian States had found no place on the Council of Agricultural Research they still had a voice at the Board of Agriculture, and he would be very glad to have a chance of hearing what the Provinces in India were doing in the way of extension work.

Mr. Henderson agreed with the views of Sir Frank Noyce but said that this subject always took up a great deal of time and he thought it would be advisable to put it on the agenda every third or fourth year.

Mr. Plymen asked whether this came under the crop and soil or the animal husbandry wing or both. If it came only under one, discussion would take place once every two years. He thought that the most valuable material would be obtained if Deputy Directors of Agriculture put forward their views on their failures and successes.

Dr. Burns said that propaganda was not a matter of methods but was really a question of intensity and money. He had never heard of any "*bloc*" in a Legislative Council vehemently demanding more money for the Agricultural Department.

Mr. Plymen said as regards the Central Provinces he had never found any difficulty in getting the Council to vote for an increase of staff. His real danger now was that they might demonstrate far in advance of the research work.

It was decided to **include the words "by both wings" after the word "Agenda" in the resolution** proposed by Sir Frank Noyce.

The **amended resolution was carried unanimously.**

The Board adjourned for lunch.

The President then met the Chairmen of the several Committees to fix times for Committee meetings.

The Board re-assembled at 2-30 P.M. and dealt with—

Subject X.—To select a place and date for the next Cattle Conference and to discuss the advisability of combining this with Sectional Meetings of Officers representing veterinary, medicine, animal nutrition and animal genetics.

The President said that the Council of Agricultural Research had decided that the time and place of the next meeting of the appropriate wing of the Board of Agriculture and Animal Husbandry should be fixed by the Chairman of the Advisory Board, and that Sectional Meetings would also be held in connection with the general meeting of the wing.

Mr. Viswanath said that if Sectional Meetings were held at the same time as the meeting of the Board of Agriculture and Animal Husbandry, the programme would be far too crowded. He asked whether it would not be possible to arrange Sectional Meetings in alternate years.

The President said that it should be given a trial for one year and experience would show whether a change was necessary.

Mr. Ware said he agreed that the time and place of the meetings should be left to the Chairman.

This was agreed to.

Subject VIII.—To consider recommendation 27 of Chapter XIV of the Report of the Royal Commission on Agriculture, to make recommendations and to suggest suitable problems for economic enquiry.

The President asked Mr. Burt to open the discussion.

Mr. Burt said that he was under the great disadvantage that neither Dr. Hyder nor Dr. Coleman was present. Dr. Hyder was an economist as well as a member of the Royal Commission, while Dr. Coleman had submitted a very interesting note on the subject (p. 206).

The recommendation of the Royal Commission on Agriculture was as follows :—

> *Recommendation 27.*—" The establishment of a Bureau of Rural Economic Research in each of the Provinces, on lines similar to those on which the Board of Economic Enquiry in the Punjab has been established, would prove of value ".

These Boards of Economic Enquiry, he said, permit of enquiries being conducted into certain economic problems in the Provinces. All agricultural officers realise the importance of these surveys, but nothing has been done in the past due to the lack of funds. When the Central Cotton Committee carried out its investigations into the marketing and financing of cultivators' cotton, it was found that it was necessary first of all to ascertain actual facts and any attempt to obtain the economic facts of village life was important to all agricultural officers. It was clearly desirable that an agricultural officer should know the full economic significance of any changes in agricultural practice, whether these took place naturally or through the efforts of the Agricultural Department. There was no doubt that this particular recommendation of the Royal Commission had arrested interest in several Provinces. Mr. Milne would tell the meeting how the Punjab Board of Economic Enquiry worked. Some subjects might be suitable for investigation in some Provinces, while other Provinces might not be interested in the same type of enquiry. He made several suggestions regarding the subjects and asked for others to be put forward by the meeting. He hoped the Board would endorse the recommendation of the Royal Commission.

Mr. Milne agreed that these Boards of Enquiry could perform very good work. The composition of the Punjab Board was 25 members, of whom nine were officials and 16 were nominated. The money for financing the Board came from the Government but this was put into the Imperial Bank and was left entirely at the disposal of the Board. It did not lapse as in the case of other Government funds but was subject to audit. The funds were mainly devoted to pay the investigators and for the publication of the results. The work already carried out by the Punjab Board of Economic Enquiry had supplied a great deal of very useful information. The last enquiry was the marketing and financing of cultivators' cotton. Three-fourths of the funds for this had been supplied by the Indian Central Cotton Committee. The work of these enquiries involves a great deal of labour on the part of the investigators and the supervisors. A questionnaire for each enquiry was first drawn up by the Board and the aim of it was to get facts and not opinions. He would strongly advise other Provinces to institute similar Boards. The work had increased so much recently that it was found necessary to give the Secretary a small honorarium. If they were started in other Provinces, it might be well to get a whole time Secretary to do the work.

Dr. Burns said he would welcome a Board in the Bombay Presidency if it could be financed in the same way as in the Punjab.

He thought a Board of this nature would be very successful in the Bombay Presidency as they had already a School of Economics, which however did not touch agricultural subjects, and attached to the Agricultural College they had a Section which dealt entirely with agricultural economics.

Mr. Johnston said that he had been responsible for supervising two of the enquiries in the Punjab and gave details of the work carried out. The actual work was carried out by the investigators and the officer in charge had to give general supervision. The most difficult part was the writing up of the report and interpreting the figures acquired during the course of the investigation.

Mr. McKerral asked Mr. Johnston the status of the investigators.

Mr. Johnston said that they were usually graduates in Arts or of an Agricultural College awaiting appointments. They were appointed for one year on a pay of Rs. 100 a month and Rs. 50 a month bonus at the end of the period if their work had been satisfactory.

Mr. Plymen said he would like to know more about the personnel of the staff. As far as he could see, these enquiries only meant extra work being put on to the already hard-worked Agricultural Department. He considered that these enquiries should be carried out by a special staff, otherwise the other duties of the Agricultural Department would suffer. Any resolution of this Board should, he considered, recommend extra staff. He thoroughly agreed that these investigations were important.

Mr. Milne said that in the Punjab these investigations were carried out by whole-time investigators but not by permanent employees of the Board. In some cases agricultural assistants were granted leave in order to take up the work.

Mr. Plymen asked Mr. Milne whether the Agricultural Department in the Punjab had a special leave reserve to take the place of those agricultural assistants who went for economic surveys.

Mr. Milne said that he had no leave reserve but he considered that the work was so important that the assistants were allowed to be turned off from their legitimate duties.

Dr. Burns asked Mr. Milne what the actual budget of the Board was.

Mr. Milne said it was approximately half a lakh annually.

Mr. Roberts said he considered that the success of these Boards depended entirely on the Secretary. In the Punjab the Secretary was a man who took a great deal of interest and was keen on the work. The work did not put any burden on the staff of the Agricultural Department, except on the officers required for supervision. In the Punjab the men employed had not generally been agricultural assistants, and they were now finding that raw untrained graduates were not satisfactory. There was a tendency now to keep on a man for several years to carry on different surveys.

Mr. Ulvi said his experience had been that the cultivator would not give information easily. Trained men known to the villagers were therefore necessary.

Mr. Hilson said that this particular resolution of the Royal Commission on Agriculture was discussed by the Advisory Committee in Madras. The general feeling was that, if information of any value was to be found, it would be necessary to get a man known to the cultivators in the area being investigated. The necessity of having such information was agreed to, but they did not think it necessary to appoint a Board for this purpose. For any particular enquiry they considered the appropriate Department should put men to carry out the investigations. They could not see the necessity to put the information before a composite Board.

Mr. Burt then moved the following resolution :—

Resolution II.

" That the Board cordially endorses recommendation 27 of Chapter XIV of the Report of the Royal Commission on Agriculture, and desires to emphasise the need for whole-time investigators for economic enquiries as it is impossible for agricultural assistants to carry out these investigations in addition to their ordinary duties."

He said that the recommendation of the Royal Commission on Agriculture was a very sound one, and he hoped it would be accepted by the Board. He would like to add one point ; he felt strongly that, when an economic enquiry was being undertaken, plans should be drawn up by a technical officer and an economist and the results should be compiled and interpreted by a trained economist. He also preferred that the primary investigator should be an Agricultural Assistant or a graduate from an Agricultural College, as it is necessary to get the confidence of the cultivator before he will give any information.

Dr. Burns seconded the **resolution** which **was carried unanimously.**

Mr. Hilson asked whether the recommendation of the Royal Commission on Agriculture mentioned the word " Board."

Mr. Burt said the word used was " Bureau," which he thought meant merely an " organization."

Mr. Burt asked for suggestions regarding the problems for enquiry. He read out the following list which he had collected :—

1. Marketing of crops.
2. The finance of the cultivator with special reference to marketing.
3. Consolidation of holdings.
4. Size of holdings and the number of uneconomic holdings.
5. The cost of production of crops and cattle.
6. Cost of maintenance of cattle.

Mr. Smith asked for the inclusion of " Dairy produce " under No. 5.

This was agreed to.

Mr. Plymen thought it would be a good thing if the economics of a village herd were to be investigated to get some idea of the number of useful and useless cattle in the ordinary village herd.

This was agreed to.

Colonel Matson said that any enquiry into cost of production of cattle must include an inquiry into the availability of the products consumed by them.

Mr. Warth said he thought this was covered by the wording of Mr. Plymen's suggestion.

The President asked the meeting whether they should not wait to hear the views of Dr. Coleman who seemed to be very interested in the subject. He did not think it would add very much to the time required for finishing the business on Thursday.

This was agreed to.

It was decided to meet on Thursday the 12th December 1929 at 10-30 A.M.

SECOND AND THIRD DAYS.

The second and third days were devoted to meetings of the several Committees and to the drafting of their reports.

FOURTH DAY.

The President called on the Secretary, Mr. Ritchie, to read the minutes of the first day's proceedings relating to Subject VIII, the discussion of which had been postponed to hear the views of Dr. Coleman.

Dr. Coleman said he had to confess that his note was not prepared off his own bat but was suggested to him by Mr. Hydari. He wished to point out that his remarks dealt strictly with Mysore conditions, and it did not follow that they would be applicable to other Provinces. It was said the previous day that the staff of the Agricultural Departments was so over-worked that it was impossible for them to undertake the work of economic surveys. It had to be remembered that Mysore was a one-crop State, and the agricultural assistants could be utilised when there was no crop on the ground. No funds were available for such work and he saw no reason why the agricultural assistants should not be utilised for this purpose. It had also been recorded in the minutes that trained men were necessary and, as far as Mysore was concerned, the local agricultural officer was best suited for the work. In Mysore they had an Economic Conference of non-officials under which body the Board could work.

Mr. Burt said he was very interested to hear that Dr. Coleman shared the view that the agricultural assistant was the best type of primary investigator. He asked the Board to pass on to the subjects suitable for survey.

Mr. Mayadas said there was one subject he would like to see included, *viz.*, the relationship of landlord to tenant. There were great possibilities of co-operation between them in the cause of higher production. At the Cawnpore Agricultural College he had done a certain amount of work in this direction which had benefited the grower considerably and, if real co-operation could be established between landlord and tenant, both would be materially benefited. He also thought that the *Batai* system was much more profitable than the cash rent system and this also required investigation.

At the instance of the President Mr. Mayadas agreed to call his subject "co-operation between landlord and tenant" instead of "the relationship between landlord and tenant."

Mr. Ulvi said that the *Batai* system was common all over India with differences in different parts. In Sind and in the Punjab the tenant was a tenant at will and very frequently changed his holding from year to year. A lot of work could also be done in irrigated areas. The results would depend on whether the irrigation

was by lift or by flow. Under lift irrigation the cultivator barely gets a living wage, but under flow irrigation, especially if double cropped, the grower gets much more than a living wage.

Mr. Higginbottom said he would like one other subject included in the list, *viz.*, " an investigation into over-population of the land where such occurred." It would be well if the Board of Enquiry could find some way in which over-population on land could be reduced and diverted to other channels.

Mr. Burt then moved :—

Resolution III. ***" That the following subjects for economic study should be agreed on :—***

1. ***Marketing of crops.***
2. ***The finance of the cultivator with special reference to marketing.***
3. ***Consolidation of holdings.***
4. ***Size of holdings and the number of uneconomic holdings.***
5. ***The cost of production of crops, cattle and dairy produce.***
6. ***The cost of maintenance of cattle.***
7. ***The economics of a village herd.***
8. ***Co-operation between landlord and tenant.***
9. ***The study of over-population of land whereby excess population could be diverted from the land into other channels."***

Mr. Higginbottom asked for some machinery whereby the list could be enlarged if necessary.

The President said that any other subject wou'd be added to the list as it was brought forward.

The **resolution was** seconded by Mr. Mayadas and **carried unanimously.**

The President then called on Dr. Coleman to introduce the report of the Committee on—

Subject IX.—Mathematical assistance in the study of agricultural genetics and economic problems.

The Committee on this subject consisted of Dr. L. C. Coleman (*Chairman*), Dr. W. McRae, Dr. F. J. F. Shaw, Dr. J. Sen, Mr. G. R. Hilson, Dr. G. P. Hector, Dr. W. Burns, Mr. A. P. Cliff, Mr. W. Roberts and Mr. W. Robertson Brown.

Terms of reference.—" To consider the need for mathematical assistance in the study of agricultural genetics and of economic problems, and to suggest how this need should be met."

Dr. Coleman said his Committee had drafted two resolutions which summed up the conclusions arrived at and he called on Dr. Burns to read the first resolution which was as follows :—

> " *Resolved that the Board of Agriculture considers the establishment of a Statistical Section in the Imperial Agricultural Research Institute with a Statistician of high training in statistical methods as applied to agriculture as its head, a question of urgent importance. In view of the fact that the advice and assistance of such an officer would be of very great value to agricultural research workers throughout India, they further consider that the financing of the scheme, at least in its early stages, could be fittingly undertaken by the Imperial Council of Agricultural Research.*"

Dr. Burns said the report was clear and convincing and there was little need for further remarks. It was well known to all who worked with plants and animals how variable they were in appearance and behaviour. All scientific workers wanted expert advice, assistance and instruction. There had been great developments in this line all over the world and though a good deal of work had been done in India, there was no one to help workers to tabulate and work up the data acquired. Many workers had to pick up a knowledge of statistics as they went along but those who were not mathematicians were compelled to leave the statistical part alone. Not every mathematician would be of help. The person engaged must be one who had specialised in statistics as applied to agriculture.

Dr. Shaw in seconding the resolution said the suggestion that the staff of the Pusa Institute should be increased by the employment of a statistician was a very welcome one. The history of progress in all physical sciences had been towards accuracy, and accuracy in the interpretation of scientific results in agriculture was especially necessary. He considered that the officer who came to Pusa should be primarily a mathematician and not necessarily an agriculturist. It was needless for him to say that no amount of juggling with figures would make up for clear thinking. The creation of a statistical section at Pusa was one of its most urgent needs.

Col. Matson said that the Government military dairy farms had accumulated a mass of information and the figures require to be interpreted.

Dr. Coleman called attention to the paragraph of the report dealing with the question of training research workers in statistical methods. This function of the officer's duty should not be lost sight of as the Provinces will require statistical officers who would be trained by the specialist attached to Pusa.

Mr. Burt said that in the remarks which he was about to make he was expressing his personal views and not speaking in his capacity of Expert Adviser to the Imperial Council of Agricultural Research. He was in full agreement with the general trend of the report and entirely concurred with the view that there should be a Mathematical Statistician of high qualifications at the Pusa Research Institute. He was glad to see that the Committee had emphasised that the work of this officer would include assistance in the planning of field experiments as well as in the interpretation of results. He thought, however, that any resolutions coming from the Board of Agriculture should clearly explain the technical aspect of the Board's recommendations, rather than make recommendations regarding administrative detail. What was wanted was a highly qualified Mathematical Statistician and staff, and the Board would be quite right in emphasising the importance of such an appointment to the proper development of agricultural research in India, but he did not think it desirable to make a definite recommendation regarding the internal administration of the Imperial Institute of Agricultural Research by recommending the creation of a new Section at Pusa. Nor did he think it desirable that the Board should definitely recommend that the cost of this additional appointment at Pusa should necessarily be met by the Imperial Council of Agricultural Research. The Royal Commission on Agriculture had expressed the view that the Research Council should stand in the same relation to both Provincial and Imperial research institutions. He therefore thought that a recommendation of a more general nature, which might appropriately follow that section of the report dealing with provincial requirements, would be preferable. By suggesting that the cost of the appointment must necessarily be met by the Imperial Council of Agricultural Research, the Board might even be hindering the making of the appointment instead of expediting it. Personally he could not accept the view that no developments of the Imperial Institute of Agricultural Research could take place unless they were financed by the Research Council. As he was in entire sympathy with the general trend of the report, he would rather not move an amend-

ment but would be glad to support a modified resolution which commended itself to the members of the Committee.

Dr. Coleman said he thought the proper procedure would be for Mr. Burt to propose an amendment. He personally agreed with Mr. Burt regarding the last sentence of the first resolution, though he was sure the Committee did not mean the definiteness that Mr. Burt had put into it. The idea at the back of the minds of the Committee was that there was more possibility of getting money from the Council of Agricultural Research than from the Government of India. He did not wish the first sentence of the resolution to be altered.

Dr. Burns agreed with Dr. Coleman that the first sentence should stand as there was nothing in it which interfered with internal administration. He was prepared to accept a modification of the last portion.

Dr. Coleman suggested that the first sentence should be moved as a separate resolution and then Mr. Burt could move an amendment or a fresh resolution dealing with the second sentence.

Mr. Burt proposed the following amended resolution :—

> " *Resolved that the Board of Agriculture considers the appointment at the Imperial Institute of Agricultural Research of a mathematician with a high training in statistical methods as applied to agriculture, a question of urgent importance. The advice and assistance of such an officer would be of very great value to agricultural research workers throughout India.*"

Mr. Richards seconded the resolution. He thought it would make the services of a statistician more useful if he was not a definite member of the Imperial Research Institute at Pusa.

The President said that under the new resolution the statistician would still be attached to Pusa.

Mr. Burt said his resolution definitely contemplated that the statistician would be part of the staff at Pusa, but he should be as free as possible to give his services to the Provinces.

Mr. Richards said he would still continue to support the amendment if he could be certain that Mr. Burt's idea would be fulfilled.

The President said he could not accept Mr. Richards' seconding of the amended resolution if conditions were attached. It must be unconditional.

Mr. Afzal Husain seconded the amended resolution.

Dr. Coleman said that if Mr. Richards had read the report carefully he would have seen that the statistician must be available to the Provinces. If this were not so, his whole work would be wasted.

The President put Mr. Burt's amendment to the vote and it was lost.

The first sentence of the first resolution in the report was then put to the vote and carried :—

Resolution IV. *" Resolved that the Board of Agriculture considers the establishment of a Statistical Section in the Imperial Agricultural Research Institute with a statistician of high training in statistical methods as applied to agriculture as its head, a question of urgent importance."*

The second resolution was then proposed by Dr. Coleman—

Resolution V. *" The Board of Agriculture considers that the necessity of providing statistical staff in the various Provincial Departments of Agriculture which has been emphasised by previous Boards in 1919 and 1924 should once more be impressed upon Local Governments. They further consider that the Statistical Sections of Provincial Agricultural Departments should be organised on such a basis as to permit of the inclusion of the statistical treatment of experimental data among their regular duties."*

Mr. Hilson in seconding said that the resolution was in two parts ; the first one pointed to the necessity for a Statistical Section in each Province and the need for the development of those Sections which already existed to deal with statistical data. In Madras they had a Statistical Section, but it dealt mainly with forecasts of crops and ginning and pressing returns. It did nothing with the working up of agricultural data from 17 stations and 3 Sections. It was necessary to have this extra staff if they were to make the fullest use of their experimental results.

Mr. Plymen supported the resolution as it would help Departments to get officers of the right type. They had managed in the Central Provinces to obtain a scholarship for an agricultural student to study under Dr. Fisher at Rothamsted. He wished to put on record his appreciation of Dr. Shaw at Pusa for what he had done in giving statistical training to the students sent from the Provinces to work under him.

Mr. Milne strongly supported the resolution. He had sent a man to Pusa under Dr. Shaw who had been of great help. A Punjab

man had also worked under Dr. Fisher, but the trouble was that both had several other duties to perform and they needed extra men to help with crop statistics and factory returns.

The President put the **resolution** to the vote which **was carried unanimously.**

Mr. Burt then proposed the following resolution :—

Resolution VI.

" The Board of Agriculture trusts that the Imperial Council of Agricultural Research will encourage the greater application of modern statistical methods to agricultural and veterinary problems both in Imperial and Provincial institutions in such manner as they consider most effective."

Dr. Coleman seconded the **resolution** which **was carried unanimously.**

Dr. Coleman then moved the adoption of his **Committee's report as amended.** This was seconded by Dr. Shaw and **carried.**

The Report of the Committee was as follows :—

The Committee considered the portion of the Report of the Royal Commission dealing with this matter as well as the notes of Mr. Burt and Dr. Burns (p. 208). They are in agreement with the views expressed in the report and the notes and wish to emphasize the urgency of the need of mathematical assistance in all branches of agricultural research and enquiry.

The Committee consider that the first step in the direction of providing mathematical assistance should be the appointment on the Pusa staff of a statistical expert with special training in agricultural statistics. The advice and assistance of this officer should be available to all those engaged in research connected with agriculture throughout India.

The services of such an expert would be extremely useful in many ways. In the first place, they would be invaluable in connection with establishing sound methods of statistical analysis of experimental results. Such foundation work should lead to the unification of statistical methods throughout India. The statistician would also be available for consultation by agricultural workers who so frequently require advice in such matters.

His services are, in the second place, required in connection with the statistical study of the immense amount of experimental data which has already been accumulated in all parts of India and in all branches of agricultural research. A considerable amount of statistical material is the result of imperfectly planned experiments, and failing critical examination by an expert, is likely to remain largely useless. A thorough and critical examination of such data would, it seems certain, yield results of real value.

In the third place, the advice of a statistical expert would be of the greatest use in the planning of new experiments so as to ensure the greatest accuracy possible under the existing conditions.

Lastly we have the question of training young research workers in statistical methods which the Committee feel should form an essential part of the post-graduate training given at Pusa. Without the employment of a statistical expert adequate training in statistical methods will be out of the question.

The above considerations must make it clear that an officer of high attainments will be required and that the establishment of a statistical section at Pusa will necessitate a considerable expenditure of money. The Committee feel that there are few ways in which funds at the disposal of the Imperial Council of Agricultural Research could be so usefully employed for the advancement of Indian agriculture as in the employment of a statistician on the Pusa Staff and in the organisation of a section of statistics in the Imperial Agricultural Research Institute.

In the light of the above considerations the Committee recommend the adoption of the following resolution by the Board—

> "*Resolved that the Board of Agriculture considers the establishment of a Statistical Section in the Imperial Agricultural Research Institute with a Statistician of high training in statistical methods as applied to agriculture as its head, a question of urgent importance. In view of the fact that the advice and assistance of such an officer would be of very great value to agricultural research workers throughout India, they further consider that the financing of the scheme, at least in its early stages, could be fittingly undertaken by the Imperial Council of Agricultural Research.*"

The Committee considers that the needs of the situation will not be met by the establishment of a Statistical Section at Pusa. While this section will be of immense service to the Provincial Departments in assisting them by laying down guiding principles, in the planning of experiments and in interpretation of experimental data, there will still remain a very large amount of statistical work which in the nature of things must be carried out in the Provinces themselves. At the present moment statistical analysis of experimental data appears to be the exception. This is no doubt to a considerable extent due to the lack of the necessary training on the part of the research workers, while in many cases it is due to the lack of staff and time for the somewhat laborious and exacting calculations necessary. The Committee feel strongly that this situation can be improved most satisfactorily by strengthening the statistical section of the Provincial Departments where one at present exists and by the creation of a statistical section where one does not exist. The Committee wish to draw attention to resolutions passed by the Board of Agriculture in 1919 and 1924 in connection with the provision of staff for statistical work. Those resolutions were, however, confined to the question of staff in connection with work in general agricultural statistics and did not take into account the need for the statistical analysis of experimental data. The Committee feel that the importance of providing staff for this work also should be impressed on local Governments and recommend the adoption of the following resolution by the Board—

> "*The Board of Agriculture consider that the necessity of providing statistical staff in the various provincial departments of agri-*

culture which has been emphasised by previous Boards in 1919 and 1924 should once more be impressed upon local Governments. They further consider that the Statistical Sections of Provincial Agricultural Departments should be organised on a basis such as to permit of the inclusion of the statistical treatment of experimental data among their regular duties."

Subject XI.—Protection of crops from wild animals.

The Committee for this subject was composed of Mr. F. J. Plymen (*Chairman*), Mr. T. Bainbrigge Fletcher, Mr. P. V. Isaac, Mr. B. T. Vagholkar, Mr. P. B. Richards, Mr. C. Mayadas, Mr. Afzal Hussain and Mr. F. D. Odell.

Terms of reference.—"To review the progress made in regard to the protection of crops from the depredations of wild animals since 1925, and to advise whether the recommendations made by the Board of Agriculture in that year require modifications in the light of the knowledge and experience now available."

Mr. Plymen, Chairman of the Committee, in moving the adoption of the report, said that the terms of reference covered a very wide field and the list of animals given in the report which cause destruction to crops was only a tentative one. No action had been taken on resolution No. 4 of 1925 by Government. Mr. Afzal Hussain had put in a minority report as he thought the field covered by the proposals was too much for one man to undertake. The Entomologists on the Committee thought they should not go beyond their proper sphere of duty in dealing with crop-pests. They had emphasised the need for coercive legislation to deal with men who refused to enter co-operative societies organised for the purpose. The 1925 Committee had stated it would be impossible to eradicate the pig entirely and that methods of protection should be taken up. The question of wire fencing came before the Simla Conference a year ago and it was proposed that wire fencing should be allowed to come into the country free of duty. There had been some trouble in obtaining a rebate however.

The President said he thought it would be better to move a resolution which would have much more weight with the Government of India than the mere report.

Mr. Plymen then proposed the following resolution :—

Resolution VII

"Resolved that the Board of Agriculture draw attention to resolution No. 4 of the 1925 Board of Agriculture recommending that a specially suitable officer should be deputed to study the life-history of the wild

pig, and recommend that the scope of the enquiry be extended to include all animals other than insects which do extensive damage to crops. The Board further recommend that a special officer with necessary staff be appointed to investigate the whole question of the protection of crops from the depredations of wild animals."

Mr. Fletcher in seconding said that the intention of the Committee was not merely to re-affirm the resolution passed in 1925. The Committee felt that a whole-time man to carry out the work was required.

Mr. Afzal Hussain said that research officers were required to do far too much and he hoped this would have been altered by the report of the Royal Commission on Agriculture. The term " wild animals " was far too wide a definition and he thought they should deal with mammals only. A second point was with regard to the scope of the enquiry. The person investigating rat control should be different from the person dealing with eel-worm control. He therefore wanted the scope of the enquiry reduced to mammals only. Even that he considered was far too big. He thought it was necessary to split the enquiry into various groups. He therefore moved the amendment—

" That the scope of the enquiry should be limited to mammals only."

Mr. Henderson seconded the amendment.

Mr. Fletcher said that the first duty of such an officer would be the collection of information and if this were restricted to mammals, much valuable information would be missed regarding damage done by other pests.

Mr. Burt asked what qualifications the Committee had in view for the special officer. He agreed that this officer's energies should not be too diffused but there was a great deal in the point made by Mr. Fletcher.

Mr. Richards said that the Committee had visualised the special officer to be an Economic Zoologist. He should have a good zoological training with a *penchant* for field work in addition. He thought it would be possible to get hold of a man of this nature if sufficient inducement were given. He would be greatly relieved to get the advice of an officer regarding other pests of crops.

Mr. Vagholkar agreed that a zoologist was required. It was first necessary to investigate the life-history of the pests. It was not difficult, he thought, to organise a campaign against them,

but they could not go ahead without a knowledge of their life-history.

Mr. Plymen said that the Committee did visualise an Economic Zoologist with a field outlook. It might be possible to get a man in the Forest Department.

The President put the **amendment** to the vote which **was carried** by 21 votes to 16.

The **resolution as amended was** then put to the vote and **carried.**

Mr. Plymen then proposed the **adoption of the report** which **was** seconded by Mr. Fletcher and **carried.**

The Report of the Committee was as follows :—

1. The Committee first considered which animals should be included in the list of those doing considerable damage to crops and decided upon the following :—

Elephant, wild pig, deer of various kinds, nilghai, jackal, porcupine, monkeys, hares, rats and crabs.

The Committee also took cognisance of the fact that although not usually included under the term " wild animals " a considerable amount of damage to crops is done by birds and eel-worms. In addition, the damage caused by ownerless and stray cattle was noted.

2. The Committee observed that since the year 1925 there has been no marked innovation in the methods for dealing with the damage caused by wild animals. Resolution No. IV of 1925 recommended that a specially suitable officer should be deputed to study the life-history of the wild pig in its own habitat for some years, but in reviewing the present position the Committee considered that the resolution did not go far enough. The Committee recommends that the scope of the proposed enquiry should be extended to include all animals (other than insects) which do extensive damage to crops. The Committee further recommends that a special officer with necessary staff should be appointed to investigate the whole question of the protection of crops from the depredations of wild animals and consider the following animals are of the greatest importance in this respect :—

Pigs, rats, deer, jackals, monkeys, crabs and birds.

The Committee did not consider that any order of importance could be prescribed as the damage done by these animals in different provinces varies in intensity. The Committee was of the opinion that the primary duties of the officer and his staff should be the collection and collation of such information as is available throughout India regarding the methods found effective in the protection of crops. When the information already available has been collected, the special officer should investigate such problems for the protection of crops as may require further elucidation. He should also advise Provincial Departments upon their particular problems in the light of information obtained.

3. Regarding the methods for dealing with the pig nuisance, Crop Protection Societies, Co-operative Fencing Societies and Shikar parties appear to give the best results. In order to make Crop Protection Societies more effective some form of legislation appears to be necessary to compel a small minority of the landholders affected to co-operate with the majority. In certain similar cases of coercive legislation it is understood that the decision of a minimum of 75 per cent. of the holders of the cultivated area is binding upon the remainder and the Committee suggests this as a suitable proportion.

4. Where Crop Protection Societies are established the Committee considers they should receive every encouragement and assistance from the Governments concerned, such encouragement including subvention where necessary.

5. In view of the importance of extending the use of wire fencing for crop protection, the Committee would support any suggestion to bring such fencing within the scope of Recommendation 71 of Chapter IV of the Royal Commission's report and considers that it should be exempt from import duty. In view of the difficulty of deciding whether fencing is imported for agricultural purposes or not, a rebate of the import duty paid should be given on the recommendation of an officer duly authorized to grant certificates to this effect. If this proposal is not feasible, as an alternative the Committee recommends that specified types of woven wire fencing, mainly or entirely used for agricultural purposes, should be exempt from duty.

6. The principles recommended regarding the assistance to be afforded by Governments in the destruction of pigs should also be adopted in the case of rat destruction.

7. The Committee finally emphasizes the importance of impressing upon the cultivating classes the necessity for organising, on their own account, operations for destroying injurious animals, and that Government assistance should only be expected in proportion to the initiative and energy shown by the people themselves.

Mr. Afzal Hussain signed the report subject to the following note :—

I will like the scope of work of this officer to be restricted to 'wild mammals' to begin with.

Subject I.—Development of Cattle-breeding and Dairying ; and Subject II.—Extension of Work on Animal Nutrition.

Terms of reference.—Subject I.—To review the progress made in developing cattle-breeding and to make recommendations on :—

(i) The standardization of records which should be maintained at cattle-breeding farms with a view to determine correctly the progress in the improvement of cattle.

(ii) The possibilities of organising the dairy industry on a co-operative basis by the Co-operative Departments in India.

(iii) The position of grassland in the improvement of cattle and the possibility of improving such grassland.

Subject II.—"To review the work done up-to-date on animal nutrition in India and to recommend (*a*) what steps should be taken to develop and extend this work and (*b*) ways in which the Provincial Departments can best co-operate with the Physiological Chemist in work on this subject."

The members of the Committee on these two subjects were—

1. Dewan Bahadur Sir T. Vijayaraghavachariar (*Chairman*).
2. Mr. F. Ware.
3. Mr. Wynne Sayer.
4. Mr. Wm. Smith.
5. Mr. F. J. Warth.
6. Mr. P. G. Malkani.
7. Col. G. F. Mellor.
8. Lt.-Col. J. Matson.
9. Mr. P. T. Saunders.
10. Mr. R. W. Littlewood.
11. Mr. P. J. Kerr.
12. Mr. F. J. Gossip.
13. Mr. N. N. Bose.
14. Mr. K. Hewlett.
15. Mr. A. M. Ulvi.
16. Major P. B. Riley.
17. Mr. T. F. Quirke.
18. Mr. J. S. Garewal.
19. Mr. A. McKerral.
20. Mr. G. S. Henderson.
21. Mr. C. A. Maclean.
22. Mr. W. Harris.
23. Mr. R. C. Woodford.
24. Mr. S. M. A. Shah.
25. Mr. G. K. Devadhar.
26. Mr. Charan Singh.
27. Mr. Harchand Singh.
28. Mr. H. H. Pandya.
29. Mr. C. V. Sane.
30. Mr. M. S. A. Hydari.
31. Mr. B. Viswanath.

Mr. Z. R. Kothawala (*Secretary*).

The President said this Committee had crystallised its report into a number of resolutions and he asked Mr. Smith to explain them.

CATTLE-BREEDING.

Mr. Smith proposed the following resolution:—

"***(i) This Board, as a result of evidence placed before the meeting, supports the view that to effect general improvement in the cattle of India attention should be concentrated on the indigenous breeds.***

Resolution VIII.

(ii) The question of increasing the milk supply in urban areas is one which can be dealt with separately and the best means of obtaining the desired result will depend on local conditions.

(iii) The interesting experiments in cross-breeding now being conducted at the Hosur Cattle Farm and at the Allahabad Agricultural Institute may usefully be carried out to their conclusion."

It was seconded by **Mr. Ware.**

Mr. Mayadas asked why the experiments in cross-breeding mentioned in Clause (*iii*) were restricted to two stations.

Mr. Smith explained that outside milk production nothing was being done in cross-breeding with foreign blood. The Committee were agreed that the improvement of stock in rural areas must follow the selection of the indigenous breeds.

Mr. Mayadas said that he did not see why other experiments being carried out in other parts of India should be stopped.

After further discussion it was agreed to make the third part of the resolution read as follows :—

"(iii) The interesting experiments in cross-breeding with imported stock now being conducted at the Hosur Cattle Farm and at the Allahabad Agricultural Institute under the consideration of the Board may usefully be carried out to their conclusion."

Mr. Burt asked Mr. Higginbottom for details of the experiments being carried out at Allahabad.

Mr. Higginbottom said that they were interested in securing firstly the supply of milk for Allahabad and secondly in developing a better bullock. They had four Indian breeds—Hissar, Sindhi, Montgomery and Kankrej, and the imported stock consisted of the Holstein-Friesian, Jersey, Brown Swiss and Guernsey. They had no progeny far enough advanced to draw any conclusions. They did not deal with more than two bloods at a time which gave sixteen possibilities. He thought these experiments were of such superlative importance to India that success would mean a great deal, and if they failed on a sufficiently grand scale, they would be justified. He meant to try them out to the end. They wanted facts and not opinions, and the only way they could get facts was to try the experiments. They knew so little even about Indian cattle that the Board should welcome any rational experiment.

Mr. Vagholkar said that the second part of the resolution was not very clear.

Mr. Smith said that this resolution was really a compromise. The feeling of the Committee was all against the introduction of foreign blood and the question of buffaloes also came in. It could

not be dealt with in detail, and therefore they had made a general resolution. The cattle-breeding problem in India was purely a rural one, and they considered that the urban milk supply could not be dealt with on the same lines, as it did not come within the scope of cattle-breeding in India.

The **resolution as amended was** put to the vote and **carried.**

The **following resolution was** proposed by Mr. Smith, seconded by Mr. Ulvi and **carried unanimously :—**

Resolution IX.

" That in the opinion of this Board the custom of dedicating bulls as Brahmini bulls without selection militates against the improvement of the cattle of the areas where it prevails ; the Board accordingly suggests to local Governments that they adopt such measures as may be found feasible to make this custom contribute to the improvement of the cattle."

CO-OPERATIVE DAIRYING.

Mr. Smith in proposing the following resolution said he had supplied a written note (p. 102) which explained the full position. The only line in which development could take place in countries of small holdings was by means of co-operative dairies :—

Resolution X.

" The development of the dairy industry and the improvement of the various breeds of cattle in India are lines of work which are interdependent and complementary ; in regard to the former the Board considers that India like Denmark and Holland being a country of small holdings can best develop her dairy industry on co-operative lines as has already been successfully achieved in Bengal and to this end recommends that the organisation of co-operative societies be undertaken through the agency of Government Co-operative Departments working in conjunction with the Agricultural and Veterinary Departments for the utilisation of milk and all its products."

Mr. Bose said that three things were necessary to translate the resolution into action. The first was faith in the Co-operative Department, secondly, a body of trained workers, and thirdly, research work in the distribution and suitable methods of preservation of milk. He proposed the following addition to the resolution :—

" The Board further considers that facilities for the education of Co-operative officers in this particular class

of organisation and for the training of expert dairy and cattle farm staff to manage co-operative dairies and cattle-breeding be provided."

Mr. Smith accepted Mr. Bose's addition to the resolution.

Mr. Mayadas said that the Agricultural Department in the United Provinces had given some training in dairying to officers of the Co-operative Department, but the difficulty so far had been to give them an adequate training. If the Co-operative Department were to set aside some of the staff with a bent for the work they would fulfil a very useful function.

Mr. Milne said they gave short courses in dairying at the Lyallpur Agricultural College to men of the Co-operative Department but that was not enough. He considered that the Co-operative Department should take agricultural assistants in larger numbers.

Mr. Smith considered Mr. Milne's idea an excellent one. The Co-operative Department had a large staff and it would be of great value to the movement if they had an agricultural training.

The **amended resolution was** seconded by Mr. Gossip and **carried unanimously.**

IMPROVEMENT OF GRASSLANDS.

Dr. Burns proposed the following resolution which was seconded by Mr. Vagholkar :—

Resolution XI.

"(*i*) *In view of the importance of grazing areas in connection with the cattle industry, steps should be taken, on the lines of those already initiated in the Bombay Presidency, to conserve and improve existing grasslands.*

"(*ii*) *In respect of forest grazing areas the Board recommends that the Forest, Agricultural and Veterinary Departments of Provinces and States acting in concert should take suitable measures for their control and better utilisation.*"

Mr. Mayadas asked whether the Committee had taken into account the work being done in Scotland on the effect of manuring and rotation on the extra feeding value of grass.

Dr. Burns said that this particular point was not considered. He did not think land could be dealt with as intensively in India as in Europe.

Mr. Mayadas said he would bring this point up again when the resolution under animal nutrition was before the meeting.

Dr. Coleman said that with regard to section 2 of the resolution the Agricultural and Forest Departments in Mysore were working out a scheme of forest grazing in co-operation to get some idea of how forest grazing areas could best be utilised.

The **resolution was carried unanimously.**

ANIMAL NUTRITION.

Mr. Smith said he had many opportunities of seeing the valuable, important and thorough work carried out by Mr. Warth at Bangalore, the results of which read like a fairy tale. He should like to see Mr. Warth's work extended to all Provinces. The improvement of cattle depended not only on breeding but on the proper nutrition of the animal. He proposed the following resolution which was seconded by Mr. Littlewood :—

Resolution XII.

" The Board commends the work on animal nutrition now being done by the Imperial Physiological Chemist to the notice of officers of the Agriculture and Veterinary Departments in the Provinces engaged in the administration of cattle farms and on animal nutrition problems with a view to their co-operating with him in conducting as many experiments as possible ; and, to enable the Physiological Chemist to undertake these outstation experiments,' the Board recommends that the Field Staff of the Nutrition Station be strengthened as necessity arises and be transferable."

Mr. Mayadas drew attention to his remarks on the previous resolution. He had found that stall-feeding was very expensive and the same results could be got more cheaply by manuring for pasture.

Mr. Milne said the question of nutrition was of very great importance and the figures obtained in Europe and America were of very little use to workers in India. A certain amount of work had been started under Dr. Lander in collaboration with the Military Farms Department. They had found for instance that certain kinds of hay gave a maintenance ration in the plains and not in the hills. Further work was therefore necessary and he hoped it would be greatly extended.

Mr. Ulvi said the grasslands mentioned by Mr. Mayadas could only be artificial. The resolution dealt with natural grass and it was neither desirable nor economic, in the greater part of India, to utilise fields for artificial grasslands.

Mr. Hilson said he had been carrying out work at Hosur with Mr. Warth and he could assure him that, if additional staff were obtained, all help and assistance would be given to him by the Madras Agricultural Department.

Dr. Harrison asked the significance of the last word of the resolution, *viz.*, transferable.

Mr. Smith said the idea was that it should be possible to send the staff to any part of the country.

It was decided, in place of the word " transferable ", to put the following :—

" made available for duty in all parts of India."

The **resolution as amended was** put to the vote and **carried.**

The meeting adjourned at 1 P.M. and re-assembled at 2-45 P.M.

The President asked Mr. Wynne Sayer to move the resolution regarding cattle-breeding forms which was as follows :—

Resolution XIII. ***" That the Forms as recommended by the Cattle Committee be adopted by the Board."***

This **resolution was** seconded by Mr. Littlewood and **carried unanimously.**

The Proceedings of the Committee will be found in Appendix I (p. 75) and the forms in Appendix II (p. 85).

Subject XII.—Permanent Experiments at Pusa.

Terms of reference.—" To consider the recommendations of the Board of Agriculture, 1919, the report of Messrs. Henderson and Sayer and the opinion expressed by the Pusa Council on November 14th, 1929, and to advise what changes should be made in the existing series of the permanent manurial and rotation experiments of Pusa."

The Committee consisted of—

1. Dr. W. H. Harrison (*Chairman*).
2. Mr. J. H. Walton.
3. Mr. Wynne Sayer.
4. Mr. D. P. Johnston.
5. Mr. G. S. Henderson.
6. Mr. J. N. Chakravarty.
7. Mr. B. Viswanath.

Dr. Harrison explained briefly that the scheme of permanent experiments at Pusa was formulated in 1908 and they were continued till 1919, when a special Sub-Committee reported on them to the

Board. This Sub-Commitee proposed splitting them into three series with certain modifications. The incidence of wilt in *rahar*, however, gave rise to very interesting observations, and the Committee put a rider in their report that the scheme should not be put into force for one year to allow the Mycologist to complete his observations. The Mycologist however had not been able to complete the work within this period and with the concurrence of the Agricultural Adviser to the Government of India the original experiments had been carried on to the present time. No results were therefore available for the modified scheme proposed in 1919, but ten years' results had been added to the original experiments. One thing had been proved by these experiments, *viz.*, that the manure being given was not sufficient to maintain fertility, which had shown a continuous drop. The present Committee therefore felt that certain modifications were necessary which were to be found in the report. His Committee had also suggested that barley and wheat should be substituted for oats as being more in agreement with local agricultural practice. In series (*ii*) the 1919 Committee drew attention to the fact that the amount of potash and phosphate applied depended on the amount of farmyard manure. They have now recommended that standard dressings should be given. They have also recommended that the modified scheme should be put into operation commencing from the next monsoon season.

He proposed the **adoption of the report.**

This **was** seconded by Mr. Sayer and **carried unanimously.**

The report of the Committee is as follows :—

A Sub-committee of the Board of Agriculture of 1919 examined the question of the continuance of the Permanent Manurial Plots at Pusa and made certain proposals regarding the system of cropping to be adopted in future and suggested the rearrangement of the plots in three distinct series. These proposals were adopted by the full Board.

In their report they drew attention to the effect of varying manurial treatment on the incidence of wilt in *Cajanus indicus*, and recommended that the experiments should be continued unchanged for one year in order to permit these observations to be completed. This was not found to be possible and with the concurrence of the Agricultural Adviser the experiments have been carried on without alteration until the present time. This Committee in reviewing the results of the experiments has therefore had the advantage of an additional 10 years' results to guide them, and have been impressed by the fact that five-yearly averages of the grain yield for the whole period show a sequence of diminishing yields, indicating that the manurial treatments given in the past have not been sufficient to maintain fertility. Impressed by this fact the Committee have reviewed the recommendations of the 1919

Board and whilst agreeing with them in general they recommend certain minor alterations for consideration.

2. The recommendation to divide the plots into three separate series is accepted with the reservation that the system of cropping over series I and II should have barley and wheat substituted in place of oats as being more in agreement with local agricultural practice. The cropping scheme now recommended will consequently be a 4-year eight-course rotation arranged as follows :—

1.	Maize	Barley.
2.	„	*Cajanus indicus*.
3.	„	Wheat.
4.	„	Peas.

3. *Series I.*—In regard to series I designed to test the effect of organic manures on the fertility of the plots, the gradual decrease in the returns indicates that the quantities supplied in the past have not been sufficient and the suggestion is made that Plots Nos. 1—5 should be treated as follows :—

Plot No.	Treatment.
1	No manure (Check Plot No. 1).
2	4,000 lb. Farmyard manure per acre.
3	8,000 lb. Ditto.
4	4,000 lb. Farmyard manure *plus* rape cake at the rate of 20 lb. N per acre.
5	Rape cake at 40 lb. N per acre.

The farmyard manure should be applied in accordance with local practice, *i.e.*, in the hot weather and the cake applied to Plot 4 should be given at the time of the last inter-cultivation. For Plot No. 5 one-half of the cake should be applied at the time the kharif crop is sown and the remainder when the cake is given to Plot No. 4.

4. *Series II.*—The 1919 Board agreed that plots in this series should be arranged so as to form a series dealing with the application of manurial ingredients singly and in combination and proposed that Plots Nos. 11, 13 and 14 should be included in the series for this purpose so as to extend the existing range of combinations.

This recommendation is accepted by the present Committee for the reason that if new plots are instituted in order to complete the series they would be detached from the main block and possibly be subject to different conditions of drainage, etc. It is also accepted that the amounts of the several manurial constituents should be defined and this Committee suggests that the following doses are suitable—

N in the form of ammonium sulphate to be applied at the rate of 40 lb. per acre.

K_2O at the rate of 50 lb.

P_2O_5 at the rate of 80 lb.

On this basis the plots would be as follows :—

Plot No.	Treatment.
6	Ammonium sulphate. N=40 lb. per acre.
7	Potassium sulphate. K_2O =50 lb. per acre.
8	Superphosphate. P_2O_5=80 lb. per acre.
9	Potassium sulphate and superphosphate at above rates.
10	Potassium sulphate, superphosphate, ammonium sulphate at above rates
11	Ammonium sulphate and super at above rate.
13	No manure (Check Plot No. II).
14	Ammonium sulphate and potassium sulphate.

It is further recommended that, except during the year when *ralar* is grown, the artificial manures should be applied in two doses, half the total quantity being given previous to sowing the monsoon crop and the remainder before the rabi crop is sown.

5. *Series III.*—Consists of Plots Nos. 12, 15 and 16 together with additional new plots to be laid down and called Nos. 17 and 18, and in accordance with the general recommendation of the previous Committee this series would be subject to the following treatment :—

Plot No.	Treatment.
12	Green manure in conjunction with a purely cereal rotation.
15	Effect of green manure and a leguminous crop in the rotation.
16	As for No. 15 but with the additional application of super (P_2O_5=80 lb. per acre). The super to be applied with the green manure.
17	No leguminous crop and no green manure.
18	The proposed new cropping scheme without any manurial applications. (Check Plot No. III.)

6. Finally, this Committee recommends that, subject to the modifications indicated in the preceding paras., the recommendations of the 1919 Board of Agriculture be put into operation with the next monsoon season, and that the suggestion of Messrs. Henderson and Sayer that sowings should be done by hand and that cultivation operations should be confined to each separate plot be adopted.

Subject V.—(A) Mechanical Cultivation and (B) Bullock-drawn Implements.

Terms of reference.—Subject V. A. "To review the present position of mechanical cultivation in India with special reference to (*a*) the possibility of extending tractor cultivation and (*b*) the

special kinds of cultivation for which mechanical cultivation is advantageous, and to make suggestions for co-operative action by the various Departments of Agriculture to determine the best type of machine for Indian conditions and for the interchange of information and experience."

Subject V. B.—" To consider recommendation 65 of Chapter IV of the Report of the Royal Commission on Agriculture and to make suggestions for investigations into the best method of determining the draught of bullock-drawn implements."

The members of this Committee were :—

1. Mr. G. S. Henderson (*Chairman*).
2. Mr. B. P. Vagholkar.
3. Mr. C. Mayadas.
4. Mr. D. P. Johnston.
5. Mr. D. R. Sethi.
6. Mr. F. D. Odell.
7. Mr. E. A. H. Churchill.

Mr. Henderson said his Committee considered the best way to deal with the subject was to issue a brief questionnaire which would be found attached to their report. The information was in compact form and should prove of value to the trade. They had found that the three chief centres of power cultivation in India were in Gujarat, the riverain tract of Burma and the old indigo tract in Bihar. It was necessary for tractor agencies to carry enormous supplies of spare parts and it was not therefore surprising that the tractor business did not pay its way. Some makers of tractors did not make provision for spare parts and the Committee therefore recommend that only well-known makes should be employed. The Committee dealt only with the internal combustion engine.

Mr. Churchill said that users of tractors all over India had experienced the same difficulties. The distribution agencies had been very capricious as only a few had taken themselves seriously. Service was better near large cities where railway freight was small but in the *mofussil* it was practically non-existent. The results so far could not be considered satisfactory. In paragraph 3 of the report it was stated that the tractor outfits at present on the market were designed for Western conditions, but he considered that many parts of the United States had conditions sufficiently near to those in the East to enable manufacturers to turn out machines suitable for India. All that was necessary was to modify slightly certain parts to make them suitable for Indian conditions, as was done in

the case of motor cars. The expert proposed by the Committee would keep in touch with the latest manufacturing processes and would get manufacturers to alter small details before sending new machines to India. The Committee considered this was not quite the work of the ordinary agricultural engineer. The expert should be well up in design and manufacturing processes. He proposed the following resolution :—

Resolution XIV.

" Resolved that a whole-time Expert should be appointed and attached to the Agricultural Expert to the Imperial Council of Agricultural Research who will be available for giving advice to the Provinces on problems connected with mechanical cultivation. This Expert must possess extensive knowledge of current agricultural machinery, design and manufacturing practices and will act as a co-ordinating agency.

Further resolved that he should, in addition to his other duties, take up the investigation in connection with the determination of draught of bullock-drawn implements."

Mr. Mayadas in seconding the resolution drew attention to the fact that the future for tractors in most parts of India was assured. It was important to observe the improvements in tractor design and manufacture which had taken place within the last few years and they now showed a likelihood of being suitable. He referred to the fuel consumption which a few years ago was 1·25 pints of kerosene per B. H. P. per hour, whereas a modern up-to-date machine consumed ·42 pint per B. H. P. per hour of crude oil. Another distinct improvement was in the available horse power at the drawbar. A few years ago this amounted to 50 per cent. of the total horse power, while now-a-days it was 75 per cent. Another great advance was in the flexibility of power for ploughing, especially virgin land. The Diesel type of engine claims to have made the tractor equal to steam power in this respect. One of the drawbacks of the tractor in the past was its short life, due to its high revolutions of 1,000 per minute, but in the Diesel type this has been reduced to 300, thus giving it a life three times as great as previously. The idea underlying the resolution was to employ an expert who would get into touch with the manufacturers. It should not be supposed that the most suitable type of tractor for India had been found, and it would be one of his duties to find the type most suitable. He would also do very valuable work in investigating and experimenting with the machinery to go along with the tractor.

Mr. Sayer said he wished to corroborate what Mr. Mayadas had said regarding the Diesel engine. He had seen an engine of this type working along with Fordson and International tractors. They were engaged not in agricultural work but in pulling cane trucks. The Diesel with its engine revolving slowly moved with ease 70 trucks. The kerosene oil engines were run up to full revolutions and stalled badly. If the Diesel class of engine were imported for use in India, working costs would be reduced considerably and the life of the tractor increased. These tractors were being turned out in very small numbers at present and until they were produced on a large scale, no one, except perhaps Government, could experiment with them, as the cost was too high. It was hopeless to expect a firm which was at present dealing with kerosene oil tractors to give any help in introducing another type which would kill their business, and the same could be said with regard to implements. A large number of tractor ploughs sent to India were by no means suited for work in the country. The expert would be able to tell the makers exactly what was required. Also he thought that much more work could be done in the matter of finding a cheap lubricating oil, and he considered research could be carried out into this very important subject by the expert.

Mr. Vagholker gave his strong support to Mr. Sayer and Mr. Mayadas. In Gujarat there were 100 tractors and the greatest difficulty of the purchaser was to find the best and most suitable machine. As a rule the purchaser bought the cheapest and before the end of the season he had to spend a lot on spare parts. The expert would be useful for designing and advising and also for collecting useful information regarding different makes.

Mr. Sane said for 10 years the Baroda State had taken great interest in tractors of which there were 40 in the State, mostly owned by growers. At first most of them paid the penalty of all pioneers. Latterly the tractors were owned by men of substance to open up new land and to hire out on contract. They purchased on the recommendation of the makers which was far from satisfactory. All such machinery needs to be run by skilled drivers. The Government had assisted in opening classes for some years but the risk of employing a careless driver would always be present. He thought the Government could render real service by supplying expert engineers. The service proposed in the resolution would be very useful in making the tractor go much further than it did before. If makers were to produce a tractor which was absolutely foolproof, most of the complaints about them would go. No mention had been made in the report of the Committee of the Orwell cul-

tivator which they had found more useful than the disc harrow on sandy loams.

Mr. Pandya said that Gwalior had experience of mechanical cultivation for 15 years. They had very large tracts of virgin land available at Gwalior for cultivation. They had introduced steam tackle 15 years ago but for want of expert advice the development scheme fell through. They then tried another make of steam tackle and again the same thing happened. They then bought Avery tractors with the same sad experience. The problem then was to know exactly what to do with all their derelict machines. Some of them were sold to factory owners for ginning. Their whole trouble was due to the lack of trained mechanics. The kerosene oil tractors did not prove a success because they could not get good drivers. Then they had trouble with spare parts, and in order to keep the tractors going they had to keep a large stock of spares which meant a big investment of money. The firms in the meantime had designed new machines and when fresh parts were required they were unobtainable, and they were told it would be cheaper to purchase new tractors. Before taking up further tractor cultivation in India it was first necessary to find out their utility so that previous failures should not be repeated Regarding implements, the Agricultural Engineer in Gwalior has designed a very efficient type of plough called the "Scindhia" plough which had proved very useful and had been taken up largely by cultivators.

Mr. Mayadas said he had certain information regarding the failure of tractors and steam tackle in Gwalior, and this was due to the fact that the Gwalior Government paid very low wages to the drivers and thus did not get good men. There was no reason why a good, even though old, tractor should not give good service if it was well looked after. He did not share the view that there was no future for tractors in India.

Mr. Pandya said he was not against the use of tractors in India. He believed there was a great future before them but what he wanted to emphasise was the difficulties the Gwalior Durbar had experienced. If they had had expert advice they would not have been put to loss. The pay given to the tractor drivers in Gwalior was very high, amounting from Rs. 50 to Rs. 100 with a bonus in addition. He would support the resolution.

Mr. Higginbottom said he was very glad the Committee had put the resolution in the way they did. He believed that the limiting factor in the use of tractors in India was not money, but trained men to run them and keep them running. He thought that Agri-

cultural and Engineering Colleges should make more provision for training in tractor driving. He had seen a man driving a tractor well, but he did not know how to adjust the plough so that the tractor got a bad name. In the training of such tractor drivers it was necessary for the teacher to have some knowledge of agricultural conditions. In his experience tractors could cultivate much cheaper than bullocks.

The **resolution was** put to the vote and **carried unanimously.**

The Report of the Committee is as follows :—

The subject of mechanical cultivation in India with special reference to motor tractor cultivation was considered at the 12th meeting of the Board of Agriculture in India. Since then a good deal of information which covers all the sub-sections of item V(A) of the agenda of the Board is summarized in a tabular form (attached herewith) from the details supplied to the Committee by the representatives of the Provinces. This form is lacking regarding information about Bengal and Indian States.

2. From this tabular summary it will be seen that motor tractor cultivation is spreading in some Provinces. In others, such as the Punjab, the tractor has practically no future under existing conditions, because of the difficulties that have to be surmounted in laying out fields for canal irrigation purposes and also because of the plentiful supply of labour and absence of direct cultivation. In some Provinces the sphere of usefulness of the present day tractors is limited because of the small size of fields for such crops as paddy and the unsuitability of the existing implements to cultivate these satisfactorily.

3. The tractor outfits at present on the market having been designed for Western conditions can hardly be expected to fulfil the varying needs of the different Provinces. The Committee, however, consider that if expert advice with regard to suitable modifications in design for tractors and implements with due regard to manufacturing practices were available, it would help the Provinces considerably in solving some of their difficulties.

4. The post of an Agricultural Engineer to the Government of India has already been sanctioned and the Committee, after careful consideration, have come to the conclusion that the time has now arrived to attach an expert in mechanical design to the Agricultural Expert to the Imperial Council of Agricultural Research. He should possess extensive knowledge of current agricultural machinery, design and manufacturing practices in order to be in a position to advise the Provinces on problems connected with mechanical cultivation. He will also act as a co-ordinating agency for design and for the pooling of information and will be able to take up the work in connection with the determination of draught of bullock-drawn implements referred to in Subject V (B).

5. Papers have been put before the Committee on the special problems on mechanical cultivation in Sind and on the production of agricultural implements by a firm in Bombay Presidency. This Committee is not in a position to give specific advice in these cases but the request shows that there is a considerable demand for reliable advice from a mechanical expert.

Points on which information is wanted from the Provinces.	The Punjab.	United Provinces.	Bihar and Orissa.	Burma	Central Provinces.	Madras.	Bombay.
1. Number of tractors and steam ploughing tackles in existence.	About 40 tractors and six sets of steam ploughing tackles.	Under 50 . .	About 200 .	200 A few sets of steam ploughing tackle also working in the Province	Under 100 One set Fowler's steam ploughing tackle, especially meant for reclaiming Kans-infested lands and owned by Government is in use	Not known but probably not considerable.	About 160 exclusive of Sind and States.
2. Prominent makes	International Harvester Co.'s in the majority followed by the "Case."	International Harvester Co.'s 15 30 tractor, the "Case" is also popular	International Harvester Co.'s 15-30 predominates	Fordsons predominate	International Harvester Co's 15-30 tractor The big "Case" equally suitable, probably more so.	International Harvester Co.'s predominating	International Harvester Co.'s, Fordson and Cletrac predominating. Principally used for ploughing.
3. Particulars of work for which best suited.	Very suitable for reclaiming limited areas infested with weeds and jungle which cannot be brought under cultivation by means of country implements.	Chiefly useful for sugarcane cultivation, opening up of virgin lands and farming of wheat lands on large scale.	Useful for preparatory cultivation of sugarcane lands	Used exclusively for cultivating lands lying along the river banks and which are annually flooded.	Tractors suitable for ordinary cotton cultivation in black cotton tracts Completely unsuited for the heavy soils of Nerbudda Valley.	Ploughing black cotton soils to eradicate *doob*.	....
4. Whether privately owned or purchased with State aid.	....	Chiefly owned by prosperous zemindars.	Chiefly privately owned.	Practically all privately owned.	Mostly private. Demand on the decrease	All privately owned	Almost all privately owned. Ploughing average Rs. 6 to Rs. 9-13-0 per acre.
5. Cost of different kinds of work.	Please see Appendix A. *	Please see Appendix B. *	Please see Appendix C * Data supplied by the Imperial Agriculturist.	Rs 8 per acre charged by contractors for double discing, actual cost of operation Rs. 3-12-0.	Actual cost of ploughing with steam tackle about Rs 17 per acre Steam ploughing cheaper than tractor farming. Rs. 17 per acre for tackle ploughing too small margin.	....	..
6. The most suitable implements.	Mould-board plough more suitable than disc plough as it does not disturb the land levels to any appreciable extent.	Three-furrow mould-board plough the best implement; the new "harrow plough" becoming very popular.	Three-furrow mould-board plough and tandom disc harrow most suitable.	Chief implements disc harrows	Mould-board plough and disc harrow the best implements	Mould-board plough more satisfactory than disc harrow	....

* Not printed.

Points on which information is wanted from the Provinces.	The Punjab.	United Provinces.	Bihar and Orissa.	Burma.	Central Provinces.	Madras.	Bombay.
7. Possibilities for use during the off season.	....	As far as is known threshing the most remunerative operation during the off season. [Please see Appendix B (I)].*	Threshing, pumping, road haulage.	Pumping and threshing. Not much used during off season at present.	Pumping, sowing, ginning threshing, fodder cutting, flour mills, cane crushing	Making *kachha* road during off season with the help of grading machinery.	Stationary work such as haulage, cane crushing, chaff-cutting, ginning, pumping, etc.
8. Practical problems arising out of the introduction of tractors— (*a*) Supply and training of drivers. (*b*) Availability of spare parts. (*c*) Size and contour of plots. (*d*) Communications. (*e*) Depreciation. (*f*) Special climatic difficulties in each province.	Tractor cultivation under present conditions has no chance in the Punjab because of the plentiful supply of tenants willing to cultivate land on the half share system. Also the land for tractor cultivation requires special laying out and this as a rule interferes with the distribution of canal water. These difficulties limit the use of tractor machinery.	Existing designs generally unsuitable for opening up uneven forest land. A type that will reduce the size of the head lands very desirable. Flexibility of power desired.	....	After sale service defective at present Further facilities required for the supply of spare parts locally at reasonable prices. Modern tractor outfits are unsuitable for ordinary paddy cultivation.	Suitable drivers not available at all.	Difficult to get drivers.	Non-availability of trained drivers. Better service after sales required.

* Not printed.

Subject VI.—Work on Soils in India.

Terms of reference.—To recommend measures for the collection and publication of work on soils in India.

The members of the Committee were :—

1. Mr. D. Milne (*Chairman*).
2. Mr. J. H. Walton.
3. Mr. G. R. Hilson.
4. Mr. B. Viswanath.
5. Mr. D. R. Sethi.
6. Mr. W. Roberts.
7. Mr. P. H. Carpenter.
8. Dr. J. Sen.

Mr. Milne, in introducing the report, said his Committee had suggested the establishment of a Central Bureau of Soil Science. There were so many different aspects of soil science that they could not all be taken up at once. They had recommended that the Bureau should be in charge of an experienced soil scientist. The Bureau was intended to assist any research institute in India and any workers engaged in soil research. He moved the following resolution :—

Resolution XV.

> ***"That a Central Bureau of Soil Science under the direction of an experienced soil scientist is a matter of urgent importance and should be established as early as possible."***

This was seconded by Dr. Sen.

Dr. Sen said that the need of such institutions was felt in advanced countries like England. Many important results of researches were not available away from the locality in which they had been carried out. The workers had neither time nor opportunity to sort out what data they had collected, nor had they a place to put it in a form liked by scientists. The Bureau would also act as a centre where scientists would get an opportunity of discussing their subject. The Committee had suggested a Bureau on the lines of the Imperial Soil Bureau but much more modest to start with. Workers in the field would have confidence in the Bureau and it was necessary to make every effort to reinforce the work already being done.

The **resolution was carried unanimously.**

The Committee's report is given below :—

The Committee feel that as India is a large country with soil problems as diverse as those of Europe and America it is necessary to institute a permanent

organisation for soil work on lines similar to what exists in these countries. Further it was felt that a large amount of research work has been done to-date in the Provinces which has not been made available for the rest of India, and that the collating and publishing of the records is the function of a central body. The Committee, therefore, recommends :—

That a Bureau of Soil Science should be instituted to deal with this work and that this Bureau should ultimately undertake duties analogous to those undertaken by the Imperial Bureau of Soil Science in England (headquarters, Rothamsted).

The different aspects of soil science are too numerous, however, to allow the proposed Bureau to start work on all at once, therefore, it should begin by—

(*a*) getting into touch with research workers on soils in India,

(*b*) collecting, abstracting and collating information from all Indian sources bearing on the most important problems under investigation in different parts of the country.

Later developments may be decided upon in the light of experience.

The Committee recommends that an experienced scientist who has worked on soils should be appointed to take charge of the Bureau ; and that the Imperial Council of Agricultural Research should give assistance to Provinces in the collection of data. The members agree that much uncollected data exist and that workers in the Provinces have not sufficient time to devote to this task.

The records of the work on soils should be prepared for publication by the staff of the Bureau, and published in the proposed journals and monographs of the Imperial Council of Agricultural Research.

The Committee therefore commend to the Board of Agriculture for approval the following resolution :—

That a Central Bureau of Soil Science under the direction of an experienced Soil Scientist is a matter of urgent importance and should be established as early as possible.

Mr. Carpenter was unable to sign the Report as he had left Pusa.

Subject VII.—Water Requirements of Crops.

Terms of reference.—"To consider the question of accurately measuring the amount of water required for various kinds of crops, especially the more valuable crops, and the period during which waterings should take place to give optimum results, and to suggest methods of investigation."

The members of the Committee were :—

1. Mr. W. Roberts.
2. Mr. D. Milne.
3. Mr. G. R. Hilson.
4. Mr. J. H. Walton.
5. Mr. P. H. Carpenter.
6. Dr. J. Sen.
7. Mr. D. R. Sethi.
8. Mr. D. P. Johnston.
9. Mr. B. Viswanath.

Mr. Roberts, in introducing the report, said the Committee felt that the terms of reference were rather narrow. The subject was considered fully in 1917 at the Board of Agriculture at Poona and they thought it best to review that work and see how far present conditions agreed with the recommendations then made. With three irrigation projects in train amounting to 60 crores of rupees and 50 crores of rupees already involved in large-scale irrigation works in India it was necessary that something should be done to study the economy and duty of water. No business company would spend such a large amount of capital without employing a big staff of investigators to try to reduce the amount of water used, etc. He proposed the following resolution which was seconded by Mr. Hilson :—

"*That an experimental station or stations to carry out the work enumerated in this report be established.*" **Resolution XVI.**

Mr. Vagholkar said that 11 crores of rupees had been spent in canal irrigation in the Bombay Presidency and except for sugar no work had ever been done on the water requirements of crops. He had been unable to find in any report that work of this nature had been carried out in India though the subject was discussed 12 years ago. He considered it very necessary that work should be started at once.

Mr. Ulvi said that economy in the use of water was essential. He had carried out experiments on the water requirements of many crops and as different tracts had different climatic conditions he thought it desirable that research should be conducted in as many stations as possible throughout India. In Sind the cultivator supplied 5 to 6 irrigations to wheat and the Agricultural Department had found that two irrigations after the initial watering of the land gave better results.

Mr. Henderson said that the knowledge of the duty of water was very limited as they had no scientific data on which to base their information.

Dr. Burns said that this work would have to be done in close collaboration with the Irrigation Department and it should not be forgotten that each Department would have a distinct work to do.

Mr. Sane asked whether the resolution meant that new stations would have to be opened or whether the old ones would suffice.

Mr. Roberts said that the staff required was given in detail in the 1917 report and his Committee had therefore not mentioned it. If separate stations, as recommended, were opened, the fullest use should be made of existing ones.

Mr. Burt said that he was glad that the Committee had brought to notice the Poona report. He would like to mention that Mr. Clarke, Director of Agriculture, United Provinces, had obtained a very useful meter for measuring the water applied to experimental plots which was in use at Shahjahanpur; it was comparatively inexpensive and portable. It was a great advance on previous methods and he believed Mr. Clarke, after lengthy experiments, had given the makers full particulars of the requirements of an agricultural research station.

Mr. Mayadas asked whether the Committee had investigated the problem of the loss of water from the plant and the soil. No work had been done on this subject in India but a lot had been done in America.

Mr. Milne drew Mr. Mayadas' attention to para. (*a*) of their report which defined one of the objects of their proposal that the subject should be taken up as a central subject by the Imperial Council of Agricultural Research.

The **resolution was** put to the vote and **carried unanimously.**

The Committee's report is as follows :—

The Committee consider that the terms of reference are indefinite but that if its members are desired to select and recommend devices to be employed in measuring water, they are of opinion that this is the work of an expert engineer with experience in hydraulic work. Further, in view of the comprehensive manner in which the subject of water requirements of plants was considered by the Board of Agriculture held at Poona in 1917 under the chairmanship of Mr. Ward (now Sir Thomas Ward), they think that it would be a retrograde step to consider only a small portion of this problem. In view of the overwhelming importance of water for the growth of crops, and the capital expenditure involved in large and small irrigation schemes in India, and further as the Committee was informed that several Provinces are already

engaged on, or, are contemplating taking up certain aspects of the problem, the members feel that the subject is of such importance that it should be taken up as a central subject by the Imperial Council of Agricultural Research, the object being—

(*a*) to conduct fundamental research including, for example, the water requirements of crops under various conditions (*vide* Dr. Leather's paper), effect of physical factors on loss of water from the soil, plant physiological, soil micro-biological effects of water supplies, etc.

(*b*) the study of economics of different systems of irrigation farming together with the cost of water under the different systems.

(*c*) the study of methods of application of water, *e.g.*, " kiaris " or bed system, " grading," " furrows and ridge system," etc.

(*d*) the study of irrigation practices in other parts of the world and their application to India.

(*e*) the study of " meters," " modules " and " outlets " and their bearing on water distribution and economy together with volume measurement of water and payment by volume.

(*f*) the study of intensity of irrigation and effect of proportion of summer and winter water supply on " duty " and " demand ".

(*g*) the working out of statistics and putting together the mass of information already at hand with agricultural and irrigation officers and in Secretariat files.

(*h*) the study of well irrigation as far as pumps and different methods of lifting are concerned.

(*i*) to give advice to Provinces interested.

The determination of the periods during which waterings should take place to give optimum results will be part of the work undertaken. In this connection the Committee wish to refer to the very valuable work done by Dr. Leather on the movements of water through soils and the relationship of water supply to plant growth.

The Committee wish to endorse the recommendations of the Board of Agriculture held in Poona in 1917 and consider that the lines of investigation required have been fairly fully enumerated above.

The Committee therefore commend to the Board of Agriculture the following resolution :—

That an experimental station or stations to carry out the work enumerated in this report be established.

Mr. Carpenter was unable to sign the report as he had left Pusa.

FIFTH DAY.

The Board re-assembled at 10-30 A.M.

Subject III.—The Locust Problem in India.

Terms of reference.—" To discuss the question of investigating the biology of the insect and to make suggestions for control measures."

The members of the Committee were :—

1 Mr. B. C. Burt (*Chairman*).
2. Mr. T. Bainbrigge Fletcher.
3. Mr. P. V. Isaac.
4. Dr. W. Burns.
5. Mr. A. K. B. Cazi.
6. Mr. C. V. Sane.
7. Mr. Afzal Hussain.
8. Mr. P. B. Richards.
9. Dr. L. C. Coleman.

Mr. Burt, in moving the adoption of his Committee's report, said that this subject appeared on the agenda of the Imperial Council of Agricultural Research as well as on that of the Board of Agriculture. It would clearly have been better if the Research Council could have had the advantage of considering the recommendations of the Board of Agriculture but it so happened this year that the Research Council meeting was held before that of the Board. In view of the importance attached to the subject by several Local Governments, the Research Council had appointed a Committee whose terms of reference would be found in the report now under discussion. It would be observed that the Committee of the Board had divided their report into three sections, *viz.*, intelligence, investigation and control. On account of the magnitude of the subject, they were unfortunately unable to complete their task but they had embodied in the report all the information which they had been able to put together in the time available. The Committee proposed a series of resolutions for acceptance by the Board which would be moved subsequently.

He desired to emphasise that locusts differed from most insect pests in that the damage, though occasional, was enormous and produced famine conditions. In every Province in India there was a permanent organisation for dealing with famine, and he thought that anti-locust measures should be planned on similar lines. Provincial organisations for fighting famine did not only deal with relief during a famine but included methods for protection against famine and intelligence organisations to enable relief measures to be promptly organised. He thought that the same principles should be adopted in dealing with locust invasions. If locust-control was to be effective, it could not be left to individuals or to small units but must be controlled by a large organisation. The magnitude of the problem would be clear from the fact that the present locust visitation was estimated to mean a loss to cultivators in Northern India of anything from Rs. 3 crores to 5 crores.

Mr. Sane seconded the adoption of the report.

Mr. Roberts asked what sort of help India could expect from the Committee of Civil Research.

Mr. Burt said the printed papers before members included the report of the Committee on Civil Research, one of whose recommendations was that organised locust research should be undertaken throughout the Empire. This Committee suggested that a fund of £4,000 should be raised of which the Dominions and Colonies should contribute half. The idea was to send out two pairs of Entomologists, probably to Kenya and the Sudan, to make a general study of the biology of the insect. Full details were given in Mr. Fletcher's note (p. 153).

Mr. Mayadas asked whether the Committee had got exact information regarding the damage done by locusts or whether it was only a generalisation.

Mr. Burt said that in some Provinces at least it was possible to assess the damage done from the amount of revenue remissions.

Mr. Richards said in the United Provinces the damage was now being investigated by field to field enquiry. The figures, he understood, were now with the Revenue Department and had not come through to him. He himself had a certain number of reports from Collectors of the area attacked and the damage done, and though it was difficult at present to give the actual damage, it had been estimated that in the Aligarh District the loss incurred amounted to Rs. 18 lakhs, in Muttra somewhere in the vicinity of Rs. 50 lakhs and in several other districts from Rs. 15–20 lakhs. This loss had been incurred during the month of September and was caused entirely by the insect in the hopper stage. In the United Provinces he estimated that the probable loss of crop would approximate to Rs. 1½ crores.

Mr. Afzal Hussain then moved the following resolution :—

Resolution XVII.

"***Resolved that immediate steps should be taken for the establishment of an Intelligence Bureau***".

He said that we were now planning war against one of the most serious pests in nature. The magnitude of the damage done was very great and it should be remembered that the loss was not confined to one year, because zemindars were compelled to borrow money so that they would be in debt for several years to come. Locusts should be looked on as a perpetual enemy. In war, the Intelligence Branch is the most important, especially as the enemy is not always present. In the case of locusts the invasion comes suddenly when the people are unprepared for it. It was necessary to get into immediate touch with the invasion and a well-organised bureau was necessary. In the Punjab they had the assistance of

all Patwaris, Inamdars and revenue officials who had to report to the Tahsildars the first appearance of locusts, the hatching of the eggs and the amount of damage done. This information was passed on to the Director of Agriculture and the Entomologist. This organisation should be elaborated and it was necessary to obtain a true record of the events and help sent immediately. It was also necessary to know the movement of the locusts from one Province to another. The last invasion in the Punjab came from Sind and no information was received about it. What was required was a central organisation with branches in the Provinces, one of whose duties would be to collect information.

Mr. Mayadas seconded the resolution.

Mr. Milne said that one of the resolutions proposed by the Committee commended the organisation in the United Provinces to other Provincial Governments. He would like to remind the Board that the Punjab had a very fine organisation which was fully set out in the Land Administration Manual. He would like this to be brought to the notice of other Governments.

Mr. Richards said that the United Provinces would appear to be the eastern extremity of the pest. When he first heard casually that there was a danger of locusts coming to the Province, he warned the Government but till the invasion actually came nothing was done. A provincial organisation was not what the resolution was driving at, because a provincial organisation was useless unless there was a central one. If he had been able to obtain funds and apparatus when he first heard of the invasion, he thought he would have been able to save one out of Rs. 1½ crores damage in the United Provinces. They were in no better condition now than they were four months ago. Entomologists in the various Provinces might inform one another of an invasion, but what about Indian States? The main function of the Central Bureau would be to obtain all information available from all over India.

Mr. Milne said that the organisation laid down in the Punjab was of great assistance in dealing with the locusts in a particular area, and he quite agreed that a Central Bureau was necessary.

Dr. McRae said that in June last (fully a month before their usual time), the Resident of one of the Central India States had reported to him that locusts had appeared and he had telegraphed to the Governments of the Punjab, United Provinces, Bombay and Sind.

Mr. Burt said one of the duties of the Intelligence Bureau would be to issue warnings similar to the storm warnings issued by

the Meteorological Department. As isolated items of intelligence were difficult to interpret, the Bureau would send out information in *extenso* to the various Provinces.

The **resolution** was put to the vote and **carried.**

Mr. Fletcher was asked by the Chairman to move the following resolution :—

" The Board of Agriculture recommends that fullest advantage should be taken by India of the present opportunity of co-operating with the Council of Civil Research in an Empire anti-locust investigation ". **Resolution XVIII.**

Mr. Fletcher said he had mentioned in his note how wide was the distribution of locusts in the world. India was only one end of the region of occurrence. On page 130 of his note he had included a statement of recent occurrences from which would be seen that there appeared to be a common impulse of increase, and it was more than a coincidence that when outbreaks occurred in India there had generally been outbreaks elsewhere. No one knew what this was due to, whether to conditions in the permanent breeding grounds in Persia, Arabia or Africa, etc., or to a periodic increase. It was most important that we should know the exact cause. It would not be possible to send our own investigators outside India. The Council of Civil Research proposes to employ two pairs of Entomologists and send them to Kenya and the Sudan, and it is desirable that India should take the opportunity of co-operating in the investigation and also that India should contribute its quota to the scheme and, if possible, obtain the services of Entomologists to carry out the work here.

Dr. Burns seconded the resolution.

Mr. Warth asked what form the co-operation was intended to take.

Mr. Burt said the Committee had considered this point as would be seen from paras. 8 and 9 of the report (pp. 64-65). The Committee felt that the details could best be left to the Agricultural Research Council, and the Board should confine itself merely to a recommendation that India should take advantage of co-operating in a world campaign.

The **resolution was** put to the vote and **carried.**

The Chairman asked Mr. Richards to propose the following resolution :—

" The Board of Agriculture desires to emphasize the importance of securing the necessary staff at once to carry out **Resolution XIX.**

(a) investigation on control measures, (b) a survey of permanent breeding grounds of the desert locust in India, and subsequently the further investigation into the bionomics of the insect referred to in the Committee's report".

Mr. Richards said that the subject matter would be found in paragraphs 13, 14 and 15 of the Committee's report (pp. 66-67). Of the problems requiring solution, the most urgent were control methods. In India they had a very limited experience of these. It was necessary to find out which was the most effective and cheapest method of control, whether mechanical or chemical. In India there seemed to be a deep aversion against the use of poisons. In other parts of the world arsenical poisons were used but it was feared that, if this method were adopted in India, there would be a great deal of cattle and other poisoning. What it was required to know definitely was whether there was any risk. The work of determining whether these poisons are dangerous can be done now before the next locust invasion. This does not require the presence of the hopper as we know that they are killed by the poisons. Following the determination of its safety it was necessary then to work out the economic possibilities of various methods. This can be done only in the very short period of four weeks in the history of the hopper. As soon as the first move begins work can be started. Following this comes the question whether there are permanent breeding grounds in India. If they do occur in India it would be possible to nip an incipient outbreak in the bud by dealing with the eggs. All this work can best be done by the staff controlled by the Central Bureau.

Mr. Ware in seconding the resolution said that the Imperial Institute of Veterinary Research, Muktesar, might be made use of on the question of poisoning of domestic animals as they had a large number of animals of little value to experiment on.

Mr. Burt said he welcomed the suggestion of Mr. Ware. It would be valuable to find out something about sodium fluosilicate which was known to be more toxic to locusts than arsenical poisons and less dangerous to cattle.

Mr. Mayadas asked whether the Committee had considered the question of the staff and the number required.

Mr. Burt said that the Committee put forward no specific proposals as they thought it best to leave details to the Research Council.

The **resolution was** put to the vote and **carried.**

Mr. Burt proposed the following resolution :—

Resolution XX.

" Resolved that since the aim of locust-control operations should be the complete eradication of the pest from the whole of the affected area within a single generation, and since inadequate or delayed expenditure may entirely vitiate the success of the operations, it is essential to locust control that there should be an immediate adequate provision for funds, apparatus and labour ".

Mr. Burt said this resolution dealt with control measures as distinct from investigation. Several members of the Committee had supplied valuable notes, and the Committee was also fortunate in hearing Mr. Richards who had personal experience of locust control in the United Provinces and in Malaya. The Committee had been rash enough to put on record a few suggestions regarding methods of control, but they considered the problem to be so urgent that every help should be given to those Provinces faced with the invasion. What was required was organisation and money to enable immediate measures to be taken, and he thought there should be an emergency fund. The establishment of an Intelligence Bureau would materially assist in giving effect to this resolution as Local Governments would not be entirely ignorant of the risks of an attack. It was necessary to wipe out the pest completely. In this way money could be spent once and for all. It was also important that all energy and labour available should be devoted to profitable control methods.

Mr. Fletcher seconded the resolution.

Mr. Roberts said the resolution stated that what was wanted was immediate provision of funds, while Mr. Burt's remarks dealt mainly with funds on the analogy of famine relief.

Mr. Burt said he had mentioned the famine relief fund as an example but it would be for Local Governments to decide by what method an emergency fund should be established.

Mr. Richards said that no provision for financing an anti-locust campaign existed in the United Provinces. When the pest was known to be serious he asked the Local Government for money, and owing to financial stringency he was able to obtain only a small part of his demand at first. When he finally obtained the sum originally asked for, it came too late as the locusts had started flighting. There was no use trying to tackle locusts unless all requirements were met within 24 hours. The money he received could not be spent to the best advantage. No proper arrangements had been made for labour. The Government said at first that

cultivators should not be paid because it was a question of crop protection, but in many cases it was found necessary to make payments. He considered there should be some form of compulsory service but payment should be optional. He considered it absolutely essential to have the organisation, funds and apparatus all ready

The resolution was put to the vote and **carried.**

The Chairman asked Dr. Burns to move the following resolution :—

Resolution XXI. ***" Resolved that an adequate organisation for locust control is essential in each Province or State within the area subject to locust visitations. The organisation adopted in the United Provinces (see Chapter 2 of memorandum by Mr. Richards which forms an appendix to this report) for dealing with the 1929 visitation is commended to the notice of all Local Governments and the Government of India. Though details must necessarily differ in the various Provinces and States, the anti-locust organisation should include :—***

(*a*) ***an adequate intelligence branch,***

(*b*) ***an executive for each district or other administrative unit, and***

(*c*) ***a central controlling authority".***

Dr. Burns said that the previous resolution dealt with funds, apparatus and labour, but he thought it was necessary also to have an organisation ready to be called up in an emergency. The idea was that the existing personnel should be applied to emergency conditions, just as in boat drill on board ship. In the Punjab there was such an organisation and to some extent also in the United Provinces, whereas in Bombay and Sind it had still to be formed. He considered this should be arranged for at once. He wished it to be understood by members of the Board that the Committee's recommendation regarding the United Provinces was meant only as an example and was not intended to be followed necessarily in all Provinces. He was sure Mr. Richards would like his organisation to be criticised and improved on. He considered the responsibility should be put on the head of the district because there was no other organisation in a position to apply measures simultaneously over a large area.

Mr. Fletcher seconded the resolution.

Mr. Milne said he would like to have the following words inserted after the words " 1929 visitation " in the resolution :—

" and that described in the Land Administration Manual of the Punjab ".

He agreed with Dr. Burns that the revenue staff was best able to deal with the problem.

Mr. Richards cordially seconded the amendment. He said the Committee had no copy before them of the Land Administration Manual and therefore were unable to consider the organisation in the Punjab.

Mr. Mayadas asked whether the intention was to employ staff in addition to the Revenue and District staff.

Mr. Richards said the intention in the United Provinces was to utilize only the District staff. Provision would be made to requisition all assistance in the area attacked.

The **amended resolution was** put to the vote and **carried.**

The Chairman called upon Mr. Richards to propose the following resolution :—

Resolution XXII.

"Resolved that the Central Government should carry an adequate store of material for anti-locust campaigns for issue to Provinces or States as required".

Mr. Richards said the object of the resolution was an endeavour to cut down expenses as far as possible. The estimate of expenditure in the United Provinces for the next year on locust control amounted to Rs. 3 lakhs and it is possible that locusts may not prove a pest, whereas the Punjab may have a severe attack. If all Provinces and States in India have to maintain their maximum requirements of stores, it will mean a very large expenditure of money. The Committee considered that if stocks were held by the Central Government, much unnecessary expenditure would be saved. So long as stocks were in the country, there was no necessity for every Local Government to carry them. The idea was to pool resources to save unnecessary waste of public money.

Mr. Afzal Husain in seconding the resolution said it was difficult to obtain even ordinary insecticides and appliances in India, and he considered that stores for the destruction of locusts should be kept either with some firm or with the Central Government.

The **resolution was** put to the vote and **carried.**

Mr. Burt moved the adoption of the report as amended by the Board.

Mr. Mayadas in seconding said he was sure the Board would like to show it's appreciation for the large amount of work and useful information which the Committee had put before them.

The adoption of the Committee's Report on Locusts was carried unanimously.

The Committee's Report is given below :—

It was brought to the notice of the Committee that the Imperial Council of Agricultural Research has appointed a Sub-Committee of the Council with the following terms of reference :—

(*a*) To work out the technique and organisation required for the control of the desert locust, including measures not involving the use of poisons.

(*b*) To make recommendations for the scientific study of the desert locust in India and to work out the staff, equipment and funds required to carry this out.

(*c*) To recommend to what extent locust research should be carried out by Imperial and Provincial agencies respectively.

(*d*) To report what action should be taken on the recommendations of the Committee of Civil Research.

The Imperial Council of Agricultural Research has lost no time in dealing with this problem and it is hoped that funds will be allotted at an early date. In dealing with this subject the Committee of the Board of Agriculture have kept in view the fact that the Research Council will shortly be dealing with definite proposals for scientific work on the desert locust.

2. Serious damage to crops from locusts only occurs in India at intervals but when a serious invasion occurs, the damage done is enormous and the loss is comparable only with that caused by a failure of the monsoon leading to famine. The long interval between outbreaks has led to the pest being ignored in intervening years ; there is in consequence great ignorance as to the major facts concerning locusts in India and we do not know, for example, whether there are permanent breeding grounds within Indian limits, how many generations may be expected annually in India or how many egg-masses one female lays. The locust problem in India can only be dealt with if a central organisation is set up for investigation. Actual control measures must necessarily be carried out by Provincial Governments and Indian States, though central action is necessary in certain respects which we specify. The aim of locust control is to destroy all locusts rather than to protect individual crops. This must include measures to check incipient outbreaks by the destruction of locusts in any permanent breeding grounds at the commencement of the swarming phase. The migratory habit of the desert locust in the swarming phase necessitates co-ordinated effort throughout India both in British India and in Indian States. Some centrally administered areas and a number of Indian States are frequently important as breeding grounds. It is hence necessary that the Central Government should play an active part in the organisation of control measures, especially as the locust-affected areas under the Central Government and Indian States are much larger than those under Provincial Governments.

3. The work required in India may be divided into three sections—(*a*) an Intelligence Bureau which will centralise and summarise all information regarding locust outbreaks and movements, disseminate such information and inform areas liable to attack of impending or expected invasions, (*b*) investigation and (*c*) control.

Intelligence.

4. Control measures in various provinces have been greatly hampered both by lack of timely warning, which could have been given had a central organisation been in existence, and by lack of knowledge of the behaviour of swarms, some information as to which could have been made available had past records been centralised and studied.

5. In view of the orders contained in Punjab Financial Commissioner's circular letter No. 4147 of July the 2nd 1891 (subsequently issued as a circular) it appears probable that records exist in the Punjab on the following points :–

(*a*) Years and months in which the desert locust has appeared and in what district it has been reported.

(*b*) The months in which egg-laying was reported in the various districts.

(*c*) The months in which the hatching of eggs and the movements of hopper bands took place in various districts.

If such records exist for a period of 38 years they would be of the greatest importance even if they are incomplete. The compilation and summarising of these records should furnish very important information.

6. There is reason to believe that similar records may exist for the United Provinces, Bombay and Sind and Baluchistan. The Committee recommend that the Local Governments concerned should be asked to issue such orders as may be necessary for the supply of these records to the Central Intelligence Bureau.

7. From the nature of the work done it is clear that the Intelligence Bureau must be a central organisation and the Committee recommend that the Research Council should take early steps for the establishment of such a Bureau.

Investigation.

8. *Recommendations of the Civil Research Committee.*—The Committee strongly recommended that the fullest advantage should be taken by India of this opportunity of co-operating in an Empire campaign against the desert locust. There is reason to believe that the locust invasions which cause periodic losses in India have their origin not only outside India but in remote countries. Northern India appears to be the Eastern limit of the area affected by the desert locust which extends to North Africa on the West.

9. The Committee consider that, in view of the magnitude of the present locust invasion, the Committee of Civil Research be invited to send two entomologists to India at an early date, as they consider that a study of the present

locust attack in India would lead to important additions to knowledge of the biology of the desert locust. It is also recommended that the attention of the Committee of Civil Research be invited to the importance of Arabia and Persia as it is necessary to determine what the intermediate link between Africa and India is. Investigation in intervening countries is desirable since, even if control measures in those countries cannot be organised, regular intelligence of the behaviour in them of the desert locust would be of economic value.

10. The Committee have examined the recommendations for anti-locust work contained in paragraphs 5, 6 and 7 of the second report of the Civil Research Committee, and offer the following observations:

I. The study of methods of control for use in India must be carried out in India by the Indian central organisation, though the results obtained in other parts of the world would be of great assistance.

II. The location of possible permanent breeding areas and migration routes.

The Central Intelligence Bureau for India, which we have proposed, will furnish the Imperial organisation with Indian information. The notes prepared for this meeting of the Board of Agriculture summarise information regarding locusts in India which has not previously been collated, and we recommend that these notes should be forwarded to the Imperial Bureau of Entomology.

III. Bionomics of the Locust and the Periodicity of its outbreaks.

(*a*) "Study of its annual life-cycle in different areas in relation to local conditions".

This study must be made for India in India.

(*b*) "Laboratory studies on the influence of temperature, humidity, crowding, etc., on its development, behaviour and phase variation".

These may be left to the Imperial Bureau of Entomology to organise.

(*c*) "Study of the ecology of the locust; climatic factors of control; natural enemies, associated animals and their balance."

We understand that the term "natural enemies" includes fungal and bacterial diseases. This aspect of the problem must be studied in each locality and the work must therefore largely be done by the staff which we propose that the Imperial Council of Agricultural Research should organise but in collaboration with other scientific workers in India and the staff of the Imperial Bureau of Entomology.

(*d*) "Study of its phase and race variation as observed in nature; biometric studies of mass materials."

At present this line of investigation appears to be directed to the establishment of a means of diagnosing the change of phase. These investigations can best be carried out by the Imperial Bureau.

(*e*) " Study of meteorological conditions in the affected countries and correlation of the data with the course of outbreaks."

Such correlations can best be worked out by the Imperial Bureau ; the Indian Central Bureau will furnish all information which is available. If the existing meteorological records are inadequate, the question of setting up small stations can be subsequently examined by the Indian Bureau. Some agricultural stations, *e.g.*, Sakrand, maintain meteorological records which might well be utilised.

(*f*) " Studies in the anatomy, physiology and embryology of the locust."

These investigations can best be carried out by the Imperial organisation.

As we have already stated, the Indian Bureau would pass on to the Imperial Bureau all available information as requested in paragraph 7 of the Report of the Committee of Civil Research.

11. *Paragraph 8 of the Civil Research Committee's Report.*—It is understood that figures for land revenue remissions and estimates of the damage caused by the locust visitation of 1929 will be available shortly for the Bombay Presidency, the United Provinces and the Punjab. It is suggested that the Imperial Council of Agricultural Research should obtain these reports and forward them to the Imperial Bureau of Entomology.

12. It is necessary to draw attention to the fact that in the event of two entomologists from the Imperial Bureau visiting India for locust work, considerable expenditure by India would be involved. It appears that the Imperial organisation will only pay the salaries and possibly the sea passages of the entomologists sent abroad and that the Civil Research Committee interpret the phrase " local facilities as, for example, transport, labour and laboratory accommodation " in the widest sense. It would fall on the Indian organisation to meet the travelling allowance, pay of assistants, laboratory contingencies, etc., for these officers during their period of work in India, and while no estimates are possible until the work to be done is more clearly defined, our general experience suggests that a charge of, say, Rs. 30,000 per annum would be involved. This charge would fall on the Imperial Council of Agricultural Research as the budgets of the Imperial and Provincial Entomologists cannot meet such charges.

13. *Investigations in India.*—It will appear from the foregoing that, whatever the extent of the assistance which India may receive from the staff to be employed by the Imperial Bureau of Entomology (if the scheme recommended by the Committee of Civil Research is adopted), there is a large amount of investigation work which must be carried out in India and largely by a special staff. The two most urgent problems are :—

(1) an investigation of control methods including a comparison of their efficiency and cost, and

(2) a survey of possible permanent breeding grounds of the desert locust in India, notably Baluchistan, Rajputana, Sind and the Suleman Mountain range.

A further group of problems to which we have referred above in connection with the bionomics of the locust and the periodicity of outbreaks, also require investigation in India, notably the study of the locust's annual life-cycle in different areas in relation to local conditions and a study of the ecology of the locust, climatic factors of control, natural enemies, associated animals and their balance, fungal and bacterial diseases.

14. The investigation into control measures should be carried out in a province where methods involving the use of poisons can be employed; the use of aeroplanes will also be necessary.

15. The survey of permanent breeding grounds is most important; the flights of locusts which caused such serious damage in the United Provinces and Punjab in 1929 undoubtedly came from outside the Provinces. The Committee desire to emphasise the importance of securing the necessary staff at once in order that the work on these urgent problems may be started without delay.

Control.

16. We have already pointed out that a large locust visitation is comparable with a famine, in the widespread loss and distress which it causes. The fighting of locusts involves an adequate organisation and a prompt supply of whatever funds may be necessary. As an indication of the magnitude of the expenditure involved, it may be pointed out that in South Africa the following amounts were spent on locust control:—

	£
1923-24	325,000
1924-25	377,000
1925-26	217,000

Large as these figures are, they do not represent the total expenditure as State funds were devoted mainly to the supply of poisons and apparatus and these figures do not include the cost of labour. Large as the expenditure was, official reports state that it was entirely justified by the saving of many million pounds worth of crops. In dealing with a locust visitation, there is no time to waste in arranging for funds which should be forthcoming immediately to the extent required, for it is clear that money spent early may save much heavier expenditure later as well as greatly reduce the loss of crops. The Committee propose the following Resolution for adoption by the Board:—

> "*Resolved that since the aim of locust control operations should be the complete eradication of the pest from the whole of the affected area within a single generation, and since inadequate or delayed expenditure may entirely vitiate the success of the operations, it is essential to locust control that there should be an immediate adequate provision for funds, apparatus and labour.*"

17. *Organisation.*—The individual cultivator of the individual village is quite unable to protect crops against a serious locust attack much less to eradicate the pest. Only by thorough organisation can results of any importance be achieved. Nor is action by a single Province or State sufficient. Neglect of locust control in one territory must often lead not only to loss of crops within that territory but to the invasion of the adjoining territory on a greatly increased scale. We have already drawn attention to the probable importance of some centrally administered areas and Indian States in connection with the locust problem. The Committee propose the following resolution for adoption by the Board :—

> " *Resolved that an adequate organisation for locust control is essential in each Province or State within the area subject to locust visitations. The organisation adopted in the United Provinces (See Chapter 2 of memorandum by Mr. Richards which forms an appendix to this Report) for dealing with the 1929 visitation is commended to the notice of all Local Governments and the Government of India. Though details must necessarily differ in the various Provinces and States, the anti-locust organisation should include :—*
>
> (a) *an adequate intelligence branch,*
>
> (b) *an executive for each district or other administrative unit, and*
>
> (c) *a central controlling authority.*"

18. *Various Control Methods.*—The Committee consider it desirable to summarise the knowledge and experience at present available regarding the various control measures : It is necessary, in the first place, to state that, whatever control methods are selected, the apparatus and materials must be provided by Government ; this duty cannot be devolved on private persons whether by legislation or otherwise.

19. *Control Methods against Flying Locusts.*—This is the most difficult stage in which to control the pest and the main problem is to attack the locust at earlier stages in its life, but the following methods do a certain amount of good especially if applied to flying swarms on first arrival in a new area or to complete the destruction of a generation which has been attacked by suitable methods at earlier stages. Attempts to destroy flying locusts by day by mechanical methods are practically useless except when they are pairing or laying eggs when masses can sometimes be satisfactorily dealt with. Poison baits are not practicable as a general control method for flying locusts ; the direct dusting of locust swarms from aeroplanes, using sodium arsenite or other poisons, is still in the experimental stage. At night especially during cold weather locusts are sluggish and organised destruction by villagers will lead to useful results.

20. *Breeding Grounds.*—Miscellaneous egg collecting, especially if rewards are offered, is practically useless. Rewards for information as to where locusts have laid eggs will be far more profitable. Egg destruction combined with other operations on definite breeding grounds is useful. The ringing of breeding

grounds combined with the destruction of hoppers within the ringed area is the simplest, cheapest and most effective method of control. The best general method of ringing is trenching with the addition of a protective band of oil-cloth. In the case of small breeding grounds, this method of control will often render subsequent large-scale operations against hoppers unnecessary.

21. *The Control of Hoppers.*—The Committee desire to draw attention to the fact that the experience of other countries shows that poisoned baits should be adopted as the main method of destroying hoppers. Where poisoned baits are properly prepared and spread in front of advancing bands of hoppers, the risk of poisoning domestic animals is far less than is commonly assumed. Moreover a new insecticide (sodium fluosilicate) is now known to be more toxic to locusts than arsenical poisons and at the same time far less dangerous to domestic animals.

22. The dusting of food plants of the locusts with stomach poisons, whether by powder-guns or aeroplanes, is a method specially applicable to large uncultivated areas.

23. Spraying or dusting with contact poisons is not at present a practicable general method of control.

24. Where poison baits cannot be used, reliance will have to be placed on mechanical methods for the destruction of the bulk of the hoppers. Of such methods the driving of hoppers into trenches provided with American cloth strips, using oil-cloth screens to guide the locust bands, seems to be the most generally efficacious method.

25. *Burning.*—Burning of bushes is only an accessory method of hopper destruction adopted to special conditions. The use of flame throwers against hopper bands, and against winged locusts when congregated, is a method which is being extensively employed in Palestine and which is being tested in the Punjab. The present indications are that, in the Punjab, the method is expensive.

26. *Central Stores of Materials.*—We have already emphasised the fact that complete locust control is far from being an entirely provincial matter. A practical difficulty in organising control measures is that stores of the necessary materials are not available in India in adequate quantity: nor is it economical for each Province or State to maintain the stocks of materials required to fight an outbreak. If mechanical control is adopted, a single province may require as much as a lakh of yards of 48″ oil-cloth costing anything from 1½ to 1¾ lakhs. This quantity cannot be purchased in India at short notice. If poison baits are to be used, each million acres of affected area would require some 10 tons of either sodium fluosilicate or sodium arsenite. Neither of these chemicals is available in quantity in India. A cheap commercial quantity is required and a central store of 50 tons costing, say, half a lakh would probably be needed. It is suggested that both in the interest of economy and prompt locust destruction, the Central Government should carry a store of material for anti-locust campaigns which it would issue to Provinces or States as required. The central staff for locust work which we have proposed would be in a position to advise where supplies are most urgently needed.

Sir Vijayaraghavachariar said he was sure he was expressing the views of all members of the Board in thanking the authorities at Pusa for their collective official kindness and for individual kindness. Speaking for himself, he had enjoyed himself thoroughly at the meetings and he assured the members that his ignorance of agricultural subjects was less profound now than before. There could be no doubt that these meetings of the Board were very useful even though nothing else was achieved beyond bringing together agricultural, veterinary and animal husbandry officers to give them an opportunity both in the Board and at informal meetings of discussing their problems. This in itself, he considered, justified the existence of the Board. He would look forward with great pleasure to the next meeting and he thanked the members for their efforts to make the meeting a success. He also said he was sure the Board would like to thank the Secretaries, Messrs. Ritchie and Kothawala, for the hard work they had put through and for the efficiency with which they had done it.

Dr. Burns said he was sure the Board would agree with him that the success of the meeting was due mainly to the President to whom their thanks were due.

The President then dissolved the Board.

Resolutions passed at the 15th Meeting of the Board of Agriculture in India held at Pusa from the 9th to 13th December 1929.

Subject IV. 1. That a review of the organisation for all methods of agricultural propaganda and other extension work, should find a place in the Agenda by both wings of this Board at its future meetings.

Subject VIII. 2. That the Board cordially endorses recommendation 27 of Chapter XIV of the Report of the Royal Commission on Agriculture, and desires to emphasise the need for whole-time investigators for economic enquiries as it is impossible for agricultural assistants to carry out these investigations in addition to their ordinary duties.

3. That the following subjects for economic study should be agreed on :—

i. Marketing of crops.

ii. The finance of the cultivator with special reference to marketing.

iii. Consolidation of holdings.

iv. Size of holdings and the number of uneconomic holdings.

v. The cost of production of crops, cattle and dairy produce.

vi. The cost of maintenance of cattle.

vii. The economics of a village herd.

viii. Co-operation between landlord and tenant.

ix. The study of over-population of land whereby excess population could be diverted from the land into other channels.

Subject IX 4. Resolved that the Board of Agriculture considers the establishment of a Statistical Section in the Imperial Agricultural Research Institute with a statistician of high training in statistical methods as applied to agriculture as its head, a question of urgent importance.

5. The Board of Agriculture considers that the necessity of providing statistical staff in the various Provincial Departments of Agriculture which has been emphasized by previous Boards in 1919 and 1924 should once more be impressed upon Local Governments. They further consider that the Statistical Sections of Provincial Agricultural Departments should be organised on such a basis as to permit of the inclusion of the statistical treatment of experimental data among their regular duties.

6. The Board of Agriculture trusts that the Imperial Council of Agricultural Research will encourage the greater application of

modern statistical methods to agricultural and veterinary problems both in Imperial and Provincial institutions in such manner as they consider most effective.

7. Resolved that the Board of Agriculture draws attention to Resolution No. 4 of the 1925 Board of Agriculture recommending that a specially suitable officer should be deputed to study the life-history of the wild pig, and recommends that the scope of the enquiry be extended to include all animals other than insects which do extensive damage to crops. The Board further recommends that a special officer with necessary staff be appointed to investigate the whole question of the protection of crops from the depredations of wild animals. Subject XI.

Resolved that the scope of the enquiry should be limited to mammals only.

8. (i) This Board, as a result of evidence placed before the meeting, supports the view that to effect general improvement in the cattle of India attention should be concentrated on the indigenous breeds.

(ii) The question of increasing the milk supply in urban areas is one which can be dealt with separately and the best means of obtaining the desired result will depend on local conditions.

(iii) The interesting experiments in cross-breeding with imported stock now being conducted at the Hosur Cattle Farm and at the Allahabad Agricultural Institute under the consideration of the Board may usefully be carried out to their conclusion.

9. That in the opinion of this Board the custom of dedicating bulls as Brahmini bulls without selection militates against the improvement of the cattle of the areas where it prevails; the Board accordingly suggests to Local Governments that they adopt such measures as may be found feasible to make this custom contribute to the improvement of the cattle.

10. The development of the dairy industry and the improvement of the various breeds of cattle in India are lines of work which are interdependent and complementary; in regard to the former the Board considers that India, like Denmark and Holland, being a country of small holdings can best develop her dairy industry on co-operative lines as has already been successfully achieved in Bengal and to this end recommends that the organisation of co-operative societies be undertaken through the agency of Government Co-operative Departments working in conjunction with the Agricultural, and Veterinary Departments for the utilization of milk and all its products.

The Board further considers that facilities for the education of Co-operative officers in this particular class of organisation and for the training of expert dairy and cattle farm staff to manage co-operative dairies and cattle-breeding be provided.

11. (i) In view of the importance of grazing areas in connection with the cattle industry, steps should be taken, on the lines of those already initiated in the Bombay Presidency, to conserve and improve existing grasslands.

(ii) In respect of forest grazing areas the Board recommends that the Forest, Agricultural and Veterinary Departments of Provinces and States acting in concert should take suitable measures for their control and better utilisation.

Subject II. 12. The Board commends the work on animal nutrition now being done by the Imperial Physiological Chemist to the notice of officers of the Agriculture and Veterinary Departments in the Provinces engaged in the administration of cattle farms and on animal nutrition problems with a view to their co-operating with him in conducting as many experiments as possible; and, to enable the Physiological Chemist to undertake these outstation experiments, the Board recommends that the Field Staff of the Nutrition Station be strengthened as necessity arises and be made available for duty in all parts of India.

Subject I. 13. That the forms as recommended by the Cattle Committee be adopted by the Board.

Subject V. 14. Resolved that a whole-time Expert should be appointed and attached to the Agricultural Expert to the Imperial Council of Agricultural Research who will be available for giving advice to the Provinces on problems connected with mechanical cultivation. This Expert must possess extensive knowledge of current agricultural machinery, design and manufacturing practices and will act as a co-ordinating agency.

Further resolved that he should, in addition to his other duties, take up the investigation in connection with the determination of draught of bullock-drawn implements.

Subject VI. 15. That a Central Bureau of Soil Science under the direction of an experienced soil scientist is a matter of urgent importance and should be established as early as possible.

Subject VII. 16. That an experimental station or stations to carry out the work enumerated in this report be established.

Subject III. 17. Resolved that immediate steps should be taken for the establishment of an Intelligence Bureau.

18. The Board of Agriculture recommends that fullest advantage should be taken by India of the present opportunity of co-operating with the Council of Civil Research in an Empire anti-locust investigation.

19. The Board of Agriculture desires to emphasize the importance of securing the necessary staff at once to carry out (*a*) investigation on control measures, (*b*) a survey of permanent breeding grounds of the desert locust in India, and subsequently the further investigation into the bionomics of the insect referred to in the Committee's report.

20. Resolved that since the aim of locust-control operations should be the complete eradication of the pest from the whole of the affected area within a single generation, and since inadequate or delayed expenditure may entirely vitiate the success of the operations, it is essential to locust control that there should be an immediate adequate provision for funds, apparatus and labour.

21. Resolved that an adequate organisation for locust control is essential in each Province or State within the area subject to locust visitations. The organisation adopted in the United Provinces (see Chapter 2 of memorandum by Mr. Richards which forms an appendix to this report) for dealing with the 1929 visitation and that described in the Land Administration Manual of the Punjab are commended to the notice of all Local Governments and the Government of India. Though details must necessarily differ in the various Provinces and States, the anti-locust organisation should include :—

(*a*) an adequate intelligence branch,

(*b*) an executive for each district or other administrative unit, and

(*c*) a central controlling authority.

22. Resolved that the Central Government should carry an adequate store of material for anti-locust campaigns for issue to Provinces or States as required.

APPENDIX I.

Proceedings of Cattle Committee.

FIRST DAY.

The Chairman invited Mr. Littlewood to open the discussion on—

SUBJECT I.—TO REVIEW THE PROGRESS MADE IN CATTLE-BREEDING AND DAIRYING.

Mr. Littlewood expressed the view that he had given full details of the work done in his Department in the note submitted by him. He referred to the results obtained in his cross-breeding experiments (p. 88) and invited discussion on the subject.

Mr. Woodford said that he had worked on the Hosur farm for three years and was well acquainted with what was being done in this particular line. He suggested that the experiments might be carried on till a definite decision was arrived at although the results were negative.

Mr. Smith said that the nature of the experiment was very important and it should be continued. He, however, invited the views of the authorities of the military dairies who, he said, had done considerable work in cross-breeding.

Colonel Matson expressed the opinion that cross-breeding was not quite a success. The system was uneconomic and the percentage of wastage owing to casting of unprofitable animals was high.

Colonel Mellor gave the results of his observations by referring to some very interesting figures he had obtained about the various crosses between Holstein and Indian breeds and Ayrshire and Indian breeds. He was of the opinion that crossing was successful to a certain extent and was particularly suitable for the class of dairying carried out by the military farms department.

Colonel Matson said that his remarks about cross-breeding referred only to breeding of cross-bred on cross-bred and he did not condemn the whole system of cross-breeding. In crossing a hybrid with a hybrid wastage came to nearly 75 per cent. and was therefore unprofitable.

Mr. Littlewood enquired if Colonel Mellor included any cross-bred animals obtained by breeding half-bred on half-bred in the figures he gave.

Colonel Mellor was of the opinion that the introduction of foreign blood for the improvement of Indian breeds for the country as a whole was not desirable. The object of the military dairies was mainly to obtain milk and milk alone and this crossing was a short-cut in achieving this object.

Mr. Higginbottom said that the wastage of 75 per cent. referred to by Colonel Matson was too conservative a figure. He said that in his place it reached as high as 80 per cent. In spite of this heavy loss it was justifiable to carry out all the experiments undertaken in this line. He thought that by mating a good pedigreed foreign bull to a good cow of the Indian breed greatly increased milk yields were certain.

Mr. Henderson suggested that Mr. Littlewood should carry on his experiment at the Hosur farm. Referring to the work done at Pusa he said that the mating of half-bred with half-bred was a failure. The important problem was to improve the Indian cow and this could only be done by breeding on pure lines. Where crossing was resorted to with the primary object of obtaining milk, it was of advantage to mate the half-bred cow with a good Indian bull.

Mr. Smith enquired if Mr. Higginbottom wanted to evolve a new breed of cattle for India by his experiments. Milk was not the only requirement of this country. In his-

opinion the present Indian breeds were better than anything that could be evolved. Cross-bred cattle no doubt had their use where milk supply was concerned, but so far as a general policy for the whole country was concerned, breeding on pure lines was the only sound policy when we take into consideration all the requirements of the cultivator. He agreed with Mr. Henderson that mating the half-bred with an Indian bull was beneficial.

Major Riley said he agreed with what Mr. Smith had said. He referred to the note submitted by Mr. Littlewood (p. 88) and said that the loss of young stock was too high and the cross-bred cows showed a considerable drop in the milk yield in the successive generations. He also preferred to improve the indigenous cattle by strict selection.

Mr. Higginbottom said that the cattle problem was so important that all the avenues opened must be investigated. He made reference to the system of cross-breeding by two or three foreign breeds at one and the same time carried out at Allahabad, and said that the Pusa results were not very convincing as only one indigenous and one foreign breed were experimented upon. If at Pusa they had taken up more breeds the results might have been different, and in spite of the criticism that was offered, he was determined to carry out the experiment at Allahabad to its conclusion.

Mr. Gossip in stating his experience said that the cross-bred cattle were altogether undesirable in Bengal. The animals were unable to stand up to village conditions, and he went to the extent of suggesting that the Committee might recommend that cross-bred bulls for breeding purposes in the villages should be prohibited.

Mr. Littlewood said that his Government did not permit of cross-bred bulls to be distributed to the ordinary cultivator. In most cases they were castrated.

Mr. Ulvi said that in Bombay there was very little importation of cross-bred cattle and that was very fortunate. He said that he had seen some half-bred cows at a farm in his Province and they were in very poor condition. Some of them were found to be suffering from Johne's disease and they were very susceptible to foot-and-mouth disease. The breeding policy of his Government was to breed on pure lines and he said that they were very successful in it. He gave the instance of the Chharodi farm where Kankrej cattle of the dual purpose type were maintained and there was a great improvement in the milk yield by selective breeding. A similar policy was adopted for all other farms in the Presidency.

Mr. Ware said that there was no doubt that cross-bred cattle were very susceptible to disease and this question was thoroughly thrashed out at the Veterinary Board meeting of 1919. The question of breeding out susceptibility was very intricate, but it was possible, and this work was taken up by the Institutes at Edinburgh and Pretoria, but the work was still in its infancy. It seemed from the general opinion expressed at the meeting that the only practical method of improving the Indian breeds was by selection. With reference to Mr. Higginbottom's work he thought that it should be continued and also suggested that Mr. Littlewood should carry out his experiments to a conclusion.

Mr. Higginbottom said that he agreed with all that was said against the introduction of cross-bred animals into villages. He was, however, of the opinion that there were two things to be kept in mind in improving the cattle of this country. (1) supplying better type of animal to the villager and (2) the question of city milk supply. In making reference to the milk supply of the cities of Calcutta, Bombay, Allahabad, Delhi, etc., he said that the cows for this purpose were drafted from breeding areas and that after a period of a year they were destroyed in slaughter-houses. This naturally depleted the breeding areas of their best cattle, with the result that the cattle to-day were comparatively poorer than what they were some 20 years back. He was of the opinion that both the systems of breeding must be pursued to develop the Indian breeds.

Mr. Ulvi disagreed with Mr. Higginbottom that cows were imported for the supply of milk to the Bombay City. What Bombay wanted was buffaloes. Cows' milk was made use of only for children and invalids. The public preferred buffaloes' milk. He thought that the city milk supply should be improved by improving the buffalo. His Government were planning to remove the Bombay cattle stables to a place away from Bombay City where the animals could be maintained under more natural conditions, as the present system resulted in great loss of cattle.

Mr. Ware then moved the following resolution :—

(*i*) "*This Board as a result of evidence placed before the meeting supports the view that to effect general improvement in the cattle of India attention should be concentrated on the indigenous breeds.*

(*ii*) *The question of increasing the milk supply in urban areas is one which can be dealt with separately and the best means of obtaining the desired result will depend on local conditions.*

(*iii*) *The interesting experiments in cross-breeding now being conducted at the Hosur Cattle Farm and at the Allahabad Agricultural Institute may usefully be carried out to their conclusion.*"

Mr. Smith seconded the resolution.

BRAHMINI BULLS.

Mr. Littlewood in opening the discussion referred to the comments made in his note on this subject and requested that the suggestion made therein should be supported by the Cattle Committee. He was of the opinion that the castration of unsuitable Brahmini bulls was very important in the improvement of cattle in general.

Mr. Harchand Singh said that the question of Brahmini bulls was very important. In the Patiala State special attention was devoted to it and there was a law to the effect that the bull dedicated must be selected by the Government. The State was spending Rs. 55,000 on cattle improvement.

Mr. Garewal said that in the Punjab they had no difficulty in castrating the Brahmini bull. This work was undertaken by the District Boards under the advice of the Government officials. There was such a demand for good bulls that they could not cope with it. Special rules and regulations were framed for the care and maintenance of premium stud bulls.

Mr. Shah said that in his Province cattle-breeding was still in its infancy, but the results of the policy adopted were very encouraging. The local cattle were very small in size but the size of the progeny obtained from the selected bulls was considerably bigger. Propaganda work was necessary to bring about the desired improvement.

Mr. Warth was of the opinion that the size of cattle could be improved by breeding but it could not be maintained unless the question of nutrition was given an equal importance.

Mr. Sane said that in the Baroda State they were experiencing some difficulty in this direction. In the Navsari district they had a suitable breed of cattle and they tried to improve it by castration and by the distribution of approved bulls on certain conditions. In Central Gujarat, however, there was no proper method of breeding. Consequently the animals were rather poor. In Kathiawar, where there was the pure breed of Gir cattle, propaganda work had helped in improving the breed. But taking the State as a whole, the work of castrating the undesirable bull was rather difficult.

Further discussion on the subject took place.

Mr. Ware thought that in a matter of the control of Brahmini bulls the details must be worked out by each Province according to its requirements. The Cattle Committee should lay down only general principles. He further suggested that a Sub-Committee as under might be appointed to draft a suitable resolution :—

The Chairman,
Colonel Matson,
Mr. Ware,
Mr. Smith,
Mr. Littlewood, and
The Secretary

Mr. Smith was also of the same opinion.

The Chairman put this proposition to the meeting and it was agreed to.

The Chairman then invited Mr. Smith to open the discussion on the progress made in developing dairying.

Mr. Smith said that the work done by the Government Departments could be divided into two classes, (1) by the Provincial Governments and (2) by the Central Government. He added that since the last meeting of the Board great progress had been made in developing the dairy industry in this country and some of the most important recommendations of the Board of Agriculture had been carried out. Livestock officers had been appointed in the various Provinces and the work now being done was on sound lines. The development of cattle was taken up according to local requirements and it was done mostly by breeding by selection. As the representatives of the various Provincial Governments were present at the meeting, he would like them to give some account of the work that was being done under them. Public opinion was awakened and mere sentiment in the matter was giving way to practical ideas. Referring to the work done by the Central Government, he said the progress on the whole was satisfactory, but the work in certain directions was delayed due to the uncertainty which prevailed in view of the Royal Commission's recommendations.

Mr. Higginbottom indicated that what he was doing at his Institute was not controlled by any Government. The Institute was primarily an educational one where a special course in dairying for the Indian Dairy Diploma was given. He agreed with Mr. Smith that a great deal of public interest had been aroused regarding the dairy industry, and this he said was mainly the result of the very valuable work done by Mr. Smith. The training in dairying given at the Institutes at Allahabad and Bangalore had opened a new field for the young men of this country in starting their own private business. Only a small number of such trained men looked forward to securing Government jobs.

The meeting then considered Subject I (ii) dealing with the possibilities of co-operative development in connection with cattle-breeding and dairying.

Mr. Kothawala referred to the note submitted by him (p. 105) and said that the question of city milk supply was so important that he wanted to bring it to the notice of the Committee. The present state of city milk supply was unsatisfactory. He gave an idea of the present system and said that if the supply of milk from the suburban areas which was nearly 30 per cent. of the total daily supply could be organised on co-operative basis, the results would benefit the milk producer as well as the public in general. This question was so vital from the point of view of public health as well as from that of the cattle wealth of the country, that it should form one of the first items in the organising of the dairy industry of this country on a co-operative basis.

Mr. Bose then emphasised the importance of developing dairying on co-operative lines and went on to describe what was being done in Bengal. This he said resulted in two things, one was the supply of good and clean milk to the public and the second was that the producer was encouraged to keep good cattle and produce milk under sanitary conditions. The aim of the co-operative society all along was to do away with the middleman and this had been fairly successful. Referring to the Calcutta Milk Union, he indicated the progress they had made since its registration in 1919. The Milk Union when it was started handled only 40 lb. of milk per day and now it was handling 12,000 lb. daily. Its working last year showed a profit of Rs. 26,000, and it now possessed an up-to-date milk depôt constructed according to the recommendations of the Imperial Dairy Expert. This had encouraged the spread of co-operative dairying in other parts of the Province. Darjeeling had one of the biggest societies in Bengal and it would very soon have an up-to-date milk pasteurising depôt for handling large quantities of milk. In this respect also he had received very valuable help from the Imperial Dairy Expert. He further added that there was no doubt that there were a number of difficulties in developing the dairy industry in this country. One of them was the want of men who possessed a combined knowledge of co-operation and dairying. He went on to say that the training at one time given at the Bangalore Institute to the officers of Co-operative Departments was of immense value and suggested that it should be revived. Another difficulty was that of regulating the supply of milk throughout the year as during certain seasons of the year milk was

difficult to obtain. The third difficulty was about the efficient transport of milk and he thought that the railways could help a great deal in this respect. He also pleaded for a closer co-operation between all the Government Departments concerned, *viz.*, Co-operative, Agriculture and Veterinary. He was also of the opinion that the development of the milk industry had given an impetus to cattle-breeding in his Province, and had greatly stimulated milk production.

Mr. Littlewood said that in Madras very little had been done in this direction. A society was started, but had had difficulties in inculcating the principle of loyalty amongst its members.

Mr. Higginbottom said that there were several communities of cattle-owners in Allahabad, but they did not seem to be in a flourishing condition. He at one time made an effort to help some of these people by giving them the assistance of his students in supervising the milk production, etc., but this proved a failure. He also attempted to get the milk producers to maintain their cattle on his farm where they could be fed and looked after well, with the idea of securing good quality milk, but this also proved a failure. There was a good scope for developing dairy industry in this country, but the difficulties were enormous.

Mr. Smith indicated that, in the absence of the Registrars of Co-operative Societies, nothing could be said with authority on the purely co-operative aspect of this matter. He however briefly reviewed the work done in other Provinces in this direction and made particular reference to Madras where he said they were thinking of starting an up-to-date city milk depôt on a co-operative basis. He admitted that organising co-operative societies was rather a difficult task, but it was not an impossible one. He was firmly of opinion that the dairy industry will thrive in this country if developed on co-operative lines as it had done in other parts of the world. In support of this he related the experience of other Western countries, such as Ireland, Denmark, Holland, etc. He added that the first point in the improvement of cattle was the milk question. He gave the instance of Sind and said that the animals of the place fetched high prices, because they were good milk producers, and he was of the opinion that the organisation of the dairy industry must precede cattle improvement.

Mr. Plymen thanked the Chairman for allowing him to speak although he was not a member of the Committee. He was of the opinion that the Agricultural Department could not do much in improving the dairy industry without the help of the Co-operative Department. Referring to the Telinkheri Dairy Farm which was run on co-operative lines, he said its success was mainly due to its being continuously supervised and to its favourable situation where facilities such as water supply, etc., existed.

The Chairman at this stage suggested that the Sub-committee should draft a resolution on the lines of the discussion.

The Committee then proceeded to consider the question of *standardisation of records* (Subject I(a)).

Mr. Littlewood briefly stated what was being done on his farm and referred to the forms of records submitted by him. He said that this method of recording yielded very valuable information.

Mr. Ulvi then explained the forms which he had submitted for circulation.

Mr. Henderson at this stage suggested that, as it was a highly technical subject, it was better to refer it to a Sub-committee. This was agreed upon and following members were appointed to the Committee :—

1. The Chairman.
2. Mr. Littlewood.
3. Mr. Smith.
4. Colonel Matson.
5. Mr. Ulvi.
6. Mr. Wynne Sayer.
7. **Mr. Zal R. Kothawala, Secretary.**

The subject of grassland improvement and management (Subject I(iii)) was then discussed.

Mr. Warth said that he would like samples of pure strains of grasses grown under careful supervision and harvested at different stages to enable him to carry out important nutritional experiments. He referred to the help already given by Dr. Burns in this connection and also to the important work of the same nature that was being carried out in the Madras Presidency. He therefore asked for the support of the Committee to help him in the matter.

Mr. Plymen said that he would be prepared to give all possible help to Mr. Warth in this respect.

Dr. Burns also agreed to do this. Dr. Burns then went on to describe what was being done in his Presidency with the object of conserving and improving the grassland. Much important work had already been done and results published in the Memoirs of the Agricultural Department. In his opinion improvement of grassland was an integral part of the scheme for the improvement of cattle. He was following the lead of American investigators, because the conditions there were more or less similar to those in this country. The work done under him could be divided up into two classes: one dealing with areas with a very high rainfall and the other with areas with scanty rainfall. He wanted this work to be duplicated in other Provinces. One of the difficulties met with lies in the cost of fencing of the areas being treated and this is an important item in the experiment.

Mr. Ware spoke in support of the maintenance of pasture lands and of forest areas. He said that although much had been said in recent years about breeding and stall feeding of cattle, good grazing was indispensable in rearing young stock. Enough attention was not given to this point in this country and he therefore welcomed Dr. Burns' suggstion. The Royal Commission had also recommended that the grazing areas should be reserved; the first essential was to control these areas and then to bring about the desired improvements. In the Madras Presidency they objected to diseased cattle being admitted to forest grazing lands and to unfit breeding bulls being allowed to graze there. These difficulties could be overcome if all the Departments, *viz.*, Forest, Agriculture and Veterinary, co-operated.

Mr. Harris spoke in support of this, but said that open grazing areas were very scarce and they had to depend mainly on the forest areas. He wanted a resolution to be passed by the Committee to help the Forest Department in controlling such grazing areas. This should include such restrictions as the number of cattle to be grazed on the area, the prohibition of diseased and emaciated cows, the prohibition of grazing in the event of outbreak of diseases, compulsory inoculation and also castration of undesirable bulls.

Mr. Ware further endorsed these ideas.

Major Riley, in supporting this, made a further suggestion and said that barren cows, useless stud animals and working animals should be excluded from such areas.

Mr. Woodford wanted to know what would be done with the animals which would be refused admittance to the grazing land.

Mr. Littlewood suggested that a prohibitive tax should be levied on unsuitable bulls, etc., which were not approved of by the Government official of the district.

Mr. Plymen did not agree with this suggestion. He said that this question was very intricate and was being tackled by several Committees at present sitting in various Provinces. The demand for grazing was enormous in his Province and the ryot wanted it to be as cheap as possible. The best way to utilise grazing areas was to start cattle-breeding farms on them. The supervision would be difficult if restrictions such as suggested were put into force and he thought these were more or less impracticable.

Dr. Burns indicated that without suitable restrictions the grasslands would soon be ruined. Any indiscriminate grazing will give rise to poorer types of grasses.

Mr. Higginbottom enquired if this discussion referred only to the forest grazing areas and wanted to know what would be done to improve the village grasslands, as this question was equally important. In his opinion the village cattle had mostly to rely on the village grazing areas and with a view to improve these he suggested a method of rotation.

Dr. Burns indicated that the improvement of the village grazing areas could be done as a side line of village uplift, and he gave an instance of this in the Bombay Presidency and said that very encouraging results had already been obtained by controlling such areas.

Mr. Plymen was of the opinion that the village grazing areas were utilised more as exercise grounds than for providing fodder, and it was not possible always to get the cattle-owners to graze their animals on areas reserved for this purpose.

The Chairman was of the opinion that the discussion must be confined to forest areas only and leave the question of the village grazing areas for the consideration of the next Board's meeting.

The drafting of a resolution on the subject was then referred to the Sub-Committee.

SECOND DAY.

SUBJECT II.—TO REVIEW THE WORK DONE UP-TO-DATE ON ANIMAL NUTRITION IN INDIA AND TO RECOMMEND (*a*) WHAT STEPS SHOULD BE TAKEN TO DEVELOP AND EXTEND THIS WORK AND (*b*) WAYS IN WHICH THE PROVINCIAL DEPARTMENTS CAN BEST CO-OPERATE WITH THE PHYSIOLOGICAL CHEMIST IN WORK ON THIS SUBJECT.

The Chairman called upon Mr. Warth to open the discussion.

Mr. Warth gave a review of the very important work he was doing at Bangalore. He said that as soon as he had started work he found that he would require to operate on a wide front, as enquiries from various directions had to be attended to in connection with animal nutrition. He studied this question from various aspects and the results were published in the annual report of his section. It appeared that experiments were very important and necessary in order to ascertain what our animals could do with various Indian fodders. Accordingly several experiments were conducted to ascertain quantitative results. Comparative feeding trials on rice straw, wheat straw, young hay, mature hay, etc., were made for this purpose. Another important investigation made was for the purpose of ascertaining the starch equivalent values of Indian feeding stuffs. Important experiments were carried out at two places and they gave different results. He thought that more tests were necessary to arrive at definite conclusions. What he wanted most of all was fieldmen for work at outside stations, men who could be moved from place to place. He also referred to the graphic method of classification of fodders and estimating starch equivalent values developed by him. These were put to two uses: (1) to provide a practical working basis and (2) to enable workers to ascertain faults. Regarding physiological enquiries, this work was being taken up. In his opinion fodders grown on certain types of soil when fed to animals gave alkaline reaction in the urine. This, in the long run, would affect the health and life of the animal. He again emphasised the great importance of the work that was being carried out and indicated how little was known about the subject of animal nutrition in India.

He made a passing reference to the work done at Coimbatore and Lyallpur, and said that it would be of interest to hear from the workers as to what was being done at those places.

Mr. Ulvi said that the cultivator, whether in irrigated or in dry zones, always aimed at the economical maintenance of his cattle and therefore tried to utilise as much of the farm-grown product as possible. It was therefore necessary that along with his system of cropping he should also incorporate a judicious plan of feeding. He further added that the same kind of fodders and grasses varied in quality in different tracts and this affected the stamina and development of the local cattle accordingly. He therefore thought that a comparative study of the nutritive value of the various feeding stuffs in each Province was necessary, and he would welcome the suggestion that local feeding trials be conducted under the direction of the Physiological Chemist in all the Provinces.

Colonel Matson said that during his last visit to Bangalore he was very much impressed with the very valuable work carried out by the Physiological Chemist. He was of the

opinion that Mr. Warth should be given every facility possible as the results obtained by him were invaluable to all concerned with cattle-breeding.

Mr. Ware supported Colonel Matson and added that the Physiological Chemist could still further expand his activities. He referred to the questionnaire circulated by the Imperial Bureau of Animal Nutrition at Aberdeen and said that the enquiries were not merely of a nutritive nature but also pathological in so far as the feeds affected the structure and functions of the animal. He added that the reason for raising this question was because it was reported that the animal nutrition scheme of the Imperial Agricultural Department was likely to be considerably enlarged and transferred from Bangalore to another part of the country. If this scheme had not developed too far, he thought that such an Institute should be located at a place where Mr. Warth could co-operate with the veterinary research workers.

Colonel Mellor said that military dairies had great facilities for carrying out nutrition work and he was willing to lay at the disposal of the Physiological Chemist all that he could in the way of supplying cattle, provided expert supervision was given by the Agricultural Department.

Mr. Warth accepted the suggestion of Colonel Mellor and said that the large herds which the military authorities were prepared to put at his disposal would certainly add to the available facilities. He again emphasised the necessity of having more men for this kind of work, and said that his difficulty at present was not merely want of men but lack of authority to send them to outside areas when necessary. He pointed out that the duties and responsibilities of his fieldmen were greatly increased when they were put on duty remote from their headquarters and this demanded increased remuneration when on outside duty.

Mr. Plymen said that the question of nutrition was of very great importance to all the Provinces and expressed his willingness to co-operate with the Physiological Chemist but he asked for assistance in formulating concrete schemes. He admitted that his farms were not very big but he was prepared to provide all the necessary facilities. He was even prepared to help Mr. Warth in the matter of staff assistance as he had some men who had already been trained at the Bangalore Institute. He wanted guidance more than anything else in this matter.

Mr. Warth accepted Mr. Plymen's suggestion for help, but said that he was not in a position to suggest any line of work without studying the local problems. He thought that the provincial people should bring their difficulties to him.

Mr. Plymen said that what he wanted was the expansion of the work which was being done at Bangalore into the Provinces and stated that he was quite prepared to help in this direction.

Mr. Warth in making further reference to Mr. Ware's suggestion said that it was true that there was no contact between the Veterinary and the Physiological Chemist's Departments at present, but the problems he had to tackle were so numerous that he thought his work on the agricultural side was more important for the present. Work on some of the points suggested by Mr. Ware could only be carried out at a large farm such as he had suggested at one time, but that was not possible at the moment. It was not his idea to turn down what Mr. Ware had said, but with the facilities at his disposal now he could only deal with what might be termed the Agricultural and Animal Husbandry aspects of the problem before him. Later on when he had more time and staff he hoped to be able to co-operate with the Veterinary Research Officers in solving the problems referred to by Mr. Ware.

Mr. Ware enquired if Mr. Warth had any objection to including the suggestion for the veterinary side along with the agricultural in the resolution to be moved.

Mr. Warth said he had not.

Mr. Higginbottom said that one of his colleagues had been to Bangalore and was very much impressed with the important nature of the work that was being done there. He was quite willing to place the herd of his Institute at the disposal of the Physiological Chemist. This he said would be a co-operation from a private organisation as his Institute was not controlled by any Government.

Mr. Saunders referring to the subject said that the second part implied that concrete proposals for the co-operation of the various departments should be put forward, and he wanted to know the opinions of the experts present in the matter.

Colonel Matson thought that it was for the local people or Provinces to say what was to be done and this Committee could not prescribe it.

Mr. Smith thereupon moved the following resolution :—

> *"The Board commends the work on animal nutrition now being done by the Imperial Physiological Chemist to the notice of officers of the Agriculture and Veterinary Departments in the Provinces engaged in the administration of cattle farms and on animal nutrition problems with a view to their co-operating with him in conducting as many experiments as possible ; and, to enable the Physiological Chemist to undertake these outstation experiments, the Board recommends that the Field Staff of the Nutrition Station be strengthened as necessity arises and be transferable."*

Mr. Littlewood seconded the resolution.

Mr. Viswanath gave an account of the work done under him and said that most of it was done in consultation with the Physiological Chemist at Bangalore. His work principally related to rations required by animals for maintenance and for various classes of work. He also compared the food values of some of the local feeding stuffs with foreign standards.

The Chairman took the sense of the meeting and the resolution was carried.

The Chairman then proceeded to put the resolutions framed by the Sub-Committee for the approval of the Committee.

RESOLUTION I—

> *Part (i) "This Board, as a result of evidence placed before the meeting, supports the view that to effect general improvement in the cattle of India attention should be concentrated on the indigenous breeds ".*

Carried unanimously.

> *Part (ii) "The question of increasing the milk supply in urban areas is one which can be dealt with separately and for this purpose the use of imported animals is the quickest road to success ".*

This resolution regarding the improvement of city milk supply through cross-bred animals gave rise to a difference of opinion.

Mr. Ware, thereupon, moved an amendment and this was put to the meeting and carried.

Amended Part (ii) "The question of increasing the milk supply in urban areas is one which can be dealt with separately and the best means of obtaining the desired result will depend on local conditions ".

> *Part (iii) "The interesting experiments in cross-breeding now being conducted at the Hosur Cattle Farm and at the Allahabad Agricultural Institute may usefully be carried out to their conclusion."*

This was carried unanimously.

RESOLUTION II. *Re* Brahmini Bulls.

> *"That in the opinion of this Board the custom of dedicating bulls as Brahmini Bulls without selection militates against the improvement of the cattle of the areas where it prevails ; the Board accordingly requests Local Governments to adopt such measures as may be found feasible to render this custom innocuous."*

Mr. Higginbottom suggested an amendment.

Mr. Harris seconded.

Mr. Charan Singh suggested another amendment, but it was not seconded.

The resolution as amended by Mr. Higginbottom was put to the Committee and carried.

AMENDED RESOLUTION II—RÉ. BRAHMINI BULLS.

" That in the opinion of this Board the custom of dedicating bulls as Brahmini Bulls without selection militates against the improvement of the Cattle of the areas where it prevails ; the Board accordingly suggests to local Governments that they adopt such measures as may be found feasible to make this custom contribute to the improvement of cattle."

Mr. Higginbottom said that he took the opportunity of removing a misunderstanding which his remarks had created in the previous day's meeting. He was not at all opposed to organising the dairy industry on co-operative lines in this country. In fact he thought that the only way to improve the industry in the villages was through the agency of co-operation.

RESOLUTION III.

Subject I (ii). The possibilities of organising the dairy industry on a co-operative basis by the Co-operative Department in India.

" The development of the Dairy Industry and the improvement of the various breeds of cattle in India are lines of work which are interdependent and complementary ; in regard to the former the Board considers that India like Denmark and Holland being a country of small holdings can best develop her dairy industry on co-operative lines as has already been successfully achieved in Bengal, and to this end recommends that the organisation of co-operative societies be undertaken through the agency of Government Co-operative Departments working in conjunction with the Agricultural and Veterinary Departments for the utilisation of milk and all its products."

The resolution was put to the meeting and carried.

RESOLUTION IV.

Subject 1 (iii). The position of grassland in the improvement of cattle and the possibility of improving such grassland.

(i) *" In view of the importance of grazing areas in connection with the cattle industry, steps should be taken on the lines of those already initiated in the Bombay Presidency to conserve and improve existing grasslands.*

(ii) *In respect of forest grazing areas the Board recommends that the Forest, Agricultural and Veterinary Departments of Provinces and States acting in concert should take suitable measures for their control and better utilisation."*

Resolutions IV (i) and (ii) were carried.

ZAL R. KOTHAWALA,

Secretary.

APPENDIX II.

History Sheets of Cattle.

Form A.—History sheet for female stock.

The Committee accepts the form put forward by Mr. Ulvi, with the alterations embodied in the attached copy.

Form B.—We recommend, for breeding bulls, that Form B containing on one side the pedigree description, and when considered necessary the weight and measurement of the bull, be maintained with the details of his progeny on the reverse side. (*See* attached specimen form.)

Form A.

History sheet of the female stock.

Name and No......

Date of birth.....

Place of purchase, date and cost.....

Colour and description.....

Dam . . . . { Dam . . . . { Dam ..... / Sire ..... } / Sire . . . . { Dam ..... / Sire ..... } }

Sire . . . . { Dam . . . . { Dam ..... / Sire ..... } / Sire . . . . { Dam ..... / Sire ..... } }

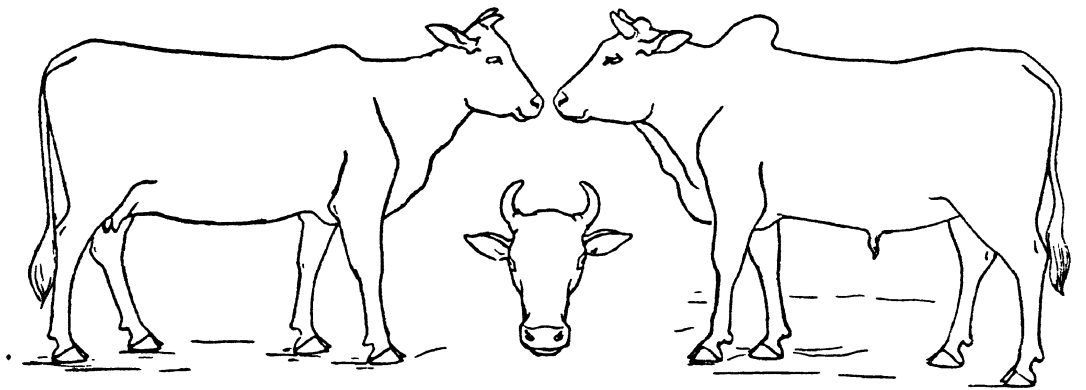
Name of Sire.	Date of service,	Date of calving.	No. of calf.	Colour, sex and description of calf.	Disposal of calf.	Lactation period in days.	Yield of milk in lbs.		Maximum yield of milk in lbs per week.	Date of going dry.	No. of days dry.	Average of daily yield from calving to calving in lbs.	Remarks.
							1st 300 days.	Full lactation period.					
1	2	3	4	5	6	7	8	9	10	11	12	13	14

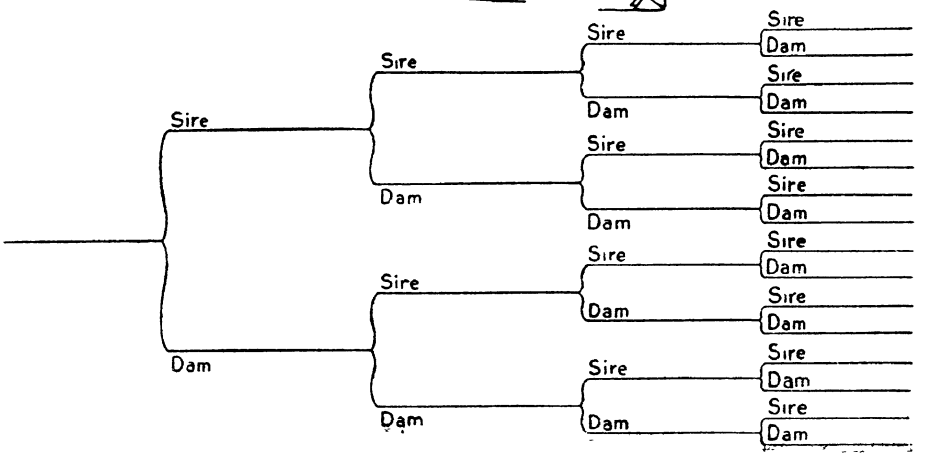
Form B.

Pedigree of.....

Born.....

Bred by.....





Remarks.....

.....

.....

.....

Form B (Reverse).

Particulars of the progeny of the bull.

Serial No.	Name of the animal.	Sex.	Adult No.	Date of birth.	Dam.	Dam's best lact.	Milk Yield.			Disposal.	Remarks.
							1st.	2nd	3rd.		

APPENDIX III.

Notes on Subject I.—Cattle-Breeding and Dairying.

(*a*)

CROSS-BREEDING EXPERIMENTS IN MADRAS.

R. W. LITTLEWOOD, *Deputy Director of Agriculture, Livestock, Madras.*

In 1919 the Madras Government approved of Mr. Carruth's scheme, *i.e.*, to use the Ayrshire bull on the Scindhe and Sahiwal cows, in order to try and evolve a new breed of cow, which would breed regularly and produce more milk than the average country animal. First cross bull (F_1) is used on F_1 cow, F_2 bull on F_2 cows and so on. In this way the breed retains half the imported blood and half the country blood. A breed of this description is required by the urban cow-keeper for milk supply.

In 1923, this Government purchased 32 cows and heifers with 3 heifer calves. Five of these cows and heifers died about 3 months after arrival at Coimbatore from various causes. In November 1924, 10 yearling heifers were purchased from the Imperial Dairy Expert, two of which died of tick fever within a few months.

Births.—From 1923 up to date 162 calves have been born of which 75 were heifers and 87 bulls.

Generation.	Heifers.	Bulls.	Total.
F_1	15	10	25
F_2	23	27	50
F_3	33	44	77
F_4	4	6	10
TOTAL	75	87	162

Deaths.—These have been very heavy. All the calves (excepting F_1) were weaned at birth and hand-fed. Improper feeding of calves caused stomach trouble, which ended fatally in several instances; in others pneumonia followed this trouble. There were 79 deaths, 49 of these being calves.

Generation.	Cows and Heifers.	Bulls.	Total.
F_1	7	4	11
F_2	21	9	30
F_3	15	20	35
F_4	1	2	3
TOTAL	44	35	79

Chief causes were:—Johne's disease 4, Enteritis 8, Pneumonia 17, Red-water 4, Rinderpest 14 (4 used as controls) and Blackquarter 5.

Castings.—15 cows, which were found to be bad breeders or poor milkers, were sold These included:—

F_1	6
F_2	8
F_3	1

10 bulls were sold for breeding purposes, chiefly for the Hills and to Planters.

Present Strength.—The number of cattle in the herd at present is:—

———	F_1.	F_2.	F_3.	F_4.	Total.
Cows and heifers	13	15	12	..	40
Breeding bulls and young bulls	5	4	7	1	17
Heifer calves	6	1	6	3	16
Bull calves	3	2	3	2	10
TOTAL	27	22	28	6	83

Calvings and average of calving.—The number of cows which have calved in each generation are:—

20 F_1 cows calved at an average age of 2 years 5¼ months.

24 F_2 cows calved at an average age of 3 years, and

7 F_3 cows calved at an average age of 3¼ years.

Milk yields.—Before stating these it is necessary to give the average number of lactations per cow in each generation. It will be seen that F_1 have reached their best, F_2 almost and F_3 have not—

F_1	3·5
F_2	2·7
F_3	1·6

It must be remembered that the foundation cows were selected Scindhe and Sahewal animals with a good milk record behind them. I have given below the milk yields of the dams of these F_1 cows and their progeny.

Class.	Average yield per lactation.	Average daily average.	Average days dry.	Average maximum yield.
	lb.	lb.		lb.
Scindhe cows	3,431	12·0	186	4,505
F_1 cows	5,079	13·6	94	6,573
F_2 cows	3,375	12·4	140	4,285
F_3 cows	3,208	11·1	78	3,351

The average number of days in milk are:—

	Days.
Scindhe cows (15)	286
F_1 cows (19)	377
F_2 cows (17)	272
F_3 cows (6)	289

The average daily yield of milk from date of first calving to date of last calving including dry periods over all cows is:—

Scindhe cows	7·2
F_1 cows	10·7
F_2 cows	8·1
F_3 cows	8·7

In the F_1 generation, there were 3 cows which had extraordinary long lactations. In one case one cow aborted after 6 months in milk. The length of their lactations were 692, 950, 894, 483 and 810 days; so these account for the large number of days in milk of F_1 cows.

It will be seen that the F_2 cows' average yield per lactation is less than that of the Scindhe cows, the daily average yield being about the same, but the average number of days dry for F_2 cows is shorter, so that if we take the average daily yield of milk from date of first calving to date of last calving we see that the F_2 cows are slightly better: 8·1 lb. per day as against 7·2 lb. per day.

Regarding the F_3 cows, these have not reached their best; the average yield per lactation and their daily yield are lower than for the Scindhes; the dry period is much less, therefore the daily average yield from date of first calving to date of last calving including dry periods over all cows is larger: 8·7 lb. as against 7·2 lb.

The above figures relate to *all the cows before castings* were considered. I have already stated that 15 cows were cast on account of irregular breeding and low yields, so we will consider the yields, etc., of the cows present in the herd (above 4 years of age).

In the F_1 class, there are 6 cows over 4 years of age; in the calculations below, I have omitted cow No. 113 whose milking periods are too long, in her second lactation she aborted after six months and her lactation was prolonged. Her yields are:—

7,590 lb. in 483 days, daily average 15·7 lb. Days dry 58;

17,092 lb. in 810 days, daily average 21·1 lb. Days dry 38.

The average figures for the other five in the herd are:—

Number of cows.	Average of average lactation.	Average daily average.	Average dry period.	Average of maximum yields.
	lb.	lb.		lb.
5	5,252	17·0	84	7,667

Cow No. 8 has the best record, 9,731 lb. with a daily average of 28·9 lb. 4 cows have yielded over 7,000 lb. in a single lactation.

In the F_2 class, there are 12 cows over 4 years of age at present in the herd. Particulars are as follows:—

Number of cows.	Average of average lactation.	Average daily average.	Average dry period.	Average of maximum yields.
	lb.	lb.	Days.	lb.
12	4,045	14·0	106	5,170

Cow No. 17 is the best yielder with 8,200 lb. (daily average 20 lb.) and 8,380 lb. (daily average 18·1 lb.). Six of these cows have yielded over 5,000 lb. milk in a single lactation and 10 have yielded over 4,400 lb. in a lactation.

In the F_3 generation, three cows are over 4 years of age; their average performances are:—

Number of cows.	Average of average lactation.	Average daily average.	Average dry period.	Average of maximum yields.
	lb.	lb.	Days.	lb.
3	3,411	11·9	102	3,549

Cow No. 101 has yielded 5,436·2 lb. with a daily average of 11·9 lb. in 457 days. This cow sufferred from Red-Water whilst she was carrying her first calf.

Cow No. 143 died at Coimbatore this year after calving, due to difficult parturition and septicaema; she gave in her last lactation 4,514 lb. with a daily average of 11·5 lb. in 392 days.

Cow No. 200 gave in her first lactation 3,984 lb. with a daily average of 14·7 lb. She was dry for 62 days and has yielded up to the present 1,101 lb. with a daily average of 20·7 lb.

Now I will compare the performances of the cows *present in the herd* with the foundation cows (Scindhes).

Class.	Average yield per lactation.	Average daily average.	Average number of days dry.	Average maximum yield.
	lb.	lb.	Days.	lb.
Scindhe	3,431	12·0	186	4,505
F_1	5,232	17·0	84	7,667
F_2	4,045	14·0	106	5,170
F_3	3,411	11·9	102	3,549

The average number of days in milk are :—

	Days.
Scindhe cows (15)	286
F_1 cows (5)	309
F_2 cows (12)	288
F_3 cows (3)	286

The average daily yield of milk from date of first calving to date of last calving including dry periods over all present cows is :—

	lb.
Scindhe cows	7·2
F_1 cows	13·3
F_2 cows	10·2
F_3 cows	9·0 (approximate).

The milk yield appears to drop considerably between F_1 and F_3 although it must be remembered that the F_1 cows are selected animals, whereas F_3 are not and one only of the three has finished 3 lactations.

The average age of first calving of these different generations is :—

F_1 20 animals	2 years 5¼ months.
F_2 24 animals	3 years.
F_3 7 animals	3 years 3 months.

The F_1 calves suckle their dams and grow at a quicker rate into bigger animals. F_2 and F_3 calves are hand-fed ; they do not thrive so well as the calves which suckle their dams. They take a longer time to grow to maturity. Although they could be mated earlier, they are not allowed, as their size is small.

After weaning, the calves are treated in the same manner as country animals in order to test whether they can stand up to conditions. Quite a number of them appear not to thrive well until they have reached the age of 2 years and then they seem to make better headway.

Weights, etc.—I give below the average weights, lengths, heights and girth measurments of the various classes. The average weight of calves at birth is :—

Generation.	Heifer calves.	Bull calves.
	lb.	lb.
F_1	44½	57
F_2	50	58
F_3	40	55½
F_4	42½	47½

For cows over 4 years of age, the following are recorded:—

Generation.	Weight.	Height.	Length: point of shoulder to root of tail.	Girth.
	lb.	Inches.	Inches.	Inches.
F_1	862	47	47	68
F_2	821	47	47	66
F_3	687	44	45½	63

In the case of bulls, the F_2 bulls are in some cases as heavy as the F_1 bulls, *i.e.*, about 1,100 lb. One F_3 bull at 3 years weighs 931 lb. and is still growing. The size of the cows is dropping in F_3 generation, although one cow weighs 740 lb.; another, now dead, was about the same size and weight.

There are great variations in the weights and size of F_2 and F_3 animals. Most of the bulls fall away in the hind quarters and take after the country animal in this respect. It is only about 1 bull in 6, which is worth keeping for breeding; quite a very large number are weak in the hind legs and have brushing hocks.

Colour, Coat, etc.—F_1 animals are generally black, dark brown, black and white and occasionally a red and white animal. In the F_2, we get mostly reds, light brown and red and white. In F_3 and F_4, light red and white with occasional fawns and blacks and black and white. Most of them have fairly smooth coats; occasionally we get a few with rough coats.

Herd Yields.—The best of these animals have been kept at Coimbatore for supplying milk to the Agricultural College Estate. In 1926-27, there were 17·8 cows in milk and 4·8 cows dry on the average throughout the year, the percentage in milk being 79. The daily average per cow worked out to 14·5 lb. and the average for the whole herd 11·8 lb. per day.

In 1927-28, there were 15 cows in milk and 4·7 dry on the average throughout the year, the daily average per cow in milk being 17·2 lb. and for the whole herd 13·2 lb.

In 1928-29, there were 19 cows in milk on the average throughout the year, the percentage in milk being 80; the daily average for cows in milk was 14·5; the average for the whole herd was 11·6 lb.

Conclusions.—For an experiment of this kind, a very large number of animals is required in order that the best animals of each generation can be selected for breeding. About 25 per cent. of these animals would be selected in the ordinary course of events and the others discarded, but we have had a very limited number to work with and so could not afford to discard many animals, unless they were really bad.

There is a deterioration in size and milk yield in the F_2 and F_3 generations, although sufficient numbers of F_3 cows are not available at present to judge their qualities.

Regarding the bulls, only one in 5 or 6 is fit for breeding.

From a health point of view, the young stock give no more trouble than the Indian breeds, provided they are looked after well.

The cross-bred animal cannot stand up to the privations of this country and keep fit like the native breeds of cattle.

I attend the Board with an open mind and welcome any suggestions or decision they may offer on this subject.

Cross-breeding—Ayrshire-Scindhe.

List of Scindhe Dams with their average yields.

No.	Yield.	Daily average.	Days dry.	Maximum yield.	Remarks.
	lb.	lb.	Days.	lb.	
749	2,786	11·6	232	3,081	
722	4,464	12·1	155	5,531	
452	4,621	13·4	145	5,741	
644	4,588	12·6	156	6,147	
657	5,266	14·4	117	5,686	
560	3,692	12·7	249	4,800	
575	3,047	14·8	159	4,859	
44	2,982	10·7	153	3,902	
658	3,029	9·2	412	4,205	
643	3,472	12·5	215	4,155	
684	3,204	12·2	93	4,192	
600	2,417	11·0	184	2,417	
142	2,809	11·6	177	4,128	
505	2,373	9·2	199	3,398	
417	2,726	12·1	148	5,344	
Total . 15	51,476	180·1	2,794	67,586	
Average . ..	3,431	12·0	186	4,505	

Average yield of 15 Scindhe cows=3,431 lb. Daily average 12 lb.

List of F_1 cows with average yields.

No.	Number of lactations.	Average yield.	Daily average.	Days dry.	Maximum yield.	Remarks.
		lb.	lb.	Days.	lb.	
1	7	5,469	17·1	164	7,396	
2	7	5,917	16·8	66	8,377	
3	5	3,139	10·6	57	3 735	Dead.
4	4	3,756	15·2	88	4,267	,,
6	3	1,968	8·1	136	2,178	Sold.
7	7	3,370	14·2	98	5,189	,,
8	6	6,006	20·8	77	9,731	
9	3	4.314	14·7	72	5,752	Dead.
10	2	7,375	15·4	290	9,347	,,
11	1	6,286	15·5	..	6,286	,,
12	3	2.483	10·1	158	2,974	Sold.
14	2	11,775	12·7	99	12,731	,,
21	5	3,487	12·7	77	4,948	
23	2	1,042	6·8	220	1,541	Sold.
61	6	4,526	13·7	81	7,594	,,
113	3	12,341	18·3	48	17,092	
129	4	5,384	18·0	37	7,886	
210	1	4,873	14·6	3[illegible]	4,873	
209	1	3,001	9 4	..	3,001	
Total . 19	..	96,512	259·7	1,801	124,898	
Average .	..	5,079	13·6	94	6,573	
Average Minus No. 113 .		4,676	12·8	94	6,000	

List of F_2 cows with their average yields.

No.	Number of lactations.	Yield.	Daily average.	Days dry.	Maximum yield.	Remarks.
		lb.	lb.	Days.	lb.	
15	6	3,415	14·0	121	5,627	
16	6	4,211	14·0	93	6,693	
17	4	7,050	17·9	77	8,380	
19	3	1,769	9·1	185	3,702	Sold.
22	3	2,008	11·0	139	3,587	„
82	3	4,718	14·2	169	5,254	
84	4	5,046	17·1	89	5,897	
86	4	3,436	12·6	90	4,411	
87	5	2,668	10·8	125	3,489	
90	4	3,056	11·8	218	4,440	
92	3	4,455	14·8	85	5,088	
102	4	3,486	11·9	53	4,728	
120	2	970	7·4	263	1,007	Sold.
122	3	3,945	13·4	63	4,684	
127	2	970	6·1	201	1,092	Sold.
130	5	3,055	14·4	99	3,352	
164	2	2,544	12·4	105	2,660	Sold.
112	1	2,016	7·7	447	2,016	„
201	1	5,314	15·6	47	5,314	Died.
Total . 19	..	64,132	236·2	2,669	81,421	
Average .	..	3,375	12·4	140	4,285	

List of F_3 cows with their average yields.

No.	Number of lactations.	Milk yield.	Daily average.	Days dry.	Maximum yield.	Remarks.
		lb.	lb.	Days.	lb.	
101	3	5,021	14·9	72	5,436	
139	2	1,229	6·1	174	1,229	
143	2	4,514	11·5	..	4,514	Dead.
163	2	1,295	8·2	84	1,595	Sold.
200	2	3,984	14·7	62	3,984	
Total . 5	..	16,043	55·4	392	16,758	
Average of 5 cows .		3,208	11·1	78	3,351	

(o)

CATTLE-BREEDING WORK IN MADRAS.

R. W. Littlewood, *Deputy Director of Agriculture, Livestock, Madras.*

In Madras, the work as outlined to the Board at their last meeting has been continued. This comprises the raising of pure herds of the following cattle :—

1. Ongoles.
2. Kangayams.
3. Scindhes.
4. Cross-breds.
5. Buffaloes.

The Ongole herds are maintained at the Livestock Research Station, Chintaladevi, and Livestock Research Station, Hosur Cattle Farm. The present strengths of the herds are :—

——	Cows and Heifers.	Bulls and young bulls.	Calves.	Total.
Livestock Research Station, Chintaladevi.	92	28	44	164
Livestock Research Station, Hosur Cattle Farm.	62	27	26	115
Total .	154	55	70	279

This breed appears to thrive at both the places. At Chintaladevi, heifers have calved down at the average age of 3 years 3 months and at Hosur at 3 years 1 month. The average weights of the calves born at both the places are :—

	Bulls.	Heifers.
	lb.	lb.
Livestock Research Station, Chintaladevi . .	63	58½
Livestock Research Station, Hosur Cattle Farm .	57	53

At Chintaladevi there is plenty of lime in the soil, whereas at Hosur there is a deficiency. The cows at Hosur have plenty of good grazing and keep condition well, whereas at Chintaladevi there is very little grazing to speak of and the cattle are not in such good condition. The mature animals show no appreciable difference in size and weight. Perhaps constant inoculations against diseases at Hosur like Rinderpest, Blackquarter, etc., have some effect on the cows.

Cows are milked out fully one day per week and at times two days a week in order to obtain an idea as to their milk yielding qualities.

47 cows at present in the herd at Chintaladevi have averaged 2,852 lb. milk with a daily average of 9·8 lb. per cow. Three cows have yielded over 5,000 lb., 12 over 4,000 lb., and 11 over 3,500 lb. milk in their maximum lactations.

18 cows have averaged 2,251 lb. milk with a daily average of 8·8 lb. per day at Hosur. The best cows are transferred to the Ongole Cattle Farm from this herd periodically. Their yields are lower than the ones at Chintaladevi although they have excellent grazing for 6 months in the year. The constant inoculations have influenced the milk yields at Hosur. The cows at Chintaladevi are mostly farm-bred, whereas the ones at Hosur described above are chiefly purchased cows and heifers.

The Kangayam Herd.—This is not a milk breed, and in the breeding of this herd draught qualities form the basis of selection, although at the same time efforts are being made to improve the milking qualities. A farm-bred bull from the best milker (4,000 lb. cow) has been reared ; it is a typical draught animal and will be used as one of the stud bulls for the herd. This breed thrives on scanty rations, the dry cows and heifers get plenty of grazing, hay and silage and at times a small amount of concentrates. It is the most economical breed on the farm.

The present strength of the herd is :—

Cows and heifers over one year	86
Breeding bulls and young bulls	28
Calves	46
TOTAL .	160

Bulls from this breed for breeding purposes are in great demand and the herd will have to be increased to keep pace with the demand. It is the best draught animal in Southern India.

To give an idea of the milk-yielding qualities of this breed, the average yield of 41 cows is 1,308 lb. with an average daily yield of 5·8 lb. per cow.

7 cows have yielded over 2,000 lb. milk in their lactations.

The heifers calve at an average age of 3 years 2 months.

The average weights of calves at birth are—bulls 45 lb. and heifers 42 lb.

Scindhe Herd.—This is being maintained to build up a herd of dairy cows for urban use and for the improvement of the cattle on the West Coast, which are very poor milkers and small. A pair of West Coast bullocks, 4 years old, only realise Rs. 20 to Rs. 30 at present.

Demands for these breeding bulls from the West Coast are increasing and the South Kanara District Board have proposed that Government should open a small cattle-breeding

station in the District for the improvement of their cattle. A scheme is now under consideration to open a sub-station and to stock it with Scindhe cattle. Scindhe cows for milk purposes are in great demand but the farm is unable to supply good cows and heifers at present.

From my experience, I find that Scindhe cows are much more susceptible to "mammitis" than our own local breeds.

The strength of the herd is :—

Cows and heifers.	Bulls and young bulls.	Calves.	Total.
64	24	26	114

37 cows including first calvers have averaged for their average lactations 2,737 lb. milk with a daily average of 10·6 lb. Most of these animals were purchased in Karachi. One cow has yielded over 6,000 lb., 4 over 5,000 lb., and 3 over 4,000 lb. in a lactation.

These yields are not as high as those of our Ongoles but it is hoped that the progeny will be better yielders.

This breed thrives on scanty rations and retains its condition well. The heifers have calved down at an average age of 3 years 3 months.

The average weights of the calves at birth are—

	lb.
Bull calves	43
Heifer calves	42

Buffaloes.—A small herd of Delhi, ¾ and ½ bred Delhi she-buffaloes are maintained at Guntur. The object is to build up a herd of buffaloes which are larger than the ordinary country buffalo and will yield more milk. Bulls for breeding purposes are sold to the public.

The strength of the herd is :—

She-buffaloes and heifers	33
Breeding bulls and young bulls	19
Calves	17
TOTAL	74

Milk is sold daily in Guntur town.

Twelve bulls have been issued for breeding purposes. Six of these bulls served outside she-buffaloes at the farm, and when they were sent to other parts of the Presidency, they refused to serve a she-buffalo. Some have been fed on different rations and worked half a day, others have been given drugs and two have been fed on sprouted grains, but up to the present only one bull has started to serve again. The Secretary of the Animal Breeding Bureau under the Imperial Agricultural Research Council, England, has been addressed for advice and he admits that they are "stumped" regarding this question.

Supply of bulls.—Good breeding bulls are very necessary all over this Presidency, one of the chief objects of this Section being to breed and supply bulls of good type of the main indigenous breeds of the Presidency. It is seen that small Rajahs and Zemindars do not take much trouble to try and improve the cattle in their Zemindaries. Government should try to influence these gentlemen to follow the example of the old English Noblemen, who in most cases kept a pedigree herd of some good breed in their home farms. If these gentlemen maintained a herd of good cattle under proper conditions, they could distribute

bulls for breeding purposes to their tenants. Some assistance of this kind is very necessary if improvement is to be seen, as it is impossible for Government farms to supply sufficient bulls for this purpose.

Madras Government have loaned bulls to public bodies, stationed bulls in Veterinary Hospitals and also sold bulls at concession rates to Co-operative Societies, Missionary Settlements and others for the improvement of cattle in their district. Premia of Rs. 100 per annum is also given towards the cost of maintenance of good breeding bulls approved by the Department on certain conditions.

The number of premia bulls has increased from 9 to 47 : most of these are farm-bred bulls.

The Department maintains :—

18 bulls in Veterinary Hospitals,

17 bulls at Agricultural Stations, etc.,

besides loaning 13 others to public bodies such as Co-operative Societies and Panchayats.

Ayrshire bulls are maintained at the two hill stations Ootacamund and Kodaikanal.

The demand for bulls in the Ongole tract is very small. This is due to the system of dedicating bulls as Brahmini bulls. An influential man dies, his relatives wish to perpetuate his name and dedicate a bull. Prices for good bulls are high and good animals are not plentiful, the bull has to be chosen and dedicated within 15 days of the death of the person, the relatives have not much time and are not anxious to spend much money ; so any ordinary bull calf is purchased or selected from his own herd and dedicated. Proposals have been submitted asking Government to stop this practice and to appoint a Committee of leading ryots. together with an officer of the Livestock Section, to select bulls for dedication and breeding.

Cattle Survey.—The main breeding tract of Ongoles, in the Guntur District of this Presidency, was surveyed. 844 villages were visited during the survey. It was found that there are about 93,000 cows of the Ongole breed together with 789 breeding bulls of which 119 are old and useless, thus leaving 670 fit for breeding. If we assume that an Ongole cow on the average has one calf in two years, then it can be said that there are 46,500 cows to be served each year ; deduct from this 15 per cent. for deaths and barren and old cows past breeding, and we have approximately 39,500 cows. Seeing that the bull runs loose with the herd and that it probably serves the same cow two or three times during the oestrum period, we can allow 40 cows to each bull and this means that 1,000 bulls are necessary for this number of cows, whereas the survey has shown that there are 670 breeding bulls fit for breeding, so that the District is short of 330 bulls. It was also discovered that there are 316 villages which possess no breeding bull at all. Of these, 148 villages possess 60 or more cows of the Ongole breed. Therefore if breeding of good cattle is to progress, it is essential that these villages should possess a bull of their own. Most of the services take place during two periods of the year, February to March and August to September, so that the bull becomes overworked. It is essential that it should be well fed and cared for, if it is going to prove a successful stock getter. The ryots are said to drive the Brahmini bull from their fields in these days, so that it would not be a hard fight to persuade the ryots to have the bull tied up and stall-fed in the village and allow cows to be brought to it. If this was done, the bull would be much fitter, services could be controlled and the bull would not waste his vitality in serving a cow in heat two or three times in the same heat period, which is usually the case now. Each ryot owning cattle should be made to contribute to the bull's upkeep, according to the number of cows he owns, in the way of fodder and grains, and the bull's maintenance could be supervised by the village officer or headman of the village. If this were done, the breeding period of the bull's life would be prolonged and its services would be more efficient. With the exception of 13 privately owned bulls, all the remainder are Brahmini.

It is seen that Ongole Taluk, which is the centre of the main breeding tract, is the worst off for breeding bulls. The number of cows to each bull works out to 216, and as the cow calves once in two years on the average, each bull is responsible for 108 cows. This number is too high ; at the most 60 to 70 cows per year is sufficient for one bull to manage.

There are also 25 villages in this taluk, each possessing over 60 cows and owning altogether 4,213 cows, which possess no breeding bull at all.

The heifer calves are not cared for very much and the mortality amongst these is rather high. About 2,500 Ongole cows are exported annually to Madras for milk purposes; some are sold to the dealers from Godavari, Hyderabad State, etc. It was found that an average Ongole cow produced 4 or 5 calves on the average during its life.

21,677 bull calves are born annually and it is estimated about 30 per cent. of these are sold to dealers from other Districts for work purposes after the requirements of the District are met.

Milk recording.—Milk recording at the General Hospital, Madras, was stopped owing to shortness of staff. An extra demonstrator has been appointed to Madras to record the yields of the cows at the General Hospital, to supervise clean milking and advise the cowkeeper on calf-feeding.

Other large milk contractors at Hospital, etc., in Madras, will be approached and efforts made to record milk yields of their cows.

Silage.—Demonstrations in silage-making have been given in different parts of the Presidency with success and some cultivators are taking it up.

Sheep breeding.—This is the Bellary Sheep, which comprises animals, white with black face, black and white and black sheep. The object is to try and evolve a white breed of sheep which will yield more wool and develop a larger carcase. The number in the flock at present is 225, of which 171 are females.

The average wool yield from the flock last year was 2 lb. 6 oz. for adult sheep; this is an increase of 2 oz. over the previous years. Two rams clipped 7 lb. 2 oz. and 6 lb. 4 oz. The white sheep born are difficult to rear, their constitution is not so strong; and up to the present no suitable white ram has been reared which is fit for breeding purposes.

Poultry.—Work is proceeding in this line. Poultry are maintained at Hosur and Combatore. Eggs of Rhode Island Red, White Leghorns and Light Sussex are sold to the public at Rs. 2 per dozen.

New pens of these three breeds are expected from England this month.

Disease.—An outbreak of Rinderpest occurred at the Livestock Research Station, Hosur, in July 1928; 21 animals died as a result. All these were protected by the Serum Simultaneous method as calves (1 Ongole, 15 Cross breds and 5 Kangayams).

(*c*)

S. T. D. WALLACE, *Deputy Director of Animal Husbandry, Central Provinces.*

Up to the end of the year 1926-27, there were, excluding the dairy herd attached to the Agricultural College, nine Cattle-Breeding Farms and one Dairy Farm.

The average size of each of these cattle-breeding farms did not exceed 300 acres and thirty breeding cows.

During the past two years six of these small farms have been closed down and replaced by two large farms of 2,000—3,000 acres each. These will each be capable of carrying 200—300 breeding cows when fully developed.

Cross-breeding with the Montgomery has been dropped and efforts are now being directed to the establishment of pure herds of Gaolao, Malvi, and Hissar, each of which will provide suitable draught animals.

One new dairy farm has been opened and here a milking strain of Hissar cattle will be developed. On the Telinkheri Dairy Farm which has been in existence for a number of years, the Montgomery is being used as a dairy animal with considerable success.

It is hoped that in the coming year an area of 6,000 acres in one block will be placed at the disposal of the Department for the purposes of cattle-breeding. The policy adopted during the last two years aims eventually at the production of 400—500 pure bred bulls

per annum or about ten times the present output. The budget allotment during the past two years has risen from about Rs. 60,000 to Rs. 1,30,000 per annum.

Regarding records to be maintained at cattle-breeding farms to indicate the progress in a particular breed of cattle, the following measurements are suggested as forming a basis of comparison from one year to another. These measurements to be made annually up to the age of four years, and the average for each age noted for comparison with similar figures for future years.

(*a*) Height to base of hump.
(*b*) Length from top of shoulder to root of the tail.
(*c*) Girth immediately behind the hump.
(*d*) Weight at ages of 1, 2, 3 and 4 years.

I. Regarding records for dairy breeds a difference of 1,000 lb. in an average of three lactations shall distinguish 1st class animals from 2nd class and the latter from 3rd class animals, *e.g.*, the following should be regarded as minimum yields for cattle of a dairy breed :—

1st class	4,500 lb. and above.
2nd ,, ...	3,500—4,500 lb.
3rd ,, ...	2,500—3,500 ,,

(ii) Successful co-operative dairies can be formed without the active assistance of the Co-operative Department. The latter department is of assistance in framing rules where such assistance may be thought necessary. Otherwise the less the Co-operative Department interferes with the working of dairies run by practical dairy men the better.

II. For many years to come the chief efforts of the department in this province will be devoted to the founding of pure bred herds, for the issue of bulls of first class quality. The more scientific problems of animal nutrition can very well be left to a Central Institute of Animal Nutrition. The Provincial Department could, however, carry out experiments designed by the Physiological Chemist in such cases as where a particular breed, fodder or deficiency disease is peculiar to the province concerned.

In short, work in this province should be on the lines followed by practical cattle-breeders and dairy men, help and co-operation being given and asked for from a Central Institute of Animal Nutrition when considered necessary.

Notes on Subject I (ii)—Organisation of the Dairy Industry on a Co-operative Basis.

(*a*)

(Wm. Smith, *Imperial Dairy Expert.*)

In the first place it seems advisable to refer to the necessity for the development of the dairy industry in India as an integral and necessary part of any scheme for the improvement of Indian cattle.

According to the latest figures available there are in British India some 4,57,93,625 adult bullocks and 3,78,85,686 adult cows. Assuming that 90 per cent. of the above bullocks are actually required for the cultivation of the soil and that the average life of a working bullock is 9 years, British India requires to breed 45,79,362 bullocks per annum to carry on the work of cultivation. To do this only some 1,40,00,000 cows are necessary, so that in addition to this number India carries some 24 million cows not required for bullock-breeding purposes. If these figures be accepted, the most pressing and immediate problem in connection with Indian cattle-breeding seems to be the economical use of her surplus cows.

It is probably correct that some 50 per cent. of the people of India are meat-eaters in some form or another but it is certain that a very large proportion of this 50 per cent do not eat beef and are unlikely to become beef-eaters. The Parsis are meat-eaters but

most of them will not eat beef. In the great majority of the Mohammadan villages of Northern India oxen are not killed and eaten with the exception of one or two animals slaughtered for sacrificial purposes once a year at the Id festival. Then again a great number of low caste people who have no objection to meat-eating really eat very little animal flesh of any kind in their ordinary diet, so that notwithstanding the apparently large numbers of non-vegetarians in the country India's surplus cows are not likely to be killed and eaten. The utilisation of cows as work cattle in India is practically unknown. Popular opinion, or sentiment if the word is preferred, will not permit the cow to be put to the plough or harnessed for draught work of any kind, and we are therefore forced to the conclusion that India can only obtain a suitable return to pay for the feed and keep of her surplus cows by using them as milk-producers, or better still by developing the cattle of the country so that all cows will at one and the same time serve as the mothers of efficient draught cattle and yielders of a reasonable quantity of milk, which means the development of a dairy or milk industry throughout the land. I am well aware that this assumption means the acceptance in our breeding policy of the dual-purpose cow, a policy at one time regarded as debatable and even doubtful by some authorities, but I think that to-day all schools of thought who have studied this question are prepared to admit that milk production must be one of the factors in our breeding policy, and the debatable part of this question is now narrowed down to the quantity of milk which we shall aim at in our dual-purpose policy. Indian cows on the average give such lamentably poor yields of milk that at the present moment the quantity of milk which shall be expected from our cows need not worry anyone. Improvement in this direction will be slow; the aim of all breeders should be to make it sure.

If then it be accepted that milk production be one of the factors to be arrived at in th development of Indian cattle, a study of the methods employed by the countries which in the past half century have made the greatest progress in this direction seems advisable. It is a remarkable fact that in countries like Denmark, Holland, Sweden and New Zealand which have made enormous strides in the improvement of their cattle in the last fifty years, the organisation of the dairy industry, *i.e.*, the utilisation and sale of milk and milk products, preceded in every instance the general improvement in their dairy cattle. In other words in these countries it was not until the cow-owner was assured of a ready and profitable market for his milk that he could be induced to realise the value of a better cow, of better feeding, and of all round cattle improvement, and it does not seem unreasonable to suppose that the same path must be followed in India. If and when the Indian cultivator can be given a profitable cow, and if and when he can be assured of a fair price for the product from his cow, then and then only will he feed and treat her properly, and then and then only will he ever strive to improve the quality of his cow and to respond to propaganda for careful breeding by selection. The cow must always be the mother of the bullock and to get a better class of work cattle we must have better cows.

India is a country of small holdings and in every country similarly situated where the dairy industry has made progress the development has been on co-operative lines, so much so that in the most up-to-date dairy countries of the world to-day the utilisation and sale of the milk of the individual cow-owner is almost altogether co-operative *i.e.*, the farmers united together in the form of co-operative dairy societies, themselves sell their milk, and the products manufactured therefrom and thereby retain for themselves the whole of the profits from this business. In Ireland, in Denmark, in Holland, and in New Zealand, proprietory creameries or milk-handling concerns are practically unknown to-day. The milk-producers organised co-operatively do all the manufacturing, grading and selling of their milk and its prepared products. Milk is the most perishable of all farm produce and to convert it into a non-perishable product of the highest market value requires capital, technical knowledge, and business ability which the individual cow-owner cannot hope to possess; so he must follow the example of the rest of the world and organise or be organised on co-operative lines in order to obtain for himself the full value for his milk.

All the Indian Provinces have Government Departments for the organisation of agricultural co-operation, and if this country is to make real progress in the direction of cattle improvement, one of the first steps to be taken is the organisation of co-operative societies through the agency of the Government Co-operative Departments for the utilisation of milk and all its products. The cow owner who sells *ghi* to a dealer at As. 12 per lb. when the

world's value of butter fat is twice that figure is not likely to feed his cow properly nor to strive to obtain a better cow. Co-operative dairying is not unknown in India. The success achieved by the Co-operative Departments of Bengal and Madras in organising the milk-producers in the vicinity of their capital cities is well known, and the old established and successful co-operative dairy society at Telinkheri near Nagpur is a further proof of what can be done.

In 1925 the Imperial Institute of Animal Husbandry and Dairying at Bangalore gave a course of instruction to officers of the Co-operative Departments with a view to encourage this form of agricultural co-operation (a copy of the syllabus of this course is attached). The class was largely taken advantage of, there being more applicants than could be taken. This course was not repeated as it was not considered to be the function of the Central Government to give elementary instruction of this kind, but whether conducted by the Central or Provincial Governments such instruction to officers of the Co-operative Departments would certainly give these men confidence in the organising of co-operative dairy societies, and would generally quicken the interest of co-operative officers in the necessity for co-operative dairy organisation.

SYLLABUS OF THREE MONTHS' COURSE OF STUDY FOR CO-OPERATIVE OFFICERS.

General principles of cattle breeding,

Indian dairy breeds of Cattle (Cows and Buffaloes), their relative merits, habitat, etc.

Stock judging and handling.

The dual purpose animal for India.

Cattle feeding, including calf rearing and feeding, for milk production.

Indian feeding stuffs, relative values, etc.

Growing of fodder crops with special relation to mixed farming systems.

Dairy farm buildings for—

Farm dairies.

City dairies.

Dairy factories.

Milk production—

Milking;

Recording of milk yields;

Milk pasteurising, cooling and bottling;

Cold storage and transport of milk;

Sterilisation of milk;

Selling milk;

Importance of milk and butter in the dietary of the people.

Butter making.

Ghi manufacture.

Cheese making.

Manufacture of casein and dried milk and utilisation of by-products.

Dairy machinery—

Steam boilers.

Steam engines.

Cream separators.

Pasteurisers.

Milk sterilising plant.

Butter and *ghi* making plant.

Co-operation as applied to the dairy industry—

Co-operative dairying in other lands.

Suitable methods of co-operative dairying in India.

Business methods in dairying.

(*b*)

(ZAL R. KOTHAWALA, *Assistant to the Imperial Dairy Expert, Bangalore.*)

The great importance of organising the dairy industry in general in this country is amply emphasised in the note submitted by Mr. W. Smith, Imperial Dairy Expert. There are, however, certain problems connected with the dairy industry which require immediate attention. One of these problems is the question of city milk supply.

It is a well-known fact that the milk supply in Indian cities to-day is far from satisfactory. The milk sold is unclean, impure and dear. It is also known that in many cases the major portion of this supply is produced in the very heart of the city, a very undesirable thing. On an average, about 60 per cent. of the total supply in Indian cities is produced this way. Of the remaining quantity, about 30 per cent. is produced in the suburban areas, that is, places lying within a radius of 5 to 20 miles of this place. It is this source of supply which, if organized on co-operative basis, will tend to solve the problem of supplying good milk to cities to a considerable extent.

As compared to the town milk-producers, the milk-producers in the suburbs are put to great disadvantage. They are scattered about in the area and the quantity of milk they handle, each individually, does not permit of their employing extra men or a special quick method of transport other than the railway. This prevents their competing in the retail milk trade. The only way open for the disposal of their milk is through the "wholesale market," where more often than not they are at the mercy of the traders, who always form a ring against them. Thus they are deprived of the profits which they otherwise would derive by maintaining their animals under more natural conditions than the city *gowalas*.

In the matter of supply of feeds and fodder they are put under an equally great disadvantage.

If, therefore, this particular source of supply is organized on a co-operative basis and if the difficulties in the matter of efficient transport, security of customers and the wholesale supply of feeds and fodder with which the producers are handicapped at present, are removed by a collective effort, the result will not only benefit the milk-producers but even the general public of the place with whom the supply of good and clean milk is very acute at present. It must, however, be mentioned that this in itself will not solve the whole problem of city milk supply. The indirect effect of such an organised effort will be to dislodge the "town *gowala*" and this should be the primary essential in any scheme formulated to solve the problem of city milk supply in this country. This question is so acute from the point of public health as also from the cattle wealth of the country that it should form one of the first things to be tackled in organising the dairy industry in this country on co-operative basis.

(*c*)

(N. N. BOSE, *Superintendent, Co-operative Milk Societies, Calcutta.*)

The gradual and steady growth of Co-operative Milk Unions and Societies not only in Calcutta but also in other parts of Bengal has fully established the necessity of organising and developing the milk industry on co-operative basis. The working of the Calcutta Milk Union, since its inception in 1919, may rightly be termed as a period of probation and experiment towards the solution of the problem of Co-operative Dairying in general and

of milk supply of a city on a co-operative basis in particular. The Union has emerged from the stage of experiment to that of assured success. The experience thus gained can only lead to the following two main conclusions. The first is that co-operative method is the best means of providing a pure and plentiful supply of milk for a city at a reasonable price. The other is that it is through co-operation that the actual milk-producers can best be trained and induced to adopt and to keep to improved sanitary and economic methods in their trade by team work which the co-operative movement practise and preach and finally leading to considerable monetary assistance, advice, profitable business and other advantages derived therefrom.

The aim of Co-operative Societies for the production of milk combined with sale of milk is to get rid of middlemen whose interference in the town accounts for the low price often received by the producers. The problem is to replace them by an efficient democratic organisation of the producers themselves, which would give better service than the parasites who ought to be eliminated. The Co-operative Milk Organisation in Bengal is composed of two sections: (1) the rural milk societies which form the producing centres and (2) the Milk Union in the city which is the financing and distributing agency.

The Calcutta Milk Union maintained a record of steady progress. The number of affiliated milk-producing societies rose to 104 and its working capital to Rs, 2,80,000. The Union began with a supply of ½ maund of milk in 1919: the quantity now distributed is no less than 150 maunds or 12,000 lb. The total amount realised by sale of milk during the last year amounted to Rs. 6,08,000. Starting with a loss of Rs. 5,000, its profit has now risen to Rs. 26,000 and the reserve and other special funds built out of its profits now exceed Rs. 80,000. According to Mr. Smith's plan and specification, the Calcutta Milk Union has constructed in Calcutta its own dairy, fitted up with modern pasteurising plants and automatic bottling, capping and washing machines. In fact, the factory is regarded as the most up-to-date milk plant in India. Out of its profit it annually spends Rs. 1,000 in aid of schools, Rs. 800 for the upkeep of cows and one dispensary. It has contributed liberally towards welfare work among the milk-producers; this has been considerably appreciated in all quarters. It sank 25 tube-wells and distributed 20 stud bulls and also organised 4 Cattle-Breeding Societies in its area of operation, and encouraged the cultivators in the growing of fodder crops by the free distribution of seeds.

The successful working of the Calcutta Milk Union and Societies has resulted in a remarkable expansion of the milk movement in 6 other districts of Bengal and the formation of 5 Milk Unions out of which the Darjeeling Milk Union is still mainly a Creamery Society and the Shahzadpur (Pabna) is manufacturing *ghi* only. To the best of my knowledge nowhere in India can the milk supply of a single village compete with the milk production of the villages in Darjeeling District. One Society alone produces 20 maunds of cow's milk which is also very rich in fat. It varies from 6 per cent. to 7 per cent. The construction of the dairy building of the Darjeeling Union has been taken up during the year, and the factory working on the gravitation system will be first of its kind in India. All the Unions are working at a profit.

The possibilities in this direction are indeed vast and immense but the difficulties are equally great and many. In the first place, we cry not so much for money as for men. It is very difficult to find the right type of officer who combines business sagacity and driving power with expert technical knowledge and skill and who really feels for his less fortunate brethren. Secondly, it is to keep the supply regular throughout the year. How to make up the deficiencies in the tight season and how to dispose of, to the best advantage, the surplus in a slack season are our greatest problems. Next is the difficulty of transport and mode of conveyance of milk. No doubt the Railways can help considerably in this direction both as regards the reduction of rates as also providing better facilities for transport. It will interest others to know that New Zealand butter is competing favourably in the Calcutta market and has taken up the contract of supply to some Calcutta Hotels. The difficulty of preserving milk in tropical countries, especially during summer, is also great. No doubt we have taken up pasteurisation of milk following the practice in Western countries but I am yet to be convinced that this is the only and the best method. Research work with tropical milk may be undertaken in this direction. I am of opinion that the closest co-ordination between the Agricultural, Veterinary and

Co-operative Departments is necessary in such matters. The presence of Registrars of Co-operative Societies is essential at these meetings in order to arrive at a mutual understanding and general agreement about the organisation of co-operative dairies in their Provinces.

In conclusion, I may remind you that the Co-operative Milk Movement is essentially a movement of actual producers. It gives much more to the producers without increasing the cost to the consumers and, therefore, encourages the producers who deserve a lot of encouragement to continue their hitherto profitless trade with increased zeal. It is a matter of common knowledge that the striking developments in the dairy business with these actual producers have been effected in other countries such as Denmark, Holland, Switzerland, etc., by the agencies of Co-operative Societies, and I sincerely believe that such progress may be made in this direction in this country by the same agency.

Notes on Subject I (iii).—The position of grassland in the improvement of cattle and the possibility of improving such grassland.

(*a*)

(W. BURNS, *Offg. Director of Agriculture, Bombay Presidency.*)

It is necessary in the first instance to find out exactly what part grassland does play in the feeding problem of cattle in India. The following is a brief statement regarding one or two of the main tracts in the Bombay Presidency :—

In all parts of the Presidency cattle have to depend on grass for a certain number of months in the year which may vary from three months to eight months according to the area. This grass is both cut and grazed. If grasses of good quality can be made more plentiful and cheaper, there will be a corresponding improvement in the quality and quantity of cattle and this will react upon the cultivation and the milk supply. In areas where the soil is poor and the rainfall is precarious a very poor type of herbage exists over which the cattle roam and browse it practically level to the ground so that there is no possibility of improvement. In the heavy rainfall area of the Konkan there is a good deal of grass much of which is however wasted either by too early grazing or too late cutting. In certain areas also, for example, the tracts drawn upon by the Bombay City, there has been a decrease in the demand for grass due to the increase of motor transport in the city itself and hence there are large areas in which the grass is not being utilized to the extent to which it might be.

In Poona conditions it is not difficult to keep animals in good condition from July to October on grazing and supplemented by cut grass. Later on however this is not sufficient.

The management of grassland in India is a problem more akin to the management of ranges in America than to the management of grassland (largely artificial) in Britain. Experiments in the Bombay Presidency indicate that the quality and quantity of grass can be markedly improved by a scientific system of management. This system has to be altered according to the nature of the soil and the rainfall. The main points are :—

1. Land development of a cheap type to prevent run-off and erosion.
2. Keeping cattle off in the early part of the rains.
3. Grazing and cutting in rotation.
4. Grazing only that number of animals which the land will carry.
5. The use of salt—
   (i) for the health of the animals.
   (ii) for keeping the animals in the neighbourhood of slightly unpalatable herbage to ensure its being grazed.
6. Provision of water supply.
7. Provision of shade.

The following results have been obtained :—

On poor and medium land in precarious and medium rainfall the herbage has altered from species such as *Aristida funiculata* and *Andropogon contortus* to fairly good perennial grasses such as *Ischaemum laxum* and *Andropogon monticola* associated with some good annuals such as *Iseilema anthophoroides* and *Andropogon pumilis*. The yield per acre can be tripled within five years. In the heavy rainfall areas the change in species is not so marked but a considerable increase in yield can be obtained particularly by a combination of silage, grazing and cutting for hay.

(*b*)

(R. W. LITTLEWOOD, *Deputy Director of Agriculture, Livestock, Madras.*)

Grass'and and cattle improvement go hand in hand especially if a herd of 50 animals or more is maintained.

Young growing stock require plenty of exercise ; if they are turned out to graze, they naturally get this. In a district where rainfall is distributed for 6 months or so, like Hosur, where in some years showers are received from April to November, concentrates can be reduced considerably, money is saved in cooly labour, carting, etc.

Cattle should be turned out to graze after the first showers, when the young grass is about 3-4 inches high, close rotational grazing of the stock must be followed and the stock kept in one paddock. After 10 days they should be moved to another paddock and so on. The sheep follow the cattle in certain fields as they eat closer.

Chain harrows are passed over these fields each day to break up and spread the droppings.

For this close grazing ¾-1 acre per animal is enough as all the grass is eaten and no patches left. At Hosur I allocate about one acre per adult animal for grazing and the remainder is utilised for hay.

Fencing is not necessary if two or three boys are engaged to stop the cattle wandering out of the paddock.

I consider spear grass in its young stage quite good for young cattle and cows in milk. Our young stock seem to thrive and grow on a concentrated ration of 1 lb. cake and 1 lb. rice bran.

I attach to this a note on the cultivation and management of grassland at Hosur Cattle Farm, which gives full particulars to those desiring information on the subject.

Note on the cultivation and management of grassland at the Hosur Cattle Farm, Madras Presidency.

The Central Cattle Farm, Hosur, is situated on an elevation of 3,000 feet above mean sea level with good climatic conditions all the year round. The locality has an average annual rainfall of 25 inches most of which is received during the North East Monsoon. The place is also favoured by the South West Monsoon for sowings.

The total acreage of the farm is 1,633·35 acres, out of which 800 acres are reserved for hay each year. The pastures reserved for hay are usually closed for cattle from July to December and are open for grazing during the remaining months. If the rains fail in August and grass becomes dry, cattle are allowed to graze paddock after paddock in quick succession till the break of the North East Monsoon.

Grazing.—Efforts are made to see that grazing is alternated in the cropping scheme each year so as to give the land a rest at least once in every 2 or 3 years. The rainfall plays a considerable part in the management of grassland here, as the success or otherwise of the management depends not only on the total amount of rain received, but also its distribution throughout the year. During months when prolonged drought is experienced, the paddocks that are closed for cattle are grazed through necessity.

The bulk of the area is covered with spear grass (*Andropogon controtus*) and some special pastures are under Rhodes grass (*Chloris Gayana*) and Kolukkattai grass (*Pennisetum cenchroides*).

Andropogon controtus, commonly known as spear grass, thrives well on all kinds of soils in this tract, does not require much moisture, grows erect with fairly good leafy growth, resists drought conditions more than any other grass and provides some grazing even in bad seasons. This responds to the slightest shower and grows quickly. It makes very good hay just before flowering and is also suitable for making ensilage when made under proper care and supervision. The grass is so slender that for silage-making it ought to be cut between 6 and 7 a.m. when the dew is on, raked and carted immediately to the silo pit. No time should be allowed for the grass to dry inside otherwise poor quality silage is produced.

Chloris Gayana.—An introduced variety, known as Rhodes grass, is suited for low-lying heavy soils. It has got a profuse leafy growth, grows about 3 to 4 feet, makes very good hay and ensilage. This grass seldom thrives on elevated lands and much less when land gets dry. Remount officers informed me that this is not a good grass for horses as it causes skin trouble.

Pennisetum cenchroides—Kolukkattai grass.—Two or three years ago, Kolukkattai grass was introduced on this farm and so far it has done well. It is a succulent grass with plenty of leaf and yields heavily. It makes good hay and ensilage. The grass was introduced as a substitute for spear grass, as the latter has the disqualification of developing awns and these are very disagreeable from a feeding point of view as they penetrate the inside skin of the mouth, causing ulcers and abscesses. Kolukkattai grass is promising and attempts are being made each year to put more area under this grass. About 100 acres have established themselves up to the present.

There are also various other grasses that appear in the pastures, the important of these are given below.

Andropogon annulatus and *Andropogon caricosus.*—These thrive well in low-lying paddocks and are encouraged wherever possible by sowing seed.

Andropogon pertusus is a perennial slender grass and is able to resist drought conditions. One peculiarity about the grass is that it thrives well in paddocks where cattle constantly graze.

Degitaria sanguinalis—VR. *cilliaris* and *Degitaria sanguinalis*– VI. *extensum* are also good grasses that grow as a mixture with spear grass. The seeds are collected and sown to improve the pasture grasses.

The following are the important operations carried out on the grassland :—

Manuring.—Manuring usually begins about March and continues up to May. The correct system of manuring the grassland would be to apply partially fermented, or otherwise called slow acting, manures, the idea being borne in mind that the root system of indigenous grasses are in existence already and being perennial do not require the readily assimilated plant food which is necessary for a cultivated crop of short duration. The manure that is applied to the grassland is intended to last for at least 3 or 4 years, whereas for a cultivated crop which remains on the land for a short duration, it is necessary to apply a readily available manure.

Manuring improves the grassland considerably. It not only improves the outturn but also the quality of grass. It increases the light coloured, coarse foliage grass to a rich, dark, succulent one.

Farmyard manure at 20 cartloads per acre is usually carted, dumped and spread immediately on the grassland. The manure should not remain in heaps as the grass under them becomes burnt and this would leave a number of circular bare patches all over the land. Chain harrow is passed soon after application as it breaks down the big lumps of manure and in a way incorporates it with the soil. It is very essential that the farmyard manure should be thoroughly spread, otherwise the pastures might become

tufted and coarse in some places. Although the correct system would be to apply " raw manure " to the grassland, the system followed on this farm is to usually apply a year old rotted farmyard manure which spreads easily and evenly, besides the fact that it ensures the absence of weed seeds. Another difficulty that stands in the way is that the season suffers a continued drought which does not permit the application of " raw manure " which would only fall in large lumps and kill the grass under them.

It is also necessary that grassland should receive occasional dressings of lime; this helps to improve the quality of the grasses and also the texture of the soil. Slaked lime is used at the rate of 3 cwt. per acre and is spread about June-July.

Bonemeal plus super 3 : 1 is also applied on a still wet day; as otherwise if spread on a windy day some of the bone dust and super will be blown away and all the manure intended for the land will not fall on it.

Ant hills.—Simultaneous to manuring, ant hills come up in the grassland after the summer rains. These have to be dug out and the queen ants killed. This is rather a costly work. A new scheme introduced is to pump cyanide dust into the hole, block up all openings and this kills off most of the ants. We do not allow ant hills to grow; as soon as a mound is seen, the dust is pumped in and this has been found rather effective. If they are neglected, they become a source of great damage to mowing machines and cattle, besides becoming a safe abode for snakes which is very undesirable.

It is observed that the nests are numerous and deep in paddocks which have soft deep soil, whereas they are not much noticed in paddocks which are gravelly underneath. One reason that contributes for the increase of ant hills in the grassland is that when the dropping of cattle is left in lumps the white ants breed below and eventually form nests; therefore chain harrows are passed over the land which has been grazed the day before in order to break up the clods and aerate the soil. This produces a regular and even distribution of the droppings which results also in more uniform growth. Another advantage is that they no longer serve as breeding grounds for pests.

Gatta Bunding.—Gatta bunding is a method by which the land is divided into plots by means of earthen bunds. They are made by ploughing with a deep plough such as the Sabul Plough and forming ridges. When doing this the natural direction of the water course and the slope of the land is taken into consideration. This conserves moisture, stops soil erosion and prevents the manure from being washed away. The plots are bigger on level land and small on steep land.

Cultivation.—The importance of harrowing cannot be too greatly emphasised for grasslands. Even under ordinary conditions it is quite essential that harrows should be used on grassland at least once in a season. It is beneficial in the way that it prevents tufty and coarse herbage.

From May onwards every rain should be taken advantage of and grubbers or cultivators should be used which tear up the soil 1″ to 2″, and at the same time care should be taken to see that they are passed along the contours. This operation is very important as the grubbers break open the hard surface soil, disturb the root system and allow the rain water to soak well in the soil, giving a stimulus for the grass to develop fresh roots and tillers. It also creates more room for the young grass to grow.

Mixture legumes.—The grasslands at Hosur are unfortunately devoid of any pasture legumes and attempts are being made to introduce *Phaseolus-semi-erectus* and other legumes. The *Phaseolus semi-erectus* which was sown in 1927 has just come up and at present it is not known if this will make a good mixture. Clovers were introduced this year but they all perished due to the prolonged drought.

Another operation connected with the grass cultivation is to keep the land clean of weeds. It is the experience in this farm that every endeavour has to be made to concentrate all available labour for weeding the pastures soon after the summer showers and July rains as it is found that the seeds germinate then; if they are thoroughly cleaned, there will be less difficulty later on. If it is found that the whole area cannot be weeded before the flowers develop seeds, scythes are used to cut the weeds before seeding takes place.

The grass growing season is August, September and October. The heaviest yields are produced if the rains are received during these months. Example :—

Year.	Rainfall : Inches.	Yield per acre lb.
1924-25	30—3	1,546
1925-26	29—37	1,024
1926-27	15—60	717
1927-28	33—81	1,781
1928-29	27—98	726

Late rains, however much, result in a poor yield, the grasses flowering and seeding when about a foot high. If the rains are heavy during the growing season, the yield is also heavy ; otherwise the crop is poor.

Harvest.—The outturn and quality of the hay largely depends on the judgment exercised regarding the correct time of cutting the grass which is a matter that can only be gained by practical experience. It is a matter of great importance that all grasses, whether for consumption in green state, for silage or for hay, should be cut before they seed. There is no difficulty in the case of green grass and silage as their utilisation does not depend on weather, but in the case of hay every precaution must be taken in selecting the time for cutting as nothing does more harm to hay than rain.

From a financial point of view it is economical to cut in its green stage and feed the animals as all animals thrive well on green feed. In places where it is not possible to secure green feed always, recourse must be had either for making silage or hay.

Hay and its preparation.—The grass becomes hay when it is dried, cured and partially fermented in stacks. We cannot correctly class any dry grass as hay when it has not undergone the process of curing or fermentation. Good hay must be free from dirt, must have an agreeable sweet smell, light greenish colour, pliable and soft to touch.

The best time for cutting grass for hay would be when it is in short blade or just before or at the time of flowering. It is only at this stage that the grass is succulent, the foliage tender, green and highly nutritious.

At Hosur the cutting of grass for hay usually commences about the latter part of October and early November. At this time of the year the days are generally cloudy with occasional showers. All available labour should be concentrated and the work of cutting, raking and cocking pushed on in order to cover the maximum area. Every endeavour should be made to make hay as quickly as possible.

Cutting.—It is preferable to cut the grass when it is dry, otherwise the machines will clog. Howard and MacCormick mowing machines are used on this farm and each machine covers 4 or 5 acres per day horse driven ; bullocks do 3 to 4 acres per day.

It is necessary that the machines should be handled by skilled men who know the working and mechanism of the machine. Each driver should provide himself with an oil can filled with lubricating oil and a spanner. The bearing should be oiled very often and all nuts carefully examined ; these should be tightened if they are found to be loose. Machines should not be left out in the rain.

A boy usually goes in front of the machine to guide the mower as there may be obstructions such as stones and ant hills which damage the knives. The mowing knives should be kept sharp ; it is better to have trained men kept on the spot sharpening knives.

To save time and labour it is also important to see that the machines are driven straight, otherwise strips of uncut grass are left.

Hay tedding.—The tedder is worked when hay is to be made quickly, especially when monsoon breaks, without much handling. It is drawn by a horse and the draught becomes fairly heavy when a thick layer of grass has to be tossed. This admits air and sun into the grass and dries it quickly and at the same time it produces a uniform curing. This prevents the top portion of the grass from being exposed too long to sun and at the same time exposes the bottom layer of grass to the sun and air. Hay can be tossed by forks instead of tedders but it should not be knocked about too much as it damages the hay and loss incurs.

Sometimes it has become possible to make hay in one day, *i.e.*, the morning cut grass will be tossed, raked and cocked in the same evening. Horse-drawn tedders do 7·8 acres and bullocks 5-7 acres per day.

Hay Rake.—This is another labour-saving machine used for collecting hay before cocking. Horse-drawn rakes about 10 feet wide will rake about 12 acres per day and bullocks 8 acres.

Cocking.—The next process after raking is cocking. The cocks should be high and shaped conically to assist rain water to run off quickly. The hay remains in cocks for about a week or until such time as it becomes convenient to stack it. Hay which has been exposed to heavy rains after being cut has no aroma, it is dark, discoloured and does not weigh as heavy as good hay. A lot of the goodness is washed out of it. If the hay in cock becomes wet through rains it should be exposed to sun immediately and recocked although the quality of hay is affected. Before stacking, the cocks at random are to be examined thoroughly by inserting the hand into them. If there is too much heat which means the presence of excess moisture, the hay should be spread, exposed to the sun and recocked.

Stacking.— Stacking is essential not only from the point of storage for hay by itself, but it affords the dry grass to be converted into hay after sweating. The site should be on dry raised ground, centrally situated to the area in which the grass is cut, as this saves a lot of labour, time, expenditure, etc. There is no necessity to have a platform constructed for the stack, as the damage, if any, is not so high to justify any expenditure on this item. The hay is stacked on the ground itself, and built up to 10′ with the aid of hay forks; after this an elevator to raise the hay is necessary.

The hay elevator is a simple, useful labour-saving machine, which, when working, has an endless chain with spikes, rotating round an inclined plane, it has gear arrangement connected to a shaft pole, to which a pair of bullocks is yoked and driven round in a circle. The hay is forked into the hay receptacle, which is at the bottom of the inclined plane, and on the rotating movement of the endless chain, the hay is lifted with the aid of the spikes and dropped on the top of the stack. The stack can be built up to the desired height of 20 to 22 ft. or so. It is essential to feed the elevator constantly by drawing the cocks from the field. Depending on the lead, it will be necessary to have 10 pairs to pull the cocks to the stack and 10 men for stacking — 4 men to feed the elevator, 2 pickers and 4 men stacking.

In stacking, the grass should be laid layer on layer, the sides and ends should be kept fairly well out until the stack is of the desired height. Care should be taken not to increase the overlapping on the sides and ends too much, The middle must be kept well filled at the same time. An hour before finishing the day's work, it is advisable to put plenty of hay in the middle of the stack so that if it rains, too much water does not soak into the stack. When the stack is of the desired height, 18 to 20 feet high, topping should be started. This is done by manœuvring each successive layer as it is laid, until the ridge is reached. That is, the top portion is sloped off to either side like the roof of the house. The slope should be steep so as to carry off rain water quickly.

All the stacks should not be made in one place. On account of risk of fire, it is far better to put them in different places.

The stackers should be trained men. Stacking is an art by itself requiring considerable experience and skill.

No damage to stacks has been recorded at Hosur through white ants or rats and there are plenty of both on the farm.

The size of the base of the stack has to depend on the quantity of grass to be cut; a rectangular shape is preferable.

If one has plenty of grass to convert into hay, it is a mistake to make small stacks, as there is much more loss from dryage through the sun and warm winds, and outer surface damage by exposure, in small stacks. The larger the stack, the less the loss.

Whilst making the stack and after its completion, it is advisable to rake down the sides and pull at the loose hay so as to make the stack look well.

A trench about six inches deep and a foot wide can be dug round the bottom of the stack to prevent water getting under the stack. If the stack is built in a field, it is a good thing to put a heap of sand right round it so that if the grass catches fire, the stack is protected to a certain extent.

Thatching.—If the stack has to stand out in the rains tank grass can be used.

Measurement of stacks.—The contents of a stack can be ascertained fairly accurately by measurement. Measure the length and breadth of the stack at the base, the middle and round the eaves, take the average by dividing by three, multiply the average length by average breadth and by height from base to the eaves. For the upper portion, measure length of ridge and the eaves, take the average length and the width at the eaves, next measure the height from eaves to ridge, divide by two and multiply all three together. Add together the totals of the upper and lower portions for the cubical contents of the stack.

The weight depends on various factors such as the quality and fineness of the hay, the amount of pressure according to the height of the stack and the length of time the stack has stood on the ground. At Hosur it is found that spear grass does not compress so compactly as other fine grasses. Stacks after they are made begin to sink and the density increases so the weight per cubic foot of a stack, one week old, will be much less than the weight of a cubic foot of hay from a stack 3 months old. We have found that spear grass hay, which has been stacked for 2 months or so, weighs 4 lb. per cubic foot.

Cutting stacks.—Hay can easily be cut in trusses with the use of a hay knife. A cooly starts on the ridge, rakes off about 1½ yards of thatch and commences to cut downwards trusses about a yard wide, and he continues this width to the ground and when this is all cut and carted, he takes another width of a yard and cuts down to the ground again so that if rains come, not much hay is exposed and the remainder of the stack is intact.

Aftermath.—This is the name given to the grass, after hay has been cut and carted away. Cattle can be turned on to graze this, a week or so after the hay has been carted. It gives a good grazing for another month or so.

Comb for combing the spears from Spear Grass.—This is a simple implement and is very useful in haymaking if the grass is chiefly spear grass. It collects the spears from the grass and its efficiency increases as the awns become mature. In most cases its efficiency is about 80 to 90 per cent.

It consists of an iron comb with teeth about 6 inches long attached to a rectangular iron frame work with two small wheels and a seat for the driver. The comb is 7 feet long with iron teeth, having an inter-space of ¼ to ½ inch.

The framework also has an arrangement to adjust the height at which the comb should pass, which depends on the growth of the grass and also another arrangement to adjust the angle at which the comb should work.

This is easily drawn by a pair of bullocks and is able to comb on an average 8 to 10 acres per day, depending on the level of the ground.

If the grass is thick, the awns choke the comb and they have to be removed very often, otherwise the teeth will be bent.

The awns should be removed from the comb at regular intervals and immediately removed from the field lest they become mixed up with the hay.

APPENDIX IV.

Notes on Subject II.—Work on Animal Nutrition.

(*a*)

(B. VISWANATH, *Government Agricultural Chemist, Madras, Coimbatore.*)

Work on Animal Nutrition at Coimbatore is still in its infancy, having been commenced in April 1928.

1. The main problem under investigation is the determination of the digestive co-efficients of the different feeding stuffs and fodders in common use in South India and to fix feeding standards for animals at rest, on light work and on heavy work.

Animals are fed at different planes of nutrition and records of live weight and food intake are kept. In addition, the digestive co-efficients and nitrogen balance are determined.

From information so far available it may be stated that, starting with the Armsby standard for resting Catabolism, it would appear that the protein requirement of a 1,000 lb. live weight animal is about a third of the stand when the animal is at rest; on light work it is 1·33 times that of the Armsby standard for maintenance. Thus the experimental evidence so far obtained would appear to suggest that the Madras bullock possesses a highly economic system.

2. The study of seasonal changes in the composition of pasture grasses is also in progress. This investigation was recently commenced with spear grass (*Andropogon contortus*) grown on the Central Cattle Farm at Hosur. Periodical samples are collected and analysed for protein, fibre and minerals.

3. In collaboration with the Deputy Director of Agriculture, Live Stock, Hosur, the effect of a mineral supplement consisting of bone meal and lime on growth in calves is being studied. The experiment is only of a qualitative nature and no attempt is being made to study the mineral metabolism. The feeding of roughage, stalling, and looking after the animals is being attended to by the Deputy Director of Agriculture, Live Stock; only the feeding of concentrate and the feeding of accurate amounts of mineral supplements, taking of live weights, measurements and other observations are done by the Chemical Section.

4. Work on small animals like rabbits, rats and chickens is also being done to study the effect of manuring on the nutritive value of the resulting crop as judged by growth and other external symptoms.

(*b*)

This Department has co-operated with the Physiological Chemist, Bangalore, for the last four or five years in conducting experiments to study the nutritive value of spear grass fodders. This grass is very common on many pasture areas in India. It is converted into fodder and hay in large amounts and is baled and transferred from place to place.

2. Owing to its wide distribution and extensive use it certainly deserves study. The Hosur Cattle Farm produces a representative natural growth of spear grass herbage and is therefore conveniently suitable for the enquiry it was proposed to carry out.

3. The following products have been considered and reports of these experiments are under publication at present (I believe):—

(*a*) *The Standard Product Prime Spear Grass Hay—Andropogon contortus.*—This suffers from the grave disadvantage that it is full of spears (the awns of the seed).

(*b*) *Mature Hay—86 per cent. spears removed*—Mr. Woodford, late Superintendent, Hosur Cattle Farm, obtained a comb whereby spears could be removed effectively and economically by combing if the grass were allowed to mature. Hence the second common and now widely used fodder—mature hay spears removed.

The improvement of this comb is now being considered by the Research Engineer, Coimbatore. A machine is required to remove the spears at the optimum period; the present comb pulls either the stalk or the root out, the spears not being loose at this period.

(*c*) *Early Cut Hay.*—This department made repeated efforts to make early cut hay. In suitable seasons, excellent early cuts have been obtained at Hosur.

(*d*) *Spear Grass Silage.*—Silage-making from spear grass at different stages of development has been carried out by the Madras Agricultural Department at Hosur.

Experiments with other grasses such as Kolukkattai (*Pennisetum cenchroides*) and Rhodes grass (*Chloris Gayana*) are to be conducted; samples of early cut, optimum and over ripe are to be tested.

This Department has put as many as 56 head of young stock at a time at the disposal of the Physiological Chemist, together with cattle sheds and store rooms, and has also loaned him cattle for experiment use at Bangalore.

The Physiological Chemist comments, "If Madras can continue to offer such facilities at Hosur as they have given in the past, he will be more than satisfied."

This remark bears testimony to the hearty co-operation which exists between the Physiological Chemist and the Madras Agricultural Department.

APPENDIX V.

Notes on Subject III.—The Locust Problem in India.

(*a*)

THE LOCUST ATTACK OF 1926-27 IN SIND, KATHIAWAR AND GUJARAT.

(HAROLD H. MANN, D.Sc., *Director of Agriculture, Bombay Presidency* AND W. BURNS, D.Sc., *Joint Director of Agriculture, Bombay Presidency.*)

From October 1926 until February 1927 swarms of the North-West Locusts appeared in Sind and did considerable damage.

From December 1926 till February 1927 similar attacks occurred in Kathiawar and in Northern Gujarat.

Our account of these attacks is necessarily faulty due to the very fragmentary information received. One of the objects of this report is to ensure that in any succeeding attack, information shall be immediate and complete. In point of time the earliest notice we have of the attack under discussion is the appearance of locusts on 25th September 1926 at Sujawal, Jati, and Shah Bunder in the Karachi District. The Deputy Collector, Tatta, Karachi District, reported on November 3rd to the Collector of Karachi that locusts, still in the hopper stage, had been noticed all round the Karachi Talukà and that they were in abundance in the *dehs* near the Hab river. The Collector, in passing on this information to the Deputy Director of Agriculture in Sind, said that his information was that the hoppers were advancing from the sandy bed of the Hab river. On 16th November the Deputy Director of Agriculture in Sind reported that locusts had developed wings and become scattered. This is the only available report describing any locusts actually in the hopper stage.

After this, reports of locust swarms were received from many places in Sind. The attack in Kathiawar appears to have started later and was not reported until December, several villages in the Katosan Thana of the Mahi Kantha Agency having been affected on December 14. Attacks continued until about the end of February and then ceased in both Sind and Kathiawar.

The following tables will give a very rough idea of the intensity of locust attack in the various months:—

TABLE I.

SIND.

Month.	Number of attacks reported.
September 1926	2
October 1926	11
November 1926	30
December 1926	22
January 1927	42
February 1927	26
March 1927	..

TABLE II.

KATHIAWAR AND GUJARAT.

Month.	Number of attacks reported.
September 1926	..
October 1926	..
November 1926	..
December 1926	41
January 1927	73
February 1927	14
March 1927	1

We fully recognise that the paucity of our information renders these tables very rough but associated with the statements of various observers we conclude that the attacks gradually increased, reached their climax as regards frequency in December 1926 and then decreased, ceasing in February 1927.

I.—PLACES OF ORIGIN OF THE LOCUSTS.

We have already stated that hoppers were observed advancing from the sandy bed of the Hab river near Karachi and we may assume that this was one breeding place. It was not, however, the only one. Previous experience shows that the Sind-Rajputana Desert is a fertile breeding place of locusts and the District Agricultural Overseer, Nawabshah, states that the locusts affecting his district came from the Thar and Parkar District which is a portion of the desert above mentioned. He states that the locusts finally returned there to lay eggs but he does not state that egg-laying was actually observed. It is very difficult to decide whether the locusts which visited Kathiawar and Gujarat were from either of these origins. It is a fact that Eastern Kathiawar and the neighbouring Talukas of northern Gujarat and particularly the northern part of these areas were badly affected by locusts. This may have been due to an invasion coming from Thar and Parkar passing the eastern end of the Rann of Cutch and so into Kathiawar.

We have no definite records of locusts arriving by sea but the appearance of locusts at Porbandar on the Eastern coast of Kathiawar and adhering to the coast for some time may point to a flight having come from Karachi partly across the sea. The Bombay Steam Navigation Company and the British India Steam Navigation Company both kindly instructed the commanders of their ships to report to us any flights of locusts over the sea, but no such reports were received by us. It is possible, of course, that there may be many more breeding places from which the present attack occurred but these are only two of which there is definite observation.

II.—MOVEMENTS OF LOCUSTS.

Here again we are badly handicapped by insufficient information although this had been asked for from all the authorities concerned in Kathiawar and Gujarat. Our general impression is that there are many locust swarms. Whether these were originally separate or whether they split or recombined we cannot tell, but there were several swarms appearing simultaneously is without doubt. A study of the following tables III and IV and particu-

cularly of dates such as November 13, 1926, in Sind and January 5, 1927, in Gujarat and Kathiawar shows this clearly :—

TABLE III.

SIND—LOCUST ATTACKS REPORTED.

Date.	Place.
September 25	Karachi, Thar Parkar.
October 1	Karachi.
,, 2	Karachi.
,, 9	Karachi.
,, 11	Karachi.
,, 12	Karachi.
,, 16	Karachi, Hyderabad.
,, 23	Karachi, Hyderabad.
,, 30	Thar Parkar.
,, 31	Thar Parkar.
November 3	Karachi.
,, 6	Thar Parkar.
,, 7	Nawabshah, Hyderabad.
,, 8	Upper Sind Frontier, Nawabshah.
,, 9	Larkana, Nawabshah.
,, 10	Upper Sind Frontier.
,, 11	Upper Sind Frontier, Nawabshah.
,, 12	Larkana, Nawabshah.
,, 13	Karachi, Nawabshah, Larkana, Hyderabad, Thar Parkar
,, 14	Karachi.
,, 16	Larkana.
,, 20	Karachi, Hyderabad.
,, 24	Karachi.
,, 25	Karachi, Nawabshah.
,, 26	Nawabshah.
,, 27	Hyderabad, Nawabshah.
,, 28	Upper Sind Frontier.
,, 30	Thar Parkar.
December 2	Nawabshah.
,, 4	Karachi, Thar Parkar, Nawabshah.
,, 6	Karachi.
,, 8	Thar Parkar.
,, 10	Karachi.
,, 12	Karachi.
,, 13	Nawabshah, Karachi.
,, 14	Karachi.
,, 15	Karachi.
,, 16	Larkana.

TABLE III—*contd.*

SIND—LOCUST ATTACKS REPORTED—*contd.*

Date.	Place.
December 17	Karachi, Larkana.
„ 18	Thar Parkar, Karachi, Larkana.
„ 20	Thar Parkar.
„ 22	Thar Parkar.
„ 25	Karachi, Hyderabad.
January 4	Thar Parkar.
„ 5	Thar Parkar.
„ 8	Thar Parkar.
„ 12	Nawabshah.
„ 13	Nawabshah.
„ 14	Karachi.
„ 15	Hyderabad, Thar Parkar, Nawabshah, Karachi.
„ 16	Nawabshah.
„ 17	Sukkur.
„ 18	Sukkur, Larkana.
„ 19	Nawabshah, Sukkur.
„ 20	Larkana, Thar Parkar, Nawabshah, Sukkur.
„ 21	Larkana.
„ 22	Thar Parkar, Larkana.
„ 23	Sukkur, Larkana.
„ 24	Larkana.
„ 25	Sukkur, Larkana.
„ 27	Sukkur, Larkana.
„ 28	Karachi, Larkana, Upper Sind Frontier.
„ 29	Karachi, Thar Parkar, Nawabshah, Larkana, Sukkur.
„ 30	Larkana, Sukkur.
„ 31	Larkana.
February 1	Sukkur.
„ 3	Larkana.
„ 4	Larkana, Sukkur.
„ 5	Karachi, Hyderabad, Thar Parkar, Upper Sind Frontier, Sukkur.
„ 7	Sukkur.
„ 8	Sukkur.
„ 10	Karachi.
„ 11	Thar Parkar.
„ 12	Karachi, Hyderabad, Thar Parkar, Nawabshah, Sukkur, Upper Sind Frontier.
„ 13	Upper Sind Frontier.
„ 19	Karachi, Hyderabad, Larkana, Sukkur, Nawabshah.

TABLE IV.

GUJARAT AND KATHIAWAR—LOCUST ATTACKS REPORTED.

Date.		Place.
December	7	Broach.
,,	9	Banaskantha Agency.
	10	Mahi Kantha, Western Kathiawar Agency.
	11	Western Kathiawar Agency, Mahi Kantha and Jhinjhuwada Thana.
,,	12	Ahmedabad, Western Kathiawar Agency.
,,	14	Mahi Kantha, Ahmedabad, Banaskantha.
,,	15	Mahi Kantha, Ahmedabad, Kanthad Vala State.
,,	16	Mahi Kantha, Ahmedabad.
,,	17	Ahmedabad, Jhinjhuwada Thana.
,,	18	Western Kathiawar Agency, Dhrol State.
,,	19	Dhrol State.
,,	20	Ahmedabad, Dhrol State, Jetpur, Sardarghad.
,,	21	Ahmedabad, Navanagar, Dhrol State.
,,	22	Eastern Kathiawar States, Navanagar State, Dhrol State and Western Kathiawar Agency.
,,	23	Kanthad Vala State.
,,	27	Dhrol State.
,,	30	Porbunder, Sorath, Banaskantha.
,,	31	Porbunder, Ahmedabad, Jetpur.
January	1	Porbunder.
,,	2	Porbunder, Mahi Kantha.
,,	3	Ahmedabad.
,,	4	Mahi Kantha, Ahmedabad.
,,	5	Bhavnagar, Morvi, Sorath, Baroda State, Navanagar State, Mahi Kantha and Western Kathiawar Agency.
,,	6	Ahmedabad, Mahi Kantha, Bhavnagar.
,,	7	Bhavnagar.
,,	8	Bhavnagar, Dhola, Panch Mahals.
,,	9	Bhavnagar, Vakaner, Mahi Kantha.
,,	11	Bhavnagar.
,,	12	Bhavnagar, Broach.
,,	13	Bhavnagar, Mahi Kantha, Halar, Kanthad Vala State.
,,	14	Halar, Navanagar State, Kanthad Vala State.
,,	15	Halar, Kanthad Vala State.
,,	16	Bhavnagar, Eastern Kathiawar States, Mahi Kantha.
,,	17	Panch Mahals, Bhavnagar.
,,	18	Panch Mahals, Bhavnagar.
,,	19	Bhavnagar.
,,	20	Bhavnagar.
,,	21	Bhavnagar.
,,	22	Bhavnagar, Eastern Kathiawar States, Junagad.

TABLE IV—*contd.*

GUJARAT AND KATHIAWAR—LOCUST ATTACKS REPORTED—*contd.*

Date.		Place.
January	23	Bhavnagar, Eastern Kathiawar States, Broach, Junagad.
,,	24	Eastern Kathiawar States, Mahi Kantha, Junagad, Panch Mahals.
,,	25	Junagad.
,,	26	Junagad, Ahmedabad, Mahi Kantha.
,,	27	Mahi Kantha, Ahmedabad, Junagad.
,,	28	Mahi Kantha, Ahmedabad, Junagad.
,,	29	Ahmedabad, Junagad, Broach.
,,	30	Junagad, West Khandesh.
,,	31	Junagad, Mahi Kantha.
February	2	Ahmedabad.
,,	3	Ahmedabad.
,,	5	Mahi Kantha, Himatnagar.
,,	6	Broach.
,,	9	Mahi Kantha, Idar State.
,,	10	Mahi Kantha, Idar State.
,,	11	Ahmedabad.
,,	12	Ahmedabad.
,,	13	Ahmedabad.
,,	19	Ahmedabad.
,,	24	Panch Mahals.
March	20	Surat.

We have no means of ascertaining whether the same swarm visited a place more than once. In fact, we have no really reliable information as to the movements of any swarm. To keep in touch with a swarm requires an observing and reporting organization that does not at present exist. Within the areas which we are describing the direction of flight of swarms varied a great deal, sometimes they came from one point of the compass and sometimes from another. We had hoped that the February reports would show a definite drift in one direction, but with the exception of a doubtful northerly and north-easterly movement in Sind, we got few data regarding the direction of the final flight.

III.—SIZE OF SWARMS.

Here again reports are rather vague, but the majority of swarms reported were large. The swarm actually seen by one of us at Porbunder on 31st December 1926 was conservatively estimated by the Port Officer, Porbunder, to be 5 miles long. It was about half a mile broad and 12 ft. thick, and contained at a very rough estimate, over thirty million locusts. Swarms of from one to six miles in length and of variable breadth appear to have been common. Another swarm observed in Central Sind (Sakrand) in the middle of November 1926, was 1½ miles broad, moved constantly westward towards the Indus, and took two hours to pass over at a computed rate of 2 to 3 miles per hour—the insects being very thick during most of the time. This must have been 5 to 6 miles long.

IV.—FEEDING HABITS.

It has been the custom to state that locusts devour every green thing in their path. Observations made during the attacks now discussed show that this is not necessarily

always the case. One of us (H. H. Mann) in a note to be published in the Bombay Natural History Society's Journal has drawn attention to certain facts regarding the feeding habits observed in Central Sind (at Sakrand) on jungle trees. There the locusts settled most abundantly on the leafless and thorny shrubs *Capparis aphylla* and stripped it of its succulent green outer portion. *Khabar* or *jhar* (*Salvadora specice*) was also occasionally attacked, the young shoots on some trees only being completely defoliated. Many *jhar* trees were left almost untouched. The *babul* (*Acacia arabica*) and the *kandi* (*Prosopis spicigera*), both valuable fodder trees, were scarcely attacked. The same was the case with the species of *Tamarix* (*lai*). At Porbunder, one of us (W. Burns) observed that the *Casuarina* trees were heavily attacked in the same manner as the *Capparis Aphylla* in Sind. Coconut palms suffered little. *Calotropis gigantea* and *Ipomea pescapra* suffered not at all. Mr. B. B. Vaidya of Porbunder very kindly sent the following list of plants observed by him as damaged and undamaged during this attack.

Damaged.	Undamaged.
Casuarina equisetifolia.	*Ixora parviflora.*
Terminalia catappa.	*Tecoma stans.*
Thespesia populnea.	*Mimusops elengi.*
Ficus religiosa.	*Melia aa dirachta.*
Poinciana regia.	*Nerium odocorum.*
Millingtonia hortensis.	*Croton.*
Ficus indica.	*Solanum nigrum.*
Bongainvillia spectabillis.	
Mangifera indica.	
Jasminum sambac.	
Murraya koenigii.	

The same observer also stated that he found locusts eating their own dead, four or five being engaged in devouring one corpse.

All crops suffered, sometimes severely.

Wheat, rapeseed, *jowar*, cotton, castor, and also mango blossom were damaged in Kathiawar and Gujarat.

In Sind, cotton, sesame, *jowar*, *jambo* (*Brussica*), gram, vetch, and wheat were damaged.

There was no standing *crop* in any attacked area that was left absolutely untouched.

V.—Severity and extent of attacks.

The severity of attacks was variable. Occasionally the locusts halted only for a short time and then damage was slight. Thus three successive visitations in the Bhorka Thana of the Eastern Kathiawar Agency in the month of January were reported as resulting in little damage. In the taluka of Sudasna, in the Gadhwara Thana circle, of the Mahi Kantha Agency, the locusts on January 16th stayed a night in trees and on fallow land, going on next morning without damaging crops. At Mandal, however, also in the month of January the damage to cotton, wheat, and rape was estimated at from 50 to 60 per cent., but it is not definitely stated that this is the result of *one* attack. At Viramgam, however, one of our Departmental Cotton Breeders, in a detailed account of a personally observed attack, states that a swarm of three miles long, 50 feet broad and about 4 feet deep during the period 5-10 P.M. to 6-15 P.M. damaged 10 acres *jowar* to the extent of 10 per cent. At Sakrand during November 10 and 11 the damage was estimated as cotton 6 annas, *sesame* 4 annas, *jowar* one anna, rape, *jambo* and gram 1 anna. Generally speaking where locusts merely halted for the night damage was insignificant, but where they settled during the day damage was greater up to at least 50 per cent. We have, of course, to take into account that cultivators naturally did what they could to scare away the locusts, and hence the possible damage was reduced. Of the extent of the attacks our figures are undeniably deficient, but the statistics we have actually collected indicate

a total area of 82,000 acres damaged in Sind, and an area of 15,000 acres damaged in Gujarat and Kathiawar. These figures were compiled in May 1927 after sending out special enquiry forms very widely. We may assume that 20 per cent. can be added to these figures.

In Gujarat and Kathiawar the main attacked area was in Eastern Kathiawar and the adjoining British districts. Locusts however were reported as far South as Broach on January 29.

VI.—Methods of defence against Locusts actually employed

At Porbunder nothing stopped the locusts from coming over, but the beating of kerosene tins, firing of shots, and movement of people prevented their settling. How far ore sound prevents their settling is doubtful. The movement of people probably does as much. However, beating drums is helpful psychologically, in giving a cause for movement, in keeping up the people's spirits, and in its intuitive associations with the driving away of evil spirits. Similar methods with the addition of smoke fires and the waiving of cloths were successful in changing the direction of locusts at villages in Katosan Thana in the Mahi Kantha Agency in attacks dating from December 14 to January 27. The Cotton Breeder, North Gujarat, reports that smoke and drums had no effect on the locusts uptill 9-30 A.M. on February 11 at Viramgam, the locusts still being comatose after the cold night. We have on the whole very few data regarding defensive measures taken, their success or failure, but such reports as we have and our own personal observation indicate that once a swarm settles, the game is up. It is necessary to mobilise every man, woman, and child to *prevent* settling. The really weak point of the winged locusts as observed by us is their inertness at night. They can then be killed by the thousand by mere beating down, trampling, burning or other mechanical means.

VII.—Summary.

Locust swarms appeared in Sind from September 1926 to February 1927 and in Kathiawar and Gujarat from December 1926 to February 1927. Several swarms operated in both areas, travelling erratically. Many places were repeatedly visited, though there is no evidence that a given swarm visited the same place repeatedly. The only observed place of origin of these locusts was the Hab river bed near Karachi, but the desert areas of Thar and Parkar are also a possible source. The extent of attack is reported as 82,000 acres in Sind, and 15,000 in Kathiawar and Gujarat. All crops suffered, but the locusts showed definite preference as regards wild plants. The traditional methods of defence against the locusts were employed by cultivators in some places, with some success. The attack was at its worst everywhere in December and died away in February. Information as to the final direction of flight is wanting.

Conclusions.

There are one or two points that emerge prominently. These are:—

(1) the entire lack of information as to the appearance of locusts in the hopper stage with the one exception of the Hab river at Karachi;

(2) the lack of information as to the movements of a particular swarm and of the final movements of the locusts (and hence no information as to where they went to lay eggs);

(3) the general helplessness of the population due to lack of information regarding swarms and of organisation to deal with them.

There is no difficulty in dealing with locusts if they can be attacked in the egg or hopper stage. Once they have got wings, they are uncontrollable. Considering the speed with which they move, the great distances they cover, the many differently ruled territories they traverse and invade, it seems to us that nothing less than a Government of India organisation is capable of dealing with the menace. An information service is the first essential. Afterwards must come organisation of parties for dealing with eggs and hop

pers and last of all both information (necessarily telegraphic) and organisation to defend crops after swarms are actually on the way. Much can be done by organisation as was abundantly proved by the success of the Bombay Government in dealing with the Bombay locusts in 1904-05.

NOTE.—The urgency of the problem is indicated by the fact that after the above article was written a widespread and severe attack of North-West locusts occurred and is continuing in Sind, especially in Eastern Sind. The appearance of these locusts at this season in Sind is unusual, and if these lay their eggs and produce further swarms there is a black look-out for both kharif and rabi crops of this year.

(*b*)

LOCUSTS IN INDIA.

(T. BAINBRIGGE FLETCHER, *Imperial Entomologist, Pusa.*)

1. The following Note is an attempt to answer the following questions regarding the subject of Locusts :—

(1) What existing information is available ?

(2) How the additional information necessary to frame a scheme to combat locusts can best be obtained ?

(3) Whether it is possible to correlate the occurrence of Locust Swarms with meteorological conditions in the probable breeding areas in the preceding year or even in the year before that ?

2. The existing available information about Locusts is very large, very scattered, and often very indefinite. It may be summarized as follows :—

(*a*) Three species of Locusts occur in India but the only one which it is necessary to refer to further, is the Desert Locust (*Schistocerca gregaria*) often called the North-West Locust (*Acridium peregrinum*) in previous literature.

(*b*) The Desert Locust occurs practically throughout Africa, Arabia, Syria, Persia, Afghanistan, and North-West India.

(*c*) It occurs in two distinct phases as a solitary grasshopper and as a swarming locust. In its solitary phase it lives normally in rather desert areas, but in its swarming phase it invades cultivated areas in large numbers, breeds there and continues to do damage for two or three years.

(*d*) Its breeding grounds are therefore—

(1) permanent, in the desert areas, and

(2) temporary, in the cultivated areas. These permanent areas seem to be situated mainly in the Great Kirman Desert and in Rajputana.

(*e*) Locust swarms in India may therefore originate outside or inside Indian limits. In any case outbreaks in India seem to have some definite correlation with outbreaks outside of India.

(*f*) Some account is given of previous Locust outbreaks in India and of control methods.

3. The correlation of meteorological records with locust outbreaks is difficult because such records are not available for breeding areas outside of India and there is little exact information regarding permanent breeding areas in India. So far as information is available, however, it tends to indicate that—

(*g*) Shortage of rainfall in the breeding area tends to produce the swarming phase of locusts by concentration of the normal solitary phase. If this idea is confirmed by future observations, we should be in a position to forecast Locust outbreaks, so far, at least, as these are not complicated by invasions from abroad.

4. As regards the obtaining of additional information regarding Locusts, we require—

(*h*) Full information regarding the biology and occurrence of the Desert Locust in its permanent breeding areas and the location and extent of these.

5. The following recommendations are also made:—

(*i*) That co-operation in the work of the Locust Sub-Committee of the British Committee of Civil Research is desirable.

(*j*) That a Locust Staff is also required in India to obtain the information outlined under (*h*) and to assist in control measures during outbreaks.

(*k*) That a permanent Locust Board be set up to correlate information and control measures.

Locust Swarms.

6. So far as historic records extend, India has always been subject to invasions by swarms of Locusts. Some two thousand years ago Pliny mentions Indian Locusts which were three feet in length, with legs so strong that the women used them as saws; from which it is evident that in those days Travellers' Tales lost nothing in the telling.

The spectacular effects of the arrival of a large flight of Locusts, together with the ravages which may be effected by such swarms, have furnished a theme for naturalists and historians in all ages. Such visitations have been taken to be natural phenomena, and it is only in the last decade that any real light has been thrown on their origin.

Swarms vary much in size and their dimensions are doubtless often exaggerated by observers but there are credible reports of flights which were square miles in extent and sometimes so thick as to hide the sun from sight, as they passed overhead, and to break down with their weight thick branches of the trees on which they settled. In the case of a fairly small flight which passed over Ujjain (Gwalior) on 2nd October 1929, a local observer reported that the sunlight remained screened over half a mile width of ground for 20 minutes on account of the transit of the insects.

Such swarms usually fly fairly low over the ground (some 20-100 feet above ground-level) but lately there was an interesting record by the pilot of a Dutch aeroplane on his way to Calcutta who reported having encountered swarms of locusts at a height of 2,500 feet over Nasirabad on 10th October 1929. There are several records of locust flights having ascended the Himalaya, even above the snow-line, to a height of 17,000 feet or so above sea-level, but this is, I think, the first record of any flight being observed at any great altitude above ground-level.

What is a Locust?

7. The term "Locust" is generally applied to any species of short-horned grasshopper which is naturally gregarious and, in the winged stage, is capable of sustained flight. Amongst all the hundreds of different kinds of grasshoppers known throughout the world —and of these India has its fair share—such a restricted definition will be found to cover only some eight or ten distinct species. Of these again India has three different grasshoppers which deserve the name of Locusts, and these are:—

(1) The migratory Locust (*Locusta migratoria*, Linnæus), which, although a true Locust, does not seem to occur in India in its swarming phase but only in its *danica* phase as a solitary grasshopper. This Locust occurs in a swarming phase in South-Eastern Europe, West-Central Asia, Tropical Africa, Malaysia, Borneo, the Philippines, China and Formosa.

(2) The Bombay Locust (*Patanga succincta* Linnæus) which occurred in swarms in Bombay in 1882 and again in 1903-04-05-06, but which is normally a solitary grasshopper widely distributed throughout the Plains of India and Ceylon and ranging over Southern and South-Eastern Asia and the Malayan Archipelago.

(3) The Desert Locust (*Schistocerca gregaria*, Forskoal), commonly called the "North-west Locust" (*Acridium peregrinum*) in literature on locusts in India. This insect is the one which has occurred so commonly in North India during the last three years and is the Locust referred to in this Note.

The Desert Locust (*Schistocerca gregaria*).

8. *Distribution.*—The area of occurrence of this Locust, both in its solitary and swarming phases, covers practically the whole of Africa exclusive of the more humid and forested areas of Central and Western Africa, the whole of Arabia, Palestine, Persia, Afghanistan, Baluchistan and North-Western India. In India swarms and solitary specimens have been recorded from as far East as Sikkim, Dacca and Assam, and as far South as the Bellary district in Madras, but its main area of occurrence is in Baluchistan, Sind, Rajputana, the North-West Frontier Province, the Punjab and the United Provinces.

9. *Life-history.*—The life-history of the swarming phase of the Desert Locust is known fairly well and there is no need to go into it in further detail than is required for control measures.

The eggs, which are laid preferably in areas of light soil which is more or less damp, are enclosed in a thin and fragile capsule which contains about 70-100 eggs, sometimes as many as 130 eggs, and each female locust may lay several of such egg-pods. The female locust digs a deep hole in the ground with her abdomen, which is extremely extensible, so that the egg-pod is sometimes as much as six inches below ground-level.

The eggs, under optimum conditions in India, hatch in about a fortnight but the period may extend to two months, or perhaps rather more. There is, however, no evidence that eggs remain unhatched, in the absence of moisture, for several years, as has been noted in the case of other locusts (in the case of the Brown Locust, in South Africa, eggs kept dry have been hatched after three years).

The young Hoppers pass through about five moults, growing all the time, before attaining the winged stage, which is reached in 5-7 weeks. In the case of the swarming phase, there is then a period of a month or more before the Locust becomes sexually adult, after at least one migration flight.

The whole life-cycle, from egg-laying to egg-laying, can be passed through in about 3 months under optimum conditions, but in practice it seems probable that two (or at most three, perhaps partial) life-cycles are actually gone through in the year in Northern India.

The above details apply to the swarming phase only. We have no satisfactory information on the life-history of the solitary phase.

Swarming and solitary phases of Locusts.

10. The preceding references to the swarming and solitary phases of the three Indian Locusts require some explanation. A species of Grasshopper, to which in its gregarious condition the term "Locust" is applicable, is also found, when not massed in a swarm, as a solitary grasshopper. The individuals of a swarm, which breaks and becomes scattered, become solitary grasshoppers: conversely, solitary grasshoppers which band together to form a large swarm become swarming grasshoppers, *i.e.*, true Locusts. The swarming and solitary phases are separable by differences of habit, colour and structure, but both are only phases of one species of grasshopper and they are convertible into one another. This does not mean that such conversion is immediate but it may happen in the course of one generation, so that the progeny of the solitary phase may show the characteristics of the swarming phase, or *vice versâ*. The differences between the swarming and the solitary phases of the Desert Locust may be summarized as follows:—

Swarming Phase.	Solitary Phase.
Hoppers are coloured yellowish or whitish with well-defined black markings and are dark in colour.	Hoppers are variable in colour but usually greenish.
Hoppers are inclined to form into bands and to wander.	Hoppers do not form bands or wander.
The adults form dense swarms . .	The adults do not form swarms.
The adults show an imaginal diapause and do not develop sexually without a migratory flight.	The adults develop sexually without a diapause or an imaginal flight.
The adults undergo a colour change (becoming yellowish) in connection with sexual maturation.	The adults do not change colour in connection with the maturation of the genital products.

11. The cause which leads to the transformation of the solitary into the swarming phase is supposed to be directly due to the influence of crowding together. Experiments with *Schistocerca gregaria* in the Sudan have shown that either the swarming or the solitary phase is obtainable at will by regulating the density of the population in a given area. Also, when bands of swarming hoppers have been thinned out by control measures, it has been noted that the scattered hoppers which escape turn into the solitary phase, changing their colour and gregarious habits and dispersing completely.

12. Such observations throw an interesting light on the possibility of Locust outbreaks originating locally by the concentration of scattered solitary grasshoppers which, by crowding together, are (if, hoppers) transferred into or are parents of locusts. Thus, in the case of the Brown Locust in South Africa, Lounsbury pointed out in 1915 that this species is permanently resident, not common enough to attract casual attention, but occurring in small numbers here and there in localities specially suited to it, and capable of excessive multiplication during an unusually favourable season. In the case of *Schistocerca gregaria* in German East Africa, also, Morstatt definitely stated in 1921 that the periodicity of locusts in that area was due not to invasions from outside but to periodical increased multiplication of local insects, living usually scattered on dry grass-lands. Morstatt also was inclined to attribute the periodical increases in the number of locusts, leading to the formation of swarms, to abnormally dry years. It is not evident that Morstatt adduced any reason for this but it would seem that a dry season (possibly following on a wet season or other condition favourable to the temporary increase of the solitary phase) would, by restriction of available food-supply, tend to concentrate the solitary grasshoppers in such areas as still produced food for them and, as soon as such concentration becomes sufficiently dense the solitary phase would tend to transform into the migratory phase with the usual result of the formation of swarms and the dispersal of the winged locusts in search of more favourable localities. It seems probable that this is the cause of the formation of Locust swarms, whether such swarms have their origin in more or less desert areas or in more cultivated ones.

13. In this connection, I would call attention to the numerous occasions on which has been noticed in India that areas in which the rainfall has been deficient, so that there was already some degree of famine condition prevalent have been subject to locust attack. Thus, in Ahmedabad, in 1834, where the rainfall was deficient, the distress was increased by vast swarms of locusts. Again, "in 1869, after prolonged drought, the whole of Rajputana and the Punjab were invaded by vast flights of locusts" and again, in 1870, in Rajputana, after the damage of the previous year (practically amounting to a famine) "a breadth of land equal to half the usual quantity was sown. The grain everywhere sprouted splendidly, and all reckoned that the famine had passed, when another scourge visited the country in the shape of locusts." It is scarcely necessary to add the case of the United Provinces in 1928 and 1929, both years of short rainfall and excessive damage by locusts. Such conditions tend to prolong locust outbreaks merely by concentrating the locusts in such smaller areas as are still kept verdant by artificial or natural irrigation, whereas, under more favourable conditions for finding food over larger areas, the swarms would disperse and disintegrate into solitary grasshoppers.

Breeding grounds of the Desert Locust in India.

14. A factor of importance in dealing with the Locust Problem is the location of their breeding grounds. There are (1) permanent breeding grounds, mainly in desert areas where the species lives normally and whence they send out vast swarms in years of unusual abundance, and (2) temporary breeding places, usually in or near cultivated areas, where a migrant swarm descends to feed and lay eggs. Under favourable conditions, these eggs hatch to form swarms of Hoppers which may ultimately form winged swarms which migrate further.

15. In the case of India, what seems to happen is that, at irregular intervals, large swarms invade Baluchistan from the West, probably from the desert regions South of Persia and East of Arabia, and other swarms from Rajputana invade Sind in the autumn and the United Provinces and Punjab in the Spring and form temporary breeding places,

such secondary swarms lasting for several years until they eventually die out. Then ensues an interval of some years before the occurrence of another invasion and outbreak.

16. It must be admitted that we have very little precise information regarding the occurrence of Locust swarms in India but our knowledge, such as it is, seems to agree fairly well with occurrences in other parts of the world. For example, in South Africa, where two different Locusts occur, the Brown Locust (*Locustana pardalina* Wlk.) breeds chiefly in the uninhabited deserts and throws out winged swarms which invade adjacent cultivated areas. The Red Locust (*Nomadacris septemfasciata*, Serville) was not noted to occur in Natal from 1851 to 1891; a few swarms entered in 1892 and 1893, a great invasion occurred in 1894 and was continued in 1895, after which the pest remained more or less endemic, at its worst during the summers (winters) of 1903-04 and 1906-07, until in 1907 an enormous number of swarms concentrated in the Transvaal, Orange River Colony, Cape Colony and other parts of South Africa.

17. It is difficult to locate the permanent breeding grounds of *S. gregaria* on the fragmentary evidence avilable. In his report in 1891 the late E. C. Cotes quoted a statement of Surgeon-Major Moore, regarding the invasion of 1869, that permanent breeding grounds exist in the sandy and desert districts of Rajputana, especially in the sand-hills of South Western Manour and Mullanni. This locality presents a succession of sand hills from 50 to 200 feet high and some miles long and extends over thousands of square miles, commencing near the Rann of Kutch and forming a broad belt of country towards Bhawalpur and Bikanir; during the monsoon season it is fairly green but at other periods it presents a bright blinding whitened appearance. In this Report Cotes mentioned two regions in which breeding usually takes place, *viz.*, (1) Rajputana, including the South-east corner of the Punjab and extending into the North-Western Provinces, an area which generally receives its locusts from the permanent breeding ground in the sand-hills of Western Rajputana; and (2) the North-West Punjab, including most of the region bordering upon Afghanistan and Baluchistan, where the locusts seem generally to come from breeding grounds along the Suliman range or beyond the frontier.

18. Further, Cotes states that the evidence points to the region of sand-hills in Western Rajputana as the permanent home of this locust. Subsequent reports, while confirming this point, seem to indicate that, though most of the flights issued from this breeding ground, others invaded India from breeding grounds which probably lie along the Suliman Range, or even perhaps, in some cases, beyond India's western frontier, in the sandy deserts of Baluchistan, Southern Afghanistan and Persia.

19. Although the Rajputana deserts may provide a permanent breeding ground for this locust, it appears doubtful whether this area can produce all the large swarms which invade India. In some cases, however, they seem to have served as a focus for locust invasions. Thus, in 1903, Kathiawar and Gujarat received swarms in November which passed through the Surat district in early December, and these swarms were reported as occurring all along the coast, apparently after a flight across the Gulf of Cambay. It is possible that this 1903 invasion, which came to nothing, originated in Rajputana, but the swarms may have flown down the coast line from Persia; there is no evidence either way. In the case of Baluchistan it has been recorded by Colonel Webb-Ware that locusts enter the Province from the Persian side.

Origin of Locust Swarms in India.

20. From the foregoing, it will be seen that there are two possibilities:

(1) Invasion by migration flights from outside of India.

(2) The formation of migration flights, by the transformation of the solitary into the migrant phase of locusts in India.

As regards invasion from abroad, we have a definite statement that in 1913 Baluchistan was invaded by Locusts whose origin was traced to be the Great Kirman Desert.

As regards the formation of true migration flights in India, there is also some evidence that these originate in the Marwar Desert.

21. It would thus appear that Locust outbreaks may originate both inside and outside of India. It seems, however, significant that outbreaks in India coincide fairly definitely with outbreaks outside of India. This is brought out in the following statement which refers only to *S. gregaria.*

Year.	Locusts in India.	Locusts outside of India.
1883 . .	....	1883—88 Cyprus.
1886 . .	....	1886 Baghdad.
1889 . .	Rajputana ; Baluchistan . . .	Persia.
1890-91 .	Throughout Northern India . .	1891 whole of North Africa.
1897 . .	Baluchistan, May-October . .	Shiraz, Persian Gulf (June).
1898 . .	Baluchistan, Sind, and as far as Pabna.	
1903 . .	Kathiawar and Gujarat (November), Surat (December), swarms disappeared without doing damage.	
1904 . .	....	Egypt.
1905-06 .	Baluchistan, N.-W. F. Province, Punjab, U. P., Kathiawar.	
1907 . .	Punjab (March), extending into U. P. and found as far east as Assam. Nasik and E. Khandesh (June).	
1912 . .	Sind (said to have come from Marwar).	
1913 . .	Sind ; Baluchistan (invaded from Kirman Desert).	
1914 . .	Sind, Punjab	Egypt (small invasions).
1915 . .	Punjab and U. P.	Egypt and Syria (large invasions).
1916 . .	Died out in U. P.	Egypt ; Sudan ; E. Africa.
	Rohtak (Hoppers in early August).	
1919 . .	(No outbreak in India) . . .	Iraq (large swarms, April-May).
1926 . .	Sind	Iraq, Sudan.
1927 . .	Sind, Punjab and U. P. (March), N.-W. F. Province (April) spreading to Bihar (July).	Iraq ; Persia ; Morocco ; Algeria ; Afghanistan.
1928 . .	Sind. Punjab and U. P. . . .	Iraq (swarms in Feb., June, July and August) ; E. Africa.
1929 . .	Sind, Punjab and U. P. . . .	Algeria.

22. It has been stated by many observers that locust migrations are carried by wind. It may be noted that wind conditions, as shown by charts of wind-direction at low levels, tend to indicate the Marwar Desert as a dispersal-point, the cold-weather winds tending to blow from the Desert to Sind and the hot-weather winds from the East to the Punjab and United Provinces.

Locusts in India.

23. A very complete account of Locust outbreaks in India up to the year 1890 was compiled by the late E. C. Cotes and, as his Report is not generally available, it seems desirable to reproduce it here, as regards these earlier occurrences of Locusts in India.

"In the year 1812, according to Hunter's Gazetteer, locusts did some injury in Ahmedabad and Broach. In 1821 they visited Etawah; the following being an abstract of the account given by Playfair (*Trans. Med. Phys. Soc. Calcutta*, 1825):—

"'On 20th June 1821 a large flight of locusts appeared at Etawah, and settled in the fields; vast numbers of the locusts then copulated, and hovered about the place for about a month before taking their departure. On 18th July vast swarms of young locusts emerged, and proceeded to move slowly over the country, devouring the vegetation as they went. The cultivators tried to sweep them back from their fields, and by driving and sweeping them into heaps, which they burnt, they destroyed vast numbers; the birds also destroyed great numbers of them. By lighting fires round their fields, the cultivators endeavoured to prevent their entry. The numbers of the locusts, however, seemed to be unaffected, and the invasion proved too vast for any individual action to be of much service. The fires could not be kept constantly burning, and as soon as they went out the locusts crowded across them. The locusts were observed up to 31st July, by which time many of them had transformed into pupæ; great damage had then been done, and this, combined with the previous drought, ruined many of the cultivators. About 31st July flights of winged locusts were seen to pass overhead. When rain was actually falling, it drove the young locusts into the trees and fences for shelter, but seemed to have no permanent effect upon them.'

"In 1834, according to Hunter's Gazetteer, locusts ate up the crops in Kaira, and remissions in the revenue amounting to £19,655 were sanctioned; in Ahmedabad also, where the rainfall was deficient the distress was increased by vast swarms of locusts. In 1843-44 Rawalpindi suffered severely, the following being an extract from Hunter's Gazetteer on the subject:—

"'The locusts appeared just in time to devour the whole autumn crop of 1843; they remained for the succeeding spring crops, and at last took their departure after utterly destroying the autumn harvest of 1844. Rawalpindi is still suffering from the remote effects of this terrible visitation. The Sikh authorities insisted upon realising the utmost farthing of their revenue from the starving cultivators, who were obliged to have recourse to the trading classes and so commenced a system of chronic indebtedness which has not even yet entirely passed away. The tenures of land were completely revolutionised to the great disadvantage of the proprietary class, as the Sikhs admitted tenants to share the burdens and privileges of the landowners, in order the more readily to collect their exorbitant imposts. The British Courts were for long flooded with litigations arising from the disorganisation of this unhappy period.'

"In 1863 there was a widespread visitation of locusts in the Punjab and Rajputana, but no very complete records have been found of their history. Specimens from Muzaffargarh, preserved by Mr. W. Coldstream, shew that the insect belonged to the species *Acridium peregrinum*. As in other invasions the insect seems to have bred in the early spring in parts of the Punjab, and in the beginning of the south-west monsoon in the districts bordering upon the Rajputana desert; and the fact that a considerable flight reached Dacca in the cold weather (report of the present Commissioner of Chittagong) would seem to show that the plague continued throughout the greater portion of the year.

"In the Shahpur district (according to the report of the Deputy Commissioner) large flights appeared in February and March, but they were little noticed. When however the eggs were expected to hatch out, rewards were offered for them, and 186 maunds of

eggs were brought in by the villagers and destroyed, the total cost being about Rs. 305. Rewards were also offered for young locusts, and 2,272 maunds of them were destroyed at a cost of Rs. 710, most of them being brought in by the villagers for the reward and some being destroyed locally by driving them into trenches and fires. But little damage was done either to the old *rabi* or to the *kharif* crops. The young locusts, which escaped destruction, acquired wings, and afterwards flew about the district, but they were not allowed to settle on the crops, and did little damage.

"In the Hissar district (Deputy Commissioner's report) flight appeared in February and March, and again in still vaster numbers in June and July. Eggs began to be found about July, and ploughing was largely tried, but was generally given up as useless. In the latter part of July young locusts emerged in vast numbers; rewards were offered for eggs and young locusts, trenches were dug in all directions, and vast numbers were destroyed. In the latter part of August more flights appeared, and eggs were again deposited, the measures taken for destroying the eggs having to be continued vigorously until the middle of October. On the whole, however, very little damage was done in the district.

"In the Muzaffargarh district (Mr. W. Coldstream's notes) a large flight, from the Rajputana desert, appeared in the early part of July, and did some damage

"The above is all that has been ascertained on the subject of the invasion of individual districts in 1863, but the following extract from a report, dated 29th July 1863, by the Secretary to the Punjab Finance Commissioner, shows the serious nature of the evil:—

"'The young locusts, I regret to say, have begun to be hatched at Lahore itself where there was previously no suspicion even of eggs having been laid, as also in the Gurdaspur district, in vast numbers. The old locusts have been laying their eggs at Sirsa, Hissar Rohtak, Patiala, and other parts of the Sutlej, while they are stated to be laying them broadcast in Bikanir and other parts of Rajputana. In the Derajat and Peshawar divisions, as well as in Rawalpindi, and, it is to be feared, throughout the Salt-Range and elsewhere in the north the same process appears to be going on; so it appears certain the coming crops must be devastated far and wide, more especially the cotton crops, which have already begun to suffer, if the most resolute efforts be not made to destroy the eggs and young broods before they attain to maturity.'

"From 1864 to 1868, inclusive, the only records of locusts likely to have belonged to the species *Acridium peregrinum*, are from the Hissar district (report of the Deputy Commissioner), where a very careful record seems to have been kept. In this district, in 1864, flights appeared in July and August, and laid eggs which hatched in the middle of August, very slight damage being occasioned; in 1865 flights appeared in June, July and August, and again in November, young locusts being found as early as the end of June; in 1866 a few locusts appeared in June, and young hatched out in August. In 1867 a small flight appeared in July.

"In 1869, after prolonged drought, the whole of Rajputana and the Punjab* were invaded by vast flights of locusts, which are reported to have come in the south from the *teeburs*, or sand hills, of Western Rajputana, and to the north from the direction of the Suliman Range. They did a great amount of injury, especially in Sirohi, Ajmere, and Marwar, where the distress caused by the drought and consequent famine of 1868-69 was much increased through the destruction of a great portion of the remaining crops by the locusts. In the Dera Ismail Khan district flights from the Suliman Range appeared in the end of April and in May; eggs and young locusts were also found, about this date near the hills in the sandy tracts of the same district. Flights were also reported in the early part of May from Amritsar. But throughout Central Rajputana, and in the more southern districts of the Punjab (Multan, Sirsa, Ludhiana, Dera Ghazi Khan, Hissar) the main flights appeared about the commencement of the south-west monsoon in June and July. The eggs laid by the invading flights were distributed throughout the whole of Central Rajputana and also in the Hissar district of the Punjab, and the young locusts became full-grown and acquired wings in August and September, and were said to have

* The Peninsular and Oriental ship *Euphrates* was said to have had to plough her way through locusts for three days and nights in the Red Sea towards the end of October in this year (Swinhoe) but there is no evidence to show to what extent the invasion was a general one in the intervening countries.

been the progenitors of the second batch of eggs which were laid about end of September in the Hissar district. The crops were damaged, in the first instance, by the young locusts before they acquired wings, and afterwards by the winged swarms which seem to have flown about the whole of North-west India throughout the autumn and winter of 1869, and settled at intervals to devour the crops. Records have been found of measures, such as trenching, etc., which were adopted with considerable success in the Hissar district in the Punjab, and also on the De sa Commissariat Farm in Rajputana, for the destruction of the young insects in their wingless stage; while from Amritsar and Lahore there are accounts of how the villages collected with tom-toms, and drove the winged locusts off their crops, so that but little damage was done. Throughout Rajputana, however, the measures taken for the destruction of the pest seem to have been very much less successful, partly perhaps because they were carried on unsystematically, but chiefly no doubt, because of the vastness of the numbers of locusts by which the country was invaded and the comparative sparseness of the population. Thus a vast amount of injury was done in Marwar, Ajmer, Kishengarh, Tonk, Sirohi, and the northern part of Meywar, the crops being damaged both by the young locusts and also by the winged flights.

"The following extract from a report, dated 9th December 1870, by Colonel J. C. Brooks, Officiating Agent to the Governor General in Rajputana, shows the extent of the calamity:—

"'A breadth of land equal to half the usual quantity was sown. The grain everywhere sprouted splendidly, and all reckoned that the famine had passed, when another scourge visited the country in the shape of locusts. They entered Marwar from Jeysulmere at the end of May, and laid their eggs in every direction. These hatched as the rains set in, and by the end of August the young locusts had spread over the whole famine tract, laying fresh eggs wherever there was sand. The broods from these eggs appeared early in September, and, moving in dense masses backwards and forwards, destroyed every thing in their way. Crops were eaten down, so that the ground had the appearance of never having been sown. By degrees the locusts got their wings, and flew hither and thither over the country, devouring the ripening grain which the young broods had spared. Each swarm, of which there must have been hundreds in Rajputana, settled every night, cover every green plant over an area of 12 or 15 square miles, and left it bare as they flew away in the morning. The loss to the country by the locusts was about 75 per cent. of the crop, which originally was only half a crop.

"'Usually locusts confine their ravages to Marwar and Bikanir, but in 1869 they spread over Ajmere, Kishengarh, Tonk, and the northern part of Meywar. The same complaint was everywhere heard, that the locusts had destroyed from one-quarter to three-quarters of a splendid harvest, and that another year of famine, though not so bad as the former, had to be endured.

"'Marwar suffered most, and many villages, especially in the north, were again compelled to emigrate. They were now in much more reduced circumstances than previously. They flocked to the Ajmere poor-houses for relief, but would not take work. Those that remained in Marwar supported themselves on the *Jhoorut* grass (*Achyranthes aspera*), which now gave a means of subsistence to all who would take the trouble to collect it .....

"'The rains commenced at Tonk most auspiciously. Wheat at this time had risen to seven seers, and barley, the cheapest grain, to nine seers the rupee. Saving the high prices, all went on prosperously, till the locusts came. The first flight appeared at the end of July, but did not do much harm. They deposited their eggs in the few dry sand hills in Tonk, and in the sandy beds of the rivers. Intermediately the heavy rains had commenced, and the Bunass river rose to its brim, and flowed down a muddy torrent, 500 to 1,000 yards in width, and 30 to 40 feet deep. After it had subsided, during a break in the weather, when the usual time for hatching had arrived, the young locusts, about the size of small ants, issued from the sands of the river in myriads, and at once formed their phalanxes to go forth and devour the land. They swam the deep pools in the rivers, they escaladed the walls of Tonk, entered the city and took possession of the town, and of every house—literally driving out the inhabitants. They cleared the land of its crops, and committed great devastation throughout the country. When they had got their wings,

sundry flights which were moving about settled and destroyed what previous ones had left. This visitation intensified the calamity of famine. The price of grain rose with the destruction caused by the locusts. In July and August 1869 wheat was 6½ and barley 10½ seers per rupee. In September wheat was 6 and barley 7 seers. In October they were 5½ and 6½ respectively, and only in November did they begin gradually to fall.'

"In 1870 eggs laid by the cold-weather flights of the previous year hatched in March in the Jhelum district, and the young wingless locusts did some damage to the *rabi* crops. The people did what they could to prevent the winged locusts from alighting and afterwards destroyed the young by trenching. In the beginning of July of this year locusts appeared in the Hissar and Amritsar districts. There is no record of what became of the Hissar insects, but in Amritsar, according to the district report, they did a little damage to the crops, and young wingless locusts appeared in the end of August and early part of September, but were all destroyed.

"In 1872, in the Punjab, locusts were reported in July and August from Rohtak, Multan, Bannu, Jhelum, Dera Ghazi Khan, and Hissar. Eggs were laid in Rohtak in the early part of July, and young hatched out in Rohtak and Jhelum at the end of the month. The Dera Ghazi Khan district, however, is the only one in which any damage was recorded. In Rajputana a flight was recorded by Surgeon-Major Moore to have passed over Sirohi on the 31st of May of this year. According to Surgeon-Major Hendley's report vast flights appeared in August in Marwar, and great numbers of young hatched out about the end of August or beginning of September, occasioning "much damage" to the crops.

"In 1873 flights were reported in the Jhelum and Amritsar districts, eggs being laid and some damage done to the crops. In the Amritsar district the villagers are said to have followed the flights and destroyed all the eggs and young locusts that could be found.

"In both 1876 and 1877 locusts were observed about July in the Hissar district. In 1878, besides having been reported from Rajputana, they are noticed in the district reports as having appeared in Dera Ghazi Khan in May, and in Hissar in the end of June.

"In 1879, according to a notice in the Proceedings of the Entomological Society of London, locusts appeared only in March near Meerut, covering a tract of country about 15 miles long by 2 or 3 miles broad, and gradually moved northwards up the Anupshahr branch of the Ganges canal. They laid eggs over the whole area, and before the end of the month the ground was covered with little black larvæ. Considerable damage was done to peas and mustard, but not much to the grain which was then being cut. In the district report also locusts are noticed in this year, in Hissar, coming from the Rajputana desert in April and again in July, as well as in Dera Ghazi Khan, where damage was done in September.

"In 1880 in July and August flights appeared in the Dera Ghazi Khan district and did much damage to the *kharif* crops. Considerable damage was done about this year in Jeypur by a large flight, recorded by Surgeon-Major Hendley, who also writes that the trains on the Rajputana-Malwa Railway found it difficult to proceed owing to the rails being made slippery by the dead-bodies of the locusts. A flight also, which may have belonged to the species under consideration, though other locusts also visit the district, appeared in Jullundar in April 1880 and deposited eggs, which were all destroyed by the people."

24. Between 1880 and 1889 there were no reports of the occurrence of Locusts. In 1889, however, flights were observed in June in Sind and Rajputana. In July-August flights reached the Punjab and Hoppers hatched out in Jodhpur and Ajmer-Marwara. In September these Hoppers attained the winged stage and flights were noted in all parts of Rajputana, spreading to the Punjab, flights were also noted in Baluchistan and in Persia. In October flights were again reported from Sind, the Western Punjab, Rajputana, Allahabad, Ahmedabad, Baroda and Khandesh; also in the Kishim Island in the Persian Gulf. In November flights moved generally eastwards and were reported from many places in the United Provinces, *e.g.*, Muttra, Agra, Cawnpore, Kumaon, and a stray flight reached as far as the Godavari district in Madras. In December flights were again reported from Rajputana, the United Provinces, the Vizagapatam district, Central India and Baluchistan. In January 1890 flights occurred in Ajmer-Marwara and Sind, the North-West Frontier, Punjab and Krishna district of Madras. During the remainder of the year 1890 flights

were reported during every month until November and, generally speaking, occurred throughout the whole of Northern India as far south as the Central Provinces, with stray flights into the Ganjam, Kurnul, Cuddapah and N. Arcot districts, on the west coast as far south as Dharwar, and eastwards as far as Dhubri in Assam. Flights were recorded as having reached the Himalaya (Kumaon, Naini Tal, Simla and Bashahr) and passing and repassing over the outer ranges. In 1891 the attack seems to have continued on a lesser scale, locusts having been noted in Kathiawar on 27th May (a flight), on Upper Sind Frontier at the end of June and beginning of October, in Baluchistan at the end of August, inMay at Peshawar (Hoppers), in Kohat from the middle of April (Hoppers) to the end of August.

25. In 1892, in March, a few locusts again appeared in Sind and the western frontier of the Punjab and laid eggs in Dera Ismail Khan, while in May some stray flights penetrated into the United Provinces and Bengal. Little damage, however, was reported and the flights seem to have been too small to cause any anxiety. Small flights were reported from various localities in Sind and the Punjab until January 1893, this invasion having died out during the first half of 1893.

26. The next outbreak seems to have been in 1897 when dense swarms of Hoppers were noted in Baluchistan at the end of May and Locusts did considerable damage throughout the summer. On 5th June 1897 a large flight arrived at Jarruck (Karachi district) from the North West and on 19th June a flight was reported in the Shahdadpur *taluq* (Upper Sind Frontier). At Mahikantha flights from the North West were noted on 29th and 30th July 1897 and again on 18th October. Other flights were reported from Nasik (27th October), Broach (19th October), Kaira (28th—30th October, 2nd—5th November), Ahmednagar (27th October), Mandla, C. P. (16th October), Hoshangabad and Bhopal (October). This outbreak continued in 1898, swarms reaching as far as the Pabna district (9th January 1898), Panch Mahals (5th February 1898). Damage in Sind and Baluchistan seems to have continued with various outbreaks of locusts, throughout the summer of 1898, but there seems to be little on record regarding damage done in other parts of India.

27. In 1903 flights were noted in Kathiawar and Gujarat in November and in Surat in December, but seem to have disappeared without doing any damage.

28. In 1905 we have records of Locusts on 8th May at Chagal (? Quetta), on 16th June at Dera Ghazi Khan, on 20th July and 10th October at Agra, and on 27th August and 29th September and 5th October at Riwari (Punjab). In 1906 locusts were recorded at Hafizabad on 2nd February, at Pusa on 18th June, at Sitamarhi on 29th July, in October at Ranchi, Kishoriganj and Kathiawar, on 3rd December at Mahikantha and on 29th-30th December from villages of Lunawada State. We also have a specimen (apparently a solitary individual, not from a swarm) from Muzaffarpur in 1906. There seems to be little on record regarding any real outbreak in 1905-06.

29 In 1907, however, there was a heavy outbreak of Locusts in the Punjab in March, when control work was carried out by the Pusa staff. This attack spread into the United Provinces also in 1907 and swarms of locusts occurred as far East as Assam. In June 1907 also Hoppers were reported from Nasik and East Khandesh in the Bombay Presidency, where there does not seem to have been any large outbreak.

It is presumed that this attack died out in 1907 as we have no further information about it.

30. In 1912 Locusts occurred in Sind and are stated to have appeared to come from the Marwar Desert.

31. In 1913-14-15, there was a definite outbreak. In 1913 Locusts were noted at Kotri on 12th May in the Weather and Crop Report and we have specimens collected there on 16th June. On 21st July they were reported from Nawabshah and from Larkana, Thar and Parkar, Upper Sind Frontier; on 30th July from Digri, Eastern part of Jodhpur, Mirpurkhas, Thar and Parkar desert; and in October from some villages in Sind. In reply to a request from Pusa for information regarding Locusts in Sind in 1912 Mr. G. S. Henderson, then Deputy Director of Agriculture in Sind, wrote " that during the last season (1913) locusts are not reported as doing much damage in Sind. The year before (1912) a good many came across lower Hyderabad and Karachi districts from Marwar desert and did damage."

32. In 1913 also there was an invasion in Baluchistan and Colonel Webb-Ware, who was then Political Agent at Chagai, stated (*Agricl. Journ. India X* 159: Apl. 1915) that steps were taken to trace the origin of these flights, and the results of several months' patient investigation tended to show that the swarms had started from the Great Kirman Desert. The precise breeding grounds in this Desert were never actually traced, but as flights, coming from the same direction, made their appearance almost simultaneously in the Bam District, in Mashkel, in Kharan, in Sarhad, in Seistan, in Neh Bandan, and in the Valley of the Helmand, it may be assumed that the Desert breeding grounds embrace a very considerable area. According to Colonel Webb-Ware, Locusts appear in Baluchistan at intervals of every few years, always arrive after years of good rainfall and enter the Province from the Persian side making for Sind. There is, therefore, some doubt as to whether the invasions into Sind are always from the Marwar Desert. It seems more probable that some at least come from Persia through Baluchistan into Sind.

33. In 1914 Locusts were noted in the Thar and Parkar district on 12th February and again on 12th September, from June to October in Gurgaon and Hissar, and also in Rohtak, Ferozepur, Montgomery, Multan and Muzaffargarh districts, and on 24th June and 14th September in the Malikantha State.

34. In 1915 the outbreak continued in the Punjab and a flight visited Lyallpur on 2nd August. Locusts were noted at Quetta in July and as late as 9th November. Dehra Dun also was visited by flights in July and Budaun in September.

35. In 1916 we have a record of Locusts at Auryah village in the Etawah district and of Hoppers throughout Rohtak district (Punjab) at the beginning of August, but the 1912-15 invasion seems to have died out in 1916.

36. The next invasion was in 1926 when the present outbreak started in Sind in September, spreading in 1927 to the Punjab and United Provinces in March and to the North-West Frontier Province in April, and as far South-Eastwards as Bihar, where a flight reached Pusa at the beginning of July. In 1928-29 the outbreak continued in the Punjab and United Provinces, although we have received no details. This last remark applies to Bombay also. It is noteworthy that Iraq suffered from a large locust outbreak in 1926 and 1927 and that the Eastern boundaries of Persia were heavily invaded in 1927 by swarms said to have come from Sind and Baluchistan.

Control Methods.

37. The methods of Locust control seem to have varied little during the last two thousand years. Pliny relates that in many places in Greece a law obliged the inhabitants to wage war against locust three times in the year; that is to say, in their three states of egg, larvæ and adult. In the Isle of Lemnos the citizens had to pay as taxes so many measures of locusts. Such a recurrent toll doubtless helped to keep the numbers of locusts within bounds.

Locusts may be attacked, so far as control methods are concerned, at all stages but the eggs and young Hoppers are more vulnerable.

The eggs are often deposited in very large numbers in suitable places and can be collected and destroyed. Systematic egg-collection will often yield extraordinarily good results. Ploughing is not always practicable and, where it can be done, is not so efficient as egg-collecting.

The Hoppers, especially the young Hoppers, may be killed by beating with branches, etc., or by driving them into trenches or pits (connected with trenches or screens).

Such methods of destruction of Hoppers as by spraying them with a contact poison, using a poison-gas, or the use of stomach-poisons are also effectual under proper supervision but are impracticable for every-day use under Indian conditions.

Winged adults can often be kept from settling on crops by the effect of noise. Large numbers of adults can often be killed also when the females are busy egg-laying.

38. In connection with control methods, it may be useful to consider those methods which have been found most effective in other countries subject to Locust outbreaks.

Locust Control in Palestine.

39. During the recent (1929) outbreak of Locusts in Palestine control was attempted by various methods. Eggs were destroyed by collecting, hoeing and ploughing in of egg-masses. The eggs being laid most in inaccessible positions on stony hillsides, etc., ploughing was often impossible and hoeing only partially practicable. Hoppers were trapped by using walls of zinc sheeting some 12 inches high, as much as 35 miles of sheeting forming a continuous line on occasions; pits some 50 yards apart and with their edges covered with zinc sheeting to prevent escape were dug at intervals along each barrier; the hoppers were trampled into pulp and the pits emptied with shovels. Flame Projectors were found of value at night and in the early morning when the Hoppers and Flyers were rendered incapable by cold and concentrated in large numbers in rocks and bushes. Poisoning was also used, both by contact poisons against the young Hoppers, and by the use of poisoned baits.

Locust Control in South Africa.

40. In South Africa a permanent anti-locust organization came into existence in 1906, and is at present organized on a scale far exceeding similar organizations of other countries. The general principles of locust control are based entirely on the Law forcing all occupiers of land to exterminate eggs or hoppers before they reach the adult stage, the choice of methods being free, though arsenical poisoning is recommended and the Government supplies sprayers and poison free of charge. Specially appointed officers instruct farmers in the use of poison and also compel them, when necessary, to take measures against locusts (Uvarov, Locusts and Grasshoppers, p. 280).

41. Copies of the Local Legislation then in force in Natal are given in the *First Report of the S. African Central Locust Bureau*, pp. 83—92. In the Orange River Colony, not only are spraying materials lent to farmers for destruction of Hoppers, but rewards were offered at the rate of one shilling per bag for adult flying locusts and two shillings per bag for hoppers (*l. c.* p. 93).

42. More recent information about Locust Destruction in South Africa is given in Bulletin No. 75 (1915) from which the following extracts are taken :—

" The locust law of the Union (Chapter II of the Agricultural Pests Act of 1911) imposes certain obligations upon the occupiers of land.

Eggs and voetgangers.—The first of these is that whenever locusts deposit their eggs or voetgangers appear upon any land the occupier must notify the nearest Government official to this effect, either in writing or otherwise. This is necessary in order to secure the satisfactory destruction of the pest in its voetganger stage, and so that, through its administration, the Government can collect all such reports at one centre. But where the public refuses or neglects its duty in this respect the Government cannot be but ill-informed and to some extent unprepared to assist in combating the pest. Apart altogether, therefore, from the legal obligation, farmers having the interest of the country at heart should not only give early notice of egg-deposits, and the hatching out of young voetgangers, but should always endeavour to secure and communicate definite information, thus co-operating in what is a national undertaking.

It is perfectly true that locust eggs are often deposited and voetgangers sometimes occur upon farms without the occupier being aware of the fact. Upon the other hand if the whole farming community would awaken to the importance of the information it is possible for its members to obtain and furnish to the Government, such cases would be considerably reduced in number and the Government placed in a much better position to organise its campaigns.

At present there is no doubt that many farmers do not trouble to ascertain whether a swarm of locusts passing over their land has deposited eggs thereon or not.

Voetganger Destruction.—The second obligation is that the occupier of land upon which voetgangers appear shall cause them to be immediately destroyed. It matters not how the pest is destroyed so long as action is taken without loss of time. Many and various measures and expedients can be taken for the destruction of voetgangers, but the Department advises the use of a sweetened solution of arsenic.

Driving Locusts.—The locust law further provides that no person shall drive, or knowingly permit or cause any one else to drive, voetgangers from his land on to that of his neighbour, unless he can prove that the insect threatened to destroy growing crops upon his land. He may then drive them off, but in doing so he must take all possible steps to destroy them, and upon no account must he drive them towards the growing crops of his neighbour.

The penalty which may be imposed for the contravention of these obligations will be found in Chapter IV of the Agricultural Pests Act of 1911, Section 27 (3).

Government Assistance.

"The locust law provides that the material advised for the destruction of locusts shall be issued free of charge. In this connection the Government will not supply any other material than a concentrated sweetened solution of arsenic, and it is to be noted that such is provided free of charge, within the meaning of the law, when it has been delivered at the nearest magistrate's office or police post or police station.

The Government will not supply any other material nor contribute to the cost of any purchase that an occupier may make.

It is to be observed that, so far as the law is concerned, the Government has not failed in its obligation if, during the time which elapses between the laying of the eggs and the hatching of the voetgangers, the individual does not consult and obtain advice, or in other words does not report the deposit of eggs upon his lands.

Speaking generally, the Government through its officials spares no endeavour to secure information regarding the deposit of eggs and the hatching of voetgangers, and to place supplies of locust poison at as many centres as circumstances warrant.

In addition a large stock of pumps, suitable for applying the locust poison, is kept on hand, and these are issued upon loan to farmers.

Farmers and others who have voetgangers upon their lands or expect the pest to appear from eggs laid upon their lands should make application to the nearest magistrate's office or police patrol station for poison and for the loan of a pump; if such are not already on hand they will be supplied with the least possible delay.

Only one pump will be supplied for the use of one occupier; for this and any poison issued separate receipts are to be given to the issuing officer on forms supplied for the purpose. The loan of a pump is made conditional upon its return to the depôt from which it has been obtained, and it should be returned as soon as the locusts have been destroyed. Naturally borrowers of spray pumps failing to return them within a reasonable time will have to pay for them, but the pumps are not issued with the idea of selling them, and any application for the purchase of a pump outright will be declined."

Other methods of Locust Destruction.

"There are many ways of destroying locusts other than by killing them with locust poison, either as a spray or bait. Circumstances will usually dictate whether they are more economic or not. No exception to any of them being applied is urged by the Government as long as the result is satisfactory. In no way, however, will the Government contribute to the cost involved, nor to the purchase of the necessary materials.

The voetgangers may be treated with solutions (or baits) made with poison dips, or they may be destroyed by spraying with materials that kill by contact, such as sheep dips, soap solution, paraffin oil, turpentine, scalecide, and the like. They may be burned, trampled with stock, or beaten with flails or bushes. They may be driven into trenches and buried, or they may be trapped and preserved as food for poultry.

Soap solution.—This can be frequently used with success; the younger the insects are the better the results. About a pound of any good bar-soap is used to a paraffin tin of water. Weaker solutions are not recommended, as they may only stupefy the insects. This and other contact insecticides must be sprayed directly on to the voetgangers. To be effective, a heavy application is required, as death is caused by the clogging of the insect's

breathing pores. Early morning spraying is better than that done in the evening; but notwithstanding apparently thorough treatment, a swarm of young locusts may have to be sprayed two, three, or even more times to secure its complete destruction. Except when a swarm is clustered, as at night, spraying with contacts is very costly in materials, and, even under favourable circumstances, ten gallons of soap solution will rarely do as good work as a single gallon of the diluted locust poison.

Paraffin Oil.—Paraffin oil sprayed directly on to voetgangers kills them. Here, as with soap solution, the younger the insects the better the results. Where it can be done with safety to the veld, the destruction of a swarm sprayed with paraffin can often be assured by scattering some dry grass or hay amongst the voetgangers and at once setting fire to it. Turpentine acts like paraffin.

Dips.—Fluid sheep dips make efficient contact sprays, if applied in sufficiently strong solutions. This remark applies to the non-poisonous and carbolic dips; tobacco extracts are not recommended.

Burning.—It is often possible to destroy swarms very effectively by burning, and there is no cheaper method where a supply of dry grass is available. Farmers in threatened areas should make a point of always keeping over some dry grass for this purpose. The insects may be either driven into standing grass, or cut grass (even hay) can be placed around a clustered swarm and then fired. It is always advisable to give the fire a good start, so that the locusts cannot trample it out in their efforts to escape.

Trampling.—A good old-fashioned method, which can often be used to advantage, is that of trampling to death by means of sheep, driving the animals to and fro over the insects. Even swarms of fliers, when settled down at night, may be destroyed to a large extent by this measure.

Beating.—The massed insects may often be beaten to death by means of bushes and flails. No better flail can be made for this purpose than by binding together a sufficient number of 3 to 4 feet lengths of fencing wire into a bunch.

Screens and Trenches.—The use of screens for diverting swarms from cultivated lands or into pits or trenches, where they may be destroyed, has long been practised in all countries where locusts are a pest. The voetgangers can be excluded from valuable lands by means of a vertical barrier. A cheap grade of zinc, tin, or sheet-iron, about 18 inches in width, secured in an upright position, would serve every purpose. If the lands are already enclosed by fence of some kind there is little difficulty in placing such a barrier in position.

A simple method of catching small swarms involves driving them on to sheets of cloth, such as wagon-sails, at night. A sail is spread out with bright light placed upon it close to the sleeping swarm. Then the insects are suddenly disturbed; in their confusion they jump towards the light and may be easily gathered into bags.

Trapping.—Numerous traps have been designed for catching locusts. The value of the insects in a dried form as food for stock and poultry is well recognised, and it is often well worth while to capture, kill and bag locusts."

Locust control in the Sudan.

41. The following information is extracted from Sudan Entomological Bulletin No. 12 (1921):—

In the case of adult locusts, the only way of protecting crops is that of driving the locusts away.

It sometimes happens, especially when the site selected by the locusts for oviposition is the margin of a river or Khor [*nala*], or land artificially irrigated, that large numbers of eggs are deposited over a very limited area. Under these circumstances the eggs may be dug up, collected and destroyed. More frequently, however, the egg pockets are so widely scattered that their collection is not practicable even when the locality where they have been laid is known.

The usual methods of killing hoppers are those of beating them with branches of trees, driving them into trenches where they may be buried, and burning them in the grass or bushes in which they have congregated. Hoppers while young have the habit of collecting together in dense masses in short grass, and may then easily and economically be killed by beating them with branches of trees, but later, when they have started marching, their destruction by any of the above methods entails a very large amount of labour. At the season of the year when hoppers occur the grass and bushes are green and can rarely be burnt without the aid of paraffin, and labour is scarce as the natives are busy on their cultivation. Moreover, it is extremely difficult to effect the complete destruction of a swarm of active hoppers either by trenching or burning.

Spraying of herbage with a solution of treacle and sodium arsenite has therefore been used with some success. Up to the time of publication of this Bulletin, however, no spraying machine suitable for local conditions [necessitating transport on camel back] was available.

" *Summary of Control Measures and General Scheme for Locust Control in the Sudan.*—As has already been stated, the destruction of adult locusts on a large scale is not practicable; the destruction of the eggs is sometimes possible, while the destruction of the hoppers is always possible.

" From the beginning of the locust season a watch should be kept for flights of locusts. When a flight is seen its course should be followed with a view to finding the area selected for egg laying. This can be done by sending on news of the flight to officials of the districts towards which the locusts are proceeding. If an egg laying area is detected, and the collection of the eggs is possible, such a collection should be carried out, but if the egg pockets are scattered over a wide area the hoppers should be awaited and killed as soon as they emerge. The destruction of newly hatched hoppers can be effected with little trouble by beating them with branches of trees. It cannot be expected that all, or even the majority, of the areas in which eggs have been laid will be detected, so a continual search should be made for hoppers from the date of the commencement of the rains. All swarms of hoppers found should be dealt with as quickly as possible. As a general rule, poison, rather than mechanical methods, should be used against hoppers which are on the march —*i.e.*, hoppers which are more than ten days old.

" Except on large privately-owned estates, where the owners themselves naturally take charge of the work, the organisation and supervision of the measures required for the destruction of locusts is carried out by the staff of the province. Poison, and apparatus for applying it, together with antidote for use in case of accident and detailed instructions printed in Arabic and in English, are at present provided, free of cost, to all responsible persons willing to use it.

" Before the commencement of the locust season the natives throughout the provinces affected are reminded by the Governors of their provinces that it is incumbent upon them to keep a look-out for locusts in any stage, and to report any which are seen. Suitable monetary rewards are given to those bringing in news of locusts. There are however large tracts of land where natives seldom go and over which they can scarcely be expected to search for locusts. These areas are patrolled by " locust ghaffirs "—native camelmen—temporarily employed on the province staff for the purpose.

" It frequently happens that, owing to pressure of other work, there is no responsible province official available to take charge of the destruction of locusts. To meet this difficulty ' Temporary Locust Officers ' are employed. These Temporary Locust Officers are volunteers from among the government officials stationed at the larger centres—Khartoum, Atbara and Port Sudan—who can be spared from their regular duties for short periods. They are provided with camp equipment and receive a special allowance in addition to travelling allowance while on this duty. I would here pay tribute to the value of the work done by those officials who have served as Temporary Locust Officers.

" With regard to the supplies of materials, stocks of locust poison, tanks and other accessories, antidote, and detailed directions printed in English and Arabic are stored at all the *markaz* throughout the provinces liable to infestation by locusts. Reserve stocks are kept in Khartoum by the Entomological Section.

" All information received by province officials as to the occurrence and movements of locusts is transmitted to the Government Entomologist. This permits of records being kept which are of use during the current season, and which should also in time furnish valuable data as to the habits of the pest.

" All expenses in connection with the control of locusts such as purchase and transport of materials, rewards and labour, transport and allowances of Temporary Locust Officers, wages of locust ghaffirs, etc., with the exception of transport and allowances of permanent officials and employees on the province staffs, are charged against a central fund administered by the Government Entomologist."

42. A still later " Note on the use of dried Poison Bait against Locusts in the Sudan " has been published recently by H. H. King in the *Bulletin of Entomological Research* (XX, pp. 99—101, May 1929) and the following abstract is taken from the *Review of Applied Entomology* (A) XVII, pp. 507—08 (Sept. 1929) :—

" The various mechanical means of destroying hoppers are unsuitable for effecting the control of locusts over some thousands of square miles, and since unskilled natives were found incapable of using a spraying machine effectively or of mixing poison bran bait properly, experiments were made to find a bait that could be issued ready for use. One that had been sun-dried and only required moistening with water was tested during the winter of 1927-28 and during the rainy season of 1928, and reports on the results obtained were universally favourable. The stock solution is prepared by dissolving 168 lb. commercial sodium arsenite (80 per cent. As_2O_3) in water and making the solution up to 22 gals. ; to this is added 92 gals. molasses. This stock solution is diluted in the proportion of 1 part by volume to 17 parts water, so that 9 gals. dilute solution contain 1 lb. sodium arsenite. In preparing the bait, the bran is heaped on a cement floor and dilute poison added at the rate of 12 gals. to 100 lb. The bran is thoroughly stirred until it is uniformly moist ; it is then spread out to dry in the sun and subsequently passed through a coarse sieve to remove any lumps. The dried bait is put up in bags each containing approximately 9¼ lb. and the bags packed eight in a sack. One gallon of water is required to moisten the contents of one bag. The bait should be stirred in until evenly moist, left for ten minutes to absorb the water and become soft, and then broadcast thinly in the path of hoppers.

" After ingesting the minimum lethal dose of arsenic a well-grown hopper may live up to three days. Dead and dying hoppers are devoured by their companions and, if their bodies contain sufficient arsenic, these hoppers also perish. The proportion of poison to bran is high, but owing to the difficulty of transport, it is advisable to try and destroy the maximum number of hoppers with the minimum amount of bait. It is believed that the risk of accidental poisoning of men and domestic animals is not materially greater than if the proportion were lower. The molasses makes the bait more attractive and delays its drying up. Though the locusts appeared to prefer freshly prepared bait to bait that had been stored for two months and then moistened, the hoppers fed greedily on the latter, and adults flying not more than six feet from the ground detected its presence and settled to feed on it. Bait that has been in store for 10 months is still in good condition."

Locust Control in Baluchistan.

43. The following information regarding Locust control work in Baluchistan was received from the Agent to the Governor-General in 1928 :—

Copy of a note, dated the 6th May 1928, by C. L. Corfield, Esquire, Political Agent, Chagai.

A perusal of the latest literature regarding the destruction of locusts shows that the methods still in use in Baluchistan, though effective within certain prescribed limits of available labour and funds, are somewhat out of date. Research in South Africa and Egypt has brought to light information and selected methods of destruction, which have stood the test of practical appliance with remarkable success.

2. Of these methods maximum success has attended :

(*a*) Poison spraying,

(*b*) Poison bait,

(*c*) Poison dusting.

3. The spraying method has the following disadvantages for Baluchistan :—

(*a*) It requires the presence of herbage to spray,

(*b*) It entails carriage of water to mix with the poison, and

(*c*) It is necessary to maintain a supply of spraying instruments, which quickly deteriorate in a dry climate.

An experiment has however been carried out near Nushki. A circle of cut bushes was prepared and the bushes sprayed with the poison solution. Into this circle a swarm of hoppers (about three weeks old) were herded. This swarm made straight for the greenery and soon began to eat. A party was left on the spot to watch the swarm and see that none moved on into the neighbouring wheat fields. After 36 hours half the swarm were dead, and by the third day practically the whole swarm was exterminated.

4. The poison bait method is however easier. Bran is stated to be the most satisfactory medium, but chopped green forage and stable manure can also be used. These *media* are doped with the poison and scattered round and among a resting swarm very early in the morning, before the swarm has begun to move. The poison bait is then the first food at which the swarm arrives.

The advantages of this method are that (*a*) the bait can be prepared at headquarters during the evening, thus avoiding transport of poison and water ; (*b*) the bait can be distributed by means of ordinary animal transport ; and (*c*) no mechanical contrivances are required.

An extended experiment in this method is now in progress at Nushki. The poison dusting method is the very latest. The dusting is carried out by bellows fitted with a container. The advantages are that—

(*a*) a wider and more effective distribution of the poison is possible, and

(*b*) the poison thus distributed has a greater killing power.

The disadvantages for Baluchistan are :—

(*a*) the necessity for mechanical contrivances, and

(*b*) the extra danger of poisoning of men and animals owing to the use of the poison in a more concentrated form.

An attempt is being made to have the necessary bellows made locally, and an experiment in this method will be carried out later.

It is this dusting method which has been successfully used in America, Germany, Russia and England (principally from aeroplanes) to deal with many forms of insect pest.

5. These methods are mainly useful in dealing with the locust in the hopper stage. They can however be used against the flying swarm with some success in the early mornings before they have taken wing. As however it is the hopper that does the maximum damage, these methods if put into extensive practice would probably effect a large saving in agricultural wealth.

Copy of a memo. No. 915, dated the 21st May 1928, from the Political Agent, Chagai, Quetta, to the Revenue Commissioner in Baluchistan, Quetta.

SUBJECT.—*Locusts in the Chagai Agency.*

Please refer to my memorandum No. 818, dated the 6th May 1928, on the above subject.

2. The extended experiments in the use of poison bait have proved almost conclusively that this method is the most suitable for conditions existing in this Agency. A copy of the instructions issued in connection with these experiments (with Urdu translation) is enclosed. The swarms, which crossed the bait, died within three to twelve hours

of feeding on it. They died within 12 hours when the poison was mixed with water in the ratio 1 : 39. The disadvantage of using any stronger solution than this lies in the extra danger to grazing animals, if the bait is not well scattered.

3. Now that success on a small scale is assured, I have put a stop to other methods of destruction and am limiting expenditure to wholesale destruction by this method. Swarms of hoppers have recently appeared in considerable numbers in Shorarud, Kishingi and Chagai. There is therefore every chance that a real test can be carried out in each Tahsil.

4. Experiments with poison dusting will be made shortly but the difficulties experienced in getting the special bellows made locally, when added to the disadvantages pointed out in my previous note, indicate that this method will not be the most suitable for Baluchistan. It may however prove cheaper to distribute poison in powder than in liquid form, if equally effective when mixed with bait.

Copy of instructions issued in connection with the destruction of locusts, by the Political Agent, Chagai.

4. *Poison Bait.*

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The bait should be made up in the following manner: pour one large cupful (¾ litre) of the concentrated locust poison into a petrol tin of four-gallon capacity. Fill with water mixing well. Take another tin and pour some of the mixture into it. Then add bran, constantly mixing thoroughly, until a mash is obtained which is moist and crumbly and which does not stick together in masses. The bait should be of such consistency that when thrown the grains of bran do not adhere to each other. This ensures the optimum distribution. In mixing the bait the hands may safely be employed in kneading the bran, provided that they have been lightly smeared with fat previously, and are well washed after the operation.

The preparation of the bait should not take place long before its use. If it is to be kept a few hours store in damp sacks.

In throwing the bait the following points may be found useful:—

The bait should be thrown against the wind, never down wind, as thereby a better distribution of the particles is ensured.

As the hoppers feed most readily in the early morning the throwing of the bait should commence not later than sunrise. It may be continued for about three hours after sunrise, but as noon approaches, the locusts are usually less ready to feed, and moreover the bait dries and becomes useless as an attractant.

The poison is not immediate in its effects and very often dead hoppers will not be found till from two to three days after the bait has been thrown out.

At the time of moulting, both immediately before and after, hoppers eat little or nothing, the few which happen to be in this stage will probably be missed by the poison, but not improbably may be killed by feeding on the bodies of poisoned individuals. Should many be found alive after the first application, a second light distribution of the bait should be made on the third day after the first. It may be noted here that the use of the bait on edible plants, vegetables and fruits is without danger to the consumers.

Care should be taken to keep quantities of the bait away from the animals, as if consumed in bulk it becomes immediately dangerous.

In calculating the quantity of bran bait required an allowance of ten pounds to the acre may be considered sufficient.

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Copy of a memo. No. 1078, dated the 16th June 1928, from the Political Agent, Chagai, to the Revenue Commissioner in Baluchistan, Quetta.

SUBJECT.—*Locusts in the Chagai Agency.*

Please refer to my memo. No. 915, dated the 21st May 1928, on the above subject.

2. The results of a wholesale use of poison bait may be summarised as follows :—

Dalbandin.—Operations could not begin until considerable damage had already been done to the Political Garden at Dalbandin. The first application of the bait entirely freed this garden, and the Tahsildar reports that damage would have been negligible had the bait been available at the very outset. The Railway Officials were thankful to share the bait to protect their gardens and their occupants are enthusiastic over the results. Some difficulty was experienced in persuading the zemindars to agree to the distribution of bait near their field, but the results leave no room for further objections, unless poisoning of livestock occurs.

Nushkhi.—Most of the swarms had taken to flight before operations began, but the experiments made in the vicinity have convinced the zemindars of the value of this method.

Shorarud.—The measures taken met with some resistance at first, but the effects produced have entirely changed the people's attitude. A zemindar actually requested that some bait should be sent out to him, as his melon fields were in danger and he had every hope of saving them by this means. The malliks were almost enthusiastic, although at one place three sheep and a donkey had poisoned themselves by eating the bait. I enquired into this case on the spot and found that it was due to using the poison in too strong a solution and mixing the bait too wet, so that it was distributed in lumps instead of separate grains. Where this extra strong bait was used, however, the results were amazing. In all cases the unsweetened poison gave far more satisfactory results than the sweetened.

3. Experiments with poison dusting failed, as the locally made bellows broke at the first application. The poison dust is moreover difficult to handle in a wind without danger, and the slightest inhalation of it causes considerable irritation of the nose and mouth with subsequent internal trouble. The use of this method cannot be recommended except under expert guidance with a trained staff and proper instruments and protective appliances.

4. The conclusion is that poison bait is the most suitable method for Baluchistan. The strength of the poison solution to be used is however a point which still requires further experiment. If livestock can be kept away from the treated area, a strength of 1 : 19 or more can, I think, safely be used ; if not, mixture of 1 : 24 in accordance with the instructions is the strongest that should be used. In any case the bait must never be so wet as to coagulate. The strong bait is probably more suitable in the standing crops, when it is important to arrest the swarm at once ; the weaker bait can be distributed elsewhere.

5. On the whole I am of opinion that, until more is known of the subsequent results in grazing areas, the use of the bait should be limited to the protection of crops and gardens, where the maximum damage is threatened and the safeguarding of livestock is easiest. Later, when the instructions are fully understood and are sure to be followed, operations can be extended to grazing areas if necessary.

6. In view of the above results it seems clear that the expensive method of beating, burning and trenching are a waste of Government money, except in very exceptional circumstances.

44. In considering the foregoing methods of control, it must be realized that no one method, or combination of methods, will suit all local conditions. Where labour is abundant and soil conditions suitable, such methods as egg-collection and trenching for Hopper-destruction will yield good results ; in other places erection of barriers for Hopper-control may be feasible ; and in some localities poisoning may be permissible. But no standard control method can be laid down to suit all the various conditions found in India,

45. In any case, the people should be encouraged in every way to destroy Locust swarms at every stage and on every opportunity. Such encouragement should take the form of ample rewards for reporting and destroying swarms, including payment for egg-collection and destruction of Hoppers and Flyers at rates which will necessarily vary locally but which in all cases should suffice to secure the desired results. Although it is the duty of the cultivator to take measures to protect his crops from insect or other pests, locusts come in rather a special category owing to their migrant habits, and the community, as well as the individual, is therefore affected. The early destruction of invading swarms is essential to prevent their multiplication and migration and subsequent multiplication in another place. An expenditure of a few thousands of Rupees at an early stage of attack will save a loss of lakhs later on.

46. To provide for the necessary expenses promptly it seems necessary that there should be some definite Fund from which money can be drawn at once when it is required for this purpose. A Locust Fund, on the lines of the present Famine Fund, might be feasible. Any delay in obtaining sanction for expenditure at a time when immediate action is necessary is likely to vitiate the success of the operations.

47. In areas where such control methods as Poisoning or the use of screens for Hopper-control, are considered feasible, a reasonable amount of the apparatus required should be kept in stock ready for use. It is of little use to wait for an outbreak and then to start collecting such material which, even if available in the larger towns such as Calcutta or Bombay, usually takes days or even weeks to procure in the areas where it is wanted for use.

Effect of weather on Locust Outbreaks.

48. For the earlier outbreaks, we have no information regarding the amount of rainfall in years preceding locust attack, but in the case of the United Provinces the rainfall was above normal in 1925 and 1926, in the Punjab and North-West Frontier Province it was roughly normal in 1925 and above normal in 1926, in Baluchistan it was below normal in 1925 and a little above normal in 1926, in Gujarat, Sind, Kathiawar and Cutch it was below normal in 1925, and above normal in 1926.

49. In 1903, the rainfall in the United Provinces was roughly normal, in the Punjab and North-West Frontier Province slightly below normal, in Baluchistan normal, and in Northern Bombay, Gujarat and Sind below normal and normal in Kathiawar and Cutch.

50. In 1912 the rainfall in the United Provinces was rather below normal, in the Punjab rather below normal, in the North-West Frontier Province slightly above normal, in Baluchistan normal, in Gujarat normal, in Sind below normal and in Kathiawar and Cutch nearly fifty per cent. above normal.

51. From the annual Summaries of Indian Rainfall given in the *India Weather Review* we find the following data of percentage departure from normal :—

——	1924.	1925.	1926.
Baluchistan	+8	—38	+14
Sind	+2	—57	+44
Rajputana, West	+3	—38	+54
Rajputana, East	+40	—25	+24
Gujarat	—10	—32	+41

When, however, we go further into the actual rainfall of particular places within these areas, we find many local variations. For example, in Rajputana in 1925, although the rainfall was below normal on the whole, we find variations in Jodhpur from 1·83 inches at Gudha (normal 11·08) to 16·66 at Nawa (normal 15·62), in Bikaner from 1·33 at Anupgarh (normal 7·41) to 18·16 at Churu (normal 14·16), in Jaipur from 8·76 at Chatsu (normal 22·60) to 28·18 at Uniara (normal 24·46), and so on.

52. Again in 1910 the rainfall was generally above normal but in 1911 generally deficient in Rajputana, in 1912 generally above normal, but local variations were very large in all years. The figures may indicate an increase of solitary grasshoppers in 1910 due to extra food, their congregation into more limited areas in 1911 (due to decreased rainfall and food) and consequent transformation into the swarming phase which increased with the more abundant rains in 1912 to form migrant swarms in that year, initiating a new outbreak in Sind. This is mere supposition, but it fits the facts, so far as we know these.

53. It would be interesting to have data for the rainfall of the Arabian and Persian Desert Areas, as such might throw some light on the outbreaks which invade Baluchistan, Iraq, Syria and Egypt; but, unfortunately, such data are not available.

54. From the rather limited data available of conditions in the Rajputana Desert Area, it may be permissible to deduce that—

(1) when a year, in which the rainfall in Rajputana is above normal, is followed by a year in which the rainfall is in marked defect, the succeeding (third) year is likely to see an outbreak of locusts, and

(2) such locust outbreaks occur, on the average, once in a period of roughly seven to ten years.

Table showing the amounts of Rainfall in the years preceding the reported attack of Schistocerca gregaria, Forsk.

Divisions.	Normal rainfall.	1903 more, less or normal.	1912 more, less or normal.	Bigger divisions of the Provinces.	Normal.	1925 more, less or normal.	1926 more, less or normal.	Remarks.
United Provinces.								
1. Meerut . .	40 05	Scanty . . .	A little above normal	U. P., East . .	39·28	+11 per cent. more than normal.	+10 per cent. above normal.	
2. Agra . .	25 8	Slightly above normal	More than normal .	U. P., West . .	37·3	+13 per cent. more than normal.	+4 per cent. little more than normal.	
3. Rohilkhand .	40	Little less than normal.	ess than normal .					
4. Allahabad .	31 3	Ditto . .	Much less than normal.	*1903* —More in 4 Divisions, less in 4 Divisions, normal in 1 Division On the whole it was roughly normal.				
5. Jhansi . .	35	....	A little less than normal.					
6. Benares . .	41 2	Little more than normal.	Much less than normal.	*1912* .—More in 2 Divisions, less in 8 Divisions, on the whole it was below normal.				
7. Gorakhpur .	45·3	Heavy . . .	Little less than normal.	*1925* —More than normal.				
8. Kumaon . .	57·3	Less than normal .	Less than normal .	*1926* —More than normal.				
9. Lucknow .	36·7	Normal . .	Ditto.					
10. Fyzabad[1] . .	39	Heavy . . .	A little less than normal.					

Table showing the amounts of Rainfall in the years preceding the reported attack of Schistocerca gregaria, Forsk.

Districts or Divisions.	Normal rainfall in inches.	1903.		1912.		Big Divisions of the Punjab.	Normal rainfall.	1925.	1926.	Remarks.
		Actual rainfall.	Less, more or normal.	Actual rainfall.	Less, more or normal			Departure from normal.	Departure from normal.	
The Punjab.						*Punjab*				
(*Districts.*)										
Hissar . . .	15	15	Normal	14	About normal	East and North .	23 26	−5 per cent. More.	+15 per cent. More.	
Jhind State . .	20 6	14	Less	12	Less	South West . .	10 03	— 7 per cent. Less.	+16 per cent. More.	
Bikaner State . .	11 8	14	More	11 2	Normal					
Ferozepur . .	14 5	15	Normal	14 5	,,	In 1903 the rainfall was more in seven districts, less in 12 districts, normal in 11 districts On the whole the rainfall was less than average although the difference was not much.				
Montgomery . .	9 5	9	,,	9 5	,,					
Gurgaon . . .	22·0	14·6	Less	23	,,	In 1912, more in 1 district, less in 14 districts and normal in 15 districts. On the whole rainfall was below the average				
Rohtak . . .	19·7	14	,,	19 5	,,	In 1925, roughly normal.				
Karnal . . .	22	22	Normal	23	,,	In 1926, above normal.				
Lahore . . .	16	13	Less	14	Less					
Ambala . . .	34	33	Normal	35	Normal					
Patiala State . .	19	13	Less	19						
Nabha State . .	17	12 5	,,	10	Less					
Ludhiana . .	24 7	22	,,	23	Normal					
Jullunder . . .	25	24	Normal	14	Less					
Hoshiarpur . .	31	37	More	25	,,					
Gurdaspur . .	41	51	,,	42	Normal					
Amritsar . . .	21	26	,,	23	More					
Simla . . .	45	38	Less	39	Less					

Table showing the amounts of Rainfall in the years preceding the reported attack of Schistocerca gregaria, Forsk.—contd.

Districts or Divisions.	Normal rainfall in inches.	1903.		1912.		Big Divisions of the Punjab	Normal rainfall.	1925.	1926.	Remarks.
		Actual rainfall.	Less, more or normal.	Actual rainfall.	Less, more or normal.			Departure from normal.	Departure from normal.	
THE PUNJAB—*contd.*										
(*Districts*)—contd.										
Kangra . . .	..	61	A little less	62	Less					
Gujranwala . .	20	16	Less	15·7	,,					
Sialkot . . .	28	34	More	23	,,					
Gujarat . . .	24	26	,,	18	,,					
Jhelum . . .	20	17	Less	16	,,					
Rawalpindi . .	31	24	,,	29	,,					
Mianwali . .	10	11	Normal	9	Normal					
Shahpur . . .	14·6	14·5	Normal	13	Normal					
Jhang . . .	10	9·5	,,	7·5	Less					
Dera Ghazi Khan .	5·4	8	More	4	,,					
Muzaffargarh . .	6·4	6	Normal	6	Normal					
Multan . . .	5·8	6	,,	5	,,					
North-West Frontier Province.	15·5	14·7	Slightly less	17·7	More than normal.	1925		1926.		Remarks.
						Actual, more, less or normal.		Actual, more, less or normal.		
						15·22—2%		20·06—29% more than usual.		
						1903—Slightly less; 1912—More; 1925—Slightly less or normal; 1926—More than normal.				

Divisions.	Normal.	1903.		1912.		1925.		1926.		Remarks.
		Actual.	More, less or normal.	Actual.	More, less or normal.	Actual.	More, less or normal.	Actual.	More, less or normal.	
Baluchistan.										
Baluchistan . . .	8·12	8 3	Normal	8 3	Normal	5·03	—38 per cent	9·24	+14 per cent.	1903—Normal. 1912— „ 1925—Less. 1926—More.
Bombay Presidency.										
Sub-Division—										
Gujarat	32 3	26 6	Less	32	Normal	18·13	Less	43·67	More	1903—Less. 1912— „ 1925— „
Sind	6·7	3 8	„	4·5	Less	2 88	Less —51 per cent.	9·65	More 44 per cent.	Only in 1926, it was more.
Kathiawar . . .	23·67	24 2	Normal	32 5	More	15 24	Less	38 27	More	1903—Normal.
Cutch	15 16	15 3	„	22 1	„	7 61	„	3[illegible]·0	„	1912—More. 1925—Less. 1926—More.

Periodicity of Locust Outbreaks.

55. It would appear that there is a definite tendency to an increase to migration strength which pulsates at intervals throughout the whole area of the occurrence of the Desert Locust from Morocco to East Africa, Persia and India, and that outbreaks in India are correlated in some way with outbreaks outside of India. If this is so, it would appear probable that invasions from outside of India are of more importance than local increase in India in starting an outbreak.

56. Once started in North-Western India (Sind and Baluchistan) an outbreak usually spreads the next year into the Punjab and United Provinces, where it lasts for two or three years and then subsides. Early information regarding the arrival of migration-swarms in North-West India is therefore essential to enable other parts of India to prepare to meet invasion during the next season.

57. At present, there is no system of intelligence in vogue to report locust outbreaks either to officers of a Local Government or to any central agency. This point has been emphasized in the note by Messrs. Mann and Burns regarding the outbreak in Northern Bombay in 1926. The same thing happened the next year in the United Provinces where the Western Districts were invaded by Locusts in March 1927; the Government Entomologist in the United Provinces knew nothing of the occurrence of locusts in his Province until the middle of May, when I received a letter about locusts which I sent on to him for disposal, as it concerned his area.

58. In the case of the North-West Frontier Province the Agricultural Officer wired to Pusa in April 1927, for assistance in dealing with a flight of locusts and an Assistant was sent there at once. In his letter No. 2307 of 27th June 1927, the Agricultural Officer stated that it was proposed to request each district officer in the Province to prepare a report on his work, experience and observations in dealing with the visitation of locusts, and asked for a suitable questionnaire on this subject. A list of questions was sent to him accordingly on 4th July 1927, but nothing further has been heard on this subject.

59. In the case of Bombay, the only direct information received was a D. O. letter, dated 7th February 1927, from the Director of Agriculture who stated that locusts were doing great damage and asked for particulars of the Mattei system of destroying locusts in Cyprus. This information was sent to him on 14th February 1927. No requests for assistance in dealing with Locusts and no further information about the occurrence of locusts in Bombay have since been received.

60. As regards the United Provinces, as already noted, the Government Entomologist, United Provinces, was informed by Pusa of the Locust invasion of his Province. No requests for help from Pusa in dealing with this outbreak have come from the United Provinces, nor have we received any direct information regarding this outbreak or its control except for some specimens of *S. gregaria* sent from Dehra Dun on 7th June 1927 to Pusa for identification and for a casual remark in a D. O. letter dated 7th October 1929 from the Government Entomologist, that he "had a very bad time with locusts and some scores of lakhs worth of damage was caused in seventeen districts. He received information regarding the arrival of swarms very late and organisation and apparatus for control were practically non-existent".

It will be noted from this that local intelligence regarding locust swarms was also defective in the United Provinces.

61. As regards the Punjab we have also received no requests for assistance and very little information of the outbreak in 1927-28-29. From the Monthly Reports of the Government Entomologist we learn that in 1927 reports of locust swarms visiting Gurgaon and Ludhiana districts were received; in 1928 reports of locust hoppers were received from Talagang (Attock) and Khairan (Gujarat) in May, reports of damage to young cotton by locusts in five districts were received in June and from six districts in July, whilst in August a few reports of damage to cotton by locusts were received from Sheikhupura, Rohtak and Montgomery districts; in 1929 (report for July not traced), the appearance of locusts was reported in August from some 230 localities in 14 districts of the Punjab. No information is available regarding control measures.

62. It will be seen therefore that there is need for improvement in the reporting of the arrival of locust swarms—

(1) within the Province concerned so that the local Entomological staff (where such exists) may take early steps for control,

(2) to a central agency which will collect full information of all locust outbreaks and, where necessary, inform other Provinces liable to invasion so that these Provinces may be ready to deal with such invasions promptly.

63. Were Locust outbreaks of annual or regular recurrence, the ordinary Government routine of acquiring information, through the District Officers, would produce the desired results. But, as there is an interval of several years between locust outbreaks, on the commencement of a new outbreak, it happens that the local officers have been changed, the experience acquired during previous outbreaks forgotten, and standing Government Orders regarding reporting of locusts overlooked and not complied with.

64. In the Punjab, for example, Revenue Circular No. 7 of 1905 directed that "On the appearance of locusts in a district, immediate measures should be taken for ensuring (1) that the laying and hatching of eggs shall be reported without delay; (2) that measures shall be taken promptly for the destruction of eggs and of the young grubs when hatched", and gave definite instructions for carrying out this object. From the information available regarding the present outbreak in the Punjab, it would appear doubtful whether these instructions are still carried out.

65. In Circular No. 6-32-2, dated 14th March 1905, the Government of India requested all Local Governments and Administrations to direct the Director of Agriculture or other officer charged with the preparation of the weekly Weather and Crop Reports, to forward copies of all reports which contain references to damage to crops by insect pests direct to the Imperial Entomologist. Under these instructions a few reports of locust occurrence were received from the Governments of Madras and Bombay from 1905 onwards but no regular reports have been received of later outbreaks. During the present outbreak no reports have been received from any Province except the North-West Frontier Province which reported a locust swarm at Peshawar in April 1927, and requested assistance which was sent from Pusa. Even in this case, the information available is scanty. The Agricultural Officer, North-West Frontier Province, stated (Letter 2307 of 27th June 1927) that it was proposed to request each district officer in that Province to prepare a report on his work, experience and observations in dealing with the visitations of locusts, and that the duty would perhaps be made easier and the value of the notes enhanced if questions were issued on which information is specially desirable. In reply to this letter the following questionnaire was drawn up and sent to the Agricultural Officer on 4th July 1927:—

(1) On what date were locusts first seen?

(2) From which direction did they come?

(3) Give an approximate idea of the size of the swarm.

(4) How long did the swarm remain in your district?

(5) Damage done?

(6) On what date did the swarm leave?

(7) In which direction did it leave?

(8) Were the locusts noticed to lay eggs in the ground? If so, was any particular kind of site selected for egg-laying?

(9) If eggs were laid, please give dates, as far as possible, when eggs were laid and when the young hoppers (hatched from these eggs) were noticed.

(10) Please give full details of any measures adopted to lessen damage done by these locusts (including measures against their eggs and young hoppers) and of their effectiveness.

NOTE:—*Questions 1—9.*—If more than one swarm visited your district, please reply to these questions *separately for each swarm.*

If, however, any answers were received from the district officers in the North-West Frontier Province, they have not yet been communicated to the Imperial Entomologist, Pusa.

66. It is probable that there is a good deal of information available in various Provinces regarding the present and previous Locust Outbreaks; but, so long as it is scattered and unpublished, it is of relatively little value as it is not available. It is known for example that a large amount of information on the movements of locust flights in the Punjab during March-April 1907 was got together at that time in the office of the Director of Agriculture, Punjab; such information, if still available, might throw light on future outbreaks.

67. Under present conditions, each new outbreak necessitates an unnecessarily large proportion of local experience to be acquired *de novo*.

I consider it necessary, therefore, that all records of locust occurrence should be centralized so that all the information available may be accessible in one place. This does not mean necessarily that the Provincial staffs should be deprived of their own records but that copies of all records should be collected together so that all will be available in one place. It is often the case that an item, which seems unimportant, or even useless, when isolated, will fall into its place and prove significant when correlated with similar observations in other Provinces. Notes on control-methods found useful in one Province may also provide useful hints in others. There can be little continuity of investigation or of applied results under the present lack of any co-ordination of knowledge of what has been done and is being done in different parts of India.

68. The foregoing remarks apply to India only but it must not be overlooked that India is not the only country to suffer from outbreaks of the Desert Locust whose distribution extends throughout North and East Africa, Syria, Arabia, Iraq, Persia and Afghanistan. The present outbreak in India synchronizes with outbreaks in the Sudan, Kenya, Tanganyika, Syria and Iraq, and in this connection a Locust Sub-Committee of the British Committee of Civil Research has been formed to consider and report on—

(*a*) means for the mass destruction of the Desert Locust (*Schistocerca gregaria*), and

(*b*) methods for ascertaining the reasons for the periodic swarming of this species with a view to its control.

This Sub-Committee has issued its First and Second Interim Reports (Cmd. 3367 of 1929). From the First Interim Report, dated 31st May 1929, is extracted the following summary of Conclusions and Recommendations:—

"(*a*) Relatively less scientific information is available regarding locusts (including the Desert Locust) than is the case with many noxious insects of less economic importance. This is probably due to the danger from locusts not being sufficiently appreciated in periods of locust scarcity, though they offer better opportunities for research than periods of locust invasion.

(*b*) There is an urgent need for a scheme of anti-locust research carefully carried out over a period of years with a view to obtaining information regarding (*i*) the natural history of the Desert Locust (in particular, in regard to its permanent breeding places); (*ii*) improved methods for the mass destruction of this locust in the light of the information referred to in (*i*) above.

(*c*) A Research scheme such as that indicated in (*b*) above should be such as would command the confidence of the various Territories threatened by the Desert Locust. It is desirable, therefore, that such a scheme should be communicated in draft for the observations of the various Territories before any effort is made to obtain the funds required to carry it out.

(*d*) While the substantive Research scheme is being prepared in conjunction with the Territories concerned, it is very desirable that arrangements should be made for starting forthwith the work of collecting information from all available sources regarding the Desert Locust, and for its collation and dissemination to the Territories concerned.

(*e*) The work referred to in (*d*) above could be best and most economically carried out by the Imperial Bureau of Entomology. The net cost should not exceed £500 per annum."

" 12. We therefore recommend—

That the Committee of Civil Research should submit for the favourable consideration of the Empire Marketing Board a proposal for a preliminary grant from the Empire Marketing Fund of £500 to enable the Imperial Bureau of Entomology to undertake forthwith the cost of collecting, collating and disseminating information regarding the Desert Locust and to maintain this service for a period of one year, before the expiration of which the Locust Sub-Committee hope to be in a position to submit a definite scheme of sustained anti-locust research which commands the approval and support of the Territories threatened by this Locust."

The Second Interim Report, dated 31 May 1929, includes the following Draft Scheme of Research recommended :—

" 4. In preparing the following scheme we have had in mind a unified programme of research to be carried out in two or more Territories. The work should, we think, be carried out by four specialist entomologists to be engaged by the Imperial Bureau of Entomology. These entomologists would normally be set to work in pairs in whatever Territory appeared to offer the best experimental conditions for the particular research to be undertaken. The officers would report direct to the Imperial Bureau, which would distribute to all the Territories interested reports of work done as soon as it was sufficiently advanced to render this possible. Suitable arrangements would of course require to be made in each case with the Administration of the Territories selected to ensure that the closest and most effective relations were established between the Research entomologists sent out by the Bureau and the technical and administrative officers of the Territory in which they were temporarily stationed. It is not possible at present to determine where the whole of the Research will require to be carried out, as this must to some extent depend on developments arising from the work as it progresses. As regards the initial stages, we have no doubt that the most suitable Territories in which to start Research would be the Sudan and Kenya.

" 5. For the reasons already explained, we attach great importance to the whole-hearted co-operation of the Territories concerned. Indeed, such co-operation is the first essential to the success of the proposed scheme of Research. Until we have received the views of the Territories concerned, we think it desirable to confine ourselves to giving in broad outline the main forms which we think the research should take. They are as follows :—

(1) *Methods of Control*—

(*a*) The summarising of existing information on poisons for —

(i) baits and spraying ;

(ii) dusting.

(*b*) Laboratory studies and field tests of various baits, dry poisons and gases.

(*c*) Experimental field work with aeroplanes for dusting, for reconnaissance and for the application of other methods of control.

(*d*) The collection and summarising of information on the organisation of the actual control work in different countries.

(2) *Location of Possible Permanent Breeding Areas and Migration Routes*—

(*a*) The collection and summarising of published and manuscript records of the past occurrence, swarming and movements of the Desert Locust in the whole area of its distribution.

(*b*) The organisation of a regular system for the collection of information on the appearance, movements and permanent breeding places of the Desert Locust in all countries at present affected.

(3) *Bionomics of the locust and the periodicity of its outbreaks—*

(*a*) Study of its annual life-cycle in different areas in relation to local conditions.

(*b*) Laboratory studies on the influence of temperature, humidity, crowding, etc., on its development, behaviour and phase variation.

(*c*) Study of the ecology of the locust; climatic factors of control; natural enemies, associated animals and their balance.

(*d*) Study of its phase and race variation as observed in nature; biometric studies of mass materials.

(*e*) Study of meteorological conditions in the affected countries and correlation of the data with the course of outbreaks [as presented by 2 (*a*) and (*b*)].

(*f*) Studies in the anatomy, physiology and embryology of the locust.

" 6. Of the foregoing, the work of summarising existing information on poisons (1 (*a*)), the collection of information on control methods now actually in use (1 (*d*)), the collection of existing records of the past occurrence of the Desert Locust (2 (*a*)) and the organisation of a system for collecting information regarding its occurrence (2 (*b*)) can best be undertaken in this country. If the recommendations contained in our First Report are adopted, the Imperial Bureau of Entomology should shortly be in a position to start this part of our scheme.

" 7. The Bureau would be greatly assisted in their task if arrangements could be made for it to be given an opportunity to study in original the actual reports received from time to time from officers in the Field dealing with the history and development of the latest invasion in each Territory of the Desert Locust, *Schistocerca gregaria*, Forsk. We realise that these Reports are probably very voluminous; but as they are original Reports by field observers, they may well contain indications which, though of great scientific importance for the present inquiry, might very probably be omitted from Summaries or general Reports prepared for administrative purposes. It would also be of great assistance if the Bureau could be furnished with Reports on the methods employed in each territory for combating invasions of this locust, whether by poison baits or otherwise, and any figures bearing on the relative cost of such methods.

" 8. It would also be of great assistance to us if the Governors of the Territories concerned could give an approximate estimate of the material damage caused by the present outbreak and of the value and nature of the crops affected.

" 9. The remainder of the scheme outlined above would require to be carried out in one or other of the locust-inhabited countries. It is particularly in regard to this part of the investigation that we desire the assistance and advice of the Administrations of the various Territories in order to ensure that the scheme in its final form is one that commands their confidence and is designed to secure the information of which they stand in need. We, therefore, recommend that the Committee of Civil Research should communicate this Report to the Secretary of State for the Colonies for transmission to the Governments of the following British Colonies and Dependencies in East Africa, *viz.*, Kenya, Uganda, the Tanganyika Territory, British Somaliland, Nigeria, Sierra Leone and the Gold Coast and also to the Governments of Palestine, Transjordan and Iraq.

" 10. Similarly we recommend that the Committee of Civil Research should communicate this Report to the Secretary of State for Foreign Affairs for communication to the Government of the Sudan and to the Secretary of State for India for communication to the Government of India. We further recommend that the Committee of Civil Research should suggest to the Secretary of State for the Colonies, the Secretary of State for Foreign Affairs and the Secretary of State for India that, in forwarding this Report, they should invite the Governments concerned to indicate any points in regard to which they think that the suggested scheme could usefully be modified or expanded; and to indicate whether they would be prepared to assist such a scheme if put forward by contributing towards its cost, and by providing local facilities (*e.g.*, transport, labour, laboratory accommodation, etc.) free of charge, if arrangements could be made whereby an Imperial contribution were forthcoming to, say, one half of the net cash expenditure. As regards the cost of the scheme, it might be of assistance to the Governments concerned in con-

sidering this question if they were informed that the estimated cost of the whole of the field work, excluding services rendered in kind, is approximately £4.000 per annum and that it is contemplated that the programme would require a period of five years' work. Under our scheme one moiety of this expenditure would fall to be paid by the Territories concerned in such proportions as might subsequently be determined. Finally, as the Desert Locust also occurs in South-West Africa, we recommend that the Committee of Civil Research should forward this Report to the Secretary of State for Dominion Affairs with a request that he should communicate it to His Majesty's Government in the Union of South Africa, and should at the same time express the hope that that Government will be good enough to furnish him for the Sub-Committee with a statement regarding the occurrences and distribution of the Desert Locust in South-West Africa.

" 11. We are hopeful that it may be found possible to employ aeroplanes for purposes of reconnaissance, and perhaps for the destruction of locusts. If this is to be effected, it is very desirable that arrangements should be made to secure the co-operation of the Royal Air Force in locust-inhabited countries. We recommend, therefore, that the Committee of Civil Research should invite the Air Council to forward copies of this Report to the Air Officers Commanding in such Territories so that they may be aware of the proposed inquiries. In any case where the Royal Air Force were able to assist in this way, appropriate arrangements would require to be made to reimburse Air Votes in respect of the expenditure involved.

" 12. The problem of the Desert Locust is essentially the same in whatever region it occurs; and our inquiry would be further assisted if we could obtain information regarding the present invasion of this species in Egypt, in the French and Italian possessions in North Africa, in Italian Somaliland and in Turkey and Persia. We recommend that the Committee of Civil Research should inform the Secretary of State for Foreign Affairs that the Sub-Committee are anxious to obtain as detailed information as possible regarding the occurrence of the Desert Locust in every part of its area of distribution; that they were invoking the good offices of the Secretary of State for the Colonies and the Secretary of State for India with a view to obtaining the desired information respectively from the British Colonies and Dependencies concerned and the Government of India; and that, in their view, it is very desirable that they should secure as much information as possible bearing on this subject from Foreign Territories in which this species of locust occurs, that the areas in respect of which they desired information were the following:—

(*a*) French Morocco, Algeria, Tunis, French West Africa, French Equatorial Africa, Somaliland and Syria;

(*b*) Italian Territories in North Africa, Eritrea and Somaliland;

(*c*) Egypt (especially in regard to the plans understood to have been made by the Egyptian Government about 18 months ago for employing aeroplanes in anti-locust work);

(*d*) Turkey;

(*e*) Persia;

(*f*) Arabia;

(*g*) Abyssinia;

and that the Committee of Civil Research should ask the Secretary of State for Foreign Affairs to use his good offices to obtain for us information on this subject from the foregoing countries."

69. It seems very desirable that India should take the opportunity to co-operate in this inquiry, as such united efforts on the part of all the countries concerned are not only likely to be productive of the best results but of economy also. Co-operation in such an international scheme would not imply that nothing should be done in India also. We require facilities for—

(1) a definite locust staff to—

(*a*) centralize and summarize all information regarding locust outbreaks,

(*b*) inform areas liable to attack of impending or expected invasions,

(*c*) investigate any possible permanent breeding grounds in India to acquire information of the bionomics of the Desert Locust in periods between outbreaks,

(*d*) take any measures possible to prevent outbreaks (*e.g.*, by attacking incipient swarms), and

(*e*) advise and, if necessary, direct control measures in future outbreaks.

70. The foregoing recommendation does not imply that Provincial Entomological staffs, where such exist, would be relieved of all locust control work within their Provinces. In the case of a large outbreak (*e.g.*, a large invasion from outside Indian limits) such Provincial staffs would be fully occupied in any case; but, especially in non-locust years, they have no time to devote studying locusts, probably at the very time when control measures are most useful in keeping locusts below a swarming-concentration. Such large areas as Baluchistan and the North-West Frontier Province are also administered by the Government of India and it will undoubtedly be necessary to undertake investigation and control work in the Rajputana area.

71. I consider that the question of the size of the locust staff to be provided in India should be considered together with the question of co-operation with the Locust Sub-Committee of the Committee of Civil Research. It is impossible to set up any locust staff which will be able to deal with every outbreak of locusts over the whole area liable to outbreaks, this area being roughly 400,000 square miles comprising Baluchistan, the N.-W. F. Province and the various Indian States of North-West India, and also roughly 250,000 square miles comprised by Sind, the Punjab and the United Provinces. But it will be necessary to have a more or less permanent staff distributed over any breeding areas which are found to be regular sources of production of locust swarms to watch locust increase. Incidentally, such staff will be able to carry out very useful work on the collection of Desert-living Insects of which we know practically nothing in India. In this connection also I would point out that the subject of Indian Grasshoppers generally is one regarding which we require a great deal of information as regards the occurrence of even the commonest species; attention was called to this by Mr. B. P. Uvarov in a paper (p. 158) included in the *Report of the Fifth Entomological Meeting* 1923 (pp. 318—324) but requests for the collection of Indian Grasshoppers by Provincial staffs have hitherto met with little response. This is perhaps a small point; but, if systematic collections of grasshoppers had been made during the last few years, we should have more data regarding the occurrence of the Desert Locust as a solitary grasshopper in non-locust years, and such information would be of help in determining whether locust swarms are ever produced by the solitary phase outside of the desert areas.

Locust Board.

72. I would also suggest that to obtain the best results and to ensure the fullest co-operation between all actually concerned in control measures, there should be a permanent Locust Board or Committee which should be composed of:—

(1) The Imperial Entomologist.

(2) The Government Entomologists of the Punjab and of the United Provinces.

(3) A representative of the Agricultural Department or of the Local Government in the case of Bombay, Baluchistan, and the North-West Frontier Province (these Provinces having no Government Entomologist at present).

(4) One or more representatives of the Indian States of North-Western India.

(*c*)

THE COLLECTION AND STUDY OF INDIAN ORTHOPTERA

(B. P. Uvarov, F.E.S., *Assistant Entomologist, Imperial Bureau of Entomology.*)

The Orthoptera form, undoubtedly, one of the little collected and less well-known groups of Indian insects, notwithstanding the fact that many members of this order are serious pests of various crops. The most important family of Orthoptera, from an economic view point, are the Acrididæ†, or short-horned grasshoppers, to which belong the swarming locusts, rice grasshoppers (*Hieroglyphus*) and a good many other minor pests of Indian agriculture; the present paper deals with this family in the first place, though most of what I am going to say may be equally well applied to other families of Orthoptera.

Apart from descriptions of some odd species of grasshoppers from India, scattered in the general systematic literature, there are but very few publications dealing especially with the Indian *Acrididæ*. Brunner von Wattenwyl (see bibliography at the end of the paper) published in 1893 a list of Orthoptera collected by Leonardo Fea in Burma, including about fifty species of Acrididæ, a little less than one-half of them described for the first time; the paper is, of course, very important for the study of the Indian fauna, although it deals with but a small and, faunistically a highly peculiar, corner of India and with a very limited number of species; some of Brunner's identifications of previously known species are evidently incorrect, while his descriptions of the new species are often insufficient for their recognition without a study of the types.

A very important and valuable contribution to the knowledge of the Indian fauna has been made by I. Bolivar (1901) who published an extensive list of Orthoptera of South India, based on the collection of the Trichinopoly College. This paper, containing numerous descriptions of new genera and species, is very valuable for a student of Indian Orthoptera, although again it deals with the fauna of but one small part of India. Bolivar's descriptions are, on the whole, satisfactory, but in many cases they are somewhat superficial and do not answer the purposes of modern systematics, so that a study of his types also is quite necessary; unfortunately, Bolivar has kept in his collection only duplicates (paratypes) when available, while all single types have been returned to Trichinopoly and are, I am afraid, lost or destroyed.‡

The first and only revision of the whole of the Indian fauna of *Acrididæ* has been given by Kirby in the "Fauna of British India" series in 1914. As this book is supposed to represent a standard work on the subject, it may be useful to discuss its merits and faults. Kirby was in an unique position with regard to the numerous (about fifty) species described from various parts of India by Walker, as he could examine their types, without which examination it is impossible to recognize Walkerian species; this important part of the revision has been done by Kirby in a most unsatisfactory way, since very many of Walker's species have been referred by him to wrong genera, while others have been obviously incorrectly identified with species described by other authors. Thus one confusion in the synonymy, which had been bad enough before Kirby's book, became a great deal worse after its publication. Apart from the numerous mistakes in synonymy, the book abounds in proofs that the author knew very little about his subject, since the descriptions of the

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* Reprinted from Proc. Fifth Entl meeting held at Pusa 1923.

† Some authors follow Kirby in calling this Family Locustidæ which is both incorrect and misleading since the latter name has been for many years incorrectly used for the long-horned grasshoppers (*Tettigoniidæ*); the name Acrididæ is derived from *Acrida*, the oldest genus of the family, and must not be confused with *Acrydiidæ* (=*Tetrigidæ*) based on *Acrydium* (=*Tetrix*)

‡ I understand that this collection perished many years ago. [T. B. F.]

genera and species (as far as they are original) provide ample evidence of Kirby's lack of knowledge of the morphology of the insects studied. The matter has been still more aggravated by the fact that Kirby died without having completed his manuscript, and the difficult task of preparing the book for publication was undertaken by Waterhouse who knew nothing about the group and could not help making some most unfortunate mistakes. As for the original material included by Kirby in his book, this originated, it seems, from two principal sources—the Pusa Institute, and Mr. E. E. Green's collection from Ceylon—but they have not been worked out completely and what I have seen of the named specimens compels me to discredit the majority of Kirby's records on the distribution of species.

Additions and some corrections to Kirby's book have been published recently by I. Bolivar whose work (1918) has been based on materials from the Coimbatore Agricultural College and includes some new genera and species, and by myself when I worked out the portion of the Pusa collection sent to Kirby but unnamed (or misnamed) by him. Both these papers are, however, quite occasional and do not aim at correcting Kirby's book as a whole, which would be hardly possible and at any rate decidedly less useful for Indian entomologists than a completely new revision of the whole fauna, with new keys and redescriptions of species, which would make identification of specimens both easy and (what is more important) quite reliable.

A revision of this kind is being contemplated by myself and will be based on the collections of the British Museum containing all the types of species described by Walker and Kirby, while there is also every prospect of an examination of types of Bolivar's, Brunner's and Stal's species. A large amount of unnamed material is being sent from Pusa and Coimbatore and a superficial examination of it shows that it contains many undescribed species and genera, but in order to make the intended revision as complete as possible, much more collecting should be done and the purpose of the present paper is to draw the attention of Indian entomologists to the necessity of collecting Acrididæ and to give them a few hints as to where and how to collect.

As regards localities the fauna of which requires a thorough investigation there is little to be said, since practically the whole of India remains un-explored. Some parts of it are, however, of particular entomo-geographical interest and at the same time their fauna is almost unknown. Thus, the deserts of Sind and the Punjab must harbour a very rich and highly specialized fauna, but only a few species are known from these areas and these species are all very peculiar. To what an extent the desert fauna of Western India and the adjoining areas is unexplored, may be judged from the fact that not a single specimen of Orthoptera from the Indian desert has ever reached the hands of a specialist, whilst the experience of collectors in Persia, Turkestan, Mesopotamia and other desert countries shows that the Orthoptera always play a very prominent part in their insect fauna. Sand-hills, stony ridges and hills, clay or salt plains and other typical desert formations, possess each a peculiar fauna of Orthoptera consisting of species adapted to particular conditions.*

Another *terra incognita* is comprised in the alpine regions of the Himalaya, while odd specimens of Orthoptera coming from there give ample evidence as to the extreme peculiarity of their fauna, consisting largely of small species with abortive organs of flight, which makes them very much like larvæ and undoubtedly prevents some collectors from taking them. Such larva-like forms are very common also in the higher regions of the Nilgiris and other hills which fact must not be forgotten by collectors there; in case of any doubt as to whether the particular insect is mature or not, it is advisable always to keep the specimens and be on the safe side than to throw away a possible novelty of high zoo-geographical value, as most of these flightless grasshoppers are.

The lower regions of the Himalaya are also very badly known as regards their fauna of *Acrididæ* which seems to be very rich in the smaller species of the genera *Aulacobothrus*, *Leva*, *Stauroderus*, etc., abounding on grassy slopes and in other open spaces. Here, by the way, the contract of the Palæarctic fauna with the Oriental one must be looked for and

* Apart from my revisional work on the *Acrididæ* of the whole India, I am quite prepared to undertake the determination of any Orthoptera from the desert and alpine localities.

all records of occurrence of even the most common and well-known species on the Southern Himalaya are very valuable from that point of view, quite apart from the fact that the majority of smaller species are undoubtedly undescribed.

It may seem odd, but it is nevertheless a fact, that the grasshopper fauna of the plains of Central India is also very inadequately known—at any rate, less so than that of Southern India, for instance. Of course, there is a large amount of unnamed material from the Plains in the Pusa collection, but still more extensive collecting is necessary in order to obtain a list of species as complete as possible.

In collecting *Acrididæ* for the purpose of a revisional work it must never be forgotten that long series of specimens of each species are the only means to establish the extent of variability (individual, geographical, etc.), of characters and thus enable the student to appreciate their taxonomic value. In fact, I shall hardly make a mistake in saying that not less than one-half of all the species hitherto known have been described from single, or very few, specimens, which makes it very difficult to decide what characters, supposed to be specific, are actually so. The necessity of studying long series applies even to the most common and numerous species including those of economic importance. Thus, my revision of the rice grasshoppers (*Hieroglyphus*) has given some indications that the most widely known species, *H. banian*, F., may occur in two forms, well characterized morphologically, but connected by intermediate ones; it seems that one of these forms (var. *elongata*, Uv.) appears in years of the mass development of the species and corresponds to the "swarming phase" discovered by me in practically all migratory locusts. Even if it is not so, there is no doubt that *H. banian* is subject to variations according to years, and it is only by collecting and studying a mass of material obtained from the same locality during several years running, and from different localities in the same year, that the true character, meaning and, probably, causes of the variations may be found out, which may be of great practical value.

As regards methods of collecting *Acrididæ*, there is hardly anything particular to be said. A stout net, made of some strong fabric, and used for sweeping is the only apparatus required, but it must be noted that some species, especially those living in bunch-grasses in deserts and plains often avoid being "swept" by falling down at the slightest disturbance and hiding between the stems near the ground, where they may be detected by a careful search.

Killing of grasshoppers is best done in a cyanide bottle which should be large enough and with a good supply of blotting paper; the specimens should not be kept in the bottle too long, or else they may change their colour.

The preservation of specimens of Orthoptera seems to the majority of collectors a very difficult task, since the comparatively large size and very fat and juicy bodies of these insects are the causes of the specimens decaying rapidly if not properly handled; these qualities make the whole group anything but favoured by collectors. The means to prevent the decay of specimens are, however, quite simple. In fact, when dealing with specimens of small and medium size, all that is necessary is to take out of them the superfluous moisture. In order to do it, the abdomen (but not the breast) must be cut open, by means of a pair of fine, sharp-pointed scissors, along the thin membrane between the tergites and the sternites, on one side only; particular care should be taken not to cut the last two segments, as they supply very important taxonomic characters. Then a piece of blotting-paper folded several times, must be inserted into the opening and left there for five to ten minutes; the blotting-paper must be changed two or three times, until there is no more moisture to extract. The opening then should be closed by means of a forceps and the insect is ready. Some of the largest specimens require a little more work, since it is necessary to remove all of their insides (intestines, crop, ovaries, etc.) which is easily done through the same opening; the inside of the adbomen must then be dried by blotting-paper and stuffed with cotton-wool. In dry weather, there is practically no necessity for stuffing even large specimens, provided they are dried as indicated above

The equally good methods may be recommended for the temporary preservation and transportation of collected specimens. The first one is to wrap the specimens singly in a

porous, but not soft paper, or still better, to place them in cylindrical tubes made of paper, with the diameter corresponding roughly to the thickness of the specimens. Such tubes may be kept in a well ventilated wooden box (not in a tin), and for transportation must be packed rather tightly to avoid shaking.

Another method of preserving specimens is between layers of cotton-wool, which must be cut in layers, about one centimeter thick, and of a size exactly corresponding to the wooden box intended for the specimens; the box must be filled tightly with the layers, every one of which must be separated from the next one by a sheet of thin writing-paper of the same size as the layers are. First, all the layers but the bottom one are taken out of the box and the specimens (with the moisture extracted, or stuffed, but quite fresh and flexible) are placed on the remaining bottom layer, fairly close to each other and in more or less regular rows; each specimen is better laid on its side, with the antennæ and legs close to the body. When the first layer is filled, it must be covered by a sheet of paper on which all particulars relating to the specimens should be written; then the next layer of cotton-wool is put on the top of the first one, and so on. When all the specimens collected on a certain day are disposed of in that manner, the remaining empty layers of cotton-wool must also be put in the box in order to press the insects in the cotton-wool and thus prevent their shaking during transportation. The captures of the next day are placed in the box in the same way, always on the lowest still unoccupied layer. This method is largely used for temporary preservation of all insects by Russian entomologists, and I have always applied it for transportation of Orthoptera, with the very best results. One thing, however, must be mentioned, namely, that when damping the specimens thus preserved before their pinning, they must not be taken from the cotton-wool one by one, but the whole layers with the insects on them must be placed in the damping tin.

No special instructions are wanted for pinning grasshoppers and as for their setting, the best way is to set out only one pair of the organs of flight (usually, the right one) and leave the other as it is. The importance of careful and detailed labelling of the specimens is already perfectly well-known to Indian entomologists, if I may judge by the collections studied, and I need not dwell on that point.

Some more important works on Indian Acrididæ.

1893. *Brunner de Wattenwyl.* Revision du systeme des Orthopteres et description des especes rapportees par M. Leonardo Fea de Birmanie. Ann Mus. Civico di Storia Naturali di Genova, ser. 2, vol. XIII (XXXIII); pp. 102—164, pl. V.

1902. *Bolivar, I.* Les Orthopteres de St. Joseph's College, a Trichinopoly (Sud. de l'Inde), 3 partie. Ann. Soc. Ent. France, LXX, pp. 580—634, pl. 9.

1914. *Kirby, W. F.* The Fauna of British India. Orthoptera. (*Acrididæ*). 276 pp. 140 figs.

1918. *Bolivar, Ignacio.* Contribucion al conocimento de la fauna India Orthoptera. (*Locustidæ* vel *Acrididæ*). Revista Real Acad. Cien. Exact., Fisic. y Natur. de Madrid, XVI, pp. 278—412.

1921. *Uvarov, B. P.* Records and descriptions of Indian Acrididæ. Ann. Mag. Nat. Hist. Ser. 9, vol. VII, pp. 480—509.

1922. *Uvarov, B. P.* Rice grasshoppers of the genus *Hieroglyphus* and their nearest allies. Bull. Entom. Res. XIII, pp. 225—241, 3 figs.

Mr. Fletcher, in commenting on this paper, emphasized the need for extensive collections of Orthoptera of India and especially grasshoppers and their submission to Pusa, this being one way in which the Provincial Entomologists could assist. We were prone to assume that well-known insects were not worth collecting; as is pointed out in the paper, this is very far from being the case.

(*d*)

LOCUST PROBLEM IN INDIA.

(PHILIP B. RICHARDS, *Entomologist to Government, United Provinces.*)

I. OCCURRENCE IN THE UNITED PROVINCES.

Occasional swarms of adult locusts are met with in the United Provinces whenever there is a visitation in India. The general direction of their flight is eastward, and except such swarms as find their way into the hill districts the locusts generally do not appear to have stayed long in the United Provinces or to have caused extensive damage to crops.

Until 1927 breeding had not been reported for fifty years or over. In March-April of 1927 a large swarm oviposited on both sides of the Jumna, in Sirmur State and the western edge of Dehra Dun district. From this breeding ground, the Dehra Dun portion of which occupied many square miles, large swarms of hoppers emerged but were not reported until they were approaching the adult condition. The hoppers damaged tea gardens to the extent of between one lakh and one and a half lakhs of rupees. Thereafter flying swarms were present in the hill districts until August, occasionally damaging then standing crops, but no breeding was reported. Many swarms also crossed the United Provinces from the West and were lost track of, newspaper reports indicating that they crossed Bengal and Assam, and disappeared eastward.

Swarms, the origin of which is not known, were reported flying west in the Dehra Dun district during the first week of December 1927.

In 1928 flying swarms were frequently reported from the hill districts of Garhwal, Almora and Naini Tal, the origin of which is unknown.

In 1929 swarms were again reported throughout the hill districts from April to July but no information of breeding has so far been received. Early in July 1929 large swarms were reported from Meerut and Muttra districts. These came from the west, and damaged young *kharif* to the extent of one to two annas.

Early in August further large swarms came from the west, and bred in seventeen districts, from Saharanpur and Bijnor in the north to Lucknow and Bara Banki southward. The extent to which breeding took place in these districts varied, being most concentrated between Meerut and Agra. Owing in part to the impossibility of preparing sufficient apparatus in time to deal with this extensive and intense visitation, and in part to tardy information and late commencement of operations, I estimate that no more than seventy-five per cent. of the resultant hoppers were destroyed; although an energetic campaign was carried out in all the affected districts as soon as the presence of hoppers was intimated. In no case was a breeding ground reported.

No estimate of the damage done during the nymphal stages has yet been submitted to me, but this was very serious, large areas of the worst attacked districts being completely devastated.

Since completing their development, the locally bred swarms of fliers have been moving through the province, generally in a south-east direction. Some appear to have gone north-east into the hills, and some south into the Central India States bordering Bundelkhand. Many reports have been received of locust swarms in the extreme east of the United Provinces and some swarms have already passed eastward out of the province into Bihar and Orissa. The local locust population has however been augmented by swarms coming in from the west from the Punjab, Bharatpur State and Gwalior State.

The flying swarms vary in size from a few acres to several square miles. Where they have settled on standing crops they have caused damage to the later *kharif* crops of from one to sixteen annas in the course of a few hours' feeding. In the aggregate the sporadic damage by fliers is likely to exceed that done by the hoppers.

II. PROSPECTS OF CONTINUANCE OF VISITATION.

Unless climatic or other natural causes appreciably diminish the numbers of locusts, we must anticipate a very serious situation at the next breeding time. The extent to which North and Central India has suffered from the present visitation can only vaguely be

guessed at, but it must amount to many crores of rupees. Rumours suggest that some of the Indian States were even harder hit than the worst areas of the United Provinces; and that little was accomplished by way of destruction of the hoppers. The United Provinces would appear to be the eastern extremity of the possible breeding grounds for this pest, judging from its freedom from hoppers in earlier visitations. Recent experience however casts doubt on this, as oviposition and development was successfully accomplished so far east as Lucknow and Bara Banki notwithstanding that normal monsoon conditions were operating during the month of August. It is therefore possible that the locust may be able to thrive much further east than previous experience suggests, provided a light well-drained soil is available for oviposition.

III. CONTROL.

The problem of locust control is not one that can be solved finally by any one country even of the size of India. Much less can it be solved by an individual province. It is within the power of an individual province to eliminate its own broods of hoppers, provided that apparatus and organization are arranged for beforehand; but no expenditure of money and energy can serve to protect that province against re-infestation unless control operations are carried out equally efficiently in all Provinces and Indian States affected. A central organization capable of mobilizing and distributing adequate apparatus, of supplying expert supervision, of broadcasting information, and of ensuring and co-ordinating effort is essential to the rapid control of a widespread locust visitation.

The methods applicable to the control of locusts in the nymphal and the flying stages vary with the locality. Where population is dense, and information consequently soon available, such methods as the ring-trenching of breeding grounds and the driving of swarms may be highly efficient in controlling the immature stages. Similarly in such areas the spreading of poison bait is practicable against hoppers and fliers. In sparsely populated districts not only is information slow and labour insufficient, but the probability is that the soil will be unsuitable for digging trenches. In such areas poisoning is the only effective method. In the appended memorandum (p. 165), prepared with particular reference to the United Provinces, methods and organization for a locust control campaign are discussed. The more important of these are briefly summarized below:—

1. Fliers.

In general no great impression can be made upon flying swarms by mechanical methods. During cold nights considerable numbers may be destroyed by hand if the swarms have settled near villages, but this could only be a tithe of a big swarm. Much more effective in such circumstances would be the scattering of poison bait. This would however entail the material being available within easy reach of any village in which the swarms might have settled. This should not be dismissed as impracticable, but considerable expenditure and a very thorough system of distribution would be essential to its employment. It could only be warranted where extensive damage from flying swarms was anticipated, or if its employment would effect the practical extinction of the swarms, so preventing further breeding.

Failing the employment of baits against fliers, or where such baits cannot be available in time, following up the swarms by aeroplanes and dusting with sodium arsenite is a possible alternative.

2. Breeding grounds.

These should be discovered by a system of rewards, and should be isolated by an encircling trench to prevent emergent hoppers from moving out.

Where the sub-soil renders ring-trenching impossible, subsidiary methods may be employed; namely, digging of egg-masses and ploughing the breeding grounds.

3. Hoppers.

Comparatively small swarms of hoppers can, where labour is available, be dealt with by mechanical methods. Very large swarms can only be controlled by chemical means.

A. Mechanical methods.

Very small swarms covering areas of an acre or two can be disposed of by driving into trenches without the assistance of barriers. Larger swarms are unmanageable without such aid. In all cases where driving is employed, whether with or without the use of artificial barriers, the success of the operation is largely dependent upon the trench walls being unclimbable. This is ensured by protecting the upper part of the trench all round with a strip of shiny American oil-cloth.

Larger swarms require artificial barriers to ensure success. The barrier recommended consists of locust screens. These are lengths of cotton cloth suspended on iron stakes, and rendered unclimbable by means of a six-inch strip of shiny American oil-cloth attached near the top edge of the screen.

B. Chemical control.

In all cases where mechanical methods are inadequate, whether through inaccessibility, absence of labour, hardness of sub-soil, or density of crop or wild vegetation, poisoning is indicated. The choice of method rests between poison baits, dusting, and spraying. In general poison baits are preferable, especially if arsenicals are employed.

Dusting should be employed where practicable against large swarms in dense crops. Large swarms in uncultivated areas are probably only amenable to dusting extensively from aeroplanes.

If arsenical insecticides are to be used for swarms in rough grassland, sodium arsenite should be sprayed, as it scorches the foliage and mitigates the risk of casual poisoning of cattle.

Insecticides.

Until recently practically none but arsenicals have been used extensively against locusts. Sodium fluosilicate is better in every respect, being more toxic to locusts and far less dangerous to domestic and other animals.

Until sodium fluosilicate becomes available in adequate quantities, reliance in all poisoning operations against locusts will have to remain in arsenical poisons. The use of sodium fluosilicate will, however, simplify the situation and make the control of locusts throughout India more readily practicable, provided adequate arrangements for its utilization can be made.

4. Status of locust question.

An extensive locust visitation is at least as important as a widespread epidemic disease, to which it is likely to be a forerunner through malnutrition ; as also to famine. Its control is therefore of major importance.

It must be emphasized that individual efforts by Provinces and States are inadequate to the problem as a whole, and that piecemeal operations however efficient do little more than stave off the immediate danger so long as the battle is not equally waged everywhere. Moreover, such localized efforts are vastly more expensive in the long run than would be a general campaign throughout the whole of the infested area. Independent efforts entail obtaining material sufficient to cope with the maximum attack in each area. Pooling of resources would enable material and staff to be concentrated where required, and in view of the normally sporadic distribution of the pest in any one generation, would at once cut down the total expenditure and increase the efficiency of the campaign.

The aim of an all-India locust campaign should be to wipe out as far as possible, in one generation, the whole population of locust. This can only be attained if the Provinces and States combine and work energetically to this end, and if funds, apparatus, and organization are in immediate readiness.

5. Suggestions for an all-India organization.

1. INVESTIGATION.

Whereas control can only be partially successful on a provincial basis, biological investigation would be less so. There are many points in the biology of the insect which require investigation and no Provincial Entomological Section is likely to be able to carry this out. A complete study of *Schistocerca gregaria* in India should be undertaken through the Imperial Council of Agricultural Research either with staff seconded or recruited for the purpose in India or obtained elsewhere.

2. INTELLIGENCE.

A Central Intelligence Bureau for all India is a further essential to locust control. This bureau should be in close touch with all Provinces and Indian States subject to locust visitation and should broadcast information as to the presence of swarms of locusts, their direction of movement, and the methods employed in and the progress of control campaigns.

FUNDS, APPARATUS AND TECHNICAL STAFF.

(*a*) *Funds.*

Locusts are a common peril. The damage done by them when breeding in sparsely populated tracts is often insignificant; but not so when they migrate to more fertile lands. The expenditure upon control should therefore be distributed among all the areas subject to attack, and should not be borne solely by the Province or State in which they happen to be congregated. So far as the British India Provinces are concerned, the cost might well be a charge upon famine relief funds. Indian States should contribute towards the general cost on the basis of cultivated area.

(*b*) *Apparatus, etc.*

All necessary apparatus should also be obtained and held ready for issue by the central organization. Local Governments and States would indent upon this for their requirements which should be checked by the Intelligence Bureau.

(*c*) *Technical staff.*

Where it is desirable to supply experienced staff for organization or for demonstration of control methods, the central organization should have facilities for drawing upon the Provinces for experienced locust control officers.

(*e*)

LOCUST CONTROL METHODS AND ORGANIZATION.

(PHILIP B. RICHARDS, *Entomologist to Government, United Provinces.*)

CHAPTER I.—METHODS OF CONTROL.

1. FLYING LOCUSTS.

ADULT locusts in swarms can fly very considerable distances, and select their feeding places at will; and the individual insects are wary and difficult to approach. Throughout

their adult life measures of control are limited, in our present knowledge, to poisoning by baits or from aeroplanes, or to simple and comparatively ineffective direct methods.

A. Mechanical control.

No effective measures of this sort can be recommended for use by day. It is however anticipated that during cold nights, especially with heavy dew, the locusts will be found to be incapable of active movement in the early hours of the morning. This has yet to be confirmed, but is the case with practically all diurnal insects during the cold months.

(*a*) By day.

The most elementary way of dealing with flying locusts is for the villagers to turn out *en masse*, and endeavour to prevent the swarm from alighting by waving cloths, beating tins, and such like scaring methods. This will not, however, be effective indefinitely. Ultimately the swarms will alight for rest and food, and no demonstration will serve to move them except from one plant to another. Already, in spite of such effort by the villagers, flying swarms are reported to have caused up to sixteen annas damage in one night on various areas up to several hundred *bighas* in Cawnpore district. It is probable that such areas have been and will be exceeded in other districts with larger flying swarms; and the damage will persist, either in the United Provinces or elsewhere, so long as the swarms remain undestroyed.

(*b*) During night.

If the anticipation is verified that the locusts will become sluggish in the later part of the night, a useful proportion of settled swarms can be destroyed if all able-bodied villagers turn out, say, at 3-30 a.m., and work until the locusts again become active, say, one hour after sunrise. The insects could be collected by hand from the crops, or shaken down from bushes and trees and beaten or trampled to death.

(*c*) During copulation.

Shortly before egg-laying the locusts alight, usually in dense swarms, for pairing. When coupled, locusts are clumsy in their movements, and incapable of flight. Large numbers can then be collected by hand, or crushed by any available means during the day.

(*d*) During oviposition.

The female locust, by means of hard plates on the tip of the abdomen, bores a hole into the ground for the eggs. The abdomen remains in the hole during egg-laying. Such females can readily be destroyed by crushing, or collected by hand.

B. Chemical control (Fliers).

The application of chemical methods of control to flying locusts is practicable only by the use of attractive baits or by employing aeroplanes.

Dusting or spraying with poison, as discussed later for hoppers, is generally unsatisfactory as the swarm is likely to move away during the poisoning operation; and in India these would be impossible to employ with advantage on account of the difficulty of communication.

(*a*) Poison baits.

(i) *Composition and use.*

I have hitherto refrained from recommending the widespread use of poisons against locusts in view of the risks involved. The damage now being done by the flying swarms is, however, so extensive and serious, that I consider that the risks attached to this method of treatment should be incurred. Poison baits are composed of a poisonous material

mixed with a foundation material to give bulk; and with certain attractive substances added. The most frequently employed poisons are Paris green and sodium arsenite, both of which are highly toxic to animals as well as to insects. The material for dilution may be bran, maize meal, flour mill sweepings, cotton seed meal, or even saw-dust; and it is possible that residues from oil crushing will serve for this purpose. Water is added to give cohesion to a crumbly consistency; and molasses or some other form of sugar, or salt, and orange or lemon juice or amyl acetate are the usual attractants. The bait thus prepared is scattered thinly over the ground in areas where swarms have alighted for feeding. This method is reported to have met with marked success against flying swarms of locusts outside India. I am unable to forecast the extent of the danger of poisoning livestock by the widespread use of arsenical baits; but if the bait is scattered thinly, I do not consider that this is likely to be serious. The risk must be taken if effective measures against flying swarms are to be carried out immediately.

Sodium fluosilicate has now been shown to be a more effective poison against locusts and grasshoppers than arsenical salts, and is only about one-tenth as toxic to domestic animals as sodium arsenite. It is unlikely that adequate stocks of this material will be available in India in time to save damage by the present flying swarms. If, however, supplies can soon be forthcoming, the main disadvantage in the use of poisons against locusts will be disposed of.

(ii) *Preparation and distribution of poison bait.*

To be effective, supplies of poison bait must be present in the attacked villages. This entails the issue of supplies of poison and amyl acetate for bulk preparation of the bait at district or tahsil headquarters, whence it would be distributed in sealed tins in adequate quantities to individual villages or small groups of villages. The persistent use of poison bait on swarms moving from day to day through the province should effect material control during the flying stage, and will save the destruction of enormous areas of crop.

(*b*) CONTACT DUSTING BY AEROPLANES.

Sodium arsenite in fine powder, discharged upon swarms of fliers in the air or on crops, is claimed to have proved efficacious. Sodium arsenite is normally used as stomach poison but appears to operate also as a contact poison when in fine particles.

2. BREEDING GROUNDS (METHODS OF CONTROL).

The prevention of the escape of the first stage young locusts from the breeding grounds is the most efficient and the cheapest method of control. Three methods are employable to this end: ploughing, or digging and collection of egg-masses; flooding; and ring-trenching.

A. Ploughing or digging and collection of egg-masses.

This method of locust control is insufficient of itself. A considerable proportion of the eggs can undoubtedly be prevented from hatching by digging the egg holes and collecting the egg-masses by hand, or by ploughing the land and collecting the exposed egg-masses and disturbing the soil around the remainder. With both methods a proportion of the eggs, either those in the more sparsely occupied portion of the ground, or those on the field edges and bunds, remain to produce hoppers. The size of the emerging swarm is diminished, but, as the aim of control operations should be complete eradication, driving or other control methods still have to be employed for the residual swarms. I therefore do not recommend this method except in connexion with ring-trenching (see below).

B. Flooding.

The protracted flooding of breeding grounds, especially during the later development of the insects in the eggs, is more efficient than digging or ploughing. This method is, however, only partially successful, as bunds and other high parts of the area remain unaffected. Reliance cannot be placed upon this method for complete control even in the limited areas to which it may be applicable.

C. Ring-trenching.

(a) Digging and maintenance of trenches.

(i) *Nature of trenches.*

The isolation of breeding grounds by digging a surrounding trench, steep-sided, at least one foot in width and eighteen inches deep—the size and depth depending upon the number of locusts expected to emerge—should be the main method of control in any future visitation of locusts. This, if efficiently done and maintained, should confine all the hoppers within the breeding area. The preparation of such trenches by experienced labourers, such as road repairing gangs, should not cost more than forty rupees per mile. Where the breeding ground is extensive—and it may cover many square miles—it may be necessary to sub-divide the area by cross trenches.

(ii) *Oil-cloth protective strip.*

In dry soil it will generally be necessary, for ensuring the efficiency of the ring trench, to fasten a continuous strip of American oil-cloth along the top few inches of the outer wall of the trench. This considerably increases the expense of the operation, as the cost of an-oil-cloth strip six inches wide will approximate three annas per yard ; say, three hundred and fifty rupees per mile capital expenditure in the first instance. This is however a bagatelle compared with the loss of revenue and crop values, and the additional labour entailed if swarms escape from the ineffective trenches. I strongly advise the use of the protective oil-cloth strip under all circumstances, except, possibly, where the trenches are partly filled with water.

As the oil-cloth strips are capable of being used over and over again, the average cost of the trenching operations would be considerably less than Rs. 400 per mile.

(iii) *Oiling on water-filled trenches.*

Where the water level is so high as to ensure that the trenches will remain partly or wholly filled with water, the oil-cloth strips may be ineffective. In such case it will be necessary to maintain a layer of cheap mineral oil upon the surface of the water to kill the hoppers which enter the trench ; otherwise the bulk of the swarm would escape, either by swimming, or by walking over the corpses of those already drowned.

(iv) *Maintenance of trenches.*

As the ring-trenches may require to be dug expeditiously after the location of breeding grounds, and may have to be in commission for a considerable time, it will be necessary to provide patrols for repairing damage caused by animals, and to see that the oil-cloth remains in position. One labourer will be able to look after a considerable length of trench until the hoppers are on the move.

(v) *Emptying ring-trenches.*

If the emerging swarm is large, it will be necessary to provide additional labour for killing hoppers accumulated in the trench, and for removing the dead hoppers to make room for others. The hoppers removed will of course be placed inside the protected area, lest any should remain alive and escape.

(b) Operations within ring-trenched area.

(i) *Cross-trenches.*

The object of the ring-trench is to prevent the hoppers from moving out in search of food and so to starve the whole swarm. It is quite possible, however, that a continuous breeding ground may cover a very large area. Sub-division by cross-trenches may then be necessary. They should not be more than one mile apart ; but no definite spacing can

be laid down, and the position and number of cross-trenches must be left to the judgment of the officer in charge.

Patches of jungle, or unprotected cultivated field, may serve to maintain considerable numbers of locusts within the ring-trench. Operations against the eggs or hoppers will, in such cases, be advisable.

(ii) *Protection of crop inside ring-trench.*

Before the hoppers have hatched, further trenches should be prepared along the edge of all fields under standing crop. If breeding grounds within cultivated areas are detected at once, as they should be, there will be ample time for the preparation of such trenches by the cultivators for the protection of their own crops. This work should, however, be done under proper supervision, to ensure efficiency and a fair distribution of labour.

(iii) *Digging, ploughing or flooding breeding grounds.*

Wherever convenient, the breeding grounds may be ploughed or dug and the exposed egg-masses destroyed.

Flooding has not yet been tried in the United Provinces. Elsewhere I have found that flooding for twenty-four hours usually ensures cent. per cent. mortality. This method is limited in application as breeding grounds are generally not irrigable.

These methods are insufficient in themselves to effect control and should only be employed in conjunction with ring-trenching where they fit in with cultural operations.

(iv) *Driving.*

Within extensive ring-trenched breeding areas the mechanical methods recommended for destruction of hoppers will often have to be employed. Their need must be determined by the circumstances of the case. (*See* A, pages 170 to 172.)

(v) *Poisoning.*

Under special circumstances, as where dense crop or jungle within the ring-trench is infested with hoppers, poisoning by baits, dusting, or spraying may be essential.

Poisoning by baits may become our principal method for dealing with young swarms under all circumstances.

3. HOPPERS (METHODS OF CONTROL).

The nymphs—wingless immature stages—are highly gregarious and feed, or move from place to place, in dense swarms. The direction of their movement can be readily controlled by driving them slowly and steadily from behind. This characteristic is quickly observed by cultivators, but in general is exploited with the utmost futility in driving swarms out of their own fields into their neighbours', unless their effort is directed into more useful channels.

There are five nymphal stages before the locust becomes capable of flight. In the first stage the individuals are about one-third of an inch long, increasing by periodic moults to one inch and a half in the fifth stage. With each successive increase in size of the individual, there is a corresponding increase in activity, in the amount of food consumed, and, consequently, in the area covered by the swarm; the swarms split up and become more diffuse; and towards the end of the nymphal period they become increasingly difficult to drive.

From every point of view, therefore, it is desirable that any swarms of hoppers, either within or outside ring-trenched areas, should be destroyed before they have passed their second moult. Methods for destroying swarms of hoppers may conveniently be considered under the headings Mechanical, Chemical, and Biological.

A. Mechanical control (Hoppers).

(a) Driving.

(i) *Driving into plain trenches.*

The simplest method of dealing with hoppers is to drive them into a trench. This was the method most largely employed during the August-September visitation. It is simple, and, if the trench be properly prepared, is usually effective. It has however certain drawbacks. In the first place the soil must be capable of being cut vertical or over-hung without crumbling, and the surface of the sides and ends of the trench must be smoothed. If these conditions are not fulfilled the hoppers are liable to crawl up the sides and escape. Many of the earlier, inadequately supervised, efforts for driving into trenches proved partly or completely abortive through failure to prepare trenches correctly, thus disheartening the workers. Even from well-made trenches some hoppers occasionally escape. This usually leads to the placing of stops on the far side of the trench, where their movements frequently serve to turn the swarms back, thus delaying or spoiling the operation.

Another drawback is that for swarms of any magnitude the trench has to be prepared over a considerable front, involving, in the later stages, large expenditure of labour.

A still more serious consideration is that, to direct a swarm into the trench, a line of stops has to be stationed on both sides from the end of the trench, to prevent the swarm from breaking through. This often leads to great confusion and waste of time owing to the consequent frequent changes of direction of movement of the driven swarm. It also immobilizes a considerable proportion of the available labour.

The length, depth, and breadth of the trenches vary according to the size of the swarm and the stage of development of the individuals. During the first and second stages a trench, one foot wide by one and a half feet deep, with occasional pits to contain the hoppers in the case of a large swarm, is adequate. The width and depth have to be increased successively in the later stages, until, in the fifth stage, a width of two and a half feet and a depth of two feet constitute the minimum.

The individual fifth stage hopper is over one hundred times as bulky as a first stage nymph. Consequently many more, and deeper, trenches have to be prepared to contain a swarm of the same number of individuals than in the earlier stages.

(ii) *Trenching with protective strip of oil-cloth.*

Locust hoppers are incapable of climbing up a vertical smooth surface, as this allows no foothold. Glazed paper, tracing cloth, smooth metal surfaces such as tin or zinc sheeting are unclimbable, and have been variously used in locust control. The most satisfactory material so far employed is smooth American oil-cloth. This is less liable to damage than paper or tracing cloth, and is much more easily transported and placed in position than metal strips. It was used to a limited extent at the end of the September campaign with good results. Unfortunately extensive supplies were not available in time. In future campaigns the oil-cloth strip should be generally used in the construction of trenches.

A six-inch strip of oil-cloth greatly reduces the labour of trench preparation as the lower portion of the trench need then only be roughly dug. The top six inches are cut straight vertical, and fairly smooth, and the oil-cloth is nailed along this. Hoppers driven into such a trench find escape quite impossible, so that stops on the far side of the trench are not needed, and the advance of the swarm is not checked unnecessarily.

(iii) *Locust screens and barriers.*

The simple method of driving without apparatus is effective only for small swarms. Larger swarms tend to become congested and confused, and to break through the line of stops or to move in circles within the area surrounded by the workers. To avoid this inefficiency and delay, artificial barriers placed at an angle, obliquely to the direction of the drive, are employed to replace the stops.

Metal strips have been used largely for this purpose, but are costly, clumsy, and difficult to transport. Lengths of cloth having a six-inch strip of oil-cloth near the top, and suspended from iron stakes, are equally efficient, more easily placed in position, and readily portable.

Such screens can be quietly and quickly run up where required, without disturbing the swarm of hoppers. They completely dispense with the need for side stops, reduce the labour required for driving the swarm, increase the efficiency of each drive, and accelerate control operations. They also reduce the labour expended upon digging, as, in place of a long trench, a deeper broader pit, sufficient to contain the swarm, is dug at the apex of the converging screens.

Locust screens are intended primarily to deal with large swarms of hoppers, and have been issued in units of two hundred and forty yards, made up of ten lengths of twenty-four yards each. One set, properly disposed, will deal with a swarm frontage of one hundred and twenty to one hundred and fifty yards. For large swarms two or more sets can be combined in a series of angles along the frontage of the swarm. With five hundred yards of screens, forty tons of third stage hoppers from one swarm were destroyed in one day in Muttra district. This swarm was so extensive that driving without screens would have been useless.

Locust screens in standard sets were issued as available to affected districts during the September campaign and proved very effective when used in large units. In certain districts the sets were broken up into smaller units. This was done to satisfy the demands for screens from affected villages, and although it defeated their main purpose, the provision even of short lengths greatly stimulated the efforts of the cultivators.

It was unfortunately impossible to prepare screens in time for use against the earlier stages, when they would have been most effective. Had sufficient screens then been available, few, if any, of the swarms would have survived in cultivated areas of the districts which discovered their locusts early. Even where work commenced so late as the middle of September, the widespread use of screens would have effected almost complete control; but many more screens would have been required for the enlarged swarms.

If reliance is to be largely placed upon mechanical methods of control in future campaigns, I strongly recommend the issue of locust screens in sufficient quantity both for dealing with hoppers in ring-trenched areas and for swarms in open country arising from undetected breeding grounds.

(iv) *Canvas traps for use with locust screens.*

Where the sub-soil is rocky, or the digging of a pit is otherwise impossible or difficult, a canvas structure in the form of a rectangular open box equal in height to the screens on the two sides and the back, and similarly fitted with American oil-cloth, takes the place of the pit. The hoppers enter it by means of a long, sloping, canvas approach at the front. It is efficient, and saves much time and labour in pit digging, but as it is less simple to erect than the screens, it was not generally issued for the September campaign. Canvas traps will however be essential to locust control by driving, for swarms in areas with shallow soil and rocky sub-soil; or if in the hot months the ground is so dry and hard as to be impossible to dig.

(v) *Driving into water.*

Still water is not a barrier to locusts. They readily swim across it. Ditches and small pools may however be utilized instead of trenches, provided an adequate coating of cheap mineral oil is maintained on the surface. The locusts swimming across get covered with the oil, and although many emerge they soon die. The oil quickly becomes used up and requires frequent renewing. This method is somewhat costly in oil, but appeals to the cultivators, and the cost is largely off-set by the saving of labour in trench digging.

Fast running water, specially if broken, can at times be used for destroying swarms. The locusts enter it readily but find crossing difficult, and if they are beaten or otherwise

driven under water, the percentage mortality is high. Such devices as a line of planks across the current, or netting or cloth suspended over and touching the water, would ensure the submersion and thorough wetting of the swimming hoppers. The question of driving large swarms of locusts into canals or natural watercourses should however be examined by the Health Department before extensive operations are recommended. I am not at present prepared to accept the responsibility for recommending this method of locust destruction.

(vi) *Driving locusts in areas under crop.*

Swarms of hoppers in dense crops, such as *bajra* or *jowar* grown in mixture with leguminous plants, are extremely difficult to drive. In such cases the removal of the crop is warranted. Clearings should first be cut for the erection of screens and the preparation of a pit. These being ready, the crop should be cut from behind the swarm, and removed, until the whole area is cleared. It is false economy not to do this. If the locusts are not driven out they will destroy the crop; considerable damage is unavoidable during the driving operation; and the ratio of success is unsatisfactory. Wherever necessary, therefore, persons in charge of operations should be authorized to cut such crops.

(*b*) BURNING.

Burning is very popular during the later stages when the big hoppers frequently rest in jungle grass or bushes. It is, however, not very effective, and should only be resorted to when more efficient means are impossible.

Burning by flame throwers capable of throwing a flame to a considerable distance is a method extensively used against the migratory locust in other countries. Inquiry is being made into the possibilities of employing this method in India.

(*c*) CRUSHING.

Very large numbers of the first stage nymphs can occasionally be destroyed on fallow land by drawing a *pata* over the field. This is a method of limited application, but should be encouraged wherever possible, as it assists in destroying hoppers, and also provides a useful manure for the fields.

B. Chemical control (Hoppers).

Without doubt chemical methods provide the cheapest and most efficient means of controlling hoppers. It is unlikely that complete control throughout the breeding areas in India will be achieved without their employment.

Chemical control of insects in general is effected in three ways—by contact sprays, by stomach poisons, and by fumigation.

(*a*) CONTACT SPRAYS.

Provided that the contact spray used is sufficiently potent, locust hoppers can undoubtedly be destroyed by this means. Contact sprays are, however, in general used only upon small sessile insects, and are uneconomical against large active insects. Kerosene oil, strong caustic solutions, and the like, will kill such hoppers as receive a sufficient dose. Contact sprays of the strengths normally used against other insects fail to destroy locusts; and to ensure an effective mortality even with more potent contact poisons, such large numbers of spraying machines and labourers, and such enormous quantities of spraying material, would have to be employed as to make the cost prohibitive. The use of contact sprays should therefore be confined to the killing, when required, of hoppers in trenches or traps.

(*b*) Stomach poisons.

Insecticides which take effect through being eaten by the insects are grouped under this general term. The stomach poisons hitherto used extensively against locusts have been compounds of arsenic, notably Paris green, calcium arsenate, calcium arsenite and sodium arsenite. These are all highly toxic to higher animals as well as to insects. Recently sodium fluosilicate has been shown to be even more toxic to locusts and grasshoppers than the arsenical salts, over which it has the great advantage of being distasteful to poultry, and of being only one-tenth as poisonous to domestic animals, compared with sodium arsenite.

The employment of poisons against locusts is fraught with a certain amount of risk of poisoning domestic animals, but this should be accepted in view of the tremendous damage to crops in a severe locust visitation. In the application of poisons to pasturage, fodder crops, and truck crops, adequate precautions have to be taken to ensure that these are not eaten by domestic animals or by man until danger of poisoning is over. In general heavy rain renders the plants harmless but in its absence a sufficient period, which varies according to the material, must elapse before the plants are used for food. With the above arsenical preparations this period ranges between three and five weeks.

Stomach poisons are applied in the form of baits distributed over the food plants as a dry powder; or sprayed upon the plants dissolved or suspended in water. The means of distribution range between scattering poison mash by hand, and dusting extensively from aeroplanes. In any general campaign against a severe locust visitation throughout North India, the employment of all such aids to control must be given serious consideration. The mechanical methods, upon which reliance has so far been placed, will be inadequate to deal promptly and effectively with an extensive and severe visitation. If it be decided to employ chemical methods, these will consist mainly of baits and dusting, although spraying is in some cases superior to these.

(i) *Baits.*

I am unaware of the results obtained with poison baits in India. Elsewhere they have been widely used with considerable success against hoppers. The poison generally used is sodium arsenite as this is soluble and easy to incorporate. Paris green is sometimes used in its place when it becomes available; sodium fluosilicate will replace arsenicals in baits for India.

The method has been previously described under "B.—Chemical control (Fliers), (*a*) Poison baits," page 166. There are various formulae for the preparation of baits, the most suitable of which, for the United Provinces, will be determined after a decision has been reached upon the question of utilizing poisons. I consider that the general employment of poison baits against hoppers will prove the most generally practicable and effective of all chemical anti-locust measures.

(ii) *Dusting.*

The most economical method of utilizing insecticides on an extensive scale is to distribute them over the food plants in the form of a fine dry powder. This can be done by hand powder-guns, by power dusting machines on ground vehicles or from aeroplanes.

Dusting has the advantage over spraying of being independent of water supplies, and should be the principal method for employment upon large swarms in rough uncultivated ground or in extensive areas under heavy crop.

Hand powder-guns of the knapsack type are capable only of dealing with comparatively small areas and require suitable weather conditions to develop their maximum efficiency. The powder is distributed in a blast of air, and is carried by air currents on to the food plants to which it adheres if the plants are moist. In hot dry weather they can only be used effectively in the early morning or late evening and during night.

Aeroplanes are proving to be by far the most efficient means of distributing poison dust. Flying from thirty to fifty feet over the plants, the dust is distributed through a belt of about two hundred yards in width, and from fifty to seventy-five acres can be treated

per minute. The dust particles become positively charged with electricity, and adhere readily even to perfectly dry plants, as these are negatively charged. Dusting operations can thus be carried out throughout the day, and in areas otherwise difficult of access.

Power powder distributors mounted on motor vehicles are much more efficient than hand powder-guns, and under favourable conditions can treat about eight hundred acres per hour. Power dusting apparatus can be equipped with an electrical device for charging the issuing particles of dust so that these readily adhere to plants. Such apparatus would be available for use against large swarms in accessible uncultivated land, or in extensively infested areas under crop.

(iii) *Spraying.*

The application of stomach poison in a liquid medium has a minor advantage in that the actual distribution of the poison within an area is under direct control; whereas the range covered by dusting is dependent upon air currents. This is not a consideration of great importance.

Further, it is possible to combine stomach poisons with attractive materials such as molasses, so inducing the locusts to feed more freely upon the poisoned plants.

The main disadvantage in spraying is that water must be readily available. It is also much more laborious than dusting.

If arsenical sprays are to be used, calcium arsenite combined with lime should be employed for spraying standing crops as this does not injure vegetation.

I consider that sprays should be used in preference to dusting only where operations have to be carried out in a grazing tract. Here sodium arsenite should be used in liquid form because it turns the foliage brown within a few hours, so making the treated area conspicuous.

Knapsack sprayers can poison one acre per day. If large areas of grassland require to be sprayed, power machines on motor vehicles should be used.

(c) FUMIGATION.

Poisonous gases have been recommended for use against locusts both in the hopping and the flying stages. I have no personal experience of them, and, if it be considered desirable to investigate their possibilities, I suggest that military experts be consulted upon the matter.

C. Biological control (Hoppers).

Many attempts have been made in the various parts of the world, with varying degrees of success, to control locust visitations by inducing epidemic disease, notably that caused by *Coccobacillus acridiorum*. The method is effective under laboratory conditions, but the factors determining widespread epidemics among insects are so little known that reliance can not at present be placed upon this method of control. In the event of further breeding within the United Provinces, the possibilities of biological control should be investigated.

CHAPTER II.—PROVINCIAL ORGANIZATION.

The establishment of a definite organization for dealing with locust invasions is essential to the quick control of the pest. The form which I suggest it should take is outlined below :—

Four branches will be required, namely,—intelligence, executive, inspecting and reporting and controlling.

The intelligence branch would function mainly during the period in which flying swarms are present in the province.

In order to anticipate the date, location, and probable extent of egg-laying, it is necessary to know the number and approximate size of the swarms within the area and the stage of development of the ovaries of the swarms. For this purpose weekly reports and samples of female locusts from all districts in which swarms occur would be submitted by it to the Entomological Section of the Department of Agriculture. Upon the approach of egg-laying, information would be sent to all affected districts, and preparations made for a campaign.

The executive branch would organize and carry out the control operations on a district basis.

The inspecting branch would watch the progress of the campaign and report to the controlling branch.

The controlling branch would be responsible for supply of equipment, and for co-ordinating and expediting control operations. It might also control the allotment of funds.

1. Intelligence.

The intelligence branch, which will function mainly during the flying period, should consist of members of the district staffs on the one hand, and of the Entomological Section on the other. Its principal work will be to keep track of the movement of swarms and of the development of the reproductive organs of the females. The probable date of egg-laying can only be foreknown at present by following up all swarms week by week and examining the ovaries of specimens of the insects. Further, the probable extent of control operations can only be estimated by knowing the number and size of the swarms within the province; while the probable location of breeding grounds can only be anticipated by keeping track of the swarms.

(*a*) Fliers.

A Deputy Collector, or other competent official of the district staff, should be responsible for obtaining, through the revenue staff, regular reports of the movements of swarms within his district, for consolidating these, and for submitting the consolidated report to me weekly along with samples of locusts from each swarm. Details of the scheme as in operation in Cawnpore district are shown in Appendix B (p. 187.)

With more complete knowledge of the pest, it may in future be possible to dispense with the supply and examination of sample locusts; but at present this is necessary. Reports of the number, size and location of swarms will always be essential to locust control.

(*b*) Approach of breeding season.

When egg-laying is anticipated, the Entomological Section would advise all districts. The Intelligence Officer would then advertise the fact in all villages and offer rewards for first reports of all breeding grounds; and immediately pairing or egg-laying is reported, the executive branch of the organization should become active.

2. Executive.

(*a*) Locust Control Officer.

The Intelligence Officer should normally be given charge of the executive branch, but the responsibility for the adequacy and efficiency of control operations should rest with the head of the district. In severe visitations, during which the whole of the district staff and others may be required to participate in the work, it may be necessary to place an officer of the superior services in charge. In no case should an officer of less standing than a Deputy Collector be placed in charge of the district control operations.

(*b*) District organization.

Necessary staff for organizing control operations should be available, according to requirements, from the staff of the Revenue, Irrigation, Police, Co-operative or other

Government Departments. I do not consider it advisable that senior members of the Agricultural Service should be included in the executive branch.

Where the attack is widespread, the affected areas should be sub-divided into Circles, each in the charge of a responsible officer. Further sub-divisions may be necessary according to the scale of the operations to be undertaken. It is advisable that in every attacked village at least one intelligent individual should be detailed to direct the actual control operations. A *Qanungo* or other officer should be made overseer for a small group of such villages not larger than he can visit daily to organize the operations. The group should be supervised by an officer who would be able to visit at least once in three days and who would be in direct communication with the Locust Control Officer. Co-ordination of work within the village groups and within the Supervisor's Circle would be arranged by the officers in charge respectively. District co-ordination would be arranged by the Locust Control Officer.

(c) Breeding grounds and rewards.

It is essential that a sufficient reward should be offered to ensure that immediate information of egg-laying will be received. I suggest that this should be fifteen rupees per breeding ground. In view of the possibility of a continuous breeding ground covering two or more villages, a liberal interpretation should be placed upon the term, and the reward be available per village for areas not previously demarcated.

Reported breeding grounds should at once be verified and demarcated by the Locust Control Officer, or some other delegated by him, and arrangements made for the preparation of the ring-trench. For the lay-out and digging of the trench the services of subordinates of the Public Works Department might be of great assistance.

Telegraphic information should be sent to my office of the existence of breeding grounds and of the length of oil-cloth strips required for the ring-trenches. When the trenches have been constructed patrols should be placed in charge of its proper maintenance.

Detailed progress reports of the situation and extent of breeding grounds, and of the operations undertaken in connexion with these, and later against hoppers, should be submitted weekly, a copy each to the Commissioner of the division, the Director of Agriculture, the Entomologist to Government and the inspecting officer of the district. (*See* 3 below.)

(d) Hoppers.

(i) *Within the ring-trenched area.*

The Locust Control Officer or the Circle Supervisor should decide upon the need for dealing with the emerging hoppers. Where these operations are likely to be extensive, the Locust Control Officer should, if possible, himself determine their nature.

(ii) *Hoppers outside ring-trenched areas.*

As it is unlikely that all breeding grounds will be detected, the quick discovery of other swarms of hoppers must be provided for. This also should be effected by the advertisement of rewards for information which should be at a lower scale, say, three rupees for first stage hoppers, two rupees for second stage, and one rupee for swarms in the remaining three stages. Such swarms should thereafter be watched until they are destroyed, and the group overseer should be kept informed of their whereabouts.

3. Inspecting and reporting.

It is advisable that the inspecting agency should be independent of the revenue staff. I suggest that this can best be created by utilizing members of the Agricultural Department. The Deputy Director of Agriculture should be the chief inspector for his Circle, Divisional Superintendents and others being detailed by him to particular areas.

The inspecting unit should be such that the inspecting officer can visit and check the progress of work in it not less than once in three days. The inspector in charge of this unit should make daily reports to the officer in charge of his inspecting Circle, who would report to the Deputy Director of Agriculture and to the Entomologist to Government. The Deputy Director of Agriculture should consolidate all reports received by him for submission to the Director of Agriculture and the Entomologist to Government. In the event of inadequacy of provision, or slackness, a special report should be sent immediately to the Director of Agriculture for necessary action, and a copy to the Entomologist to Government for information.

4. Controlling.

The controlling branch should be, for administrative purposes, under the Director of Agriculture. The work of this branch falls under three heads—Supply of equipment, allocation of funds, co-ordination and enforcement of control operations.

(*a*) Supply of equipment.

The supply of equipment should be delegated to the Entomologist to Government who should be responsible for its allocation according to the requirements of individual districts. Proposals for the provision, storage, and distribution of locust control apparatus are made in a later section.

(*b*) Allocation of funds.

I am not in a position to suggest whether this should rest with the Director of Agriculture or be dealt with direct by district officers.

(*c*) Enforcement of control operations.

Power to enforce adequate control measures, upon information supplied by the inspecting branch, should be given to the Director of Agriculture.

CHAPTER III.—Funds and apparatus.

It is essential to locust control that there should be immediate and adequate provision for funds, apparatus and labour.

1. FUNDS.

In dealing with a locust visitation there is no time to waste in arranging for funds, which should be forthcoming immediately to the extent required. It is quite impossible to forecast the requirements for future locust visitations. It is however quite clear that money spent early saves many times its sum later. It is further clear that, whether spent early or late, it is essential that locust outbreaks should be completely controlled.

During the 1929 visitation I am doubtful whether seventy-five per cent. of the hoppers were destroyed, so that the number which escaped is many times that of the original swarms. The aim of control operations should be to eradicate the pest entirely, or at the worst to reduce the numbers in each generation.

The cost of control measures increases with their degree of completeness. It is much easier to destroy eighty per cent. of the swarm than the remaining twenty per cent. The expenditure in the September campaign is therefore no criterion for future work.

Ring-trenching will undoubtedly effect considerable economy over dealing with hoppers after escape from the breeding grounds. Breeding grounds may however be very extensive, and it is possible that ring-trenching operations may require an expenditure of up to forty thousand rupees in any of the more western districts. In addition the destruction of swarms from undetected breeding grounds will have to be dealt with, either by locust screens, or by poisoning; as also swarms in areas where ring-trenching is impossible.

If, therefore, Government decides upon complete control of locust, provision for financing the campaign must be available; and a considerable sum will be required at once. Most of the material for control of hoppers must be obtained beforehand. The nature and cost of this cannot be estimated until decisions have been reached upon:—

Poisoning fliers with baits.

Poisoning hoppers by baits, dusting and spraying.

If swarms of fliers are reduced by poisoning, subsequent operations will be less extensive, provided fresh immigrants do not reinfest the province. Whether reliance be placed on mechanical measures, or chemical methods to supplement these, the cost of necessary materials is unlikely to be much less than three lakhs of rupees.

2. APPARATUS FOR INTELLIGENCE BRANCH.

Samples of at least twenty locusts from each swarm are required to be sent weekly for examination of the ovaries. It is desirable that the containers and the preserving medium should be standardized. Patwaris should obtain about twenty specimens from each swarm which visits their area. The specimens should be preserved at once; otherwise the ovaries are likely to decompose. To ensure the receipt of adequate material in good condition each Patwari should receive from tahsil headquarters one stoppered glass jar of about twenty ounces capacity containing methylated spirit. Locusts from individual swarms can be placed in this; the samples from each swarm in a separate cloth wrapper. The jar containing the locust samples would be sent on a specified day to the tahsil and exchanged for another similar jar. The officer consolidating the tahsil reports for submission to the Locust Control Officer would select a sufficient number of the latest specimens of each swarm, for transmission to the Entomological Section by the Locust Control Officer or direct.

This would entail providing two glass jars per Patwari with reserves of ten per tahsil and thirty per district headquarters.

About twelve ounces of methylated spirit will be required per jar; arrangements for the purchase and distribution of this will require to be made, provision being allotted to districts according to their requirements. Stoppered jars of the size required cost approximately fifty rupees per hundred.

3. APPARATUS FOR CONTROL OPERATIONS.

The nature and extent of apparatus required to be held in stock depends upon whether or not Government proposes to utilize poisons. If poison baits, dusting, or spraying are to be generally employed, there will be less need for locust screens. This would, however, not reduce the need for American oil cloth for use in ring-trenches.

A. Oil-cloth strips.

[*See* (C) (ii) Oil-cloth protective strip, page 168.]

The stocks of suitable American oil-cloth in India are always limited, and there is great delay in obtaining such as is available in the wholesale markets. We should have sufficient American oil-cloth on hand to meet all ring-trenching requirements without recourse to local purchases.

I have no information of the total areas of the breeding grounds in the various districts, but doubt if these could have been ring-trenched and sub-divided with less than three lakhs of yards of trenches. Breeding in the next generation will possibly be more extensive, and I consider that we should be prepared to issue oil-cloth strips sufficient to protect at least eight lakhs of yards of ring-trenches. The standard width of American oil-cloth allows eight strips six inches wide to be cut. One lakh of yards will therefore be necessary. If the material is purchased direct, it should be procurable at about one rupee and eight annas to one rupee and twelve annas per yard. We have at present sufficient American oil-cloth for eleven thousand five hundred yards of trenches only. Orders should therefore be placed as soon as possible for ninety-eight thousand six hundred yards of oil-

cloth to make up the deficiency. For reasons given below I consider that this should be obtained through a local agency ; preferably the Muir Mills, Cawnpore, as they are familiar with our requirements. [*See* (*a*), page 182.]

B. Locust Screens.

[*See* (iii) Locust screens and barriers, page 170.]

It will be unsafe to anticipate that more than ninety per cent. of the breeding grounds will be located. If the swarms now present in the United Provinces survive to breed there, or if fresh swarms move in from the west, it is possible that in the next generation as many hoppers may be existing outside ring-trenched areas as in the whole of the September visitation. Extensive operations may also be necessary within large ring-trenched areas.

If reliance is to be placed solely on mechanical methods, and all locust swarms are to be destroyed within ten days of hatching, the number of locust screens must be very considerably increased. We have at present eleven thousand five hundred yards available, forming forty-eight standard sets of two hundred and forty yards each. At least ten sets should be available for each of the western districts, and four sets per district for the remaining districts of the province, say, two hundred and sixty sets in all. These would be required within fourteen days of egg-laying. Within this time, about one hundred sets can be prepared by the Muir Mills provided oil-cloth is available.

I recommend that the balance of one hundred and twelve sets should be ordered and held in stock in anticipation of requirements.

Each set costs about Rs. 325 complete with stakes and implements. Rupees 36,400 would be required now, and a further Rs 32,500 if warranted by the scale of the visitation.

C. Canvas traps.

[*See* (iv), page 171.]

The extent to which canvas traps must replace pits in driving operations cannot be forecast. The areas over which rocky sub-soil or the natural hardness of the soil during the dry months would preclude the digging of trenches or pits should be elicited from heads of districts ; and canvas traps should be prepared accordingly. The digging of the ring-trenches will indicate what additional canvas traps would be necessary, in time to get them made.

The traps cost approximately Rs. 100 each complete.

D. Poisoning apparatus.

If poisoning by dusting or spraying is decided upon, an adequate supply of apparatus must be ordered. Stocks held in India, mainly in Calcutta, are inadequate to meet the requirements of an extensive locust control campaign.

(*a*) Poison baits.

[*See* (*a*), page 166 and (i), page 173.]

Expensive apparatus is not essential to the preparation of poison baits. Where large quantities are required it is more economical to mix these by machinery, but this can probably be arranged for at suitable centres by oil mills and the like.

For the scattering of bait mechanical drills are quicker and more efficient than distributing by hand, but are not indispensable. The only essential apparatus is a large stock of containers which can be obtained locally.

(*b*) DUSTING APPARATUS.

[*See* (ii), pages 173 and 174.]

The dusting method has been dealt with in detail under " B.—Chemical Control, (*b*) (ii)," pages 173 and 174. If dusting is to be widely employed. the apparatus must be obtained beforehand.

(i) *Hand-operated powder-guns.*

Working in the morning and evening, each should be able to poison two acres per day. Night work would double their efficiency. I suggest their being used in units of five. For dealing with small swarms in dense crop and in grass jungle, I estimate that two hundred would be required for a visitation on the scale of that of September. These cost approximately rupees forty each, and call for provision of Rs. 8,000.

(ii) *Power plant on motor vehicles.*

The cost of power dusting machines suitable for dealing with big swarms of hoppers would be approximately Rs. 5,000 each, additional to the cost of the vehicles. One such machine would be able to poison about six thousand acres per day working throughout the day, exclusive of time taken up by journeys. Expressed in terms of locust swarms, it should be able to poison a band of vegetation about four hundred yards wide on a five-mile front in an hour. In view of the area visited by locusts in September, at least two such sets of equipment would be required in the event of a heavier infestation.

(iii) *Aeroplanes.*

Aeroplanes flying from thirty to fifty feet above the area to be dusted can dust from fifty to seventy-five acres per minute, and are by far the most effective medium for distributing poison dust against swarms of hoppers. They have also been used with considerable effect for scattering sodium arsenite over swarms of fliers. It is probable that if this method is to be employed machines and airmen, experienced in this form of control operations, would have to be obtained from the United States of America.

(*c*) SPRAYING APPARATUS.

The use of stomach poisons in liquid form has been discussed in (iii) Spraying, page 174.

I recommend this method only for the treatment of grasslands with sodium arsenite. The extent to which it may be necessary is a matter for inquiry from districts. I am at present unable to estimate probable requirements.

(i) *Knapsack sprayers.*

These cost approximately rupees ninety each, and should be used in batteries of ten. Such units would be able to spray about ten acres per day.

(ii) *Power sprayers.*

Where the locality is suitable for motor transport and the area to be covered is large, power sprayers are much more economical and efficient. Moving ten miles an hour, one machine should spray about fifty acres per hour. It will take about six hours to spray a sufficiently wide belt to deal with a swarm on a five-mile front. The cost of such plant would be approximately Rs. 7,000 exclusive of the vehicles.

E. Poisoning materials.

[*See* " B.—Chemical control," page 166 and pages 172 to 174.]

For immediate application, and possibly for some time, the only poisons available in sufficient quantity will be arsenicals. These have been very widely employed in countries whose cultivating classes are no more literate than the average Indian ryot, though

not to my knowledge in areas so densely populated as many parts of India. I see no reason why this method, provided proper warning is given in the treated localities, should not apply as well to India as, say, to the Philippines, Malaya, South Russia, and North-Western Asia, in all of which it has been extensively employed.

When sufficient quantities of sodium fluosilicate can be obtained, the incidental risks of the poisoning method will be greatly reduced, as this will largely, if not entirely, replace arsenicals in all methods of poison distribution.

If this material cannot immediately be obtained in sufficient quantity, I recommend that arsenical poisons should be utilized.

If poisoning is to be employed against the present flying swarms, provision should be made for this immediately; while for extensive chemical control of hoppers, sufficient material must be obtained beforehand.

(*a*) Poisons for use against fliers.

[*See* "(*a*) Poison baits," page 166.]

The alternative to sodium fluosilicate for preparing baits for poisoning fliers is sodium arsenite. I estimate the quantity of poison required, to effect persistent poisoning of all flying swarms, at four pounds per village in the western border districts, and four pounds per five villages in the remainder of the province. Additional to the poison, the foundation material and attractants must be provided for, as also the distribution of the prepared bait. An outside estimate of the cost is ten rupees per village in the first category and three rupees per village for the rest of the province.

(*b*) Poisons for use against hoppers.

[*See* "B.—Chemical control (Hoppers)," pages 172 to 174.]

Until the figures of the extent of attack by locusts in the September visitation have been received and consolidated, it is not possible to offer any estimate of the quantity of poison which would be required. Even with these figures the quantity can only be approximately estimated.

In the next generation we may be required to deal with swarms, outside ring-trenched areas, equal to the total September visitation. I estimate that of these about thirty per cent. could be dealt with more economically by poisoning than by driving, and that for at least ten per cent. poisoning is the only effective method. As we should aim at eradicating the swarms before they reach the third stage, provision need only be made for the area infested in September during the earlier stages. This I estimate to be about one-fortieth of the total. Allowing three pounds of poison per acre, the formula for obtaining a rough estimate of requirements will be $\frac{\text{Total area attacked} \times 3}{3 \times 40}$ or one pound of poison for every forty acres of the total area attacked.

(*c*) Supplies and cost.

(i) *Sodium fluosilicate.*

Of the materials now employed against locusts, sodium fluosilicate best meets the local conditions. I do not yet know the cost of this insecticide, or whether it can be obtained in sufficient quantity in time. When available, this should be used in all methods of application.

(ii) *Calcium arsenate.*

Calcium arsenate is available in limited quantities from manufacturing chemists in India at a cost of approximately ninety rupees per cwt. This would be suitable for dusting or for spraying on crops. Larger quantities to be obtained locally would require several weeks for preparation.

(iii) *Paris green.*

This is available in quantities up to half a ton at Rs. 140 per cwt. Further quantities can be manufactured at the rate of a ton a week. Paris green can replace calcium arsenate for dusting or spraying on crops.

(iv) *Sodium arsenite.*

This is immediately available in small quantities at Rs. 100 per cwt. Local supplies would probably meet all demands for this poison for spraying grasslands; larger quantities if required for the preparation of baits can be obtained locally at the rate of a ton or more per week.

4. STORAGE AND MAINTENANCE.

As large and valuable stocks of material for locust destruction are proposed to be obtained, it will be necessary to make proper arrangements for their storage and maintenance. For convenience I propose to consider separately American oil-cloth, locust screens and traps, dusting or spraying apparatus, and chemicals.

A. American oil-cloth.

This is a perishable material liable to become useless in the Indian climate if not properly cared for.

(*a*) UNISSUED STOCK.

"I have suggested above (A.—"Oil-cloth strips," pages 178 and 179) that the oil-cloth required should be obtained through a local agency, preferably the Muir Mills. The purchasing agency should hold the stocks until required for issue and should undertake the preservation of its condition so far as is possible. Such an agency would be able to give regular and proper attention to the stock more cheaply and satisfactorily than if it were held departmentally. Inquiries are being made as to the proper method of preservation of American oil-cloth.

(*b*) ISSUED STOCKS.

I do not think it desirable that oil-cloth issued and cut into strips should be returned to Cawnpore. This should be assembled at suitable centres when the campaign against hoppers is finished. The most suitable place for storage will probably be the circle headquarters of the Deputy Directors of Agriculture. These officers should be responsible for the care and maintenance of the material under routine inspection by the Entomological Section.

B. Screens and traps.

These also should be assembled at circle headquarters. Particular care will have to be given to screens and canvas traps to protect them from damage by white ants and by rats.

C. Dusting and spraying machines.

I consider that these should be stored at Cawnpore in the Agricultural Engineering Section where they could be maintained in a proper state of efficiency.

D. Poisons.

Unissued stocks of poisons should be in the charge of the Entomological Section, and stored at Cawnpore. Unutilized material issued to districts may either be stored with Deputy Directors of Agriculture or returned to stock in Cawnpore.

5. LABOUR.

The supply and organization of labour is the most important factor in a locust control campaign.

Voluntary labour is unsatisfactory and difficult to obtain when the work is arduous and protracted. I consider therefore that where the supply of voluntary labour is inadequate, or the response unequal so that the burden falls unjustly, power of compulsion must be provided. This should apply to all cultivators and occupiers of land, who should assist, either in person or by providing substitutes, in all operations when requisitioned.

I do not recommend that this should be *begar* labour; or that payment should be the invariable rule. Compulsory service, with optional receipt of payment, should meet the case of the superior sort of cultivators who would be offended by the offer of wages, and of those upon whom protracted unpaid work would inflict hardship.

I am not competent to define the classes to whom compulsion should apply. The effects of the locust invasion are not limited to the agricultural classes, and it may be that the whole community should be required to fight it.

(*a*) CASES FOR NON-PAYMENT OF WAGES.

Protective trenches isolating crops within the ring-trenched area [(*b*) (ii), page 169] should be prepared by or at the expense of the occupiers without payment.

(*b*) CASES FOR OPTIONAL RECEIPT OF WAGES.

(i) *Bait spreading* [(*a*) (ii), page 167].

The spreaders of bait against flying swarms should receive wages if they desire. This requires to be done with judgment and expedition, and casual voluntary assistance should not be relied upon.

(ii) *Destruction of fliers by night* [(*b*), *page 166*].

To effect destruction of flying swarms by night it will be necessary that large numbers of villagers turn out in the very early hours of cold mornings. They are unlikely to do this unless they receive payment.

(iii) *Trench preparation* [(*a*), *page 170*].

It may be desirable to hire labour for the preparation of trenches for driving without screens as this work is apt to be laborious and reliance upon voluntary labour often leads to delay. This is the most arduous part of control operations and optional payment for this purpose is justified.

(iv) *Driving* [(*a*), *pages 170—172*].

In general the labour for driving swarms should not require payment unless the operations in one village are protracted when payment would be optional.

(*c*) CASES FOR HIRED LABOUR.

(i) *Ring-trenches* [(*a*) (*i*), *page 168*].

The construction of ring-trenches requires to be carried out thoroughly and expeditiously and should be done on contract or by hired labour.

(ii) *Maintenance of ring-trenches* [(*a*) (*iv*), *page 168*].

Patrols for maintaining ring-trenches will be required over a considerable period, and individuals should be responsible for definite sections, the care of which will require their whole time.

(iii) *Locust screens* [(*a*) (*iii*), *pages 170 and 171*].

Each set of screens should have a permanent gang of six paid labourers for its transport and erection, the digging of pits, and assistance in directing the line of beaters. Much time is wasted and efficiency impaired when this work is left entirely to untrained villagers.

(iv) *Daily wage earners.*

Agricultural labourers and other daily wage earners who are required to assist in control operations should normally be paid; as should all Chamars or other low-caste workers required in connexion with the handling and disposal of dead hoppers.

(*d*) PAYMENT BY RESULTS.

With the possible exception of flying locust, I am averse to the system of payment by results. It is hardly necessary to stress the point that only the more easily obtained of egg-masses or of swarms would ever be dealt with by this method.

6. LITERATURE.

The widespread distribution of a simple illustrated pamphlet in English and the vernaculars should assist in the detection of breeding grounds and in encouraging effective work against hoppers. It is likely that this can most satisfactorily be done by districts issuing their own pamphlets in the vernaculars on the basis of a pamphlet prepared in English, the illustrated portion being supplied for incorporation.

CHAPTER IV.—LOCUSTS AS AN ALL-INDIA PROBLEM.

From no single point of view can the locust question be dealt with effectively by individual Provinces. Unless an organization is created which covers not only the various Provinces affected, but also the Indian States, individual effort by Provinces will be protracted until natural causes end the visitation. It is impossible to anticipate when this may be.

1. INVESTIGATION.

We are at present very ill-informed about the biology of *Schistocerca gregaria*, the locust which is responsible for the present visitation. This insect appears to have been breeding in India since the end of 1925 in various Provinces and Indian States, few of which have the staff and facilities for carrying out entomological investigation. Even where staff is available its first business in a locust visitation would have been the control of the pest rather than the biological investigation. Moreover, the wide flight range and migratory habit of the insect makes continuity of observation impossible within one Province.

Among the points upon which information is required are whether or not *Schistocerca gregaria* has permanent breeding places in India in the gregarious or non-gregarious form; whether oviposition may be expected at definite periods, and two, or more than two, broods are produced each year; whether the females deposit all their eggs at once or the egg-laying period is protracted. Such questions can only be answered by an investigation which embraces the whole area subject to visitations by this locust.

2. INTELLIGENCE.

The appearance of swarms of locusts, and the methods used in, and progress of, control campaigns only become known casually, if at all, as between Provinces; and probably never where Indian States are concerned. The disadvantages of this, from the points of view of preparedness, method, and effectiveness, need no stressing. A Central Bureau, in close touch with all Provinces and Indian States subject to locust attack, should be established under the Central Government.

3. APPARATUS AND TECHNICAL STAFF.

It would be advisable that the major apparatus, and adequate stocks of insecticides, should be provided for, and issued as required to affected areas, by the Central Govern-

ment; and that where technical supervision is required the Central Government should be in a position to find it either from their own staff or by arrangement with local Governments.

4. CENTRAL CONTROL.

The Central Government should possess the power to carry out, or to enforce the carrying out of, effective control measures wherever locusts occur.

I presume that these matters, as also the question of the financing of an all-India campaign against locusts, will be fully considered at the forthcoming meeting of the Imperial Council of Agricultural Research. I consider that it is impossible to lay too much stress upon the fact that local, and therefore incomplete, attempts to eradicate locusts are wasteful of the country's resources; and that no effort should be spared in surmounting the difficulties attendant upon the creation of an all-India scheme.

APPENDIX A.

A brief account of the life-history of Schistocerca gregaria Forsk.

1. General description of the adult.

There are two phases in the biology of this migratory locust: solitary and gregarious. In the solitary phase the insects live separately and do not assemble in swarms. It is not yet known whether the solitary phase occurs in India, nor is it clear under what conditions the solitary changes to the gregarious phase.

In the gegarious phase the adults fly in swarms of considerable dimensions, often migrating many hundreds of miles. The length of the adult life is not certain, and is probably dependent upon weather conditions and availability of food, the period being longer under adverse than under favourable conditions. The determining factor in this appears to be the development of the ovaries in the females. With plentiful food and congenial climatic conditions the development of the eggs is accelerated. During the warmer months in India the flying period is probably from twelve to sixteen weeks, but may be considerably longer during the cold months.

The general colour of the young adult locust is brown with a slight tinge of mauve or pink, the wings being transparent and colourless except for brown patches. The reproductive organs, which are rudimentary when the adult winged condition is first attained, develop gradually with age, and there is a corresponding change in colouration, in which yellow predominates, as the breeding season approaches.

2. Coupling.

When about to breed, the swarm descends on fallow, uncultivated, open ground, and coupling takes place, the areas selected usually being very densely crowded with the paired insects. Coupling occupies a few hours and the females usually deposit their eggs immediately after.

3. Egg-laying.

The eggs are laid in holes in the ground, the holes being excavated by the females by means of four horny plates at the end of the abdomen. Light well-drained soil with little or no vegetation is usually selected for the breeding ground.

Egg-laying usually takes place immediately after coupling but this is not an invariable rule. The egg-holes are generally close together, often several to the square inch. They are excavated to a depth of two and a half to three inches and the sausage-shaped eggs are deposited in the hole in a protective matrix of spongy material, a cap of which also covers the egg-mass at a half to one inch below ground level. Each egg-hole may contain from forty to one hundred and twenty eggs.

It is not yet known whether *Schistocerca gregaria* lays all its eggs at once in India or whether two or more batches of eggs are laid at intervals In North Africa this species is stated to lay as many as ten batches of eggs per female with a total egg production of eight hundred to a thousand, the egg-laying period being extended over several weeks.

4. Embryonic development.

The time required for the development of the young locusts in the eggs varies between twelve and forty days according to climatic conditions. Such as have bred in the United Provinces in 1927 and 1929 hatched after fifteen to twenty days.

5. Hatching.

The larval locust forces its way out of the egg-mass and up through the egg-hole to the surface, being protected from injury by a thin embryonic covering which is shed almost immediately. The young insect is then identical in external structure with the adult, save that it has no wings and is therefore called, in technical parlance, a nymph.

6. Nymphal development.

Locusts, in common with all insects, develop by a succession of moults, the old skin being cast off and a larger stage resulting. Five such moults occur in the development of *Schistocerca gregaria*. Locust nymphs are commonly called hoppers.

(i) *First stage hoppers.*

These are about one-third of an inch long, very nearly black in colour, and move more by running than by hopping although they are capable of making jumps of two or three inches. The individuals on casual inspection appear not unlike big black ants.

They are able to travel distances of three or four miles in search of food but usually remain in compact swarms feeding as they proceed, the individuals at the back moving forward to the front as food material becomes used up.

(ii) *Second stage.*

The second stage may be reached within five days after hatching or may be delayed if food is scarce. The hoppers climb up plants or banks, or the walls of houses, for moulting which is effected in a head-downward position, the cast skin remaining attached to the support. The freshly moulted nymph inflates itself to its greatest extent while the new skin is soft. This quickly hardens and no further increase in size can take place until the next moult. The second stage hopper is over half an inch long and the black colour is relieved by small patches of yellow on the body. In this stage also the young locusts generally move or feed in dense swarms. They are able to jump five or six inches in length. This stage occupies five or more days according to circumstances.

(iii) *Third stage.*

The third stage hopper is over three-fourths of an inch in length. The coloration is much brighter, the head and patches on the body being reddish yellow ; and the developing wings are visible as small black pads on the thorax. The insects are much more active, and can jump about a foot. The swarms are usually less compact and tend to split up. This stage occupies five days or more, dependent upon temperature and availability of food.

(iv) *Fourth stage nymphs.*

At the third moult a very considerable increase in size takes place, the fourth stage hoppers being about one and one-sixth inches long. They are extremely active, can jump at least fifteen inches, and are very voracious. The coloration in this stage is predominantly red, the black markings being much reduced. The developing wings are very obvious as yellowish-green, triangular out-growths on the upper side of the thorax. This stage occupies six or more days.

(v) *Fifth stage nymphs.*

This is the final immature stage. The individuals are over one and a half inches in length, yellowish green with small black markings. The wing pads are very prominent, nearly a quarter of an inch long, yellow with black veins. The hoppers in this stage can jump several inches in height and about two feet in length.

The fifth stage occupies nine days or more.

7. Final moult.

At the fifth moult the locust attains the adult condition, has its wings fully developed, and is incapable of further growth in size. The emerging adult is pale and flaccid, with white crumpled wings which expand and dry in a few minutes but which, along with the integument (skin), require two or three days to harden off. During this period the locusts move mostly along the ground, but are capable of short flights. Thereafter, the integument having set and the wing muscles strengthened, they are able to perform extensive flights.

8. Behaviour of nymphs.

In the intervals between moulting the nymphs are very active, remain in swarms and can readily be driven from place to place along the ground. When about to moult, and for a short time after moulting, they become more sluggish and are difficult to keep on the move. At such times driving the swarms is practically impossible.

9. Feeding.

The hoppers feed during the active periods between moults. In the first two instars feeding is mostly by day, and may be almost entirely on low-growing weeds. In the later stages feeding continues throughout the twenty-four hours if the climatic conditions permit, and it is in these stages that most of the damage to crops by hoppers is done.

The adult swarms settle at will for feeding. Trees, crops and jungle serve their purpose equally well.

On crops, if the swarm is scattered, or it remains only for a short time, little apparent damage results. If however the swarm is large and dense, the whole of the crop may be stripped within a few hours. The damage done is sporadic, but none the less serious in the aggregate and continues so long as the flying swarms remain. It has been estimated that during their nymphal development the locusts consume at least one hundred times their ultimate weight. The total consumption during the maturation of the adults probably greatly exceeds this.

10. Division of swarms.

The increase in bulk of the hoppers in successive stages is approximately proportional to the cube of the length, and there is a corresponding increase in activity and in food consumption. Consequently, after the second moult there is an increasing tendency for the swarms to split up.

APPENDIX B.

Outline of district intelligence and organization.

If any swarms have appeared in their villages, Patwaris obtain twenty specimens and preserve in spirit, sending these to tahsil weekly with their report upon the size of swarms—area occupied if settled, estimated length and breadth if flying over—as also the time and direction of approach and departure. Damage done is recorded as to area and intensity.

Tahsils submit consolidated reports, with suitable specimens of each swarm, to the Locust Control Officer weekly.

The Locust Control Officer digests the tahsil reports, maps out the number and movements of the swarms, and reports to the Entomologist to Government, United Provinces, along with locust specimens.

Comment.

Weekly reports, if received in this form from districts, can readily be correlated in my office. Daily reports by letter and telegram are unnecessary, and do not fulfil their purpose nearly so well.

(*f*)

THE DESERT LOCUST IN THE PUNJAB.

(M. AFZAL HUSSAIN, *Entomologist to Government, United Provinces.*)

INTRODUCTORY.

Schistocerca gregaria (Desert Locust) has a very wide distribution and may be considered as a crop pest of three continents. It often reaches Spain and Portugal, is a constant pest over most of North Africa and extends over Western Asia and India, where its attacks are well known in Sind, Rajputana and the Punjab. Since 1843 this insect has invaded the Punjab eight times, and on each occasion it has laid eggs and continued to breed in the province from four to six years, as shown by the following record :—

1843.

1863-66.

1869-73.

1876-80.

1889-94.

1899-1907.

1913-17.

1926-29 (continues).

The extent of the area infested has varied. When wide-spread, it does a great deal of damage, as has happened during the last three years, *i.e.*, 1927-29. For the Punjab, therefore, the Desert Locust is undoubtedly a serious pest.

The invasions for which definite records are available show that the pest comes from Sind and Rajputana into the Punjab. In 1889-94 the Desert Locust was first noticed in Sind and Rajputana in June 1889 and entered the Punjab at Sirsa in July and Dera Ismail Khan in August. In 1913 and 1915 once more locust swarms entered the districts of Multan, Montgomery, Muzaffargarh, Ferozepore, Hissar and Gurgaon, *i.e.*, the districts adjoining Rajputana, simultaneously in July and spread over the greater part of the Punjab. In 1926-27 locust swarms were appearing in Sind from the end of September 1926 onwards and they reached the Upper Sind Frontier by the second week in November and flew over Dera Ghazi Khan on the 16th-17th December and spread over the greater part of the province. In 1929 the first swarm of the year entered Rajanpur tehsil of the Dera Ghazi Khan district (extreme south-west corner of the Punjab).

This brief survey, although based on data which cannot be considered as absolutely complete, brings out some important points. The path taken by the swarms invading the main Punjab (excluding the Ambala Division), which may be called the south-western swarm, has been mainly through the south-west corner of the province. This was the route taken by the swarm of 1899 and 1926-27 and 1929. The 1913 swarm attacked all along the southern frontier adjoining Bahawalpur and Rajputana. The swarm invading the Ambala Division, particularly the south-east corner of the Punjab, usually arrives at

a later date than the south-western swarm. Thus in 1926-27 Dera Ghazi Khan was visited about the middle of September, but Gurgaon was invaded during the last week of January and the beginning of February.

It is evident that, although locust swarms arrived in the Punjab fairly frequently, yet they are not able to maintain themselves permanently in any part of the Punjab. Occasionally a few isolated breeding areas may become established, but the climatic conditions do not enable the Desert Locust to make any part of the Punjab its permanent home.

Original Home of the Migratory Swarms which Invade the Punjab.

Cotes, on the basis of his study of the movements of the 1889-92 swarms, came to the conclusion that the sand-hills of the desert in Sind and Western Rajputana are the breeding grounds of the Desert Locust. On one side the swarms enter the Punjab through the south-west, and on the other cross over Rajputana and enter the south-east portion.

Lefroy and Mann and Burns also consider Sind and Western Rajputana as the home of the Desert Locust.

Lt.-Col. Webb Ware, on the other hand, is of opinion that the Kirman Desert is the real breeding ground of this locust which visits Baluchistan and passes on to Sind, and he suggests that the progeny of the swarm may also pass on to the Punjab. Even if it is so, and the swarms start from the Kirman Desert, it seems likely that Sind and Western Rajputana are the encamping grounds where swarms stay and multiply before invading the Punjab.

The fact that the south-western corner of the Punjab is the first to be invaded, and is more frequently visited than another part, shows that the breeding grounds lie in close proximity of this locality, and Sind and Western Rajputana appear to be the likely tracts.

Although no definite survey has been undertaken yet, the fact that for some considerable time all parts of the Punjab remain free from locust attack shows that within the boundaries of the province there are no permanent breeding grounds.

Further, there is no record of the presence of the solitary phase in any part of the Punjab. It must, however, be admitted that no proper survey has been undertaken to discover the solitary phase in this province; but, if it had existed, the possibilities are that it would have been noticed.

Bionomics.

Absolutely nothing is known about the bionomics of the solitary phase of *Schistocerca gregaria*, Forsk., and the information about the migratory phase is very scanty and indefinite, based mainly on reports of district officials and in a few cases on isolated observations. From the record of egg-laying in the Punjab two broods can be followed. For instance, the swarm which appeared in December 1926 and January 1927 laid eggs mostly during March and April 1927, and the second brood laid eggs in July and August 1927. Reports of egg-laying were received again in April and May 1928. The swarm that entered the Punjab in April 1929 laid eggs in April and May in Multan and Campbellpur, and the second larger swarm that entered the Punjab in July and August laid eggs in August 1929. The previous records of locust invasions support the above observations. Thus in 1863 egg-laying took place in February and March in Shahpur district, and July and August in Hissar district. Eggs were laid in Hissar district during July 1864, June 1865 and July 1866. In 1869 egg-laying occurred in Dera Ismail Khan in April and in Hissar in July. In 1870 eggs were laid in August in Amritsar and in 1872 early in July in Rohtak and Jhelum. In 1890 egg-laying took place in March in Peshawar and Rawalpindi, in June in Gurgaon and in August in Kohat, Amritsar and Ferozepore. From this it will appear that February to April and July to August are the two egg-laying periods. Egg-laying in June may be explained as a delayed occurrence for the spring brood.

There are some stray reports of egg-laying in September, and even October. Thus in 1869 oviposition was reported from Hissar in September and October. In 1889 once

again egg-laying was reported from Dera Ismail Khan in September and October. Another report of egg-laying in September and October 1860 was received from Hissar. There is a solitary record of egg-laying in Jhelum on 20th December 1913. These stray records of oviposition have been explained by Cotes as early performances of the summer brood, although the usual time of oviposition for this brood is February and March. It is difficult to say what reliance should be placed on these reports.

The data available from other sources regarding the number of generations is also contradictory. Some investigators only admit a single generation in a year, while others are quite certain of two. Uvarao (1928) is of opinion that of the swarming phase there is probably a single generation, while the solitary phase may have more. For those making reports of the appearance of locust swarms or egg-laying it is difficult to judge where the solitary phase of the pest begins and the swarming phase ends. The adults live for many months and the broods therefore overlap, and this adds to the difficulty of definitely determining which of the broods have laid eggs in a particular area.

Regarding the life-history of the Desert Locust, the following account is based on observations made in the Punjab. During the spring the egg stage occupies 21-23 days, and the duration of the nymphal instars is 42-47 days. Thus a complete life-cycle occupies 9-10 weeks. The eggs laid in July hatch in 12-14 days, and the duration of the nymphal instars is about 37 days, the total life-cycle of the summer generation occupying less than 8 weeks. Thus the winged locusts begin to appear about the end of April and lay eggs in July-August and the next brood of winged locusts appears in September and continues to exist till March and April, when oviposition occurs. There is often slight overlapping of the two broods.

There exists a great deal of confusion regarding the bionomics of this insect, and the problem needs a very careful and detailed investigation.

Damage.

The winged locusts arriving in the Punjab do not cause much damage unless they arrive soon after attaining the winged stage, when they continue to feed till sexually mature. The main damage, however, is caused by the young hoppers which take birth in the Punjab. They complete their entire life-cycle eating up vegetation, and the winged stage also feed on crops and cultivated plants till mature for oviposition.

Besides eating up plants of economic value, they enter houses, fall into wells and tanks, render water unfit for use, hold up railway traffic and make life generally miserable.

Preventive Measures.

The measures adopted to prevent a flying swarm from descending consist of making noises, vocally by yelling and shouting, mechanically by beating tom-toms, empty canisters, etc., and by exploding bombs; also by waving cloths and branches of trees, etc. The procedure, even if effective, may help individual farmers, but is of no avail to the community at large. The swarm does descend somewhere, and, wherever it spends the night, it usually plays havoc.

Control Measures.

The control measures that have been tried in the Punjab have consisted of egg-collection, killing hoppers by driving them into trenches and burning adults and hoppers that have collected on bushes, etc., at night. Spraying has also been tried. Recently half a dozen flame-throwers were obtained and given a trial. These were found to be very expensive. A single charge of fuel (two gallons kerosene oil) costs Re. 1-8-0, and it is burnt in about ten minutes. During this period a very active person cannot deal with an area bigger than 750 square yards.

Egg-collecting has been done on a fairly large scale in certain districts; for instance, during the year 1927, 125 maunds of eggs were collected at one place (Pindigheb) in the Attock district. The difficulty, however, is that the cultivators usually want rewards for the eggs they collect; thus the method becomes expensive; and, what is more, very little

money filters down to the right person. Further, as it is not possible to collect all the eggs the hoppers hatch out in most cases, and trenching has to be practised. The zemindars therefore prefer trenching.

Trenching, when well organized, as it was in the Gurgaon district during the recent (1929) visitation of locusts, is a very effective, although a laborious, method. Its advantages are that every kind of machinery is eliminated, no precautions are necessary and there is no danger to human life or domestic animals.

In the Punjab, which is mostly very thickly populated, and where during locust years wide areas averaging many thousand square miles may be affected, such measures as baiting, gassing, spraying and burning with flame-throwers cannot be adopted economically and without danger to human and animal life. Under strict and trained supervision all these methods are possible, but the expense will be prohibitive. Moreover, the requisite machinery will have to be provided in districts, and that will be an expensive item.

The possibilities of biological control are evident, but very little definite information is available.

Over an unpopulated area where locusts breed, baiting, gassing and burning may prove very effective.

Natural Control.

It is fortunate that in the Punjab locusts do not survive very long, and even in the hotter and sandy parts of the province these insects have not been able to establish themselves permanently. This appears to be the direct result of climatic factors, particularly of severe cold.

Birds also play an important part in destroying locusts, but they are only a factor of secondary importance.

Organization for Locust Control.

In so far as the (British) Punjab is concerned, it may be stated with confidence that the permanent breeding grounds of *Schistocerca gregaria* do not lie within the boundaries of this province, and the swarms that visit the Punjab most probably come from Sind and Rajputana, and possibly—although rarely—from the Suleman Range or the sandy deserts of Baluchistan. One is inclined to think that the migratory swarms from Persia very rarely, if at all, reach the Punjab. The possibility of such an invasion, however, cannot be ingored.

The general consensus of opinion is that the sandy deserts of Sind and Rajputana are the permanent breeding grounds of this species and the source of swarms invading the Punjab.

The important point to be considered is this—

> Should the swarms be prevented or suppressed in the place of origin, or should they be controlled when they have spread over vast areas? One is inclined to hold with the poet—
>
> "The mouth of a spring it may be possible to plug with a needle, but when it is full it may not be possible to cross this spring on an elephant.—(*Sa'adi*)."

There are difficulties, one must admit, but they are not so great as those confronting us in the Punjab, where locusts spread over thousands of square miles of our fertile land. Thus efforts should be made to control locusts in their breeding grounds in India, and an inter-provincial organization set up for this work and for supplying information regarding the swarms.

Lines of Investigation.

1. Survey of the regional distribution of *Schistocerca gregaria* in the solitary phase, with a view to discover permanent breeding grounds.

2. Study of the pest in its original home, with special reference to the ecology of the insect and the factors responsible for its rapid multiplication and appearance of migratory phase, including a co-relation of climatic conditions and migratory swarms.

3. Behaviour of the solitary and migratory phases, particularly chemotropic responses, with a view to discover attractants for poisoning and baiting.

4. Preventive and control measures in permanent breeding-grounds, including possibilities of biological control.

The work can be best done by a Central Organization, with its headquarters in Sind and Rajputana, and this might be affiliated to the International Organization for Locust Control.

APPENDIX VI.

Note on Subject IV.—The desirability of discussing the subject of the best means of bringing improved methods of agriculture to the notice of the cultivators at future meetings of the Board of Agriculture.

(B. C. BURT, *Agricultural Expert, Imperial Council of Agricultural Research.*)

The Royal Commission on Agriculture, in paragraph 129 of their report, express regret that the periodical discussions on "The best means of bringing improved methods of agriculture to the notice of cultivators," which had formed a feature of the meetings of the Board of Agriculture from 1905 to 1917, had been discontinued. The Commission suggested that such discussion should be re-established, and in Chapter VI of their report repeatedly lay stress on the importance of periodical reviews of the effectiveness of different forms of propaganda. The report quotes as instances, where the Board has yet recorded no considered opinion, such questions as the comparative value of demonstration farms and demonstration plots and the extent to which the Agricultural Departments can use organised bodies to further their propaganda work.

2. The discontinuation of this annual review of propaganda methods did not result from any formal resolution of the Board of Agriculture though a proposal that the subject should be dropped was made at the Board of 1917. It was then felt that with undermanned departments in every province it was experimental work rather than propaganda which was in danger but there was also undoubtedly a certain feeling that the discussions had served their purpose for the time being. At the earlier meetings of the Board many of the agricultural officers present were new to their work and had only comparatively short experience of India ; in consequence the interchanges of opinion on methods of introducing improvements were of the greatest practical value to those who took part in the discussions. But by 1917 the relative value of the more important methods of propaganda had been established, work had settled down on sound lines, and most agricultural officers, far from finding difficulty in getting into touch with cultivators, found it difficult to meet their demands with an attenuated staff. But it may be noted that although this subject was dropped as such, closely related subjects continued to receive attention ; as examples may be quoted :—Village panchayats, preparation for famine conditions and the improvement of cotton marketing in 1919 ; the line of demarcation between agriculture and industries in 1921 ; a review of the progress made in non-credit agricultural co-operation and a review of the progress made in popularising improved agricultural implements in 1924 ; the consideration of the extent to which the co-operative departments can co-operate with agricultural and veterinary departments on cattle matters in 1926.

3. The Royal Commission's report itself contains an important review of the relative importance of various methods of agricultural propaganda, the related subject of the introduction of agricultural improvements through the medium of co-operative societies, and the equally important question of the organisation of seed-supply. The report draws attention to the need for a periodical review of propaganda methods, and doubtless each Local Government will arrange for such reviews of policy in such manner as is best suited to provincial conditions. All provinces have recently completed a systematic examination of the Royal Commission's report with a view to deciding which recommendations are suitable and which should be given preference. It is now widely accepted that conditions differ so much from province to province that no general plan of campaign could be laid down. Moreover, all questions of policy are finally decided by a Minister responsible to the Provincial Legislative Council. It is clear, therefore, that future discussions of propaganda methods in the Board of Agriculture should be limited to an exchange of experience. If conducted on these lines, such discussions might prove of great value. In all provinces the funds allotted to agricultural propaganda have been very greatly increased

since the Board of Agriculture last discussed this subject in 1917. Public interest in agricultural propaganda and the organisation of seed, implement and manure supplies has markedly increased and, as the Royal Commission point out, new propaganda methods and new propaganda organisations are under trial in various parts of India. The Royal Commission have also made important proposals in these respects. Moreover, the personnel of the Agricultural Departments has not only been considerably increased but has changed materially in character; for example, there are comparatively few Deputy Directors of Agriculture now serving as such who were occupying that position in 1917. It is suggested, therefore, that a review of organisation for and methods of agricultural propaganda and other 'extension' work might find a place in the agenda of the Board of Agriculture at a future meeting. Special attention would naturally be devoted to new methods, and to matters in which central assistance or co-operation between different provinces is needed, *e.g.*, the production of agricultural cinema films. A statement by each province on the extent how far the recommendations in Chapter VI of the Report of the Royal Commission, excluding those which refer to individual provinces, are acceptable and in what way effect can best be given to them might form a useful basis for the full discussion after which a more limited range might prove convenient. So long as it is clearly understood that such discussions are intended for the mutual assistance of those taking part in them and not to lay down lines of policy, they could hardly fail to be of great value.

APPENDIX VII.

Notes on Subject V (A).—Mechanical Cultivation.

(*a*)

(A. McKERRAL, *Director of Agriculture, Burma.*)

During the last three or four years there has been a considerable development of this form of cultivation in Burma mainly to meet the needs of land-owners who possess land in the flooded tracts along the Irrawaddy river and particularly in the delta districts. The conditions in these tracts are as follows :—When the river rises in the early monsoon, the flood waters find their way into these low-lying areas at the same time and the areas remain flooded—often under eight to ten feet of water—till late in the season. The soils of these areas do not get hard during the hot weather months like those of the ordinary paddy fields and ploughing, either with the ordinary plough or with tractors, is comparatively easy during the months January to May. The areas, however, are infested with grasses belonging to the wild *Saccharum* species and the cultivator who possesses only cattle and the small plough of the country has great difficulty in eradicating these weeds. The result is that the grasses begin to grow simultaneously with the paddy and generally the subsequent history of events develops into a struggle between the two in which the weeds are often victors. No bunds are made and only flood-resisting paddies are grown. These varieties send out branches at the nodes and float on the flood waters without getting submerged.

2. It has been found that tractors fill a marked want under these conditions and during the last five years some 200 outfits have been sold. The makes in use are mainly the following :—(1) Case, (2) Farmall, (3) Fordson, (4) Austin, (5) Cletrac. The most popular type of cultivating implement is the 28 to 32-disc harrow. A discing followed by a cross-discing is usually all the cultivation given and the seed is broadcasted with the first showers of the monsoon. The object is to get as large an area cultivated as possible between the date when the land becomes dry enough for ploughing and the break of the next monsoon.

3. A tractor outfit may be owned by a land-owner for the purpose of cultivating his own land or with the object of hiring it out to others. When the tractor is hired out, the owner of the land is usually charged Rs. 8 per acre for the cultivation and a single set can cultivate at least 500 acres in a season. The actual all-in cost of cultivation with a Fordson tractor under the above described conditions is stated to be about Rs. 3-12-0 per acre, so that the owner would appear to make a considerable profit. The yield of flood-resisting paddy in a favourable year may be as high as 80 baskets (one basket equals one and a half English bushels) but the average may be taken as about 30 baskets per acre. Under these flood conditions tractors appear to meet a felt want and to solve a definite problem.

4. The Agricultural Engineer has recently done preliminary trials on ordinary paddy land but the time during which these were made was short and the results can be regarded as tentative only. The flooded areas above mentioned and on which tractor cultivation has become popular constitute only an infinitesimally small fraction of the total paddy land of the country the bulk of which consists of the usually small bunded fields which dry up to a brick-like hardness in January and are uncultivable with the ordinary plough until the next monsoon converts them into slushy mud. These trials were made with a 12—20 Cletrac tractor followed by a two-bottom disc plough and a two-bottom mould-board plough. It was found that it was possible to cultivate the soil in the hard condition as once the ploughshare got below the surface the depth of ploughing never fluctuated. The cost of using the disc plough was higher than that of the mould-board plough, the former appearing to be on an average about Rs. 11 per acre and the latter Rs. 9. This allowed for 10 per cent. interest on capital, depreciation at 20 per cent., a head driver on Rs. 70 and a second driver on Rs. 40. The cost of ploughing by bullocks is from Rs. 3 to Rs. 3-8.

5. Trials in the slush were not satisfactory as the plough continuously buried itself and it took 4 hours to plough one acre. The corners of the small fields also presented a serious difficulty. It would appear that a proper outfit for this kind of cultivation has not yet been designed.

6. In order to popularise tractor cultivation, the following appear to be necessary :—

(1) Agents to give better service than they do at present in the way of stocking all spare parts at reasonable prices. The prices are said to be too high.

(2) The Agricultural Department to hold trials and competitions.

(3) The economics of mechanical cultivation for each particular set of conditions to be carefully worked out.

(4) Special attention to be given to the question of finding work for tractors in the off-season, *e.g.*, haulage, pumping, etc.

(5) The agricultural engineering section to give courses for training mechanics in the handling of these machines.

(*b*)

(G. S. HENDERSON, *Director of Agriculture, Bihar and Orissa.*)

In North Bihar mechanical cultivation has extended to a considerable extent in the last five or six years. It is estimated that there are over 140 agricultural tractors working now in North Bihar. These are being used chiefly in the districts of Darbhanga, Muzaffarpur and Champaran. About half of these tractors are McCormick Deering and the sales seem to be steadily increasing. They are used chiefly by old indigo concerns and in zemindaries. The conditions in this tract are such as to be very suitable for tractor cultivation development but it is doubtful if any other tract in India offers such special advantages. The chief reasons why tractor cultivation has increased so rapidly in this comparatively small area, are as follows :—

(1) *Character of land.*—The soil is a light, easily worked alluvial one.

(2) The fields are large.

(3) Irrigation is not general and so there are no *bunds* or water-courses to negotiate. The tract is dead level and for India it is not badly equipped with roads and railways.

(4) Supervision and technical skill are good. Local mistries are available who have been accustomed to steam-engines and mechanical power.

(5) As there is a large number of tractors in a comparatively small area, it is easy for the selling firms to maintain "service after sales". In fact one firm maintains travelling agents who periodically inspect the tractors and report. A sufficient supply of spare parts is maintained.

(6) A valuable crop, *viz.*, sugarcane, is cultivated. The cane is largely grown for white sugar factories. So a valuable and easily marketed crop makes it worth while to invest capital in tractors, more especially as the season of preparation is limited and the work on account of cultivation must be rushed.

Tractors do not take the place of plough bullocks but the tractor is supplementary to bullock work. Much the same conditions are now found in farms in Great Britain. At one time it was thought that tractors could replace horses on the land but the place of the tractor seems to be as a stand-by during a rush period. Several large farmers in England have told me that they keep a tractor for special work only, *e.g.*, in a late spring a tractor might prove invaluable for preparing an adequate seed-bed.

Cost.—The only reliable method of arriving at costs is to keep accurate data during the whole life of the tractor. Trials for a short period may prove absolutely deceptive The "life-histories" of three makes of tractors are available at Pusa.

Much stress is being laid on the necessity of having an agricultural engineering section at the headquarters of the Imperial Research Station. In this respect great care will

have to be taken in providing the proper kind of engineering assistance. It is the place of the agriculturist to determine the necessity and functions of new agricultural implements but the agriculturist requires the assistance of expert designers. Agricultural machinery manufacture is a highly specialised class of engineering, and what is required in India is the services of a highly qualified designer thoroughly in touch with current agricultural machinery manufacture. In my opinion this object would best be attained by getting the services of a representative designer who would come out to India for some period each year and would be available for consultation.

(*c*)

(A. P. CLIFF, *Deputy Director of Agriculture, North Bihar Range.*)

The experience of North Bihar and the neighbouring district of Gorakhpore proves the possibility of introducing tractor cultivation into Indian agriculture, but at the same time sets a definite limit to the possibilities of the expansion of such methods. Such of the old indigo factories that were once so numerous in this tract as have survived, and they are still very many, have almost all adopted tractors as their main source of cultivation power. The concerns hold, on leases of various kinds, large tracts of cultivated land and these are often arranged in fields of fairly large area, the bulk from 10 to 50 acres, many over 50 acres, and a fair number of over 100. The factories have also, from the indigo days, an old tradition of mechanical working, which has given them a source of drivers and mechanics for their tractors. The occurrence of these two factors coupled with the increasing difficulty of persuading the tenants to furnish labour as freely as of old, has made the adoption of tractor cultivation by the Bihar planter a natural sequence on their appearance in a reasonably reliable form, and it is thought that the general opinion of those who have used them is that, in these conditions and for certain operations, tractors are far more economical than factory-maintained bullocks.

It is the first of the conditions noted that sets a definite limit to the possibilities of expansion of the practice. The factory cultivates large areas which are mostly arranged in fields of reasonable size not too widely scattered. Although the factories are numerous, yet the bulk of the cultivation of the area is done by *ryots* tilling for themselves ; and their holdings are small in area, and composed of numerous tiny plots widely scattered. Mechanical knowledge is rapidly spreading with the increase of cars, buses and taxis over the whole area, and drivers and mechanics would soon be available if the demand arose ; but the small and scattered holdings make any system of tractor cultivation impracticable.

In the early days of cultivating cotton in the Gezira region of the Sudan where the Sennaar Dam has recently been completed, as the lands were canalised they were laid out in blocks consisting of three contiguous 10 feddan plots and the blocks settled with cultivators, one of the terms of lease being that each year in rotation on one 10-feddan block cotton should be grown under the control and direction of the Sudan Plantation Syndicate. That Company performed by mechanical power all the preparatory cultivation for the cotton crop and recovered its cost from the price received for the crop which was in due course marketed through it. But the land, although settled by peasant cultivators, was laid out primarily to facilitate irrigation and secondly to allow of large-scale mechanical cultivation, and the Company supplying the cultivation had from the first full control of the produce of the land cultivated.

In the newer canal colonies of the Punjab and Sind such a system might be partially possible if the desirability of mechanical cultivation is kept steadily in view during the lay-out period and if, from the beginnings of cultivation, agencies are set up to supply tractor cultivation to the colonies. But in Bihar where the land is closely settled, minutely divided and growing all kinds of crops in many kinds of rotations or none at all, the introduction of tractor cultivation on *ryots'* land, while not absolutely impossible, would be so very difficult and lengthy a process as to be practically so.

Where the conditions already enumerated are available, all cultivation for *rabi* cereals, including harvesting, can be efficiently performed by tractor-drawn implements. In sugarcane cultivation all operations up to planting, and even the opening of furrows for planting, can be done by the same means ; and the same applies to cotton. In the two

former crops fallowing and green-manuring are important features and the ability of a good tractor to handle a large area of fallow quickly when the land is in the right condition and to plough in comparatively cleanly and quickly heavy crops of green manures such as Sanai, is one of its great assets, while a second is its ability to drive the threshing outfits used on the Bihar factories for expeditious threshing of *rabi* grains. On light lands the breaking down of cane ridges and the uprooting of the cane stabble and the breaking of *rabi* lands and hot weather cultivation of those for monsoon sowing, present no difficulties to a modern tractor; and one might say that on medium light lands a good tractor can perform most kinds of dry cultivation required.

While probably no one can say what is definitely the best kind of machine, in North Bihar I fancy opinion is fairly unanimous that the fairly low first cost, reasonable running cost, simplicity, comparative efficiency at work, reasonable wearing life and availability of spares, place the International tractor in the same class for our local conditions as the Ford and Chevrolet cars hold in the car world in India. It may not be intrinsically the best tractor, but it is certainly the best one for a purchaser in Bihar to obtain.

APPENDIX VIII.

Notes on Subject V (B).—Best Method of determining the Draught of Bullock-drawn Implements.

(*a*)

(B. C. BURT, *Agricultural Expert, Imperial Council of Agricultural Research.*)

The Royal Commission on Agriculture, in recommendation 65 of Chapter IV of their Report, recommended that "the relation of the capacity of the draught cattle in India to the implements they are required to draw is a problem which requires investigation." In paragraph 107 they drew attention to the recent work at Rothamsted and to the importance of dynamometer measurements in determining the draught of an implement in different types of soils. At the Conference convened by the Government of India at Simla in October, 1928 (Proceedings, page 65), the question was raised whether the Pusa Research Institute could not give assistance in the solution of this problem. Actual determinations of the draught of implements must obviously be made in the areas where they are to be used and such work will necessarily be not only provincial but local. It is suggested, however, that the technique might be worked out at some one institute. Dynamometer measurements with bullock-drawn implements, as compared to similar measurements with horse-drawn implements, present certain difficulties, especially as many of the lighter ploughs and some other implements are designed for pole draught. Accurate recording dynamometers of the type used at Rothamsted are comparatively expensive and may require adaptation to suit Indian conditions. With the simpler forms of non-recording dynamometers it is exceedingly difficult to get a complete set of readings or even a reliable average. It is suggested, therefore, that preliminary work at one station would be of considerable assistance to several agricultural departments.

(*b*)

(D. R. SETHI, *Deputy Director of Agriculture, South Bihar Range.*)

A reference is invited to Para. 107 of the Report of the Royal Commission on Agriculture where the reasons for and necessity of carrying out these investigations have been clearly stated. The Royal Commission has also indicated the lines on which these investigations should be carried out.

The final judge of any agricultural improvement being the cultivator himself, his first objection that the agricultural officer has to face with regard to the introduction of an improved implement is his firm conviction that his bullocks are incapable of pulling the implement. The agricultural officer is unable to meet this argument as he has no evidence based on careful experiments to support him. It is, therefore, eminently desirable that all existing designs should be thoroughly and accurately tested especially in relation to the capacity of the cultivator's bullocks. This will not only help in eliminating unsuitable existing designs but would provide better facilities for implement designing in the future.

There remains the point as to where and by whom these investigations should be carried out. The investigations being of an all-India character, it is suggested that the Imperial Council of Agricultural Research should take up these investigations from the very start and the Imperial Agricultural Research Institute should be placed in a position to carry out the work on bullock-drawn implements for India on similar lines as has been done at Rothamsted for the horse-drawn implements.

It is true that it is not possible to carry out all the experiments at Pusa as all the important Indian types of soils are not to be found there. This difficulty could be got over by having the investigations carried out in different tracts of the country under the

guidance of the Imperial Council of Agricultural Research through qualified workers. The results of these investigations could then be collated at the Imperial Agricultural Research Institute which would in turn act as a clearing house for the whole of India.

APPENDIX IX.

Notes on Subject VI.—Collection and Publication of Work on Soils in India.

(*a*)

(B. C. BURT, *Agricultural Expert, Imperial Council of Agricultural Research.*)

This subject has been suggested for discussion by the Madras Government with reference to recommendation (3) of Chapter IV of the Report of the Royal Commission on Agriculture, which reads as follows:—

> "The Council of Agricultural Research should undertake the collation and publication of all the available information regarding the composition and characteristics of Indian soils."

In paragraph 78 the Commission point to the need of additional research on soils and soil conditions and emphasise the necessity for additional staff if progress is to be rapid and uninterrupted. In paragraph 76 they refer to the considerable mass of information already in existence which has not yet been fully collated and published.

2. Compilation work of this kind involves a good deal of labour for everyone concerned, and it is obvious that if undertaken it should be so arranged as to make the minimum demand on research officers whose time is already fully occupied and should be in such a form as will be of real and permanent value.

3. As a result of the recommendations of the Imperial Agricultural Conference, 1927, eight Imperial Agricultural Information Bureaux have been established and one of these, which works in collaboration with the Rothamsted Experimental Station, specialises on soil problems. The new bureau has asked for information regarding the methods used in soil improvement in India and on several other points.

4. Most Agricultural Departments have also received from the International Soil Science Congress a request for somewhat elaborate data on Indian soils. If it is decided to attempt the collection and publication of the results of research work on soils in India, it seems desirable that the information required by the Imperial Bureau and by the International Soil Science Congress should, as far as possible, be collected at the same time in order to avoid duplication of work.

5. The question for consideration is whether the recommendation of the Royal Commission should be accepted and, if so, by what methods it could best be given effect to. If the Board of Agriculture agrees that, as suggested by the Commission, this task should be undertaken by the Imperial Council of Agricultural Research, the recommendation of the Board of Agriculture would naturally be placed before that body.

(*b*)

(B. VISWANATH, *Government Agricultural Chemist, Madras.*)

1. *The existing agency for collection and publication.*—There is no separate organization for collection and a periodical for publication of work on soils in India. At present the Imperial Department of Agriculture in India is the chief central collecting and publishing agency for all agricultural research work done at Pusa and at the Research Institutes in the provinces.

The Imperial Department of Agriculture publishes from time to time Memoirs and Bulletins and once in every two months the Agricultural Journal of India. Generally,

original work of a highly technical nature is published as Memoirs and Bulletins, while articles of a popular nature are published in the Agricultural Journal of India.

The Provincial Agricultural Departments also issue their own Bulletins.

In recent years the Indian Science Congress has come into existence. This is only a collecting body for purposes of discussion at its meetings. It has no publication arrangements of its own but it issues annually in a collected form the abstracts of papers submitted to it.

The existing arrangement for publication is not all that is desirable for the reason that it takes an unduly long time between the date of submission of the typescript and the actual publication. This is perhaps unavoidable under the circumstances but this delay operates disadvantageously in three directions :—

(i) Other investigators elsewhere may forestall us.

(ii) Waste of time and labour, which could otherwise be avoided by other workers who are on the same or similar problems had another's work been published early.

(iii) There is no impelling force to collect and tabulate the accumulated data and to write up for publication.

2. *A new vehicle for publication is necessary.*—There is thus a need for a change by way of introducing a new vehicle for publication at regular intervals.

The next point for consideration is whether enough material will be forthcoming for publication. I believe it will, judging from the quantity published so far and the growth in the size in the Imperial and Provincial Departments of Agriculture in India.

Between the years 1905 and 1929, the publications (Bulletins) on all subjects by the Imperial and Provincial Departments were as below :—

	No.
Pusa	180
Burma, United Provinces, Central Provinces and Bombay . .	150
Madras	60
Total .	390

Forty Bulletins out of the 390, dealt with work on soil.

Seventy Memoirs were also published in the Chemical Series and of these 23 were on soils.

In addition to this, we have to take into consideration the papers submitted to the Indian Science Congress. This institution came into existence in the year 1914. I have not been able to secure figures for the earlier years ; but between the years 1920 and now, about 325 papers on different subjects were submitted to the Agricultural Section. Of these, 80 papers were on soils in some form or other.

It would thus appear that there would be enough material for a new venture in publication.

3. *Supply and collection of material and its publication.*—As yet the Universities do not evince active interest either in agricultural problems or in soil science. As at present, the Imperial and Provincial Departments of Agriculture must be, for some time to come, the only centres for providing material for publication.

Collection of material may be under (1) Soil Surveys, (2) Soil Chemistry, (3) Soil Physics, (4) Soil Micro-biology and (5) Soil Plant—Animal.

What we want at present is a more detailed knowledge of the composition and reactivity of soils under different climatic conditions and agricultural practices.

A detailed classification, for purposes of a journal, under the different headings mentioned, is as yet too premature, nor would I, at the present stage of our development, suggest a separate journal for soil work alone.

A general purpose journal on the lines of the Journal of Agricultural Science in England would serve admirably well for some time to come. This journal will be of a technical nature and supersede the Memoirs and Bulletins that are now published.

It is obvious that a journal of this type will have to be an all-India one and should therefore be under the management of a centrally constituted body like the Central Research Institute at Pusa or the Imperial Research Council.

Here again the question of delay in publication comes up, but this can be considerably minimised if not entirely got over, by a change in the office routine. At present the proofs for correction pass to and fro between the press and the author, through the Agricultural Adviser. In the new management, it may be so laid that when once the Board of Editors pass a typescript for publication, arrangements may be made for the direct exchange of proofs between the author and the press.

APPENDIX X.

Note on Subject VII.—Water Requirements of Crops.

(T. R. Low, *Deputy Director of Agriculture, Central Circle, United Provinces.*)

It is assumed that this subject refers to the question of artificial irrigation and not to the best methods of conserving rainfall. It is of the greatest importance in the United Provinces, as out of a net cropped area of nearly 40 million acres 10½ million is under irrigation, and it is evident that anything that can be done to save water and so raise the duty of the supplies available to enable a larger area of valuable crops to be matured will be of the utmost value.

It is, I think, generally realized by officers of the Department whose work lies in irrigated areas that considerable harm is done by over watering, and by watering at unsuitable periods of the crop's growth, particularly in canal areas, where flow irrigation is available at low rates. That this damage is considerable and that it could be mitigated, there is no doubt, but I do not consider that it can be attributed entirely to the carelessness and ignorance of the cultivator. The force of circumstances and the disadvantages under which he works are to a large extent responsible. In Pusa Bulletin No. 118 (The saving of irrigation water, A. & G. Howard) the results of over-watering are dealt with in detail, and it also shows how under proper management heavy wheat crops can be raised with a restricted supply of water.

This Bulletin explains what can be done. To get the methods advocated generally adopted is a question of demonstration and propaganda. It will, undoubtedly, be slow work but a line of activity which should be productive of encouraging results.

The question of the actual measurement of water passing on to a field to mature a crop postulates some form of meter. In the opinion of Mr. F. H. Hutchinson, I.S.E., Agriculture Engineer to Government, United Provinces, the most suitable form of meter for water measurement in relatively small quantities is the V notch combined with the use of a hook gauge and stilling chamber.

The cost of installing this apparatus together with a stilling chamber is approximately Rs. 400. If a more elaborate apparatus is required and one which is automatic and eliminates the human element as far as possible, a Kent or Lees recording apparatus can be installed at the cost of approximately Rs. 2,300. These are the same in principle except that the amount of water passing over the notch is recorded continuously on paper, in the same manner as a barograph, and the total volume can be read off on an integrating arrangement. These instruments are accurate to about 5 per cent.

With regard to the amount of water required to actually mature the principal crops of the Province, experiments were carried out at the Cawnpore Experimental Farm from 1906 to 1914 at the request of the Irrigation Commission to ascertain this, and at the same time steps were taken to collect some figures of the losses occurring by seepage and evaporation in *kutcha nalis* during the progress of the water on to the field.

The method adopted was first to pump up the water from the canal into tanks of known capacity. When required on the fields it was run from these tanks along *kutcha nalis* 150 yds. in length into a further series of measuring tanks. The loss during flow along the *nalis* was thus ascertainable. From the second series of tanks it was distributed to the fields by *pucca* channels.

The results are interesting and are tabulated below for wheat and sugarcane (Ukh and Paunda).

Crop.	Average No. of irrigations per annum to mature crop (excluding Palewa)	Total average water used on fields in gallons per acre to mature crop including Palewa	Average number of gallons of water per acre per irrigation	Average loss of water by seepage and evaporation in *kutcha nalis* 150 yards long
Wheat . . .	2·3	1,76,837 equivalent to 7·8 inches water	72·900	16·6%
Ukh Cane . .	8	4,77,036 equivalent to 20·6 inches water	59·600	12·6%
Paunda Cane . .	17	7,81,287 equivalent to 34·5 inches water	45·900	18·2%

These results being collected over a series of typical seasons may be taken to form some guide as to the usual canal irrigation practice prevalent in this part of the Provinces. Attempts were not made to raise the crops on as little water as possible but the normal routine was followed. There is no record of special facilities in the way of extra runnings being given, so it is presumed that waterings were given in the usual way when requirement coincided with an open canal. It will be seen that the average depth of an irrigation is from 2 inches in the case of frequently watered sugarcane to 3 inches in the case of wheat which, in a normal season, in these Provinces usually receives two irrigations. These depths per irrigation approximate very closely to those quoted in various Irrigation Manuals.

The total amount of water used to mature sugarcane appears high but it must be remembered that at Cawnpore between sowing and the establishment of the monsoon the climate gradually becomes intensely hot and dry and frequent waterings are necessary. Unfortunately no record appears to have been kept on the most important subject of the crop yields obtained during these trials, or of the effect on the various crops of varying times and amounts of water. If this work could be taken up where a constantly available supply of water is obtainable such as a tube-well from which it is possible to accurately measure discharges, there is no doubt that results of great interest and of immediate practical value would become available.

The question of the periods at which waterings will give optimum results raises problems of plant physiology closely connected with the management of soils. It is a well-known fact that the water requirements of crops are not constant throughout the period of their growth. In the case of wheat there appears to be a special demand for water from the time the ears shoot until they start to yellow and any marked deficiency during this time is reflected in the resulting yield.

The same is undoubtedly true of other crops that too much or too little water at certain periods has a detrimental effect on the outturns obtained.

I have not been able to discover any data on this subject with respect to Indian conditions but it is intimately connected with the amounts of water required to raise crops and would have to be studied as part of the same problem.

APPENDIX XI.

Note on Subject VIII.—Co-ordination of Work connected with the Investigation of Markets and of the Sub-division and Fragmentation of Holdings.

(LESLIE COLEMAN, *Director of Agriculture, Mysore State.*)

The recommendations of the Royal Commission on Agriculture are important and many. Most of them, if carried into effect, will involve the expenditure of very considerable sums of money. As far as Mysore State is concerned, it is very doubtful if, in the near future, additional funds will become available to carry into effect any considerable number of these recommendations. If, therefore, the Royal Commission's Report is to become for us much more than an interesting work of reference, it will be necessary for us to attempt a more efficient utilization of agencies already existing. I believe that a better co-ordination of work should make this possible.

There are two subjects dealt with by the Royal Commission which seem to me especially to lend themselves to attack through co-ordinated effort. I refer to the question of markets and marketing and the question of sub-division and fragmentation of holdings. In the case of both of these questions, much preliminary investigation is required before any definite action can be taken.

As regards the question of marketing, the Royal Commission recommend the appointment of a special staff headed by an officer of the grade of Deputy Director to deal with the subject. We have so many other activities already under way, each requiring increased allotments, that I think that we, in Mysore, should not be justified in providing a special staff for the purpose in the near future. It should, however, be possible to do a good deal with the organizations already existing.

There are in Mysore at least four agencies which should interest themselves in questions connected with agricultural markets and marketing. These are the Department of Industries and Commerce, the Department of Co-operation, the Department of Agriculture and the Economics Department of the University. Of these, the first three have considerable staffs in the Districts while the last has a number of Economics students, the services of whom could be utilized, at least during the vacations, for making enquiries dealing with agricultural economics. In addition to these possible agencies, we have our District Economic Superintendents, fairly senior officers, whose knowledge of their respective districts should prove of great value in investigations of this character. What applies to the question of marketing applies with equal force to that of the sub-division and fragmentation of holdings.

We have therefore agencies in existence which if they could spare the time would be suitable for the local investigation of these important economic questions. Can they devote enough time and attention to these questions to make it worth while and, if so, how best can they be used and their work co-ordinated ?

As regards the first of these questions, I can speak with most assurance about the possibilities of utilizing the services of agricultural officers. We have now one Agricultural Inspector for every two taluks in the State. These men have, for the most part, undergone three years' agricultural training and have obtained a fairly extensive knowledge of the areas in which they are conducting demonstration work. It should, I believe, be quite possible for these officers to take up the investigation of marketing conditions for one important crop in the chief market of their range. The investigation of sub-division and fragmentation in one village should also be possible, more especially as this could be carried out during the off-season.

I believe that the undertaking of such investigations by agricultural officers would be possible without seriously interfering with their regular demonstration work. Further I feel sure that the carrying out of definite investigations of this character would broaden and deepen their agricultural knowledge, would increase their points of contact with agriculturists, and would greatly add to their efficiency as demonstration officers. One of the chief difficulties I find in connection with demonstration work is that of making our agricultural Inspectors realize that a very thorough knowledge of the agriculture of their particular areas in all its aspects is essential for efficient work. While I am not so familiar with the duties of district officers of the Department of Industries and Commerce, and the Department of Co-operation, I have little doubt that the services of many of them could be utilized in much the same way.

It remains to consider how best this work can be directed and co-ordinated. I believe that a Board consisting of the Director of Industries and Commerce, the Registrar of Co-operative Societies, the Director of Agriculture, the Professor of Economics in the University and a few other official and non-official gentlemen selected for their knowledge and experience might be a suitable agency for planning surveys, co-ordinating the activities of the various officers concerned and collecting and analysing the data obtained. This Board would be constituted very much on the lines of the Board of Economic Enquiry in the Punjab. It would no doubt require a small clerical staff but should work in an honorary capacity. It might very well be subordinated to our Economic Conference, a body which is, in my opinion, much too large to undertake and carry out work of this kind which is likely to extend over a series of years.

APPENDIX XII.

Notes on Subject IX.—Mathematical Assistance in the Study of Agricultural Genetics and Economic Problems.

(*a*)

(B. C. BURT, *Agricultural Expert, Imperial Council of Agricultural Research.*)

This subject has been suggested for discussion by the Director of Agriculture, Bombay Presidency. It arises, at least in part, from recommendation 32 of Chapter XVIII of the report of the Royal Commission on Agriculture, which reads as follows :—

> " The application of mathematics to agriculture has introduced an entirely new factor into scientific agriculture and a specialist with the highest qualifications in this branch of agricultural science should, therefore, be attached to the Imperial Agricultural Research Institute."

2. In paragraph 538, the Commission further state that " in present conditions it will be sufficient if a specialist is attached to the Imperial Agricultural Research Institute, and if the manner in which his advice can best be made available to the provincial departments of agriculture is determined by the Council of Agricultural Research." The Royal Commission supported this recommendation chiefly by referring to the need for the assistance of a mathematical statistician in the lay-out and interpretation of formal field experiments, such as yield trials. The subject proposed for discussion at the Board of Agriculture deals with a wider issue since the question of mathematical assistance in dealing with problems in genetics and with economic problems generally is raised.

3. While it may be said that the recommendation of the Royal Commission covers the whole question—especially if their view that eventually each province will require its own expert in this branch of science be accepted—the question of mathematical assistance in genetics is not quite the same as mathematical assistance in the planning and interpretation of field experiments. In the one case assistance is required in the interpretation of accumulated data with possible suggestions as to the course of future work directed to the clearing up of any points which may remain obscure. In dealing with field experiments the aid of the mathematical statistician is required more constantly as he must be intimately associated with the design and conduct of the experiments as well as with their interpretation.

4. The reference in the title of this subject to economic problems in general might be held to extend the reference to agricultural statistics in general, excluding Crop Forecasts which are dealt with in recommendations (31), (33), (34) and (35) of Chapter XVIII of the Royal Commission's Report. This large group of questions can best be considered separately.

5. Field experiments have been discussed on previous occasions by the Board of Agriculture and the need for adequate replication and for the statistical interpretation of field trials is now generally recognised. Most agricultural officers are also familiar with the recent Bulletin by Yule and Engledow, which, in addition to giving the mathematical basis for the author's methods and most valuable suggestions as to the methods of conducting formal yield trials, emphasises the fact that such trials are a means to an end and orm only one aspect of the problem of crop improvement.

6. If the recommendation that the Imperial Council of Agricultural Research should give assistance in this matter is accepted, the next question for consideration is what form of assistance would be most welcome to the various provinces and to individual research workers. I have no proposals to make in this connection but I would remark that some confusion has arisen in the past through the use of the term " Agronomist". Some people use that term, as I do myself, to denote a scientific agriculturist concerned with

the translation of scientific results into agricultural practice through the medium of field experiments. Others use the term in a more restricted sense to denote, what I might call an agricultural mathematician, *i.e.*, a scientist with high qualifications in mathematics and statistics who devotes his time to the application of mathematics to agricultural problems. I venture to suggest that in future discussions the term "Agronomist" might be abandoned, for it is clear that the above types of scientific worker are needed for the translation of scientific results into agricultural practice and that they should work in close collaboration. Only rarely could it happen that an officer with the necessary knowledge and experience in natural science and practical agriculture would also possess the high mathematical qualifications and outlook required for the statistical side of the work.

It is not sufficient to evaluate the errors of field experiments, they must also be reduced in magnitude by all possible improvements in technique. Close observation of the behaviour of the plant, both individually and in bulk, must supplement, and may even sometimes replace, the result of formal trials so that there is abundant scope for the skilled experimentalist as well as for the mathematician.

(*b*)

(W. BURNS, *Offg. Director of Agriculture, Bombay Presidency.*)

Plant-breeders the world over now require the assistance of mathematicians in order to determine many points which arise in the conduct of field trials. Of late there has been a great output of literature on this point but the need for advice from an individual specialist remains. In my own case I have had until recently to get this advice from men who were not specially equipped on the agricultural side, for example, a Professor of Physics, a Professor of Mathematics and a Meteorologist. More recently I have been getting advice direct from the statistical branch of the Rothamsted Experiment Station. It seems to me that one really well-equipped expert located at Pusa is essential for the future development of plant-breeding in India. It is necessary to have a man who has had a thorough training in this type of work and who would be able to continue the work of Fisher, Yule, and Maskell.

APPENDIX XIII.

Note on Subject X.—To select a place and date for the next Cattle Conference and to discuss the advisability of combining this with Sectional Meetings of Officers representing Veterinary, Medicine, Animal Nutrition and Animal Genetics.

(F. WARE, *Offg. Director, Imperial Institute of Veterinary Research, Muktesar.*)

When one comes to review the history of Animal Husbandry in this country, one is at once struck with the vicissitudes through which it has passed and its present uncertain position. Going as far back only as the meeting of the Board of Agriculture held at Pusa in 1922, it is observed that a recommendation was then made for the formation of a Central Cattle Board. This was not accepted by the Government of India, but, instead, it was decided that periodical conferences of those connected with the industry should be called, and as a result of this the first Cattle Conference was held at Bangalore in 1924.

That Conference, thereupon, passed resolutions that a Central Bureau of Animal Husbandry should be established and that Cattle Conferences should be held every year at different centres, and in his opening address at the next meeting of the Board of Agriculture, which was held at Pusa in December 1925, the President announced that the Government of India had decided to establish the proposed Bureau, the control of which would be vested in the Imperial Dairy Expert. This, however, does not seem to have satisfied the Board in question, for it immediately passed a resolution to the effect that " real effective co-operation between the Central Government and Local Governments and States can only be carried out if the control of the Central Cattle Bureau (which term appears to have been substituted for that of Central Bureau of Animal Husbandry) is vested in an all-India Committee or Board." No action appears to have been taken on this resolution and no Cattle Conferences have been held since that of 1925.

One might almost imagine from its past history that the cattle question in this country is considered to be of less importance than the question of crops, but as Mr. W. Smith, Imperial Dairy Expert, remarked at the last meeting of Veterinary Officers, which was held at Calcutta in 1923, " The question of cattle is the most universal one in India and no matter what crop particularly interests the Agriculturist, he is everywhere dependent on the efficiency of the ox as the main factor in cultivation." Anyone with even a superficial knowledge of agricultural conditions in this country will confirm that remark, and yet the whole subject of Animal Husbandry in India, compared with the arrangements made for it in other Federal pastoral countries like the Union of South Africa, the United States of America, and more recently in Australia, is in a most unsatisfactory state at present.

Agriculture in India is a transferred subject and so the provinces are left, to a great extent, to organise it in the way each considers best. In most provinces cattle-breeding and those matters which fall under the term Animal Genetics are run as a separate section of the Agricultural Department; Animal Nutrition is dealt with at a composite Imperial Institute at Bangalore and at a provincial Agricultural Research Institute at Coimbatore; and Veterinary Medicine, which, in the opinion of the Linlithgow Commission, completes with the above-mentioned two sciences the major subject of Animal Husbandry, is administered separately from them except in the Punjab.

Then in regard to central organizations we find that, though successive meetings of the Board of Agriculture have been recommending the formation of a Central Cattle Board since 1922, this has not yet been accomplished, but a Central Cattle Bureau, which cannot fulfil many of the functions proposed for the Central Cattle Board, has been established in its stead.

The importance of co-ordinating the work of all those connected with livestock improvement is obvious and has recently been stressed by several authorities outside India, and the present, therefore, appears to be a very appropriate time for pressing again on the Government of India the need for a Central Advisory Board of some kind to deal with this matter, as the first step in an improved organization.

Cattle Conferences or sub-committees of the Board of Agriculture do not seem to meet the case. Something which will bring the men concerned closer together and which can speak with greater authority is required. In the past it has often been said that it is to some extent a waste of time and money for Veterinary officers to attend the meetings of the Board of Agriculture, for the agenda of this Board usually contains a preponderance of purely agricultural subjects, and they have been urging for many years that they should be allowed to meet separately at least every two years. The Linlithgow Commission have also recommended that Cattle Conferences, which would comprise all other livestock officers, should meet every two years, and it appears therefore that if a Board of Animal Husbandry were formed of all these technical officers together with the administrative officers interested in livestock questions, to meet in alternate years with the Board of Agriculture, the needs of everyone would be met.

Such a Board would enable Veterinary officers, workers in animal nutrition, and the so-called livestock experts thoroughly to discuss their special problems in committee at reasonable intervals, and the full Board would provide the best possible agency for improving measures for concerted action for the improvement of the livestock of the country and should prove an acceptable substitute for the previously proposed Central Cattle Board.

The Linlithgow Commission have given the lead in this matter by recommending the appointment of an officer on the Imperial Agricultural Research Council, who is to act as an adviser in all matters pertaining to Animal Husbandry and is to take over the executive functions of the Central Cattle Bureau, and the natural corollary to this would appear to be to give this officer an Advisory Board composed of men working on the subjects, which are to be his particular concern, in different parts of the country.

It may be argued that this proposal will lead to increased expenditure, but in most cases this will prove to be a very small amount. If the proposed Board of Animal Husbandry is held concurrently with the annual meeting of the Imperial Agricultural Research Council, in the same way as the meeting of the Board of Agriculture is being held this year, many of the administrative officers concerned would be attending the Council meeting and would be able to prolong their stay for a few days with very little extra expense, and as regards technical officers it has already been pointed out that these in any case require a meeting every two years.

Another objection which may be raised is that the separation of the animal and crop sections of the Board of Agriculture will lead to lack of cohesion, but this will be compensated for by the less unwieldy size of the Board of Agriculture, which militates against its usefulness at present, and ample provision can be made for co-ordinating the work of both sections. Many administrative officers would be members of both Boards and the Expert in Animal Husbandry would act as Liaison officer with the Board of Agriculture and the Agricultural Expert in the same capacity with the proposed Board of Animal Husbandry. In addition, the Vice-Chairman of the Imperial Agricultural Research Council would be the Chairman of both Boards.

APPENDIX IV.

Notes on Subject XI.—Protection of Crops from Depredations of Wild Animals.

(B. C. BURT, *Agricultural Expert, Imperial Council of Agricultural Research.*)

This subject was fully discussed by the Board of Agriculture at its 14th meeting, December 1925, but it is felt that a further discussion is desirable in view of the developments which have taken place in several Provinces since that date. The Imperial Council of Agricultural Research has asked several Local Governments to furnish the latest information but replies have not yet been received though it is hoped that they will be placed before the Board either in the form of notes or through the medium of Provincial representatives.

2. The Research Council has also consulted the Inspector-General of Forests with special reference to measures for the control of wild pig and Mr. Rodgers has kindly supplied a number of notes by Forest officers in the various provinces, a summary of which is attached (p. 213). Enquiry was also made from the Director, Zoological Survey of India, asking for such information as is available on the life-history and habits of wild pigs, jackals and field rats and for his opinion on the proposal of the Board of Agriculture (Resolutions IV, 1925) that a special officer should be deputed to study the life history of the wild pig in its own habitat. Copies of the Director's letters of August 28th and September 20th, 1929, with a list of references is attached (p. 218). The literature cited by the Director has been examined and with the exception of the paper on "The Rice Rats of Lower Sind," to which reference is made later, there is little of direct economic application in it.

3. *Wild Pigs.*—The papers forwarded to me by the Inspector-General of Forests show that a Committee has been appointed by the Central Provinces Government to deal with this question. It is hoped that the Central Provinces representatives on the Board may be able to give further information.

4. These papers also contain a summary (kindly furnished by the Chief Conservator of Forests, Central Provinces) of the action which has been taken in the Bombay Presidency on the recommendations of the Bombay Committee on "Measures for the Protection of Crops from Wild Animals and Stray Cattle" of 1923. The report of that Committee was before the Committee of the Board in 1925 but the action taken upon it was not then known completely.

5. In view of the recommendations contained in Chapter IV (recommendation 80 and paragraph 116) of the Report of the Royal Commission on Agriculture, the experience of the Central Provinces Government—that an increase in gun licenses has not led to a corresponding reduction in the damage by wild pig (and other animals)— is of importance. It will also be observed that Forest officers found the greatest difficulty in organising beats for the destruction of pig in forests adjoining cultivation unless the beaters were paid. On the other hand, a considerable amount of good appears to have been done by the organisation of village and Pargana Associations.

6. *Fencing.*—At the Agricultural Conference (Simla, October 1928) the point was raised that the duty on wire fencing acts as a deterrent to its more general use for the protection of crops, and it was suggested that such fencing should be brought within the scope of recommendation 71 of Chapter IV of the Royal Commission's report. The Council of Agricultural Research has been able to arrange for a detailed consideration of this question and in particular of the possibility of exempting from duty certain specified types of woven wire fencing which are mainly, or entirely, used for agricultural fencing.

7. *Rats.*—It is hoped that information will be available at the Board's meeting of recent progress in rat destruction in Bombay (Sind) and in the Punjab. In the meantime attention is invited to the paper published in the "Journal of the Bombay Natural History Society" on "The Rice Rats of Lower Sind and their Control" by Mr. P. V. Wagle, M. Ag. At the last meeting of the Board of Agriculture it was pointed out that much information is available about house rats but practically none about the field rats which cause damage to crops. In this paper it is shown that of three common field rats,

viz., the Sind Mole rat (*Gunomys sindicus*), the Indian Desert Gerbil (*Cheliones hurriana*) and Hutton's Mole rat (*Nesokia huttoni*), it is the first named which is responsible for crop damage. The habits of all three rats were studied and also their foodstuffs and a simple method of control by calcium cyanide dust worked out. In 1926 about 3,200 acres of badly affected country were dealt with, the cost per acre varying from 0-11-4 to 0-12-0 per acre, as determined from areas of 1,280 and 1,040 acres respectively. Previously successful results had been obtained with carbon bisulphide but calcium cyanide dust was found to be much cheaper as well as safer. As the actual cost of material and labour only amounts to 0-6-0 per acre, this method is clearly practicable. This work is of particular interest in that the method has been found successful with mole-rats for which experience in the Punjab (report of Board's Committee, 1925) shows the usual methods of poisoning to be unsuitable.

SUMMARY OF INFORMATION SUPPLIED BY INSPECTOR-GENERAL OF FORESTS.

Chief Conservator of Forests, Madras.—1. The Forest Department are trying trapping on the kheddah system.

2. They consider shooting the only satisfactory method and, where pig is a real menace to cultivation, there could be no objection to controlled beating and shooting in Reserved Forest—free of charge.

3. In the more developed parts of the country, particularly for the potato cultivation of the Nilgiris, wire fencing and ditching afford complete protection.

Chief Conservator of Forests, Central Provinces.—1. The Veterinary Department recommends Kheddahs (an acre or so sown with groundnut) and shift the kheddah from time to time. When a sounder is caught, destroy the sows and let the boar go.

2. The matter is now before the Central Provinces Forests Committee and an advance copy of the notes prepared for that Committee has been forwarded. The following summary has been made from these notes.

Very little is known of the—

(i) habits of wild pig except that contained in the Fauna of British India (Mammalia by W. T. Blanford 1891, page 561). It is added that frequently 2 litters of 4—6 are produced per year. When in herds pigs choose regular paths and stick to them unless scared but if any casualties occur the pigs will for a long time cease frequenting the fields to which these paths lead. Pigs are known to go long distances in search of food in one night. The damage by pigs is more marked in areas adjoining forests.

(ii) The Proceedings of the Bombay Committee of 1923, and the orders passed on it are referred to (see Bombay, p. 215.)

(iii) A Conference on the subject met in 1911 and the Government of the Central Provinces endorsed their conclusions which briefly were :—

(*a*) Production of pigs' tushes should be made a condition of renewal of gun licenses for pig destruction. In Berar it should be made more widely known that the guns are not for scaring only and pigs can be killed. Certain new facilities for destruction of pig in Government forests bordering on cultivation were sanctioned.

(*b*) In Berar villagers maintained small gangs of certain tribes to destroy pig, paying them in grain. Some difficulties arose as some of these tribes were regarded by the police as criminal tribes. Orders were issued that such gangs when *bonâ fide* should be allowed free entry to main blocks of Government Forest. Commissioners were given allotments for the encouragement of pig destruction through pargannah and village associations.

(*c*) The Director of Agriculture was asked to examine further the possibility of a trade in wild pig hides and bristles.

From 1919 to 1928 the number of gun licenses increased from 12,603 to 20,788.

(iv) In 1922 the Central Provinces Government took further measures to accelerate the reduction of pigs (and *nilgai*) by organised beats in forests in the vicinity of cultivation and by special facilities to *shikkaris* (recommended by *malguzars* or village *panchayats*)

in specified forests. The number of pigs killed in this way and by associations between 1923-24 and 1927-28 was 130,000.

(v) The increase in gun licenses has not had the desired effect partly because the guns are used for sport and display but largely because the pig are merely scared away to neighbouring fields and not destroyed.

(vi) The general consensus of opinion of Forest officers is that villagers are not willing to come out for organised beats unless paid.

(vii) Substantial work had, however, been done by associations in Saugor, Jubbulpore and Nagpur Districts.

(viii) An efficacious protective measure (for villages bordering on forests) is the construction of pits covered with brush-wood on the lines of approach of pigs to the fields. Difficulty, however, has been met with in organising these measures.

Chief Conservator of Forests, United Provinces.—Forwards a note by the Divisional Forest Officer, Afforestation Division. who has had personal experience.

Pig.—The methods employed in the Afforestation Division have been—

(I) Large nets have been spread across places where they enter and leave the plantations. Men are hidden close to these places, and when the sounder of pig are seen coming towards the net, these men let them get between the nets and themselves, when they shout and make a noise and let off a gun or two, the pig take the alarm and charge straight into the nets; a good net is made in the shape of a bag; they must be very strong of course.

(II) Another method is to dig a pit and cover it over on a jungle path. An alarm is given in the same way as in No. I.

(III) Shooting and the destruction of squeakers when first born—but this is slow.

(IV) Another method which may be tried, though a bit dangerous, is to poison potatoes or some fruits like guavas and leave them on a known path, the pig would tackle this fruit. I have never tried this method.

The great thing in all these methods is that the pig nearly always leave a forest by the same way, and return the same way; if this peculiarity is taken advantage of, they can be destroyed or kept down.

The Gorakhpur taungya plantations were effectively protected against pig by a ditch. There must be no gaps in the ditch. Access to plantation is made by planks which are removed before night fall.

Chief Conservator of Forests, Burma.—Fauna disappearing rapidly from all inhabited localities. The Game Warden considers that Indians have little to learn from Burmans in the construction of traps and snares which should be set in regular "runs." The existence of these "runs" and the wild pig's tendency to rush blindly when scared are the habits of most use in control measures.

Conservator of Forests, Northern Circle, Bengal.—Gives the following note on woven wire which is of interest.

I have very little information to give.

In 1919, when we first imported woven wire fencing, I made a small corral of this (double thickness) stapled to trees and only 42 inches high. This was done partly to test the woven wire, partly to test the pig's jumping powers and partly with the idea of catching pig if necessary.

The entrance was a short passage leading towards the centre of the corral—the idea being to make a gate at the end, on lobster-pot lines, of stout pointed wires shaped into a funnel. This was never done satisfactorily but some pig, which had followed a trail of paddy into the corral and were surprised there, repeatedly charged the wire and never tried to jump, eventually finding their way out by the passage.

The experiment was abandoned partly owing to the success of fenced plantations and partly because extensive destruction of pig might mean more cattle killed by tiger.

Conservator of Forests, Eastern Circle, Assam.—Forwards an account of the method of hunting used in the Naga hills by the Ao Nagas. This is published in the Ao Nagas by

J. P. Mills, M.A., pages 137-139, and is a form of Kheddah. This particular organisation is possible because the pork is eaten by the villagers.

The Chief Conservator of Forests, Bombay Presidency, furnishes the following note :—

I think I cannot do better than send you a copy of the Report of the Committee appointed by this Government in 1922 to study this and allied subjects. The number of pigs annually destroyed by Forest Officers or other sportsmen is quite trifling. As a result of the enquiries of the above Committee, the following measures have been adopted :—

(1) An officer has been appointed for killing pig in the Deccan Canal area and he has made good progress, and ryots are reported to be co-operating with him.

(2) The Agricultural Department is experimenting with pig-proof fencing and poisoning pig.

(3) Fencing Societies have been formed.

(4) The Veterinary Department has been ordered to investigate the diseases of pig with a view to introducing a disease by means of virus which might lead to extermination of pig.

Other measures and concessions in existence at the time the Committee was appointed, and still in force, such as the grant of rewards for killing pig and clearance of strips round cultivation have been noted in the Committee's report.

I have no other information. The cultivator's own attack on pig consists mainly in sitting over his fields or over water by moonlight with his gun. Hitherto pigs are probably kept down by tiger, panther and wild dog to a greater extent than by any other agency.

2. A summary of the recommendations of the Committee and the orders of the Government of Bombay (kindly supplied by the Chief Conservator of Forests, Central Provinces) are given below.

Part I—Damage by Wild Animals. Paragraph 49, page 34 of the Report.

(*a*) Direct damage to crop is estimated at 70 lakhs (about one-half of which is attributed to jackals) and it is increasing. The indirect damage cannot be given a money value but it may amount to several crores annually.

(*b*) As the eradication of the destructive wild animals and particularly of wild pigs is impracticable except in special areas, the methods adopted to deal with them must be essentially designed for the protection of crops from damage.

(*c*) Though extermination of wild pigs seems at present impossible, there is no reason to suppose that it will never be so if the habits of these animals are better known. It is recommended that a specially suitable officer should be deputed to study the wild pig in its own habitat for some years in order that the weak points at which it can be attacked may be ascertained. It will cost possibly Rs. 20,000 per annum, and the study should last at least three years.

On this recommendation orders of Government were :—

"The proposal for the appointment of a special officer is under consideration. The Principal, Bombay Veterinary College, and Superintendent, Civil Veterinary Department, be requested to submit a report regarding the investigation of the diseases of pig."

There are no papers to show if such a report was submitted by these officers. There is, however, a very useful note recorded by Director of Agriculture, after a meeting of officers of that department. The Director of Agriculture observes that the Department would be justified in spending a considerable sum of money in devising and demonstrating measures for crop protection and destroying pigs. Rupees 20 to 25 thousand may well be expended on a first year's effort. He suggested three main lines of attack :—

(1) *Fencing.*—The Department to concentrate on demonstration by setting up exhibition fences, enclosing a few acres, at certain selected centres. Cheap capital to be provided ; 5 per cent. should be aimed at as the rate charged to fencing societies. Forest Department to facilitate the supply of stone where this is available.

(2) *Poisoning.*—Intensive campaign over limited areas under an officer of the Agricultural Department working in collaboration with local societies organized for the purpose.

(3) *Hunting.*—Contribution from the public for organizing the operations. Govern ment to bear the supervision charges.

There is one other line of work for the Agricultural Department to undertake, *viz.* :—

(4) *Poison Research.*—Assistant Professor of Entomology at the Agricultural College to be entrusted with this work.

The only orders passed by Government were approval of a pig-killing campaign in Deccan Canal areas and construction of demonstration fencing. Sanction was accorded to the entertainment of an officer on Rs. 125—10—145 with a peon of Rs. 30 for one year.

(*d*) Really satisfactory methods are fencing either with dry stone walls or special woven iron fences costing from Rs. 1,400 to Rs. 1,800 per running mile.

(*e*) In order to reduce the cost such fencing must be for large areas, up to 1,000 acres.

(*f*) Takavi for such fencing when cultivators are willing to co-operate. Model bye-laws (page 55 of the report) issued by Registrar, Co-operative Societies, for such a co-operative effort are commended.

Government approved of this recommendation.

(*g*) Where the whole of the cultivators are not willing to co-operate, legislation should be undertaken to provide that if 75 per cent. owners are willing the remainder could be compelled.

Government orders.—Proposed legislation cannot be made applicable to Sind. Such legislation desirable for the Presidency. The exact lines of legislation under consideration.

(*h*) Government as the owner of forest areas from where pigs come should accept a definite liability towards the cost of construction of fences, contribution being one-quarter of the cost. As an alternative, remission of half the assessment for a number of years is suggested.

Orders.—Government not prepared to accept any liability for the damage, or to contribute to the cost of fencing.

(*i*) In the construction of fences, expert advice and assistance should be given free of charge by the Agricultural Department.

(*j*) Other palliative methods (*k* to *t*) are also important.

(*k*) Gun licences for crop protection should be allowed freely. These should be issued to any one owning 10 acres or more.

Government Orders.—It is impracticable to lay down hard and fast rules or prescribe any area or assessment or entitling an appeal to a gun licence. The matter should be left to the discretion of the sanctioning authority subject to the rule that licenses for crop protection should not be withheld without good cause.

(*l*) Guns for crop protection should not only be held by individuals but also by villages as a whole, guns being in charge of Village Panchayats or village officers.

Government Orders.—Consensus of opinions is against issue of communal licenses. Government has, however, no objection to the issue of licenses to *shikaris* or persons appointed by villagers or panchayats, provided the general principles of issuing licenses to individuals are adhered to.

(*m*) Such licenses should be granted with the least possible delay and by Prant Officers.

Government Orders.—There is no reason to authorize Prant Officers (Sub-Divisional Officers) to issue crop protection licenses. They should be issued without unnecessary delay.

NOTE.—In our provinces crop protection licenses are issued by Sub-Divisional Officers and there is little complaint about this matter.

(*n*) Policy of giving rewards to be continued.

Government Orders.—The present practice of giving rewards should be continued.

(*o*) Orders regarding the clearance of a wide strip of land round cultivation contained in Government resolution (*vide* page 60 of the report) seem satisfactory in this matter. Cultivators should be given assistance in the original clearing of such strips and cultivation should be allowed for 2 years.

Government Resolution.—Consensus of opinion is against the general introduction of the rule (No. 3 of Kanara Forest Privilege Rules) for the clearance of strips of land round cultivation as a means of minimising the pig nuisance. If application of this rule to any particular area is considered necessary, proposals should be submitted to Government.

(*p*) The use of poison has given promising results and should be encouraged systematically under the control of a responsible person or body of persons.

Government Orders.—Government agrees that use of poison should be extended. Associations for this purpose should be formed. Government will be prepared to consider the appointment of a small staff under Agricultural Department which would advise people and show them how to use poison. The officers of Revenue Department should also co-operate. Director of Agriculture be asked to submit detailed proposals on these lines for starting poison campaign.

(*q*) The most efficient way of using poison and preparing baits should further be investigated by the Agricultural Department.

Government agrees.—Director of Agriculture be requested to submit a report.

(*r*) Poisoning on any ordinary scale will not deal with pig trouble as a whole, but Government should plan it on a large scale as a regular campaign.

Government Orders.—Under the present circumstances the proposal is not a practical proposition. Until the people are accustomed to the idea of using poisons widely, action on the lines proposed cannot be taken.

(*s*) As regards hunting in Government Forests, the extension of the rules issued by the Collector of Kanara (given at the end of this paragraph) in March 1923, to other areas should be considered and it is recommended so far as it can be done consistent with the protection of forest property. All such rules should recognize that agricultural interest is paramount. If any animal is found to do serious damage, this fact should dominate the situation, hunting of wild pigs organised or unorganized should be encouraged everywhere (paragraph 46).

Government Resolution.—Kanara concession of throwing open forest hunting should not be extended to other districts.

Extract copy of the circular issued by the Collector of Kanara on March 10th, 1923.

* * * * * * * *

"3. The unrestricted hunting of pig will be permitted in the forests of these areas.

4. In these areas, all holders of gun licences for crop protection may (1) shoot pig in any forests, (2) shoot tiger, panther and all animals which damage the crop in the forests comprised within the limits of the villages in which their fields are situated, or if their fields are close to the forest of another village then in that forest also ;

Provided that (*a*) the skins of tigers and panthers shall become the property of the Forest Department, (*b*) there shall be no traffic or barter in the skin or flesh of any such animal. Abuse of these concessions will lead to the withdrawal of the license.

The setting of spring guns for any animals and the setting of snares or traps for other animals than pig is strictly prohibited."

* * * * * * * *

(*t*) In isolated tracts like Deccan Canal areas the wild pig pest can be kept in check at a limited cost by the maintenance of hunting parties. Two such hunting parties should be maintained at a cost of Rs. 5,000 per annum for five years, provided cultivators will pay half the cost of their maintenance under the Agricultural Department.

Government Orders.—Government agrees. Provision of Rs. 5,000 be made in the next budget. Director of Agriculture to report if ryots will contribute half of the cost. The provision should be made for one year only, the period being extended if operations prove useful.

Letter from DR. BAINI PRASHAD, D.SC., F.R.S.E., F.A.S.B., F.L.S., F.Z.S., Offg. Director, Zoological Survey of India, to the Secretary, Imperial Council of Agricultural Research, No. 1922, dated Calcutta, the 28th August 1929.

With reference to your letter No. 383, dated the 19th August 1929, I have the honour to say that there is practically no information whatsoever available regarding the life-histories and habits of wild pigs, jackals and field rats. Most of the work on Indian wild mammals has so far been confined to the systematic study of the different species of these animals which are found in different parts of India. Even this work is by no means complete, but it is hoped that with the issue of the new volume on Mammals in the *Fauna of British India* series, we will at least have something to go on with. The work is undoubtedly of very great importance and I would strongly endorse the resolution of the Board of Agriculture for the appointment of a special officer to study the life-histories of these animals. In the first instance I would suggest that he should concentrate his attention on the study of the life-history of wild pigs, but as jackals and field rats are also found in practically the same areas as pigs, he could carry on studies on these animals as well. The Zoological Survey of India will be very glad to give any assistance in the matter, but with its present staff it is impossible for the Survey to undertake this special line of investigation on its own.

Letter from DR. BAINI PRASHAD, D.SC., F.R.S.E., F.L.S., F.Z.S., F.A.S.B., Offg. Director, Zoological Survey of India, to the Secretary, Imperial Council of Agricultural Research, No. 2123, dated Calcutta, the 20th September 1929.

With reference to your letter No. 598, dated the 11th September 1929, I have the honour to say that the new volume on Mammals in the *Fauna of British India* series is being prepared in London under the direction of His Majesty's Secretary of State for India. The authors of the volume according to the information lately received from Lt. Col. J. Stephenson, the present Editor of the series, are Martin C. Hinton and R. J. Pocock. Regarding the information about the different species of rats, jackals and wild pigs and their habits, I enclose herewith a list of the different articles which have been published from time to time in the "Journal of the Bombay Natural History Society." I am afraid it is not possible for me to give any further information on the subject.

1. The Rice Rats of Lower Sind and their Control.
   (P. V. Wagle). *Journ. Bombay Nat Hist. Soc.* XXXII, p. 330.
2. Expected plague of Field Rats in 1920.
   (W. S. Millard). *Journ. Bombay Nat. Hist. Soc.* XXVII, p. 165.
3. Scientific results from the Mammal Survey, No. XVIII. Report on the House Rats of India, Burma and Ceylon.
   (M. A. C. Hinton). *Journ. Bombay Nat. Hist. Soc.* XXVI, pp. 59, 384, 716. 906.
4. Field Rats in the Deccan in 1879.
   (J. Davidson). *Journ. Bombay Nat. Hist. Soc.* XXVI, p. 1042.
5. Jackals in Lower Burma.
   (C. W. Allen). *Journ. Bombay Nat. Hist. Soc. XXV*, p. 146.
6. The Indian Jackals.
   (R. C. Wroughton). *Journ. Bombay Nat. Hist. Soc.* XXIV, p. 649.
7. **Breeding of Wild Pig (*Sus cristatus*).**
   (Major O. A. Smith). *Journ. Bombay Nat. Hist. Soc.* XXIII, p. 352.

8. Further notes on Wild Pigs.
   (Major O. A. Smith). *Journ. Bombay Nat. Hist. Soc.* XXIII, p. 5[illegible]
9. Wild Pigs' Lairs in the Rains.
   (H. R. Blanford). *Journ. Bombay Nat. Hist. Soc.* XIX, p. 254.
10. Food of the India Wild Boar.
   (R. M. Nash). *Journ. Bombay Nat. Hist. Soc.* XII, p. 770.
11. The Destructiveness of Bandicoot Rats.
   (W. F. Sinclair). *Journ. Bombay Nat. Hist. Soc.* IX, p. 97.
12. Food of the Wild Boar.
   (J. M. Mason). *Journ. Bombay Nat. Hist. Soc.* VIII, p. 447.

(*b*)

Copy of letter No. 5363-D., dated 22nd November, 1929, from W. R. WILSON, Esq., I.C.S., Secretary to the Government, Punjab, Revenue Department, to the Secretary, Imperial Council of Agricultural Research.

In reply to your letter No. 384, dated the 19th August 1929, on this subject, I am directed by the Punjab Government (Ministry of Agriculture) to intimate that a temporary staff of 4 Mukaddams and 8 Fieldmen has been engaged since 1924 on field-rat destruction work. During the year ending 30th June 1929, 246 operations extending over an area of 77,713 acres in 9 districts of the province were carried out. As a result of these operations it is estimated that 5 lakhs of field rats were destroyed. The poison used was strychnine hydrochloride. In addition, 4,492 burrows were treated with calcium cyanide.

2. The question of the control of other wild animals harmful to crops such as pigs porcupines, etc., was discussed at a meeting of the Provincial Board of Agriculture held in August last, and a copy of the relevant portion of the proceedings is enclosed for information.

An extract copy from the Proceedings of the 5th meeting of the Provincial Board of Agriculture, Punjab, held at 11 A.M. on 16th and at 10-30 A.M. on the 17th August, 1929, in Ellerslie, Simla, East.

* * * * * *

Re Item No. 6.

Necessity for measures for the control of wild animals harmful to crops.

The President sub-divided this subject into—

(*a*) animals to the destruction of which there is a religious objection, *e.g.*, wild cattle, monkeys, nilgai, black buck, deer, etc.;

(*b*) animals regarding the destruction of which there is no religious feeling, *e.g.*, pigs, bears, porcupines, rats, flying foxes, etc.

Regarding (*a*) he enquired whether anything could be done with the wild cattle in the Indora tract of the Kangra District. General opinion seemed to be that there was no simple solution. *The Entomologist* suggested research on drugs which would prevent these animals from breeding.

K. B. Maulvi Fateh-ud-Din said that the people who owned land in that locality have no objection to these cattle being removed. He thought they could be caught and sent away elsewhere.

It was suggested that the export of monkeys might be encouraged.

As far as these animals are concerned the Board had no practical proposals for dealing with the problem.

Regarding (*b*) *the Entomologist* thought that certain of these animals could be easily killed by poisonous gases. Thus, calcium cyanide was being used against porcupines. Pigs could be driven into localised areas by irritant gases and finally killed by a poisonous gas.

The Director of Agriculture considered that the problem merited the serious attention of the Department, and some responsible man was required at the head of operations to organise measures. The present field staff consisted of—

3 Agricultural Assistants,

4 Mukaddams,

8 Fieldmen,

and he was of opinion that the staff recommended at the meeting of the Board of Agriculture held in 1925 should be sanctioned. The work of this staff would be to demonstrate to the people how to deal with the pest and try to stimulate public opinion in the organisation of parties to destroy them. It would consist of—

One Provincial Service Officer,

Six Rat Inspectors,

Twenty-four Rat Mukaddams,

120 Fieldmen.

The President suggested that when action is being taken against these animals a locality should be selected which is bounded by some barriers which animals cannot cross.

R. B. Sewak Ram and *K. B. Ch. Fazal Ali* agreed with the proposal of the Director of Agriculture as far as rats were concerned.

The Agricultural Engineer suggested that lantern lectures in this connection should be given throughout the province and it was agreed that this would form part of the general propaganda work.

The Board agreed that the Director of Agriculture should approach Government to sanction the special staff as suggested by him above to take up this problem.

* * * * * *

(*c*)

Copy of a letter No. S-22010- 943 of 1929, dated the 16th October 1929, from the Director of Agriculture, Bombay Presidency, Poona, to the Secretary to Government, Revenue Department, Bombay.

SUBJECT.—Steps taken to save crops from the depredations of wild animals.

With reference to letter No. 384, dated 19th August 1929, from the Secretary, Imperial Council of Agricultural Research, Simla, sent with your endorsement No. 1045-A-24, dated 26th August, 1929, on the subject mentioned above, I have the honour to report as below :—

1. *Wild Pigs.*

(*a*) Hunting parties: I would refer first of all to the "Report of the Committee appointed (by the Bombay Government) to consider and adopt measures for the protection of crops from wild animals and stray cattle, 1923. As a result a Pig-Killing Officer (whom I shall hereafter call a "Shikar Officer) was appointed in 1924. The appointment is a temporary one and has been continued year by year till 8th December 1929, and it is

proposed to make this post permanent. The total cost of the appointment, and all other expenses connected with this work for the years 1924 to 1929 are as follows :—

Statement showing the total cost for pig-killing work in South Central Division from 1924-25 to 1928-29.

Year	Pay of Mr. Bhide, Shikar Officer	Pay of Shikari Peon	T. A. for both	Contingencies	Total
1	2	3	4	5	6
1924-25 . .	350	60	150	847	1,407
1925-26 . .	1,505	330	570	1,561	3,966
1926-27 . .	1,648	360	716	1,067	3,791
1927-28 . .	1,768	413	875	1,340	4,396
1928-29 . .	1,888	360	830	1,204	4,282
TOTAL .	7,159	1,523	3,141	6,019	17,842

Statement showing the amounts borne by villagers (i.e., *local bodies*) *for pig-killing work in South Central Division for 1924-25 to 1928-29.*

Year	Koregaon People's contribution (Dist. Satara)	Godavari canals (Dist. Ahmednagar)	Munji village (Dist. Ahmednagar)	Pravara canals (Dist. Ahmednagar)	Nira canals (Dist. Poona)	Total
1	2	3	4	5	6	7
1924-25	..	..	..	..	..	..
1925-26	..	..	..	..	92	92
1926-27	112	..	75	..	..	187
1927-28	166	325	130	46	..	667
1928-29	400	57	227	..	..	684
TOTAL	678	382	432	46	92	1,630

The total number of pigs killed up to date is 1,263. Fifty-six deer and 4 panthers have also been killed. The method of work is briefly summarised in the note attached.

I also enclose a copy of the leaflet (No. 12 of 1927) regarding this work. The areas worked over are shaded in the attached sketch map.

2. This work is definitely a success. It appeals to the people. When run in conjunction with gun clubs, it is specially effective. It has the effect of scaring away the pigs for a considerable time as well as of killing many. The following G. R.'s issued from time to time by the Bombay Government bear on this work :—

1. G. R., R. D., No. 1045/24, dated 1st December 1924.
2. G. R., R. D., No. 1045/24, dated 2nd June 1926.
3. G. R., R. D., No. 1045/24, dated 18th November 1927.

I. (*b*) *Walls.*

3. The co-operative building of walls and erection of wire fences has been developed in the Southern Division. Reference is requested to the article entitled " Fencing with stone walls as a remedy against damage by wild pigs " by Mr. S. S. Salimath, B. Ag., Deputy Director of Agriculture, Southern Division, in the Agricultural Journal of India, Vol. 22, Part 6, November 1927, page 437. The terms on which these walls and fences are erected are briefly as follows :—

The farmers are asked to pay a rent for the fence on the basis, say, of Rs. 2 or so per acre of cane area to be enclosed by the fence. On this condition an Association is formed to make arrangements of the fence for 5 years. If the Association is satisfied as regards the arrangement, it is allowed to purchase the fence at the end of the 5th year at a reasonable cost. A copy of the leaflet H. H. regarding societies for co-operative land improvement is enclosed herewith which gives detailed information regarding the formation of societies for putting up wire fencing, walls, etc.

4. There are 2 types of fencing, *viz.* (1) stone walls and (2) woven wire fence and the nature of the same is as follows :

Stone Walls.—4½ feet is the minimum height for such a wall to be effective. The cost even with a sufficient number of stones within half a mile of the site of the wall would be at least Rs. 1,400 per running mile.

Woven wire fence.—The ordinary barbed wire fences are of very little use against wild pigs, though they are effective against larger animals. The fences which are effective are composed of galvanised wire covered for a protion of their height with woven wire netting, the latter being buried at least 6 inches in the ground. The price of such a fence may be taken at Rs. 1,400 to Rs. 1,800 per running mile.

II. *Field Rats.*

5. This pest has been dealt with only in Sind where the methods employed have been (1) poisoning and (2) fumigation of the burrows. The details will be found in Bulletin No. 138 of 1927 and in G. R.'s R. D. Nos. 9431 of 28th April 1927 and 9431 of 16th May 1928. This work has been in progress since 1924. The actual work done is described in the following G. R.'s :—

1. G. R., R. D., No. 9431 of 25th September 1925.
2. G. R., R. D., No. 9431 of 23rd April 1926.
3. G. R., R. D., No. 9431 of 28th April 1927.
4. G. R., R. D., No. 9431 of 16th May 1928.

The area treated was as follows :—

Year	Area.
1924 1925	Radius of 6 miles.
1926	3,460 acres.
1927	5,776 „
1928	6,243 „

I would also request reference to Article XIII in this Department's Bulletin No. 159 of 1929 on "Agriculture in Sind under the Barrage Canals System."

III. *Jackals.*

6. We have developed no special measures against these animals.

7. The letter dated 19th August 1929 from the Secretary, Imperial Council of Agricultural Research, Simla, received with the Government endorsement under reply, is returned herewith.

The method of work (hunting parties) is briefly as follows :—

A hunting party has the following constituents :—

1. Guns 3 to 7 in number.
2. Beaters 4 to 8 in number and their dogs.
3. Barkers (working by scent and are of small size country cross-bred terriers) ; each beater has a couple. Some of these are trained and know the game thoroughly, while some are under training.
4. Spearsmen 4 to 8 or more,
5. Leashes or ropedogs. So known on account of the loop of rope on the neck-sling, one end of which is loosened and given away at the time of letting the dog loose on the pig.

The number in each of these items depends upon local conditions of open space or otherwise—outside the cover—when the open space exists leash-dogs and spears can replace part of guns. The actual method :—The beaters and the barkers trace out fresh "pugs" or prints, track out the pigs by these and hunt them out in a suitable direction working with the wind so that the pig or pigs when hunted out pass between or over one batch of gunner (2 or 3) while the other gun or guns have to do the work of facing the cover in the rear and on the flank and so short as not to allow a pig or pigs to escape out to their side. The first set of guns occupy the forward positions. Ammunition is used by gunmen only on fairly big-sized pigs, youngsters and half growers being allowed to pass through or over by the gunmen to an open space between positions occupied by the spears and leashes.

Of the leashes one or more according to the size of the pig are let loose when a pig has come up within a catching distance. The leashes approach the pig from behind and catch him by the ears, hind-quarters or testicles and held and kept stationary till the spears come, turn him over and spear him. The spear as used by the Vaidu is a short jabbing spear and is used overhand, piercing the pig in the ribs.

In forest tracts the beaters in the hunting party are freely and cordially helped by the farmers in the beating work when the party works in that tract.

APPENDIX XV.

Note on Subject XII.—Permanent Experiments at Pusa.

(W. H. HARRISON, *Offg. Director, Imperial Institute of Agricultural Research, Pusa.*)

The permanent manurial and rotation experiments at Pusa were started in 1908 with a view to study the conditions which determine soil fertility in a sub-tropical climate, and, in particular, the manner in which soil fertility is affected by the application of important manures, including green manures, and by rotation of crops. The scheme as formulated by a Committee of the Board of Agriculture held at Pusa in February 1908, and adopted by the Board, was as follows:—

SERIES I.

To determine the specific effect on soil fertility of the more important organic and chemical manures applied alone and in various combinations on a two years' four-course rotation.

No.	Kharif	Rabi	Kharif	Rabi	Manure applied.
1	Maize .	Rahar .	Maize .	Oats .	No manure.
2	Do. .	Do. .	Do. .	Do. .	Farmyard manure = 10 lb. N per acre.
3	Do. .	Do. .	Do. .	Do. .	Do. do. = 20 lb. do.
4	Do. .	Do. .	Do. .	Do. .	Do. do. = 30 lb. do.
5	Do. .	Do. .	Do. .	Do. .	Rape cake = 20 lb. do.
6	Do. .	Do. .	Do. .	Do. .	Ammonium sulphate = N in farmyard manure No. 3.
7	Do. .	Do. .	Do. .	Do. .	Potassium sulphate = K_2O in farmyard manure No. 3.
8	Do. .	Do. .	Do. .	Do. .	Superphosphate = P_2O_5 in farmyard manure No. 3.
9	Do. .	Do. .	Do. .	Do. .	P tassium sulphate and superphosph.te each equivalent to No. 3.
10	Do. .	Do. .	Do. .	Do. .	Potassium sulphate, superphosphate and ammonium sulphate each equivalent to No. 3.

The plots to be ¼ acre duplicated and all crops of each rotation to be grown in the same year. Manures to go on every year on the maize.

SERIES II.

To determine how far soil fertility is affected by growing in rotation leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures. It is

complementary to Series I inasmuch as the results obtained will give an indication of how far legumes can replace manures in a rotation.

No.	Kharif	Rabi	Kharif	Rabi	REMARKS.
11	Maize .	Barley .	Maize .	Oats .	No manure.
12	Do. .	Do. .	Sann-hemp	Do. .	Effect of green manure on cereal rotation.
13	Do. .	Rahar .	Maize .	Do. .	Effect of green manure on deep-rooted pulse crop.
14	Do. .	Do. .	Do. .	Oats and peas.	Effect of green manure on one deep and one shallow-rooted crop.
15	Do. .	Do. .	Sann-hemp	Do. .	Effect of green manure on deep-rooted pulse and green manure.

Plots to be $\frac{1}{4}$ acre duplicated and all the crops of each rotation to be grown in one year.

An extra duplicated plot was added in 1913-14 in which sann-hemp as a green manure was supplemented by a dressing of superphosphate equivalent to the P_2O_5 given by an application of farmyard manure supplying 20 lb. N per acre.

No thorough examination of the plots was carried out when the experiments were started, nor have the crops been subjected to any chemical examination. The manures have been analysed, but the farmyard manure having been taken as the basis of application of inorganic manures, the quantities of the latter have varied from year to year according to the analyses of the former.

The results obtained up to 1918 are summarised in the note submitted to the Board of Agriculture held at Pusa in 1919 and printed as Appendix I to this note (p. 227). It reviews the general conclusions which could then be arrived at, leaving aside the complications which had arisen owing to the amount of farmyard manure being taken as the basis of comparison as distinct from that of manurial ingredients themselves. The position was discussed in a Committee of the Board in 1919, whose report, which was endorsed by the Board, is printed as Appendix II to this note (p. 237). After a careful consideration of the results, the Committee came to the conclusion that the experiments as a whole were too condensed to permit the objective being attained in its entirety and that the plots will probably yield more valuable results if certain modifications were introduced. They, however, thought that as the experiments had been conducted for ten years and as the results were becoming more uniform and were furnishing information of considerable scientific interest no alteration of extreme character should be made except a remodelling of the rotation. They further remarked that one very interesting fact which had emerged from the experiments was the effect of different manures on the incidence of "wilt" in *Cajanus indicus*, and in order that the Imperial Mycologist may complete his observations in this respect, it was desirable that the existing rotation be continued for some time.

In view of the above remarks, the plots have been continued without any alteration to enable the Imperial Mycologist to complete his investigations. His report on the result obtained so far is annexed (Appendix III—p. 238) together with a note (Appendix IV—p. 244) by the Imperial Agriculturist giving a brief survey of the 20 years' results of the experiments from the agricultural point of view.

The subject was discussed at a meeting of the Pusa Council on 14th November 1929 which was of the opinion that as the observations of the Imperial Mycologist in regard to the incidence of "wilt" on these plots were now completed, and as no new facts were likely to emerge in the future, the scheme approved by the Board of Agriculture in 1919 should be put into operation commencing with the monsoon crop of 1930.

APPENDIX I.

NOTE ON PERMANENT EXPERIMENTAL PLOTS AT PUSA.

(W. H. HARRISON, D.Sc., *Imperial Agricultural Chemist.*)

The form of the present experiments arose out of a proposal of Mr. Shearer, the then Imperial Agriculturist, to lay down a series of permanent experiments at Pusa. These proposals were laid before a Committee of the Board of Agriculture held at Pusa in February 1908, and this Committee formulated two series of experiments as follows:—

SERIES I.

To determine the specific effect on soil fertility of the more important organic and chemical manures applied alone and in various combinations on a two years' four-course rotation.

No.	Kharif	Rabi	Kharif	Rabi	Manure applied
1	Maize	Rahar	Maize	Oats	No manure.
2	Do.	Do.	Do.	Do.	Farmyard manure = 10 lb. N per acre.
3	Do.	Do.	Do.	Do.	Do. do. = 20 lb. do.
4	Do.	Do.	Do.	Do.	Do. do. = 30 lb. do
5	Do.	Do.	Do.	Do.	Rape cake = 20 lb. do.
6	Do.	Do.	Do.	Do.	Ammonium sulphate = N in farmyard manure No. 3.
7	Do.	Do.	Do.	Do.	Potassium sulphate = K_2O in farmyard manure No. 3.
8	Do.	Do.	Do.	Do.	Superphosphate = P_2O_5 in farmyard manure No. 3.
9	Do.	Do.	Do.	Do.	Potassium sulphate and superphosphate each equivalent to No. 3.
10	Do.	Do.	Do.	Do.	Potassium sulphate, superphosphate and ammonium sulphate each equivalent to No. 3.

The plots to be $\frac{1}{4}$ acre duplicated and all crops of each rotation to be grown in the same year.

Manures to go on every year on the maize.

SERIES II.

To determine how far soil fertility is affected by growing in rotation leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures. It is

comp ementary to Series I inasmuch as the results obtained will give an indication of how far legumes can replace manures in a rotation.

No.	Kharif	Rabi	Kharif	Rabi	Remarks.
11	Maize .	Barley .	Maize .	Oats .	No manure.
12	Do. .	Do. .	Sann-hemp	Do. .	Effect of green manure on cereal rotation.
13	Do. .	Rahar .	Maize .	Do. .	Effect of green manure on deep-rooted pulse crop.
14	Do. .	Do. .	Do. .	Oats and peas.	Effect of green manure on one deep and one shallow-rooted crop.
15	Do. .	Do. .	Sann-hemp	Do. .	Effect of green manure on deep-rooted pulse and green manure.

Plots to be ¼ acre duplicated and all the crops of each rotation to be grown in one year.

These proposals were adopted with slight modifications by the Board, and form the basis of the experiments now under consideration, which were started in 1908. The only change since then was the introduction by Mr. Milligan of an extra duplicated plot in which sann-hemp as a green manure was supplemented by a dressing of superphosphate equivalent to the P_2O_5 given by an application of farmyard manure supplying 20 lb. N per acre.

Although the Committee divided the experiments into two separate series, it is obvious that for purposes of comparison—at least as a preliminary—the experiments should be divided into four series as follows:—

Series	Object	Plot Nos.
A	The effect of organic manures	1, 2, 3, 4 and 5
B	The effect of artificial manures applied alone, or in combination, and in amounts equivalent to that supplied by farmyard manure at 20 lb. N per acre	6, 7, 8, 9 and 10
C	The effect of pulse crops in a rotation	11, 13 and 14
D	The effect of green manures on mixed and cereal rotations, with and without addition of superphosphate	13, 12, 15 and 16

Most of the plots get the same rotation, *viz.*, maize, *rahar*, maize and oats, and conse quently there are four plots receiving no manure, namely, 1A, 1B, 13A and 13B, and these in effect form the check plots. The average croppings on these plots from 1908 to 1918 are given in the following table:—

Plot No.	Maize		Rahar			Oats	
	Grain	Straw	Grain	Bhusa	Stalk	Grain	Straw
1A	808	1,786	1,048	1,960	4,739	810	1,448
1B	634	1,593	1,072	1,340	3,574	508	1,062
13A	858	1,741	752	1,543	3,975	531	1,149
13B	709	1,809	792	1,163	3,160	440	1,040
Average .	752	1,732	916	1,501	3,812	562	1,175

The variation between individual plots is large, but for purposes of comparison it is proposed to take the average value

SERIES A.

THE EFFECT OF APPLICATIONS OF ORGANIC MANURES.

1. Effect on cereals.

Treatment	Plot Nos.	MAIZE					OATS				
		YIELD PER ACRE.		% INCREASE		RATIO	YIELD PER ACRE.		% INCREASE		RATIO
		Grain	Straw	Grain	Straw	$\frac{\text{Grain}}{\text{Straw}}$	Grain	Straw	Grain	Straw	$\frac{\text{Grain}}{\text{Straw}}$
No manure . . .	1A 1B 13A 13B	752	1,732	..	..	$\frac{1}{2\cdot3}$	562	1,175	..	..	$\frac{1}{2\cdot09}$
Farmyard manure=10 lb. N per acre	2A 2B	890	1,845	18 3	6·5	$\frac{1}{2\ 07}$	758	1,325	34·8	12·8	$\frac{1}{1\cdot75}$
Farmyard manure=20 lb. N per acre.	3A 3B	1,032	2,018	37·2	16·5	$\frac{1}{1\cdot95}$	871	1,513	55·0	28·8	$\frac{1}{1\cdot74}$
Farmyard manure=30 lb. N per acre.	4A 4B	1,059	2,030	40 8	17·2	$\frac{1}{1\cdot92}$	894	1,601	59·3	36·3	$\frac{1}{1\cdot79}$
Rape cake = 20 lb. N per acre.	5A 5B	1,053	2,107	40·9	21·6	$\frac{1}{2\cdot0}$	645	1,206	1·5	2·6	$\frac{1}{1\cdot87}$

2. Effect on rahar.

Treatment	Plot Nos.	YIELD PER ACRE			% INCREASE			RATIO		
		Grain	Bhusa	Stalk	Grain	Bhusa	Stalk	$\frac{\text{Grain}}{\text{Bhusa}}$	$\frac{\text{Grain}}{\text{Stalk}}$	$\frac{\text{Grain}}{\text{B+S}}$
No manure . . .	1A 1B 13A 13B	916	1,501	3,812	..	..	..	$\frac{1}{1\cdot64}$	$\frac{1}{4\cdot16}$	$\frac{1}{5\cdot8}$
Farmyard manure=10 lb. N per acre.	2A 2B	1,053	1,765	4,096	14·9	17·6	7 7	$\frac{1}{1\cdot67}$	$\frac{1}{3\cdot89}$	$\frac{1}{5\cdot55}$
Farmyard manure=20 lb. N per acre.	3A 3B	1,071	1,985	4,885	16·9	32·2	28·1	$\frac{1}{1\cdot85}$	$\frac{1}{4\cdot55}$	$\frac{1}{6\cdot41}$
Farmyard manure=30 lb. N per acre.	4A 4B	1,062	2,018	5,314	15·9	34·4	39·4	$\frac{1}{1\cdot9}$	$\frac{1}{5\cdot0}$	$\frac{1}{6\cdot89}$
Rape cake=20 lb. N per acre.	5A 5B	943	1,757	4,177	3·0	17·2	0·6	$\frac{1}{1\cdot86}$	$\frac{1}{4\cdot43}$	$\frac{1}{6\cdot28}$

Conclusions.—Regarding applications of farmyard manure to cereals the effect has been to increase the cropping; the extra increase, however, is not marked with amounts above 20 lb. to the acre. At the same time the proportion of grain to straw is increased.

The effect of the rape cake varies. With maize the crop produced is almost equal to that given by farmyard manure at 30 lb. N per acre, but with oats the effect produced is almost negligible. It must be remembered, however, that the manures are applied with the maize crops and that, consequently, the oats crop has only the residuals to feed upon. On this basis it would appear that the effect of rape cake is very pronounced on the crop to which it is applied but that little if any benefit accrues to the succeeding crop. Rape cake in fact would appear not to be such a lasting manure as farmyard manure.

The effect on *rahar* is peculiar. The different doses of farmyard manure have given practically the same seed production but, on the other hand, with increasing doses, the vegetative growth has increased. The effect, then, of farmyard manure is to increase the vegetative growth without materially affecting the seed production. Here again the effect of rape cake has been small, but once more we are only dealing with residuals left over from the previous maize crop, and the same conclusion is forced that the effect of rape cake does not last over a complete cropping season.

The general conclusions, therefore, which are to be drawn from Series A are (1) bulky organic manures have a very appreciable effect in increasing the total crop, but whereas with cereals the proportion of grain is materially increased, the reverse is the case with *rahar*, and (2) the residual effect of the rape cake is inappreciable on the second crop although its effect on the crop to which it is applied is very marked. Rape cake is therefore not as effective as farmyard manure when the application is only once in a full cropping season.

SERIES B.

THE EFFECT OF MINERAL MANURES.

1. Effect on cereals.

Treatment	Plot Nos.	MAIZE					OATS				
		YIELD PER ACRE		% INCREASE OR DECREASE		RATIO	YIELD PER ACRE		% INCREASE OR DECREASE		RATIO
		Grain	Straw	Grain	Straw	$\frac{\text{Grain}}{\text{Straw}}$	Grain	Straw	Grain	Straw	$\frac{\text{Grain}}{\text{Straw}}$
No manure . . .	1A 1B 13A 13B	752	1,732	..	..	$\frac{1}{2\cdot31}$	562	1,175	..	..	$\frac{1}{2\cdot06}$
Am_2SO_4 . . .	6A 6B	728	1,727	—4·5	—·3	$\frac{1}{2\cdot37}$	492	1,108	—12·5	—5·7	$\frac{1}{2\cdot25}$
K_2SO_4	7A 7B	646	1,577	—14·1	—8·9	$\frac{1}{2\cdot44}$	470	1,054	—18·8	—10·3	$\frac{1}{2\cdot24}$
Superphosphate . .	8A 8B	1,043	2,142	+38·6	+23·6	$\frac{1}{2\cdot06}$	855	1,590	+52·2	+35·4	$\frac{1}{1\cdot86}$
K_2SO_4 + Superphosphate .	9A 9B	1,000	1,942	+33·0	+12·2	$\frac{1}{1\cdot94}$	856	1,539	+52·4	+31·0	$\frac{1}{1\cdot80}$
Am_2SO_4 + Superphosphate + K_2SO_4	10A 10B	1,207	2,256	+60·5	+30·2	$\frac{1}{1\cdot87}$	875	1,634	+55·7	+39·2	$\frac{1}{1\cdot87}$

2. *Effect on rahar.*

Treatment	Plot Nos.	Yield per acre			% Increase or Decrease			Ratio		
		Grain	Bhusa	Stalk	Grain	Bhusa	Stalk	Grain / Bhusa	Grain / Stalk	Grain / B+S
No manure	1A 1B 13A 13B	916	1,501	3,812	..	..	..	1 / 1·64	1 / 4·16	1 / 5·8
Am_2SO_4	6A 6B	875	1,789	3,871	—4·5	+19·2	+1·5	1 / 2·02	1 / 4·42	1 / 6·47
K_2SO_4	7A 7B	822	1,422	3,879	—10·3	—5·3	+1·8	1 / 1·73	1 / 4·71	1 / 6·45
Superphosphate	8A 8B	962	1,692	5,031	+5 0	+12 7	+32·0	1 / 1·76	1 / 5·23	1 / 7 0
K_2SO_4 + Superphosphate	9A 9B	859	1,657	4,777	—6 2	+10·4	+25·4	1 / 1·93	1 / 5·56	1 / 7·48
Am_2SO_4 + Superphosphate + K_2SO_4	10A 10B	858	1,644	4,319	—6·3	+9·5	+13 3	1 / 1 92	1 / 5·03	1 / 6 73

3. *Conclusions.*—In general the effect of these manures on the two cereal crops is very similar. Nitrogen and potash depress the yield of both grain and straw, the depression being greatest in the case of potash. On the other hand, superphosphate has given decided increases and we may therefore conclude that this series demonstrates the fact that applications of phosphoric acid are essential for materially increasing the growth. It is further noticeable that whereas the combination of potash and superphosphate is slightly inferior to superphosphate alone, the complete combination is very materially superior in the case of maize. This would point to the conclusion that phosphoric acid is the primary limiting factor, but that there is a very important secondary limiting factor to be taken into account if maximum crops are to be produced. What this factor is, is difficult to say as the series is not a complete one in that the combinations, superphosphate and nitrogen, and nitrogen and potash, are not included. Judging by the very decided effect of potash in materially decreasing the yield and by the fact that no benefit is derived on combining it with superphosphate, it would appear probable that this secondary limiting factor is the supply of nitrogen, and I would recommend that this series be extended so as to include the two combinations given above.

As in the case of rape cake in Series A, it is here evident that the effect of the complete manure on the oats is much less marked than in the case of maize, and in the case of *rahar* it is inferior to that of superphosphate alone. With both oats and *rahar*, the manures are applied to the preceding crop, and consequently we are here dealing with residual effects. The crops of oats and *rahar* from the complete manure plots are not materially different to those from superphosphate alone, and this leads to the conclusion that the effect of the secondary limiting manure has been eliminated by the first crop of maize, and that it has not come into play with the succeeding crop. If this is the case, then it would appear preferable in this series to apply the manures to each crop and not merely once in the complete season.

It is noticeable that with these cereals those manures which depress the yield tend to decrease the proportion of grain, whereas those which give increased yields increase the proportion of grain.

In the case of *rahar* the same conclusions regarding the effect of superphosphate on the total crop emerge, but as in the case of Series A the result is to decrease the proportion of grain. In fact all these artificial manures have given a similar result in this respect.

These conclusions may be summarized as follows:—

(1) Of the manurial constituents nitrogen, potash and phosphoric acid, when applied alone, the latter is the only one which gives a distinctly positive reaction in Pusa soil, but the combination of all three gives the best results to the crop to which it is applied.

(2) In the case of cereals the use of phosphoric acid increases the proportion of grain but in the case of *rahar* all manures increase the proportion of green matter.

Comparison of the results from A and B Series.

As the Committee appointed to formulate these experiments included Series A and B in one series, it would appear that one of the objects aimed at was an endeavour to obtain a measure of the value of the organic matter in farmyard manure as distinct from that of the manurial ingredients. For this purpose they took the quantity of farmyard manure giving 20 lb. N per acre as a basis, and gave to the artificial manure plots an amount of potash, phosphoric acid or nitrogen equivalent to that contained in the farmyard manure.

Farmyard manure is a substance of very variable composition and consequently, in order to carry out in a rigorous manner the experiment as designed, it would be necessary to sample the manure, in a very careful manner, and from the result of the analysis to adjust the quantities of potash, phosphoric acid and nitrogen given to the other plots each year.

The variations of the farmyard manure produced at Pusa are shown in the following table:—

Year	Percentage		
	N	P_2O_5	K_2O
1908	0·62	0·41	0·24
1911	0·46	0·51	1·55
1912	0·40	0·21	0·52
1913	0·40	0·22	0·56
1916	0·45	0·39	0·77

On this basis, the amounts of superphosphate and sulphate of potash applied to the plots could not have been constant and, in fact, must have varied from about 70 to 150 lb. (15 per cent. P_2O_5) in the case of the former and from about 16 to 68 lb. in the case of the latter. It is a very debatable point whether a manurial experiment subject to such varying conditions is of any value for purposes of comparison, and it is open for consideration whether or not the two Series A and B should be looked upon as distinctly separate experiments and each made as uniform as possible without reference to the other.

Apart from the above consideration, if one deals with average figures then the farmyard manure applied would contain about 0·47 per cent. N and the standard plot receiving 20 lb. N would therefore be manured at the rate of about 4,250 lb. per acre. The average percentage of P_2O_5 is 0·35 and K_2O, 0·73 so that the average applications to the plots would be about 15 lb. of the former and 31 lb. of the latter. In effect this means that the plots get on the average 20 lb. N, 15 lb. P_2O_5 and 31 lb. K_2O each year and, apart from any question of these being in well balanced proportions one with the other, it must be remembered that these quantities have to answer for a whole season and feed two crops. It has previously been pointed out that there is a strong probability that the effect of one of the manurial ingredients does not persist over the first crop, and it would therefore appear desirable (1) to balance the dressings one to the other and (2) to apply them to each crop.

Turning now to such comparisons as may be drawn, the following results are obtained:—

Effect on cereals of mineral manures compared with farmyard manure.

Treatment	Plot Nos	MAIZE					OATS				
		Yield per acre		% Increase or Decrease		Ratio	Yield per acre		% Increase or Decrease		Ratio
		Grain	Straw	Grain	Straw	Grain / Straw	Grain	Straw	Grain	Straw	Grain / Straw
Farmyard manure = 20 lb N per acre	3A, 3B	1,032	2,018	..	.	1 / 1·95	871	1,513	..	..	1 / 1·74
Am_2SO_4	6A, 6B	728	1,727	−29·4	−14·5	1 / 2·37	492	1,108	−43·5	−26·7	1 / 2·25
K_2SO_4	7A, 7B	646	1,577	−37·4	−21·9	1 / 2·44	470	1,054	−46·1	−23·0	1 / 2·24
Superphosphate	8A, 8B	1,043	2,142	+1·1	+6·1	1 / 2·06	855	1·590	−1·8	+5·1	1 / 1·86
K_2SO_4 + Superphosphate	9A, 9B	1,000	1,942	+3·1	−4·3	1 / 1·94	856	1,539	−1·7	+1·7	1 / 1·80
Complete manure	10A, 10B	1,207	2,256	+16·9	+11·8	1 / 1·87	875	1,634	+0·5	+8·0	1 / 1·87

The comparison is complicated by the question of the persistence of the dressings of manure over the second cropping, but it is very apparent that both ammonium sulphate and sulphate of potash applied alone have led to greatly diminished yields. On the other hand, the dressing of superphosphate has yielded crops practically the same as that given by the farmyard manure and its efficiency in Pusa soils is thereby demonstrated. The combination of superphosphate and potash has no advantages over superphosphate alone, but the complete combination in the case of maize is much superior to either superphosphate or farmyard manure. The effect of this mixture is, however, only slightly better than that of superphosphate in the second crop (oats). It is very regrettable that for purposes of comparison there are no plots receiving N *plus* K_2O or N *plus* superphosphate in combination.

SERIES C.

This series is a comparison of the croppings under a purely cereal rotation against those from rotations which include pulse crops. The cereal rotation is one of alternate crops of maize and oats, whilst one leguminous rotation is maize, *rahar*, maize and oats over a period of two years, and the other is one of maize, *rahar*, maize and oats and peas. That is, one rotation is to evaluate the effect of a deep-rooted pulse crop, and the other to test the effect of a combination of deep and shallow-rooted pulse crops. Of these, the former corresponds to the no manure plot of Series A and B.

The results obtained are as follow :—

A.—Effect on cereal crops.

Treatment.	Plot Nos.	MAIZE					OATS				
		Yield per acre		% Increase or Decrease		Ratio	Yield per acre		% Increase or Decrease		Ratio
		Grain	Straw	Grain	Straw	Grain / Straw	Grain	Straw	Grain	Straw	Grain / Straw
No legume in rotation	11 A, 11 B	726	1,793	.	..	1 / 2·47	446	926	.	.	1 / 2 08
Deep rooted legume in rotation.	13 A, 13 B	783	1,774	+7·9	—1·1	1 / 2 26	485	1,094	+8·7	+18·2	1 / 2·26
Deep and shallow legume in rotation.	14 A, 14 B	839	1,799	+15 5	+0 3	1 / 2 14	322	683	—27·8	—26·2	1 / 2·12

B.—Effect on leguminous crops.

The only comparison which can be made in this case is the yield of *rahar* when grown in an otherwise purely cereal rotation and of *rahar* when grown in a rotation which also includes a shallow-rooted legume.

Treatment	Yield per acre			% Decrease			Ratio
	Grain	Bhusa	Stalk	Grain	Bhusa	Stalk	Grain / B+S
Rahar and cereal crops only.	772	1,353	3,567	..	..	..	1 / 6·46
Rahar with cereals and peas.	698	1,305	3,550	—9·5	—3·5	—0 5	1 / 6·97

C.—Conclusions.

Regarding maize, it is evident that the benefit due to the inclusion of legumes in the rotation is positive so far as yield of grain is concerned, but the increases obtained are not of great magnitude and there is practically no change in the weight of straw produced.

No valid comparison can be made in the case of oats, for the reason that in the rotation which includes both deep and shallow-rooted legumes the oats are grown as a mixed crop with the peas and this alone is sufficient to account for the definite decrease observed. The average crop of peas taken off these plots is 179 lb. grain and 335 lb. straw per acre, *i.e.*, the total mixed crop was 501 lb. grain and 1,018 lb. straw. All that can be said is that the introduction of a deep-rooted legume into a cereal rotation has resulted in a slight in crease in the crop of oats produced.

In the case of *rahar* the only comparison which can be made shows that the addition of a shallow-rooted legume to the rotation has resulted in slight decreases.

This series appears to me to be a most unsatisfactory one, for, if the object is to find a good system of rotation suited to Pusa conditions, the series does not cover a wide enough field and should either be extended or cut out from the series of experiments.

SERIES D.

GREEN MANURE EXPERIMENTS.

A.—Effect of green manures alone and in combination on cereals.

Treatment	Plot No.	MAIZE					OATS				
		YIELD PER ACRE		%INCREASE		RATIO	YIELD PER ACRE		%INCREASE		RATIO
		Grain	Straw	Grain	Straw	Grain/Straw	Grain	Straw	Grain	Straw	Grain/Straw
No green manure or legume	11A, 11B	726	1,793	..	..	1/2·47	446	926	..	..	1/2·08
Green manure—no legume	12A, 12B	1,040	2,038	+43·2	+13·7	1/1·96	690	1,143	+54·5	+52·6	1/2·05
Green manure and legume	15A, 15B	1,069	2,251	+47·2	+25·5	1/2·10	718	1,357	+60·8	+46·6	1/1·89
Green manure, legume and superphosphate.	16A, 16B	1,458	2,841	+101	+58·4	1/1·95	1,451	2,330	+18·0	+15·2	1/1·60

In addition to the above crops, it is possible in the case of barley to draw conclusions relating to the effect of green manures.

Treatment	YIELD PER ACRE		% INCREASE		RATIO
	Grain	Straw	Grain	Straw	Grain/Straw
No green manure	358	603	..	..	1/1·69
Green manure	498	800	+39·2	+32·6	1/1·61

B.—Effect of green manure on legumes (rahar) in a mixed rotation.

Treatment	Plot No.	Yield per acre			% Decrease			Ratio
		Grain	Bhusa	Straw	Grain	Bhusa	Straw	Grain / Bhusa + Straw
No green manure	1A 1B 13A 13B	916	1,501	3,812	..	..	..	1 / 5·8
Green manure	15A 15B	671	1,294	3,345	—26·7	—13·8	—12·3	1 / 6·9
Green manure and superphosphate.	10A 16B	581	1,173	3,277	—36 5	—21 8	—14 0	1 / 7·6

C.—Conclusions.

The very definite depletion of the yield of *rahar* under the influence of green-manuring even—when in conjunction with superhosphate—is very remarkable, but it receives some confirmation from the result in Series C when the introduction of a second leguminous crop led to a slight reduction of the yield. It would almost seem as if the use of green manures in conjunction with a leguminous crop of the type of *rahar* were deleterious, and it would appear desirable that this point should be tested more rigorously.

Regarding the cereal crops, the returns are very definite and distinctly demonstrate the great benefit derived from green manures, even in purely cereal rotations. The introduction of a legume into the rotation gives only a comparatively small increased benefit. The outstanding feature is, however, the value of a combination of green manure and superphosphate which is brought out very clearly in the following table:—

Treatment	Maize				Oats			
	Yield		% Increase		Yield		% Increase	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
No manure	752	1,732	..	..	562	1,175	..	..
Farmyard manure=20 lb. N per acre.	1,032	2,018	37·2	16·5	871	1,513	55·0	28·8
Complete mineral manure.	1,207	2,256	60·5	30·2	875	1,634	55·7	39·2
Green manure	1,069	2,251	41·1	30·0	718	1,357	27·8	15·6
Green manure and superphosphate.	1,458	2,841	93·9	63·8	1,451	2,330	159·0	98·0

Here green manure alone is approximately equal in value to farmyard manure and slightly inferior to a complete mineral manure, whereas in combination with superphosphate it is very definitely superior in all respects.

APPENDIX II.

Report of the Sub-Committee of the Board of Agriculture, 1919.

The original Committee which formulated the report to the Board of Agriculture in 1908 stated that the object of Series I was to determine the specific effect on soil fertility of the more important organic and chemical manures, alone and in various combinations, in a 2-year 4-course rotation.

The object of Series II was to determine how far soil fertility is affected by growing in a rotation, leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures.

The present Committee feel some diffidence in reviewing the results of these experiments owing to the fact that no annual review is available correlating the cropping results with seasonal factors, and they strongly recommend (1) that the experiments should be regularly reviewed by the officer in charge of the experiments in his annual report and (2) that a quinquennial report by experts interested in these experiments should also be written and placed before the Board of Agriculture.

After a careful consideration of the results of the experiments, this Committee have come to the conclusion that the experiment as a whole is too condensed to permit the objective being attained in its entirety ; and they feel that these permanent experimental plots will probably yield more valuable results in the future, if certain modifications are introduced. They would, however, make the proviso that as these experiments have now been conducted for 10 years and as the results now obtained are becoming more uniform and are furnishing information of considerable scientific interest, alterations should not be of an extreme character, and they are of the opinion that the majority of the plots should be maintained with the modifications detailed below.

(1) The experience obtained from the rotation hitherto followed shows that this is agriculturally unsound and the Committee recommend that it should be changed into a 4-year eight-course rotation as follows :—

1.	Maize	Oats.
2.	,, ...	*Cajanus indicus.*
3.	,, ...	Oats.
4.	,, ...	Peas.

The Committee are given to understand from the experience gained on the estate lands that such a rotation is likely to prove more suitable. The main reason for suggesting this change is that it has been found that *Cajanus indicus* cannot be grown in a 2-year four-course rotation without " wilt " appearing and thus vitiating any comparisons which may be drawn.

(2) The Committee propose to make no alteration in the manurial treatment given to plots Nos. 1, 2, 3, 4, 5 (A and B) which receive varying quantities of organic manures.

(3) The series of plots Nos. 6, 7, 8, 9, 10 (A and B) which are receiving applications of concentrated mineral manures are, the Committee consider, unsatisfactory. At present the amounts of the different manurial ingredients applied vary from year to year owing to the fact that the farmyard manure is taken as a basis for calculation. The variation is very great and gives no uniformity of treatment one season with another. The Committee therefore recommend (1) that in future these plots should be looked upon as a distinctly separate series from plots 2 to 5, (2) that the amount of the respective manurial ingredients to be applied each year should be constant. The proportion these ingredients bear one to the other is to be determined in the light of local experience but once fixed should be adhered to. Such uniform and standard treatment will, it is felt, permit of these plots being utilized to greater advantage in the future as new lines of enquiry emerge.

(4) An additional objection to this particular series of plots is that no provision has been made to test the effect of a mixture of ammonium sulphate and superphosphate or of ammonium sulphate and potassium sulphate, and a recommendation is now made that such omissions should be rectified by the addition of extra plots. This can be readily attained by discontinuing plots Nos. 11 and 14 (A and B). The reason for omitting these plots is that the differences in yield obtained are too small to be of any significance. Plot No. 13 will continue to be a check plot.

(5) Plots Nos. 11, 12, 15 and 16 (A and B) constitute a valuable series of experiments. The results obtained are definite and the Committee recommend that the series be retained.

Plot No. 11 has, however, been suggested for inclusion in the mineral manure series and the Committee propose to replace it by a new plot 17 (A and B) on land adjoining No. 16 and which hitherto has only been cropped with cereals. They are also of opinion that the value of this series will be increased by the inclusion of a further plot No. 18 (A and B) where green manure instead of being grown *in situ* is brought in from outside and by the introduction of a new plot No. 19 (A and B) as an additional check plot.

(6) One very interesting fact which has emerged is the effect of different manurial treatments on the incidence of "wilt" in *Cajanus indicus* and, in order that the Imperial Mycologist may complete his counts and observations, it is desirable that the existing rotation be continued without change for another year.

(7) The Committee consider that the work already carried out indicates the value of permanently maintained area for experimental work, and recognize that a sufficient area of suitable land on the farm must be brought into condition by levelling and uniform cropping for such experiments. This cannot at present be done because the amount of land available on the farm is insufficient for the equally essential work of the cattle-breeding and other research sections of the Institute which are now hampered by want of space and are likely to expand considerably in the future. They therefore strongly recommend that early steps be taken to earmark suitable areas for experimental work after providing for the other additional requirements of the Institute.

(8) The Committee infer from the records maintained of the existing experiments that it has been impossible for the Imperial Agriculturist to give such detailed attention to these as is essential; and this has been accentuated by the frequent changes in the tenure of the appointment. They, therefore, recommend the appointment of an Imperial Agronomist with the necessary subordinate staff who will be responsible for the experimental area, and will work in collaboration with the other experts. In view of this recommendation the Committee feel that it would be premature to indicate any detailed line of future work in this direction.

APPENDIX III.

NOTE ON "WILT" IN RAHAR IN PERMANENT PLOTS AT PUSA.

(DR. W. MCRAE, M.A., D.SC., F.L.S., *Imperial Mycologist.*)

Immediately previous to 1908 the land was under the local crops of which *rahar* was one and was cultivated by tenant farmers who kept no records. There was a fair amount of wilt caused by *Fusarium vasinfectum* in the *rahar* crops of that time; perhaps neither more nor less than there is now but no record exists. Not till 1917 did the amount of wilt in the various plots seem to be so distinctly different as to warrant a record being kept, when late in the season the wilted plants were counted. This count however is not given as it shows the wilted plants only in the last few weeks of the season.

The amount due to infected seed under farm conditions of handling is comparatively small. Seeing also that the fungus can exist as a soil-saprophyte the bulk of the wilt in the crop appears to be due to infection from the soil. The record shows marked variation in the incidence of wilt in the various plots and considerable consistency in the relative amount of wilt in certain groups of plots; hence it appears reasonable to look for the cause in the various manurial treatments of the soil as in all other respects the plots are treated alike. Accordingly, though the plots are adjacent in serial number, yet for the purpose of discussion the record has been arranged in groups of plots whose members are similar with regard to manurial treatment for phosphate because on a general view the amount of wilt seems to be correlated with the presence of phosphate.

In the first group plots I and XIII have no manure. Plot XIV has no manure and the shallow-rooted legume, *viz.*, peas, which is an extra crop as compared with the others, is not subject to the disease. The numbers of wilted plants in plot VI differ so little in both series from those in the no manure plots I, XIII and XIV that there is no evidence to suggest that the sulphate of ammonia within the limits of the experiment has any influence on the amount of the wilt. The same can be said of sulphate of potash in plot VII, for even though the numbers in the B series are higher, the difference is hardly great enough to have significance. These five plots have, accordingly, been considered as one group to which no phosphate has been added. In group 2 the same quantity of superphosphate is added to each plot. In addition the same quantity of sulphate of potash is added to plot IX as to plot VII and to plot X the same quantity of sulphate of ammonia and of sulphate of potash as in plots VI and VII. The numbers of wilted plants in plots IX and X approximate closely to those in plot VIII in both series so that these two salts in association with superphosphate and in the quantitites used have no apparent influence on the incidence of the disease just as was the case when they were applied separately in plots VI and VII. The three plots VIII, IX and X may accordingly be considered as superphosphate plots. Group 5 consists of three plots that get cattle-manure in increasing amounts. Groups 3, 4 and 6 consist of one plot each.

The number of wilted plants for the season 1918-19 and the percentage of wilted plants from the season 1922-23 in each plot is given in the tables.

They may be summarised as follows :—

	Average	
	A	B
The no-superphosphate plots I, XIII, XIV, VI, VII .	241	231
The superphosphate plots VIII, IX and X . . .	1,122	977
The green manure plot XV	51	120
The green manure and superphosphate plot . .	354	605

Superphosphate seems to encourage the disease and green manure to discourage it.

Plot XV is anomalous in the B series as the number of plants in that plot has been smaller than usual in late years and it has been flooded more than the others.

The corresponding percentage figures are :—

The five no-phosphate plots	8	6
The three superphosphate plots	39	22
The green manure plot	1·5	4·5
The green manure and superphosphate plot . .	14	28

WILT OF ARHAR IN THE PERMANENT MANURIAL PLOTS.

A.—Series.

Plot.	Manurial treatment	1918-19	1920-21	1922-23	1924-25	1926-27	1928-29	Average
I	No manure .	381	172	725	380	166	467	382
				17·8	12·9	7·1	11·4	12·3
II	F. Y. M. . .	443	302	683	411	189	350	396·6
				17	10·6	7 9	10·0	11·3
III	F. Y M. . .	307	260	537	340	140	213	290 1
				12 7	8·7	5 5	6·8	8·4
IV	F. Y. M. . .	478	441	1,210	596	303	382	568·3
				35 6	15·6	11·6	12 4	18·8
V	Rape cake . .	153	96	531	367	137	160	240 8
				23 6	11 2	6·2	5·2	11·5
VI	AM_2SO_4 . .	117	93	394	193	88	167	175
				12·4	6·1	3·	5 3	6 9
VII	K_2SO_4 . .	154	99	543	177	70	96	173
				15·3	4 9	3 0	2 9	6 5
VIII	Superphosphate .	698	995	1,849	1,003	582	912	1,006·5
				54·7	27 8	22 1	28 6	33 3
IX	K_2SO_4 + superphosphate.	1,035	1,128	2,236	1,131	598	987	1,186
				68 8	32 3	23 6	24 8	37 3
X	Complete manure	1,017	1,014	2,734	1,356	735	1,094	1,325
				88 5	43 1	28·	27 1	40 8
XIII	No manure .	311	237	604	217	107	127	267
				16·8	6	5·0	2·9	7 6
XIV	Shallow-rooted legume in rotation.	189	93	464	161	111	151	196·5
				11·4	4 5	5 0	3 5	5·9
XV	Green manure .	82	32	85	35	16	58	51·3
				2·6	1·1	0·7	1·6	1·5
XVI	Green manure + superphosphate.	99	124	698	411	240	555	354·5
				17·6	14·8	10·8	12·7	13·9

N.B.—The first figures in each column indicate total number and the second figures the percentage of wilted plants.

B.—Series.

Plot	Manures	1917-18	1919-20	1921-22	1923-24	1925-26	1927-28	Average
I	No manure .	129	47	37	78	16	22	54·8
				1 3	1 6	·5	0 9	1·0
II	F. Y. M. . .	126	76	71	172	74	72	98·5
				2 8	3 7	2	2·5	2 7
III	F. Y. M. . .	319	250	275	486	287	340	326·1
				11 7	11 4	8	12 0	10 7
IV	F. Y M . .	703	760	886	1,551	902	807	984·8
				37 5	39 0	28 9	31 6	34 2
V	Rape cake . .	141	253	216	320	177	133	206 6
				10 3	11·4	6 5	5·0	8 3
VI	AM_2SO_4 . .	346	360	248	482	208	142	297 6
				10 3	11 4	6 5	5 0	8 3
VII	K_2SO_4 . .	588	393	365	521	164	110	356·8
				17 2	12 1	4 7	4 0	9·5
VIII	Superphosphate .	1,903	1,452	898	1,408	687	483	1,138·5
				47	35·8	20	18 0	30·2
IX	K_2SO_4 + super-phosphate.	2,354	1,222	718	1,006	421		1,011 8
				37 8	28 4	11·4	·0	22 9
X	Complete manure	1,814	989	719	874	345	240	830·1
				40 3	21·6	11	10 4	20 8
XIII	No manure .	233	252	141	281	93	48	174·3
				7 1	6 1	3 8	2·0	4·7
XIV	Shallow-rooted legume in rotation.	386	415	215	335	169	113	272·1
				11·3	7·2	5·1	5 0	7·1
XV	Green manure .	111	189	66	150	143	64	120·3
				3·9	6·2	5	3·0	4·5
XVI	Green manure + superphosphate.	511	642	387	600	823	670	605·3
				24·8	25	31·2	33·8	28·5

N.B.—The first figures in each column indicate total number and the second figures the percentage of wilted plants.

WILT OF ARHAR IN THE PERMANENT MANURIAL PLOTS.

A.—Series.

Group	Plots No.	Manurial treatment	1918-19	1920-21	1922-23	1924-25	1926-27	1928-29	Average
1	I	No superphosphate.	381	172	725	380	166	467	382
					17·8	12·9	7·1	11·4	12·3
	XIII		311	237	604	217	107	127	267
					16·8	6	5·0	2·9	7·6
	XIV		189	93	464	161	111	151	196·5
					11·4	4·5	5·0	3·5	5·9
	VI		117	93	394	193	88	167	175
					12·4	6·1	3·8	5·3	6·9
	VII		154	99	543	177	70	96	173
					15·3	4·9	3·0	2·9	6·5
	Average .	....	230	139	546	225	108	201	241·5
					14·7	6·8	4·8	5·2	7·8
2	VIII	Superphosphate .	698	995	1,849	1,003	582	912	1,006·5
					54·7	27·8	22·1	28·1	38·3
	IX		1,035	1,128	2,236	1,131	598	987	1,186
					68·8	32·3	23·6	29·8	37·3
	X		1,017	1,014	2,734	1,356	735	1,094	1,325
					88·5	43·1	28·8	27·1	46·8
	Average .	....	917	1,046	2,273	1,163	638	997	1,122
					70·6	34·4	24·8	26·8	39·1
3	XVI	Green manure + superphosphate.	99	124	698	411	240	555	354·5
					17·6	14·8	10·8	12·7	13·9
4	XV	Green manure .	82	32	85	35	16	58	51·3
					2·6	1·1	0·7	1·6	1·5
5	II	Cattle manure .	445	302	683	411	189	350	396·6
					17	10·6	7·9	10·0	11·3
	III		207	260	537	340	140	218	296·1
					12·7	8·7	5·5	6·8	8·4
	IV		478	441	1,210	596	303	382	568·3
					35·6	15·6	11·6	12·4	18·8
6	V	Rape cake . .	153	96	531	307	137	160	240·8
					23·6	11·2	6·2	5·2	11·5

N.B.—The first figures in each column indicate total number and the second figures percentage of wilted plants.

B.—Series.

Group	Plots	Manures	1917-18	1919-20	1921-22	1923-24	1925-26	1927-28	Average
1	I	No superphosphate.	129	47	37	78	16	22	54·8
					1·3	1·6	5	0·9	1·0
	XIII		233	252	141	281	93	48	174·6
					7·1	6·1	3·8	2·0	4·7
	XIV		386	415	215	335	169	113	272·1
					11·3	7·2	5·1	5·0	7·1
	VI		346	360	248	482	208	142	297·6
					10·3	11·4	6·5	5·0	8·3
	VII		588	393	365	521	154	110	356·8
					17·2	12·1	4·7	4·0	9·5
	Average .	....	388	233	201	339	130	87	231·3
					9·4	7·6	4·1	3·4	6·1
2	VIII	Superphosphate .	1,903	1,452	898	1,408	687	483	1,138·5
					47	35·8	20	18·0	30·2
	IX		2,354	1,222	718	1,006	421	350	1,011·8
					37·8	28·4	11·4	14·0	22·9
	X		1,814	989	719	874	345	240	830·1
					40·3	21·6	11	10·4	20·8
	Average .	....	2,024	1,221	778	1,096	484	357	977
					41·7	28·6	14·1	14·1	24·6
3	XVI	Green manure+superphosphate.	511	642	387	600	823	670	605·5
					24·8	25	31·2	33·8	23·5
4	XV	Green manure .	111	189	66	150	143	64	120·5
					3·9	6·2	5	3·0	4·5
5	II	Cattle manure .	126	76	71	172	74	72	98·5
					2·8	3·7	2	2·5	2·7
	III		319	250	275	486	287	340	326·1
					11·7	11·4	8	12·0	10·7
	IV		703	760	886	1,551	902	807	934·8
					37·5	39·0	28·9	31·6	34·2
6	V	Rape cake . .	141	253	216	320	177	133	206·6
					10·3	9·1	6·0	5·0	7·6

N.B.—The first figures in each column indicate total number and the second figures percentage of wilted plants.

APPENDIX IV.

NOTE ON THE PERMANENT EXPERIMENTS AT PUSA.

(G. S. HENDERSON, N.D.A., N.D.D., *Imperial Agriculturist (1916-29)* AND WYNNE SAYER, B.A., *Offg. Imperial Agriculturist.*)

From the agricultural point of view the results of the 20 years' survey of the Permanent Experiment Plots show the following :—

I. The rotation in practice ("4 course—2 years") has proved agriculturally unsound and any further experiments of this nature should have a rotation which is correct from an agricultural point of view.

II. The land selected was not tested prior to the starting of the experiment and the number of plots laid down was insufficient.

III. No attempt was made to select properly drained land and the drainage of the B plots until a drain was dug some 7 years ago was very bad. Drainage of 15 B and 16 B is still bad. Sufficient space was not left between plots to allow for drains.

IV. One 'no manure' plot is at one end of the series on especially rich land. The plots are all very close together, only a 3 ft. margin being allowed which is not wide enough.

V. *Cultivation.*—Ploughing is done right through and harrowing and *hanjaing* also, involving a constant displacement of residues in farmyard manure plots. General drainage and wash is right across the plots. Sowing is done by drill and this causes a frequent variation in the number of plants per acre. Singling is also done on an optional basis which lends to irregularity and it is proposed in future to do all such work by hand and to confine cultivation operations to each separate plot.

VI. The quantities of artificial manures applied to the plots yearly are based on the analysis of the farmyard manure each year. These analyses have proved very variable and have resulted in the inorganic manures being largely increased or decreased. A standard figure for nitrogen in farmyard manure should be adopted and rigidly kept to. The inorganic manures should be applied in fixed quantities and no variation allowed from the above. It is also obvious that the application of such homæopathic doses is outside practical agriculture. In the farm rotation the application is: 132 lb. nitrogen (·59%); 80 lb. P_2O_5 (·36%); 179 lb. K_2O (·80%) from 10 tons farmyard manure once in 3 years.

VII. *Application of Manures.*—Those for cereals should be applied to the Rabi crop. At present all manures except superphosphate are applied to Kharif crops. Super is applied in Kharif to *rahar* and maize.

VIII. *Costs.*—The returns from the plots based on cultivation and manurial costs as against cash returns of produce are given over a 20 and 15-year period.

IX. The general figures of the experimental yields show that the entire series of plots is steadily losing fertility and that none of the manures applied nor the rotation of crops has been able to establish equilibrium in 20 years under these conditions. Under the standard farm rotation there has been a steady rise in yields of Rabi cereals and a general increase of fertility.

In view however of the fact that valuable data are now being obtained from the plots applicable to the Agricultural Section as well as to other Sections in Pusa, it is recommended that no drastic changes be made. These plots representing 20 years' regular and constant treatment have a very real value, independent of the objects for which the series was originally laid down. A very good example of this is the fact that the grain produce of some of these plots was supplied to the Committee investigating deficiency diseases. The Rothamsted series of permanent experiments is an example of the value of such continuity in treatment.

The Committee of the Board of Agriculture which reviewed the experiments in 1919 made certain recommendations not involving any drastic alterations with the exception

of the remodelling of the rotation, and it is suggested that these recommendations should be adopted and the alterations in agricultural practice proposed carried out. It is recognised that any similar series of experiments laid down in the light of recent statistical experimental methods would involve the use of a sufficient number of repetition plots.

Results of permanent manurial rotation experiments.

Plot No. 1. "A" Series.

No manure.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb	Stalks lb.	Grain lb.	Straw lb.
1908-09	886	1,706	1,238	2,009	4,074	..	..
1909-10	454	1,919	..	..	..	932	1,478
1910-11	1,196	1,791	1,402	2,126	6,562	..	..
1911-12	913	2,004	..	.	.	1,041	1,670
1912-13	749	1,472	1,396	2,644	6,193	..	..
1913-14	871	2,072	..	..	..	809	1,573
1914-15	670	1,890	653	2,217	3,400	..	..
1915-16	806	2,135	..	..	.	665	1,306
1916-17	622	1,232	552	805	3,466	..	..
1917-18	887	1,343	.	..	.	604	1,203
Total	8,084	17,864	5,241	9,801	23,695	4,051	7,239
Average for 10 years from 1908-09 to 1917-18.	808·4	1,786·4	1,048·2	1,960·2	4,739	810	1,447·8
1918-19	600	1,725	1,020	1,144	2,516	..	..
1919-20	693	1,971	.	..	.	489	702
1920-21	304	2,135	1,015	1,273	2,135	..	..
1921-22	908	1,178	..	..	.	662	1,154
1922-23	422	821	599	985	3,798	..	..
1923-24	936	3,121	..	..	.	146	511
1924-25	269	739	815	1,895	2,792	.	..
1925-26	370	1,612	.	..	..	505	1,047
1926-27	427	1,314	717	2,015	2,628	..	..
1927-28	501	2,028	.	..	..	575	903
Total	5,430	16,974	4,226	7,342	13,869	2,467	4,317
Average for 10 years from 1918-19 to 1927-28.	543·0	1,697·4	845·2	1,468·4	2,761·8	493·4	863·4
Total for 20 years	13,514	34,838	9,467	17,143	37,564	6,518	11,556
Average for 20 years.	675·7	1,741·9	946·7	1,714·3	3,750·4	651·8	1,155·6

Results of permanent manurial rotation experiments.

Plot No. 2. "A" Series.

Farmyard Manure to supply 10 lb. Nitrogen per Acre.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb	Straw lb.
1908-09	1,201	1,796	1,222	2,009	3,942	..	..
1909-10	440	1,465	..	..	..	965	1,263
1910-11	1,420	2,140	1,180	2,077	6,166	..	..
1911-12	833	2,336	..	..	..	870	1,885
1912-13	832	1,256	1,300	2,809	5,593	..	.
1913-14	946	1,585	..	..	.	868	1,595
1914-15	784	1,881	887	2,275	3,909	..	..
1915-16	1,146	2,628	..	..	..	821	1,314
1916-17	795	1,355	405	873	3,737	..	..
1917 18	1,123	2,135	..	..	..	669	1,343
Tota	9,520	18,577	4,994	10,043	23,347	4,193	7,350
Average for 10 years from 1908-09 to 1917-18.	952 9	1,857·7	998 8	2,008·6	4,669·4	838·6	1,470
1918-19	792	1,807	1,066	1,275	3,408	..	..
1919-20	829	2,217	.	..	..	581	897
1920-21	405	2,217	1,068	1,150	2,832	..	..
1921-22	1,010	2,792	.	.	..	716	1,189
1922-23	656	1,068	636	1,273	3,860	..	..
1923-24	1,166	3,285	.	..	..	302	519
1924-25	425	985	1,039	1,753	3,121	..	..
1925-26	501	1,178	..	..	..	780	1,314
1926-27	558	1,560	673	1,872	3,367	..	..
1927-28	632	2,710	..	.	..	797	1,174
Total	6,974	20,119	4,482	7,323	16,588	3,176	5,093
Average for 10 years from 1918-19 to 1927-28.	697·4	2,011·9	896·4	1,464·6	3,317·6	635·2	1,018·6
Total for 20 years	16,503	38,696	9,476	17,366	39,935	7,369	12,443
Average for 20 years	825 1	1,934·8	947·6	1,736 6	3,993·5	736·9	1,244·3

Results of permanent manurial rotation experiments.

Plot No. 3. "A" Series.

Farmyard Manure to supply 20 lb. Nitrogen per Acre.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,148	1,845	1,107	1,845	3,532	..	..
1909-10	493	1,636	..	..	..	1,193	1,519
1910-11	1,753	2,531	1,092	2,168	6,289	..	..
1911-12	1,173	2,460	..	..	.	1,113	1,817
1912-13	987	1,400	1,201	3,145	6,776	..	..
1913-14	1,053	2,302	.	..	..	875	1,425
1914-15	952	2,048	891	2,423	4,772	..	..
1915-16	1,415	3,203	..	..	.	1,055	1,772
1916-17	924	1,634	542	1,068	4,033	..	..
1917-18	1,288	2,300	..	..	.	735	1,400
Total	11,186	21,359	4,833	10,649	25,402	4,969	7,933
Average for 10 years from 1908-09 to 1917-18.	1,118·6	2,135·9	966·6	2,129·8	5,080·4	993·8	1,586·6
1918-19	1,042	2,234	1,101	1,400	3,532	..	.
1919-20	1,056	2,710	..	..	..	614	864
1920-21	511	2,259	1,164	1,191	4,106	..	..
1921-22	1,189	2,710	..	..	..	788	1,511
1922-23	831	985	842	1,560	5,051	..	..
1923-24	1,180	3,942	..	..	..	318	667
1924-25	502	1,068	1,115	2,499	3,121	..	..
1925-26	688	1,612	..	..	..	940	1,564
1926-27	727	1,807	829	3,112	2,546	..	..
1927-28	797	3,367	..	..	..	895	1,322
Total	8,523	22,724	5,051	9,762	18,356	3,555	5,928
Average for 10 years from 1918-19 to 1927-28.	852·3	2,272·4	1,010·2	1,952·4	3,671·2	711	1,185·6
Total for 20 years	19,709	44,083	9,884	20,411	43,758	8,524	13,861
Average for 20 years	985·4	2,204·1	988·4	2,041·1	4,375·8	852·4	1,386·1

Results of permanent manurial rotation experiments.

Plot No. 4. "A" Series.

Farmyard Manure to supply 30 lb. Nitrogen per Acre.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,201	1,861	1,175	2,066	4,271	..	..
1909-10	480	1,087	.	..	..	1,109	1,347
1910-11	1,593	2,999	1,099	2,151	6,266	..	..
1911-12	1,225	2,611	..	..	.	991	1,864
1912-13	989	1,219	1,336	3,170	8,262	..	..
1913-14	1,095	1,648	.	..	..	850	1,573
1914-15	1,001	2,245	949	2,842	5,585	..	..
1915-16	1,456	3,241	..	..	..	1,118	1,921
1916-17	1,018	1,560	632	961	4,435	..	..
1917-18	1,549	2,833	.	..	..	760	1,335
Total	11,607	21,310	5,191	11,190	28,819	4,828	8,040
Average for 10 years from 1908-09 to 1917-18.	1,160 7	2,131	1,038	2,238	5,763 8	965 6	1,608
1918-19	1,382	2,176	1,129	1,571	3,860	..	..
1919-20	1,251	2,505	..	..	..	733	1,074
1920-21	627	2,341	1,180	1,191	3,203	..	..
1921-22	1,426	2,792	..	..	..	1,034	1,552
1922-23	831	1,109	797	1,027	4,353	..	..
1923-24	1,574	4,353	..	..	..	335	733
1924-25	537	1,150	948	2,418	3,089	..	..
1925-26	842	1,971	..	..	..	1,164	1,751
1926-27	899	1,807	780	2,012	3,613	..	..
1927 28	920	3,449	..	.	..	985	1,478
Total	10,309	23,653	4,834	8,219	18,068	4,251	6,588
Average for 10 years from 1918-19 to 1927-28.	1,030 9	2,365·3	966·8	1,643·8	3,613·6	850·2	1,317·6
Total for 20 years	21,916	44,963	10,025	19,409	46,887	9,079	14,628
Average for 20 years	1,095 8	2,248·1	1,002·5	1,940·9	4,688·7	907·9	1,462·8

Results of permanent manurial rotation experiments.

Plot No. 5. "A" Series.

Rape Cake to supply 20 lb. Nitrogen per Acre as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,298	1,829	1,068	1,706	2,875	..	..
1909-10	590	1,637	..	..	..	931	1,453
1910-11	1,331	3,164	977	2,118	6,147	..	..
1911-12	1,338	2,381	..	..	..	558	1,356
1912-13	1,178	1,653	1,303	2,653	5,429	..	..
1913-14	1,033	1,464	..	..	..	903	1,027
1914-15	868	2,371	776	2,780	4,312	..	..
1915-16	1,251	2,669	..	..	..	558	1,248
1916-17	1,093	1,831	534	714	2,628	..	..
1917-18	1,257	2,505	..	..	..	515	1,127
Total	11,237	21,504	4,658	9,971	21,391	3,465	6,211
Average for 10 years from 1908-09 to 1917-18.	1,123·7	2,150 4	931 6	1,994 2	4,278 2	693	1,242 2
1918-19	929	2,398	990	1,339	2,741	..	..
1919-20	874	2,061	..	..	..	532	864
1920-21	585	2,300	985	1,150	2,382	..	..
1921-22	1,161	2,299	.	.	..	723	1,063
1922-23	706	903	499	985	3,531	..	..
1923-24	1,072	3,531	..	..	..	337	1,012
1924-25	335	575	1,014	1,860	3,696	..	..
1925-26	597	1,807	..	..	..	760	1,334
1926-27	755	1,684	796	2,570	3,121	.	..
1927-28	706	2,382	.		..	624	1,100
Total	7,720	19,940	4,284	7,904	15,471	2,776	5,373
Average for 10 years from 1918-19 to 1927-28.	772·0	1,994·0	856·8	1,580 8	3,094·2	555·2	1,074·6
Total for 20 years	18,957	41,444	8,942	17,875	36,862	6,241	11,584
Average for 20 years	947·8	2,072·2	894·2	1,787·5	3,686·2	624·1	1,158·4

Results of permanent manurial rotation experiments.

Plot No. 6. "A" Series.

Sulphate of Ammonia to supply 20 lb. Nitrogen per acre as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb	Stalks lb	Grain lb	Bhusa lb	Stalks lb	Grain lb.	Straw lb.
1908-09	832	1,394	1,079	1,779	3,285	..	..
1909-10	505	1,345	..	..	..	819	1,486
1910-11	1,052	2,367	1,100	2,036	5,712	..	..
1911-12	1,157	2,190	..	..	..	482	1,289
1912-13	767	1,334	1,344	3,539	5,043	..	..
1913-14	1,009	1,477	.	.	..	465	1,095
1914-15	493	1,832	686	2,833	3,491	..	..
1915-16	818	2,300	.	.	..	421	852
1916-17	808	1,724	265	953	2,505	..	..
1917-18	646	1,930	..	..	..	433	1,006
Total	8,087	17,893	4,474	11 140	20,036	2,620	5,728
Average for 10 years from 1908-09 to 1917-18.	808 7	1,789·3	894·8	2,228	4,007·2	524	1,145·6
1918-19	437	1,561	1,051	1,341	2,456	..	.
1919-20	433	1,232	..	.	..	357	972
1920-21	175	1,725	1,154	1,232	2,587	..	..
1921-22	678	1,971	..	..	..	437	830
1922-23	585	1,232	402	657	2,710	..	..
1923-24	376	2,053	.	.	..	359	873
1924-25	187	411	961	1,996	2,464	..	..
1925-26	181	1,150	..	..	..	490	979
1926-27	337	944	854	2,595	3,367	..	..
1927-28	509	1,601	..	..	..	443	706
Total	3,898	13,880	4,422	7,821	13,584	2,095	4,360
Average for 10 years from 1918-19 to 1927-28.	389·8	1,388·0	884·4	1,564·2	2,716·8	419	872
Total for 20 years	11,985	31,773	8,896	18,961	33,620	4,715	10,088
Average for 20 years	599·2	1,588·6	889·6	1,896·1	3,362·0	471·5	1,008·8

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 7. "A" Series.

Sulphate of Potash to supply K_2O as in Farmyard Manure Plot No. 3.

Year	MAIZE		ARHAR			OATS	
	Grain lb.	Stalks lb	Grain lb	Phusa lb	Stalks lb.	Grain lb	Straw lb
1908-09	890	1,640	992	1,574	3,129	..	..
1909-10	461	1,223	..	..	..	767	1,281
1910-11	1,091	2,342	997	1,913	5,453	..	..
1911-12	837	1,548	..	..	..	485	1,314
1912-13	664	1,197	1,014	2,012	5,733	..	..
1913-14	819	1,417	..	..	..	486	951
1914-15	458	1,832	620	1,930	3,269	..	.
1915-16	782	1,971	..	..	..	351	1,160
1916-17	686	1,043	312	665	2,612	..	..
1917-18 . . .	692	1,848	..	..		384	930
Total .	7,380	16,061	3,935	8,094	20,196	2,473	5,636
Average for 10 years from 1908-09 to 1917-18.	738	1,606·1	787	1,618·8	4,039 2	494·6	1,127·2
1918-19	272	1,232	897	1,376	2,497	..	..
1919-20	417	1,191	..	..	..	358	570
1920-21	204	1,684	861	1,027	2,053	..	..
1921-22	670	1,807	..	..	..	478	918
1922-23	426	944	318	1,191	2,874	..	..
1923-24	428	2,135	..	..	..	211	731
1924-25	296	821	764	1,782	2,217	..	..
1925-26	201	1,068	..	..	..	417	938
1926-27	345	821	723	2,316	2,546	..	..
1927-28	435	1,807	..	..	..	386	764
Total .	3,694	13,510	3,563	7,692	12,187	1,850	3,921
Average for 10 years from 1918-19 to 1927-28.	369·4	1,351	712·6	1,538·4	24,374	370	784·2
Total for 20 years . .	11,074	29,571	7,498	15,786	32,383	4,323	9,557
Average for 20 years .	553·7	1,478·5	749·8	1,578·6	3,238·3	432·3	955·7

Results of permanent manurial rotation experiments.

Plot No. 8. "A" Series.

Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Maize lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb..
1908-09	1,111	2,050	959	1,689	3,655	..	..
1909-10	471	1,402	..	..	..	991	1,461
1910-11	1,595	3,652	1,086	2,085	6,669	..	..
1911-12	1,243	2,268	..	..	..	1,126	2,069
1912-13	1,294	1,744	1,106	2,291	6,193	..	..
1913-14	1,054	1,702	..	..	..	817	1,441
1914-15	981	2,406	702	2,258	4,969	..	..
1915-16	1,201	2,546	..	..	..	1,162	2,033
1916-17	995	1,659	320	817	4,024	..	..
1917-18	1,267	1,971	..	..	..	842	1,589
Total	11,212	21,400	4,123	9,140	25,510	4,938	8,593
Average for 10 years from 1908-09 to 1917-18.	1,121·2	2,140	824·6	1,828	5,102	987·6	1,718·6
1918-19	1,000	2,070	1,084	1,298	4,451	..	..
1919-20	795	1,643	..	..	..	712	971
1920-21	529	2,135	979	1,068	2,382	..	..
1921-22	1,058	2,299	..	..	..	928	1,289
1922-23	709	1,232	300	616	2,212	..	..
1923-24	938	3,039	..	.	..	318	1,078
1924-25	458	1,068	700	1,764	3,039	..	..
1925-26	450	1,889	..	..	..	1,143	2,058
1926-27	714	1,437	723	1,412	2,299	..	..
1927-28	591	2,382	..	..	..	91 2	1,388
Total	7,242	19,194	3,786	6,158	14,383	4,013	6,784
Average for 10 years from 1918-19 to 1927-28.	724·2	1,919·4	757·2	1,231·6	2,876·6	802·6	1,354·8
Total for 20 years	18,454	40,594	7,909	15,298	39,893	8,951	15,377
Average for 20 years	922·7	2,029·7	790 9	1,529·8	3,989·3	895·1	1,537·7

Results of permanent manurial rotation experiments.

Plot No. 9. "A" Series.

Sulphate of Potash to supply K_2O and Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb	Straw lb.
1908-09	1,095	1,968	972	1,697	3,942	..	..
1909-10	498	1,378		..	.	920	1,363
1910-11	1,453	2,778	1,088	2,168	6,776	..	..
1911-12	1,070	2,153			.	1,102	2,246
1912-13	1,229	1,706	1,075	2,233	6,119	..	..
1913-14	1,018	1,612	..	..	..	897	1,287
1914-15	821	1,972	542	2,094	5,084	..	..
1915-16	1,117	2,628	..	..	..	1,033	2,039
1916-17	946	1,839	213	673	3,137	..	..
1917-18	1,213	1,725	.	..	..	801	1,458
Total .	10,460	19,759	3,890	8,865	25,058	4,663	8,393
Average for 10 years from 1908-09 to 1917-18.	1,046	1,975·9	778	1,773	5,011·6	932 6	1,678·6
1918-19	969	1,971	813	1,382	3,256	..	..
1919-20	790	1,807	..	..	..	617	1,025
1920-21	472	2,341	792	821	2,176	..	..
1921-22	995	2,217	..	..	..	829	1,470
1922-23	569	985	238	616	1,725	..	..
1923-24	936	3,121	..	..	..	310	758
1924-25	426	1,068	675	1,911	2,628	..	..
1925-26	416	1,560	..	..	..	1,127	1,829
1926-27	567	1,437	632	2,078	2,464	..	..
1927-28	682	1,889	..	..	..	895	1,240
Total .	6,822	18,396	3,150	6,808	12,249	3,778	6,322
Average for 10 years from 1918-19 to 1927-28.	682·2	1,839·6	630	1,361·6	2,449·8	755·6	1,264·4
Total for 20 years	17,282	38,155	7,040	15,673	37,307	8,441	14,715
Average for 20 years	864·1	1,907·7	704	1,567·3	3,730·7	844·1	1,471·5

Results of permanent manurial rotation experiments.

Plot No. 10. "A" Series.

Sulphate of Ammonia to supply Nitrogen; Sulphate of Potash to supply K_2O and Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,287	1,730	1,050	1,820	3,983	..	..
1909-10	646	1,534	.	..	..	1,035	1,461
1910-11	1,893	2,952	1,057	2,480	6,197	..	
1911-12	1,422	2,808	..	.	..	1,369	2,36
1912-13	1,187	1,655	1,092	2,455	6,015	..	
1913-14	1,242	1,775	..	..	..	780	1,602
1914-15	914	2,102	753	1,840	4,279	..	..
1915-16	1,119	2,546	..	..	..	1,006	2,033
1916-17	985	1,724	156	616	2,135	..	..
1917-18	1,349	3,039	..	..	..	866	1,597
Total	12,044	21,865	4,108	9,211	23,509	5,056	9,029
Average for 10 years from 1908-09 to 1917-18.	1,204·4	2,186·5	821·6	1,842·2	4,701·8	1,011·2	1,805·8
1918-19	1,304	2,234	858	1,158	2,850	..	..
1919-20	790	1,478	..	..	..	622	1,061
1920-21	654	2,546	764	903	1,971	..	..
1921-22	1,111	2,382	..	..	..	936	1,527
1922-23	494	985	88	181	493	..	..
1923-24	1,061	3,606	..	..	..	302	684
1924-25	350	903	628	1,343	2,299	..	..
1925-26	542	1,642	..	..	..	1,199	1,922
1926-27	657	1,500	640	1,495	2,628	..	..
1927-28	657	1,848	..	..	..	969	1,495
Total	7,626	19,274	2,978	5,080	10,241	4,028	6,689
Average for 10 years from 1918-19 to 1927-28.	762 6	1,927·4	595·6	1,016	2,048·2	805·6	1,337·8
Total for 20 years	19,670	41,139	7,086	14,291	33,750	9,084	15,718
Average for 20 years	983·5	2,056·9	708·6	1,429·1	3,375	908·4	1,571·8

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 11. "A" Series.

No Manure or Leguminous Crop.

Year	Maize		Barley		Oats	
	Grain lb.	Stalks lb.	Grain lb.	Straw lb.	Grain lb.	Straw lb.
1908-09	1,419	2,250	59	193	..	..
1909-10	473	1,145	..	..	663	887
1910-11	952	2,406	601	837	..	..
1911-12	765	1,890	..	..	380	956
1912-13	751	1,518	345	726	..	..
1913-14	640	1,301	..	..	842	931
1914-15	383	1,805	157	320	..	..
1915-16	645	1,807	..	..	400	667
1916-17	564	1,355	366	882	..	..
1917-18	593	2,176	..	..	367	864
Total	7,185	17,653	1,528	2,958	2,152	4,305
Average for 10 years from 1908-09 to 1917-18.	718·5	1,765·3	305·6	591·6	430	861
1918-19	397	1,396	304	584	..	..
1919-20	321	1,150	..	..	275	428
1920-21	129	1,560	156	255	..	..
1921-22	390	1,150	..	.	435	714
1922-23	325	616	279	706	..	..
1923-24	322	1,766	..	..	203	372
1924-25	198	493	478	671	..	..
1925-26	107	1,068	..	..	521	957
1926-27	265	821	382	604	..	..
1927-28	197	1,068	..	..	452	780
Total	2,651	11,088	1,599	2,770	1,886	3,246
Average for 10 years from 1918-19 to 1927-28.	265·1	1,108·8	319·8	554	377·2	649·2
Total for 20 years	9,836	28,741	3,127	5,728	4,038	7,551
Average for 20 years	491.8	1,437·0	312·7	572·8	403·8	755·1

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 12. "A" Series.

Green Manure in Cereal Rotation.

Year	Maize		Barley		Oats	
	Grain lb.	Stalks lb.	Grain lb.	Straw lb.	Grain lb.	Straw lb.
1908-09	1,472	2,755	35	176	..	..
1909-10	..	..	..	..	810	1,297
1910-11	1,504	2,859	893	1,387	..	..
1911-12	..	..	..	..	856	1,800
1912-13	1,055	1,578	495	841	..	..
1913-14	..	..	..	..	567	1,199
1914-15	624	2,102	257	417	..	..
1915-16	..	..	..	..	579	1,310
1916-17	909	1,232	453	930	..	..
1917-18	..	..	..	..	579	1,024
Total	5,564	10,526	2,133	3,751	3,391	6,630
Average for 10 years from 1908-09 to 1917-18.	1,112·8	2,105·2	426·6	750	678	1,326
1918-19	721	2,398	349	575	..	..
1919-20	..	..	..	..	431	850
1920-21	405	2,135	185	304	..	..
1921-22	..	..	..	..	708	1,016
1922-23	785	1,437	255	649	..	..
1923-24	..	..	..	..	343	725
1924-25	509	1,232	484	605	..	..
1925-26	..	..	..	..	567	1,281
1926-27	509	1,519	357	546	..	..
1927-28	..	..	..	..	731	1,322
Total	2,879	8,721	1,630	2,739	2,780	5,194
Average for 10 years from 1918-19 to 1927-28.	575·8	1,744·2	326	547·8	556	1,038·8
Total for 20 years	8,443	19,247	3,763	6,490	6,171	11,824
Average for 20 years	844·3	1,924·7	376·3	649	617·1	1,182·4

Results of permanent manurial rotation experiments.

Plot No. 13. "A" Series.

Deep-rooted Leguminous Crop in a Cereal Rotation.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,209	1,911	886	1,410	3,573	..	..
1909-10	609	1,422	..	..	..	802	1,215
1910-11	1,564	2,812	972	1,806	5,642	..	..
1911-12	1,068	2,037	..	..	..	550	1,556
1912-13	692	1,138	1,006	2,266	4,920	..	..
1913-14	830	1,350	..	..	..	420	1,017
1914-15	326	1,445	651	1,593	3,277	..	..
1915-16	861	2,135	..	.	.	417	979
1916-17	756	1,560	156	640	2,464	..	..
1917-18	670	1,602	..	..	..	458	979
Total	8,585	17,412	3,761	7,715	19,876	2,656	5,746
Average for 10 years from 1908-09 to 1917-18	858·5	1,741·2	752	1,543	3,975·2	531	1,149
1918-19	292	1,150	875	1,092	2,185	..	..
1919-20	427	1,643	..	..	..	371	657
1920-21	489	1,355	946	1,232	2,214	..	..
1921-22	683	1,725	..	..	..	435	901
1922-23	453	1,068	302	452	1,681	..	..
1923-24	268	1,889	..	..	..	261	807
1924-25	356	985	774	1,690	2,464	..	..
1925-26	133	1,150	..	..	..	447	907
1926-27	213	1,068	764	1,618	2,464	..	..
1927-28	452	1,478	..	..	..	501	865
Total	3,366	13,511	3,661	6,084	11,014	2,015	4,127
Average for 10 years from 1918-19 to 1927-28.	336·6	1,351·1	732·2	1,216·8	2,202·8	403	825·4
Total for 20 years	11,951	30,923	7,422	13,799	30 890	4,671	9,873
Average for 20 years	597·5	1,546·1	742·2	1,379·9	3,089	467·1	987·3

Results of permanent manurial rotation experiments.

Plot No. 14. "A" Series.

One deep, one shallow-rooted legume in the rotation.

Year	Maize		Arhar			Oats		Peas	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.	Grain lb.	Straw lb.
1908-09 . . .	1,154	1,993	666	1,197	2,957	..	..	..	..
1909-10 . . .	594	1,463	..	..	..	252	451	507	772
1910-11 . . .	1,684	2,935	954	1,695	5,042	..	..	..	..
1911-12 . . .	1,167	1,858	..	..	..	401	972	252	295
1912-13 . . .	884	1,240	1,021	2,135	4,542	..	..	..	..
1913-14 . . .	889	1,474	..	..	..	363	828	199	367
1914-15 . . .	821	1,778	591	1,675	3,449	..	..	..	..
1915-16 . . .	767	1,971	..	..	..	388	836	81	189
1916-17 . . .	798	1,724	283	437	2,587	..	..	..	..
1917-18 . . .	658	1,766	..	..	..	318	730	172	406
Total .	8,916	18,202	3,515	7,139	19,477	1,722	3,817	1,211	2,029
Average for 10 years from 1908-09 to 1917-18.	891·6	1,820·2	703	1,427 8	3,895 4	344·4	763 4	242 2	405 8
1918-19 . . .	403	1,807	445	1,031	2,341	..	..	..	..
1919-20 . . .	440	1,808	..	..	..	202	570	72	164
1920-21 . . .	115	1,643	961	985	1,971	..	..	..	..
1921-22 . . .	698	1,725	..	..	..	340	850	29	80
1922-23 . . .	527	1,119	343	427	2,546	..	..	..	..
1923-24 . . .	272	1,971	..	..	..	248	778	29	78
1924-25 . . .	428	1,150	277	2,260	2,464	..	..	..	..
1925-26 . . .	162	903	..	..	..	361	870	82	213
1926-27 . . .	267	1,232	876	2,028	2,135	..	..	..	..
1927-28 . . .	484	1,642	..	..	..	394	1,232	10	41
Total .	3,796	15,072	2,872	6,740	11,457	1,635	4,300	222	576
Average for 10 years from 1918-19 to 1927-28.	379 6	1,507·2	574·4	1,348	2,291·4	327	860	44 4	115·2
Total for 20 years .	12,712	33,274	6,387	13,897	30,934	3,357	8,117	1,433	2,605
Average for 20 years .	635·6	1,663·7	638·7	1,387·9	3,093·4	335·7	811·7	143·3	260·5

Results of permanent manurial rotation experiments.

Plot No. 15. "A" Series.

Leguminous Crop and Green Manure in the Rotation.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,111	1,910	701	1,320	3,121	..	..
1909-10	..	..	..	..	..	827	1,153
1910-11	1,772	3,444	981	1,724	5,782	..	..
1911-12	..	..	..	..	..	1,225	2,028
1912-13	1,220	1,778	839	2,020	4,607	..	..
1913-14	..	..	..	..	..	891	1,491
1914-15	800	2,049	517	1,764	3,285	..	..
1915-16	..	..	..	..	..	632	1,330
1916-17	1,320	2,127	150	542	2,464	..	..
1917-18	..	..	..	..	..	582	1,249
Total	6,313	12,217	3,188	7,370	19,259	4,137	7,260
Average for 10 years from 1908-09 to 1917-18.	1,262·6	2,443	637·6	1,474	3,851·8	827	1,452
1918-19	608	2,415	930	1,090	2,390	..	..
1919-20	..	..	..	..	..	269	1,045
1920-21	394	2,875	879	1,150	1,971	..	..
1921-22	..	..	..	..	..	710	1,343
1922-23	1,224	2,053	380	821	2,217	..	..
1923-24	..	..	..	..	..	281	1,197
1924-25	914	2,258	813	1,527	2,702	..	..
1925-26	..	..	..	..	..	493	1,068
1926-27	583	1,807	682	1,454	1,807	..	..
1927-28	..	..	..	..	..	640	1,084
Total	3,813	11,408	3,684	6,042	11,177	2,393	5,737
Average for 10 years from 1918-19 to 1927-28.	762·6	2,281·6	736·8	1,208·4	2,235·4	478·6	1,147·4
Total for 20 years	10,126	23,625	6,872	13,412	30,436	6,530	12,997
Average for 20 years	1,012·6	2,362·5	687·2	1,341·2	3,043·6	653	1,299·7

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 16. "A" Series.

Green Manure and Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	..	..	..	..	..	..	..
1909-10	..	..	..	..	..	..	..
1910-11	..	..	..	..	..	..	..
1911-12	..	..	..	..	..	..	..
1912-13	..	..	..	..	..	..	..
1913-14	..	..	..	..	..	1,853	2,712
1914-15	1,246	2,986	721	1,850	4,271	..	..
1915-16	..	..	..	..	..	1,840	2,472
1916-17	1,853	2,505	222	838	2,776	..	..
1917-18	..	..	..	..	..	1,643	2,628
Total	3,099	5,491	943	2,688	7,047	4,836	7,812
Average for 10 years from 1908-09 to 1917-18.	1,549·5	2,745·5	471·5	1,344	3,523·5	1,612	2,604
1918-19	1,473	3,450	1,150	1,228	3,647	..	..
1919-20	..	..	..	..	..	1,017	1,328
1920-21	1,049	3,614	936	2,012	2,351	..	..
1921-22	..	..	..	..	..	1,474	1,779
1922-23	1,561	2,915	431	698	2,956	..	..
1923-24	..	..	..	..	..	544	1,181
1924-25	1,345	2,669	1,308	1,566	4,106	..	..
1925-26	..	..	..	..	..	1,256	1 987
1926-27	1,043	2,874	567	1,815	1,889	..	..
1927-28	..	..	..	..	..	1,175	1,782
Total	6,471	15,522	4,392	7,319	14,949	5,466	8,048
Average for 10 years from 1918-19 to 1927-28.	1,294·2	3,104·4	878·4	1,463·8	2,989·4	1,093·2	1,609·6
Total for 20 years	9,570	21,013	5,335	10,007	21,996	10,302	15,860
Average for 20 years	1,367·1	3,001·8	762·1	1,429·6	342·2	1,287·7	1,982·5

Results of permanent manurial rotation experiments.

Plot No. 1. "B" Series.

No Manure.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,164	3,575	..	..	..	5	26
1909-10	287	1,204	1,270	1,921	5,478	..	..
1910-11	520	1,861	..	..	..	788	1,190
1911-12	421	774	1,052	1,322	4,287	..	..
1912-13	1,089	1,262	..	..	..	748	1,587
1913-14	544	989	652	985	2,053	..	..
1914-15	587	1,842	..	..	..	372	1,148
1915-16	474	1,314	1,343	1,158	3,302	..	..
1916-17	657	1,797	..	..	..	614	1,357
1917-18	598	1,314	1,045	1,314	2,751	..	..
Total	6,341	15,932	5,362	6,700	17,871	2,527	5,308
Average for 10 years from 1908-09 to 1917-18.	634	1,593	1,072·4	1,340	3,574·2	505·4	1,061
1918-19	545	1,889	..	..	..	448	1,729
1919-20	382	1,068	804	1,109	2,628	.	..
1920-21	465	2,710	.	..	..	402	664
1921-22	390	1,314	708	714	2,217	.	..
1922-23	560	1,601	..	..	..	542	1,183
1923-24	331	1,232	1,121	1,753	2,956	..	..
1924-25	368	985	..	..	..	579	1,556
1925-26	152	739	438	2,447	3,285	..	..
1926-27	349	985	..	..	..	320	419
1927-28	312	1,889	1,096	2,353	2,915	..	..
Total	3,854	14,412	4,227	8,376	14,001	2,291	5,551
Average for 10 years from 1918-19 to 1927-28.	385·4	1,441·2	845·4	1,675·2	2,800·2	458·2	1,110
Total for 20 years	10,195	30,344	9,589	15,076	31,872	4,818	10,859
Average for 20 years	509·7	1,517·2	958·9	1,507·6	3,187·2	481·8	1,085

Results of permanent manurial rotation experiments.

Plot No. 2. "B" Series.

Farmyard Manure to supply 10 lb. Nitrogen.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,404	3,001	..	..	..	23	107
1909-10	367	1,299	1,322	2,045	4,731	..	..
1910-11	904	2,226	..	..	..	985	1,453
1911-12	527	1,009	1,162	1,593	3,121	..	..
1912-13	1,067	1,340	..	..	..	962	1,835
1913-14	744	1,104	667	1,371	2,423	..	..
1914-15	849	2,217	..	..	..	624	1,306
1915-16	794	1,643	1,244	994	3,564	..	..
1916-17	801	2,517	..	..	..	794	1,201
1917-18	753	1,971	1,142	1,604	3,778	..	..
Total	8,270	18,327	5,537	7,607	17,617	3,388	5,902
Average for 10 years from 1908-09 to 1917-18.	827	1,832·7	1,107·4	1,521·4	3,523·4	677·6	1,180
1918-19	806	2,981	..	..	..	534	1,027
1919-20	471	1,380	924	1,298	3,532	..	..
1920-21	684	3,080	..	.	..	528	868
1921-22	650	1,971	745	755	2,751	..	..
1922-23	884	2,053	..	..	..	755	1,544
1923-24	454	1,314	1,166	2,365	3,449	..	..
1924-25	572	1,232	..	..	..	727	2,024
1925-26	252	903	1,092	1,864	4,106	..	..
1926-27	608	1,642	..	..	..	443	747
1927-28	550	1,766	1,236	2,377	4,106	..	.
Total	5,931	18,322	5,163	8,659	17,944	2,987	6,210
Average for 10 years from 1918-19 to 1927-28.	593·1	1,832·2	1,032·6	1,731·8	3,588·8	597·4	1,242
Total for 20 years	14,201	36,649	10,700	16,266	35,561	6,375	12,112
Average for 20 years	710·0	1,832·4	1,070	1,626·6	3,556·1	637·5	1,211·2

Results of permanent manurial rotation experiments.

Plot No. 3. "B" Series.

Farmyard Manure to supply 20 lb. Nitrogen per acre.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,777	3,419	..	..	..	20	113
1909-10	409	1,606	1,346	2,587	4,961	..	..
1910-11	1,077	2,173	..	..	..	1,028	1,716
1911-12	566	1,151	1,234	1,765	5,897	..	..
1912-13	1,058	1,268	.	..	..	1,081	1,897
1913-14	809	1,207	981	1,437	3,121	..	..
1914-15	984	2,810	..	..	..	986	1,774
1915-16	941	1,807	1,474	1,987	5,306	..	..
1916-17	899	1,659	.	..	.	930	1,698
1917-18	860	1,807	1,142	1,478	1,172	..	..
Total	9,470	19,006	5,877	9,204	23,457	3,745	7,198
Average for 10 years from 1908-09 to 1917-18.	947	1,900·6	1,175·4	1,840·8	4,691·4	740	1,439·6
1918-19	822	2,875	..	..		686	1,203
1919-20	772	1,725	1,271	1,357	3,696	..	..
1920-21	774	3,326	..	..	..	573	1,070
1921-22	801	1,889	723	723	3,285	..	..
1922-23	1,006	2,505	..	..	..	992	1,924
1923-24	724	1,642	1,039	1,384	3,572	..	..
1924-25	647	1,396	..	..	..	866	2,336
1925-26	285	985	1,068	2,710	4,270	..	..
1926-27	739	2,341	..	..	..	542	895
1927-28	608	1,907	1,297	2,644	2,874	..	..
Total	7,178	20,491	5,398	8,818	17,697	3,659	7,428
Average for 10 years from 1918-19 to 1927-28.	717·8	2,049·1	1,079·6	1,763·6	3,539·4	731·8	1,485·6
Total for 20 years	16,648	39,497	11,275	18,022	41,154	7,404	14,626
Average for 20 years	832·4	1,974·8	1,127·5	1,802·2	4,115·4	740·4	1,462·6

Results of permanent manurial rotation experiments.

Plot No. 4. "B" Series.

Farmyard Manure to supply 30 lb. Nitrogen per acre.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,835	3,665	..	..	..	27	158
1909-10	435	1,567	1,158	2,644	4,928	..	..
1910-11	672	2,149	..	..	..	993	1,650
1911-12	677	1,322	1,229	2,020	5,437	..	..
1912-13	995	1,150	..	..	..	1,151	2,151
1913-14	696	942	778	1,560	4,772	..	..
1914-15	1,029	2,793	..	..	..	760	2,115
1915-16	1,076	1,971	1,246	1,273	5,708	..	..
1916-17	1,047	1,642	..	..	..	1,185	1,903
1917-18	1,112	2,135	1,006	1,495	3,474	..	..
Total	9,574	19,336	5,417	8,992	24,319	4,116	7,977
Average for 10 years from 1908-09 to 1917-18.	957·4	1,933·6	1,083·4	1,798·4	4,863·8	823·2	1,595·4
1918-19	1,207	3,228	..	..	..	710	1,179
1919-20	779	1,708	827	1,521	3,491	..	..
1920-21	1,205	3,203	..	..	..	733	1,115
1921-22	910	1,889	519	591	2,176	..	..
1922-23	990	1,684	..	..	..	1,061	1,895
1923-24	780	1,889	620	899	2,258	..	..
1924-25	718	1,478	..	..	..	1,020	2,716
1925-26	392	1,068	895	2,226	3,121	..	..
1926-27	764	2,792	..	..	..	649	912
1927-28	772	2,628	829	1,063	4,188	..	..
Total	8,517	21,567	3,690	7,200	15,234	4,173	7,817
Average for 10 years from 1918-19 to 1927-28.	851·7	2,156·7	738	1,440	3,046·8	834·6	1,563·4
Total for 20 years	18,091	40,903	9,107	16,192	39,553	8,289	15,794
Average for 20 years	904·5	2,045·1	910·7	1,619·2	3,955·3	828·9	1,579·4

Results of permanent manurial rotation experiments.

Plot No. 5. "B" Series.

Rape Cake to supply 20 lb. Nitrogen per acre as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,714	3,649	..	..	..	25	120
1909-10	516	1,647	1,012	2,020	4,887	..	..
1910-11	1,528	2,681	..	..	..	796	1,314
1911-12	882	1,877	1,195	1,642	4,616	..	..
1912-13	992	1,121	..	..	..	949	1,761
1913-14	721	1,200	856	1,683	4,021	..	..
1914-15	784	2,713	..	..	..	571	1,400
1915-16	657	1,643	1,057	1,150	5,150	..	..
1916-17	925	1,642	.	..	..	642	1,246
1917-18	1,115	2,464	657	1,109	1,708	..	..
Total	9,834	20,637	4,777	7,604	20,385	3,983	5,850
Average for 10 years from 1908-09 to 1917-18.	983·4	2,063·7	955·4	1,520·8	4,077	596·6	1,170
1918-19	848	2,382	..	..	..	503	729
1919-20	546	1,150	910	1,801	3,089	..	..
1920-21	717	3,039	..	..	..	466	706
1921-22	676	1,478	616	698	2,053	..	..
1922-23	700	1,232	..	..	..	587	1,343
1923-24	576	2,053	811	2,024	2,012	..	..
1924-25	550	1,314	..	..	..	661	1,967
1925-26	238	1,396	805	2 275	3,449	..	..
1926-27	608	2,053	..	..	..	394	755
1927-28	616	2,135	944	2,094	3,121	..	..
Total	6,075	18,232	4,086	8,892	13,674	2,611	5,550
Average for 10 years from 1918-19 to 1927-28.	607·5	1,823·2	817·2	1,778·4	2,734·8	522·2	1,112
Total for 20 years	15,909	38,869	8,863	16,496	34,059	5,594	11,410
Average for 20 years	795·4	1,943·4	·886·3	1,649·6	3,405 9	5,52·4	1,141

Results of permanent manurial rotation experiments.

Plot No. 6. "B" Series.

Sulphate of Ammonia to supply 20 lb. Nitrogen per acre as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1 312	3,288	..	..	..	26	148
1909-10	468	1 308	840	1,856	4,189	..	..
1910-11	993	2,471	..	..	..	610	1,199
1911-12	559	1,023	986	1,330	4,813	..	..
1912-13	705	1,111	..	..	..	749	1,757
1913-14	413	1,010	616	1,191	3,244	..	..
1914-15	467	2,048	..	..	..	417	1,265
1915-16	438	1,150	873	1,002	2,669	..	..
1916-17	725	1,601	..	..	..	474	979
1917-18	307	1,643	965	1,371	3,761	.	..
Total	6,477	16,653	4,280	6,750	18,676	2,306	5,348
Average for 10 years from 1908-09 to 1917-18.	647·7	1,665·3	856	1,350	3,735·2	461	1,069·6
1918-19	463	2,242	..	..	..	378	772
1919-20	244	1,150	1,002	1,174	2,300	..	..
1920-21	387	3,121	..	..	..	309	676
1921-22	359	1,008	651	698	1,642	..	..
1922-23	702	1,684	..	..	..	389	1,377
1923-24	86	657	1,121	1,671	2,874	..	..
1924-25	396	1,150	..	..	..	482	1,530
1925-26	80	739	690	1,527	2,628	..	..
1926-27	583	1,725	..	..	..	337	567
1927-28	296	1,889	936	2,020	2,956	..	..
Total	3,596	15,425	4,400	7,090	12,400	1,895	4,922
Average for 10 years from 1918-19 to 1927-28.	359·6	1,542·5	880	1,418	2,480	379	984·4
Total for 20 years	10,073	32,078	3,680	13,840	31,076	4,201	10,270
Average for 20 years	503·6	1,603·9	868	1,384	3,107·6	420·1	1,027·0

Results of permanent manurial rotation experiments.

Plot No. 7. "B" Series.

Sulphate of Potash to supply K_2O as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	984	3,091	..	..	..	45	104
1909-10	418	1,194	793	1,847	4,394	..	..
1910-11	790	2,332	..	.	.	593	1,223
1911-12	519	855	1,004	1,404	5,002	..	..
1912-13	742	1,253	..	..	..	618	1 453
1913-14	371	856	687	952	3,408	..	..
1914-15	378	1,719	..	..	..	480	1,080
1915-16	412	1,068	883	657	3,384	..	..
1916-17	535	1,642	..	..	..	494	983
1917-18	307	1,478	924	1,267	2,406	..	..
Total	5,546	15,488	4,291	6,127	18,594	2,230	4,903
Average for 10 years from 1908-09 to 1917-18.	554·6	1,548·8	858·2	1,225·4	3,718·8	446	980 6
1918-19	395	1,813	..	.	.	415	661
1919-20	261	1,092	830	1,208	2,505	..	..
1920-21	329	2,176	..	..	..	317	668
1921-22	296	985	552	573	1,560	..	..
1922-23	506	1,560	..	..	..	413	860
1923-24	97	903	866	1,392	2,135	..	..
1924-25	385	903	..	..	..	441	1,447
1925-26	70	657	599	1,618	2,464	..	..
1926-27	411	1,232	..	..	..	287	493
1927-28	271	1,314	624	1,429	2,217	..	..
Total	3,021	12,653	3,471	6,312	10,881	1,873	4,129
Average for 10 years from 1918-19 to 1927-28.	302·1	1,265·3	694·2	1,262·4	2,176·2	374·6	825·8
Total for 20 years	8,567	28,141	7,762	12,439	29,475	4,103	9,032
Average for 20 years	428·3	1,407	770·2	1,243·9	2,947·5	410·3	903·2

Results of permanent manurial rotation experiments.

Plot No. 8. "B" Series.

Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,390	3,419	..	..	..	34	152
1909-10	478	1,470	942	2,023	5,314	..	..
1910-11	1,100	2,557	..	..	..	858	1,544
1911-12	825	1,441	1,527	2,176	6,874	..	..
1912-13	1,251	1,541	..	..	..	1,013	2,151
1913-14	703	1,313	1,519	1,412	5,240	..	..
1914-15	771	1,885	..	..	..	652	1,894
1915-16	1,151	2,053	940	1,314	5,092	..	..
1916-17	991	2,969	.	..	..	1,057	1,571
1917-18	991	2,792	567	895	2,283	..	..
Total	9,651	21,440	5,495	7,825	24,803	3,614	7,312
Average for 10 years from 1908-09 to 1917-18.	965·1	2,144	1,099	1,565	4,960·6	722·8	1,462·4
1918-19	898	2,710	..	..	..	694	1,113
1919-20	652	2,094	476	805	2,259	..	..
1920-21	600	2,464	..	..	..	573	1,234
1921-22	637	1,971	378	394	1,314	..	..
1922-23	782	2,176	..	..	..	743	1,597
1923-24	536	1,807	542	1,100	1,642	..	..
1924-25	666	1,314	..	..	..	883	2,238
1925-26	222	1,306	772	1,610	2,883	..	..
1926-27	673	1,560	..	..	..	468	1,339
1927-28	345	1,807	698	2,094	3,121	..	..
Total	6,011	19,299	2,866	6,003	11,169	3,361	7,521
Average for 10 years from 1918-19 to 1927-28.	601.1	1,929·9	573·2	1,200·6	2,233·8	672·2	1,507·2
Total for 20 years	15,662	40,739	8,361	13,828	35,972	6,975	14,833
Average for 20 years	783.1	2,036·9	836 1	1,382·8	3,597·2	697·5	1,483·3

Results of permanent manurial rotation experiments.

Plot No. 9. "B" Series.

Sulphate of Potash to supply K_2O and Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,513	3,444	..	..	..	71	280
1909-10	448	1,407	913	2,316	5,322	..	..
1910-11	1,149	2,150	..	..	..	921	1,576
1911-12	822	1,370	1,661	2,028	6,032	..	..
1912-13	1,222	1,591	..	..	..	1,144	2,051
1913-14	588	1,195	862	1,560	5,092	..	..
1914-15	758	1,972	..	..	..	751	1,466
1915-16	951	1,643	924	1,150	4,271	..	..
1916-17	1,028	1,848	..	..	..	1,008	1,628
1917-18	1,061	2,464	339	657	1,092	..	..
Total	9,540	19,084	4,699	7,711	22,709	3,895	7,001
Average for 10 years from 1908-09 to 1917-18.	954	1,908·4	939·8	1,542·2	4,541·8	779	1,400
1918-19	891	2,899	..	..	..	589	1,135
1919-20	850	1,667	476	961	1,971	..	..
1920-21	619	2,423	..	..	..	572	1,071
1921-22	611	1,889	429	452	1,725	..	..
1922-23	470	1,807	..	..	..	760	1,458
1923-24	587	1,889	651	745	2,423	..	..
1924-25	454	1,068	..	..	..	669	2,821
1925-26	265	1,232	821	2,341	3,326	..	..
1926-27	526	1,314	..	..	..	509	928
1927-28	238	2,053	1,150	2,299	3,285	..	..
Total	5,511	18,241	3,527	6,798	12,730	3,099	7,413
Average for 10 years, from 1918-19 to 1927-28.	551·1	1,824·1	705·4	1,359·6	2,546	619.8	1,482.6
Total for 20 years	15,051	37,325	8,226	14,509	35,439	6,994	14,414
Average for 20 years	752·5	1,866·2	822·6	1,450·9	3,543·9	699·4	1,441·4

Results of permanent manurial rotation experiments.

Plot No.10. "B" Series.

Sulphate of Ammonia to supply Nitrogen, Sulphate of Potash to supply K_2O and Superphosphate to supply P_2O_5 as in Farmyard Manure Plot No. 3.

Year	Maize		Arhar			Oats	
	Grain lb	Stalks lb.	Grain lb.	Bhusa lb	Stalks lb.	Grain lb	Straw lb.
1908-09	1,714	3,280	..	..	..	57	202
1909-10	623	1,874	813	1,946	4,271	..	..
1910-11	1,553	3,353	..	.	..	856	1,461
1911-12	1,176	2,432	1,496	1,938	6,266	..	..
1912-13	1,684	2,477	..	..	..	1,047	2,073
1913-14	750	1,361	788	1,256	3,737	..	..
1914-15	778	2,323	..	..	..	697	1,767
1915-16	1,213	2,053	912	1,487	4,189	..	..
1916-17	1,220	2,053	..	..	..	1,043	1,809
1917-18	1,404	2,053	468	604	1,215	..	..
Total .	12,115	23,259	4,477	7,231	19,678	3,700	7,312
Average for 10 years from 1908-09 to 1917-18.	1,211·5	2,325·9	895·4	1,446·2	3,935·6	740	1,462
1918-19	948	2,792	.	..	..	673	1,174
1919-20	1,064	2,078	618	1,107	1,971	..	..
1920-21	741	2,098	..	..	..	593	1,172
1921-22	883	1,807	378	411	1,889	..	..
1922-23	705	2,176	..	..	..	883	1,581
1923-24	862	2,135	727	1,737	2,012	..	..
1924-25	665	739	..	..	..	1,201	2,741
1925-26	345	1,478	772	2,061	3,449	..	..
1926-27	854	1,071	..	..	..	501	854
1927-28	616	2,135	1,010	2,275	2,792	..	..
Total .	7,683	20,309	3,505	7,591	12,113	3,851	7,522
Average for 10 years from 1918-19 to 1927-28.	768·3	2,030·9	701	1,518·2	2,422·6	770·2	1,504·4
Total for 20 years .	19,798	43,568	7,982	14,822	31,791	7,551	14,834
Average for 20 years .	989·9	2,178·4	722·2	1,482·2	3,179·1	755·1	1,483·4

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 11. "B" Series.

No Manure or Leguminous Crop.

Year	Maize		Barley		Oats	
	Grain lb.	Stalks lb.	Grain lb.	Straw lb.	Grain lb.	Straw lb.
1908-09	1,443	2,591	..	..	57	266
1909-10	483	1,632	716	870	..	..
1910-11	987	2,944	..	..	624	1,147
1911-12	764	1,701	519	728	.	..
1912-13	811	1,052	.	..	686	1,533
1913-14	521	1,231	180	451	..	..
1914-15	353	1,410	..	..	437	1,185
1915-16	664	1,478	309	575	.	..
1916-17	814	1,650	..	..	506	824
1917-18	515	3,121	326	452	.	.
Total	7,355	18,210	2,050	3,076	2,310	4,955
Average for 10 years from 1908-09 to 1917-18.	735·5	1,821	410	615	462	991
1918-19	273	2,382	..	.	429	678
1919-20	407	1,478	209	406	..	..
1920-21	278	2,300	..	..	371	697
1921-22	338	1,150	304	568	..	..
1922-23	159	1,273	..	..	308	1,244
1923-24	330	1,725	240	499	..	..
1924-25	310	1,232	..	..	482	1,466
1925-26	96	1,314	468	846	..	..
1926-27	353	944	.	..	394	550
1927-28	213	1,273	296	772	..	.
Total	2,757	15,071	1,517	3,081	2,084	4,575
Average for 10 years from 1918-19 to 1927-28.	275·7	1,507·1	303·4	616·2	416·8	915
Total for 20 years	10,112	33,281	3,567	6,157	4,394	9,530
Average for 20 years	505·6	1,664	356·7	615·7	439·4	953

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 12. "B" Series.

Green Manure in a Cereal Rotation.

Year	Maize		Barley		Oats	
	Grain lb.	Stalks lb.	Grain lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	..	..	..	..	178	486
1909-10	603	1,918	966	1,100	..	..
1910-11	..	..	..	..	1,292	2,266
1911-12	1,339	1,807	640	1,047	..	..
1912-13	..	..	..	..	814	1,958
1913-14	896	1,701	271	538	..	..
1914-15	..	..	..	..	562	1,408
1915-16	1,031	1,613	518	919	..	..
1916-17	..	..	..	..	671	1,382
1917-18	966	2,792	456	657	..	..
Total	4,835	9,861	2,851	4,252	3,517	7,500
Average for 10 years from 1908-09 to 1917-18.	967	1,972·2	570	850	703	1,500
1918-19	..	..	..	..	495	1,107
1919-20	535	2,094	269	552	..	..
1920-21	..	..	..	..	446	1,032
1921-22	616	1,807	271	673	..	..
1922-23	..	..	..	..	712	1,587
1923-24	598	2,546	304	476	..	..
1924-25	..	..	..	..	776	2,017
1925-26	152	1,150	591	1,051	..	..
1926-27	..	..	..	..	476	1,002
1927-28	706	2,135	308	677	..	..
Total	2,607	9,732	1,743	3,429	2,905	6,745
Average for 10 years from 1918-19 to 1927-28.	521·4	1,946·4	348·6	685·8	581	1,349
Total for 20 years	7,442	19,593	4,594	7,681	6,422	14,245
Average for 20 years	744·2	1,959·3	459·4	768·1	642·2	1,424·5

Results of permanent manurial rotation experiments.

Plot No. 13. "B" Series.

Deep-rooted Leguminous Crop in a Cereal Rotation.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	1,521	3,247	..	..	..	55	215
1909-10	483	1,487	456	1,026	2,382	..	..
1910-11	1,259	2,765	..	..	..	615	1,153
1911-12	73	1,267	903	1,347	3,794	..	..
1912-13	827	1,530	..	..	..	551	1,485
1913-14	329	892	661	952	2,957	..	..
1914-15	423	1,092	..	..	..	330	1,304
1915-16	475	1,214	916	1,150	3,532	..	..
1916-17	794	1,905	..	..	..	642	1,043
1917-18	243	1,971	1,024	1,330	3,187	..	..
Total	7,089	18,070	3,900	5,814	15,802	2,202	5,200
Average for 10 years from 1908-09 to 1917-18.	708·9	1,807	792	1,162·8	3,160·4	440	1,040
1918-19	327	1,725	..	..	..	425	766
1919-20	267	1,027	598	1,002	1,807	..	.
1920-21	284	2,464	..	..	..	399	
1921-22	389	1,068	511	575	1,642	..	..
1922-23	493	1,684	..	..	..	480	993
1923-24	149	1,390	854	1,363	1,642	..	..
1924-25	323	657	..	..	..	636	1,499
1925-26	78	821	337	1,429	2,464	..	..
1926-27	411	1,232	..	..	..	218	526
1927-28	575	1,314	723	1,659	2,135	..	..
Total	3,296	13,382	3,023	6,028	9,690	2,153	4,375
Average for 10 years from 1918-19 to 1927-28.	329·6	1,338 2	604·6	1,205·6	1,938	430·6	875
Total for 20 years	10,365	31,452	6,923	11,842	25,492	4,355	9,575
Average for 20 years	519·2	1,572·6	698·3	1,184·2	2,549·2	435 5	957·5

Results of permanent manurial rotation experiments

Plot No. 14. "B" Series.

One Deep, one Shallow-rooted Legume in the Rotation.

Year	Maize		Arhar			Oats		Pea	
	Grain lb.	Stalks lb	Grain lb	Bhusa lb.	Stalks lb.	Grain lb	Straw lb	Grain lb.	Straw lb.
1908-09	1,550	2,060	..	..	..	20	107	5	41
1909-10	435	1,819	456	1,043	2,300	..	..	..	..
1910-11	1,357	2,472	..	..	..	437	802	301	517
1911-12	945	1,578	948	1,092	3,745	..	..	..	..
1912-13	878	1,132	..	..	..	346	833	82	254
1913-14	380	1,014	578	944	2,661	.	..	..	..
1914-15	423	1,094	..	..	..	160	374	70	245
1915-16	627	1,560	903	1,232	3,778	..	..	..	..
1916-17	798	1,913	..	..	..	535	902	125	261
1917-18	477	1,043	583	1,602	3,540	..	..	.	..
Total	7,870	17,785	3,468	5,913	16,024	1,498	3,018	583	1,518
Average for 10 years from 1908-09 to 1917-18.	787	1,778 5	693·6	1,182·6	3,204 8	299 6	603·6	116·6	263·6
1918-19	353	1,807	..	..	..	343	519	109	304
1919-20	323	1,232	506	849	1,560	..	..	..	..
1920-21	295	2,587	..	..	..	186	471	78	255
1921-22	403	1,889	526	534	1,396	..	..	..	..
1922-23	601	1,930	..	..	..	443	788	92	172
1923-24	203	1,273	920	1,207	1,683	..	..	..	..
1924-25	338	739	..	..	..	636	1 581	48	135
1925-26	119	1,396	230	1,084	2,053	..	..	..	..
1926-27	444	1,232	..	..	.	181	312	16	92
1927-28	608	1,889	739	1,723	2,217	.	.	..	..
Total	3,777	15,974	2,921	5,489	8,909	1,789	3,671	343	958
Average for 10 years from 1918-19 to 1927-28.	377·7	1,597·4	584·2	1,097·8	1,781·8	357·8	734·2	68·6	191·6
Total for 20 years	11,647	33,759	6,389	11,402	24,933	6,287	6,689	926	2,276
Average for 20 years	582·3	1,687·9	638·9	1,140·2	2,493·3	328·7	668·9	92·6	227·6

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 15. "B" Series.

Leguminous Crop and Green Manure in the Rotation.

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	..	..	.	..	..	100	314
1909-10	436	671	415	1,043	1,971	..	..
1910-11	..	..	.	.	..	1,160	2,250
1911-12	1 218	1,896	958	1,232	3,318	..	..
1912-13	..	..	..	.	.	675	1,455
1913-14	762	1,887	431	821	1,889	..	..
1914-15	..	..	..	.	..	336	814
1915-16	936	1,889	805	1,281	3,302	..	..
1916-17	..	..	..	..	..	778	1,480
1917-18	1,025	2,957	821	1,191	3,622	..	..
Total	4,377	10,300	3,520	5,568	14,192	3,049	6,313
Average for 10 years from 1908-09 to 1917-18.	875	2,060	704	1,113·6	2,838·4	609 8	1,262·6
1918-19	..	..	..	.	..	636	1,211
1919-20	532	2,300	539	939	1,971	..	..
1920-21	..	..	..	..	..	569	1,074
1921-22	906	2,299	503	739	1,008	..	..
1922-23	..	..	..	..	..	998	1,835
1923-24	850	3,613	573	905	1,314	..	..
1924-25	..	..	..	..	..	948	2,295
1925-26	205	1,314	255	1,470	2,094	..	..
1926-27	..	..	..	..	..	443	870
1927-28	870	2,792	780	1,766	2,290	..	..
Total	3,363	12,318	2,650	5,819	8,746	3,594	7,285
Average for 10 years from 1918-19 to 1927-28.	672·6	2,463·6	530	1,163·8	1,749·2	718·8	1,457
Total for 20 years	**7,740**	**22,618**	**6,170**	**11,387**	**22,938**	**6,643**	**13,598**
Average for 20 years	**774**	**2,261·8**	**617**	**1,138·7**	**2,293·8**	**664·3**	**1,359·8**

RESULTS OF PERMANENT MANURIAL ROTATION EXPERIMENTS.

Plot No. 16. "B" Series.

Green Manure and Superphosphate to supply P_2O_5 *as in Farmyard Manure Plot 3.*

Year	Maize		Arhar			Oats	
	Grain lb.	Stalks lb.	Grain lb.	Bhusa lb.	Stalks lb.	Grain lb.	Straw lb.
1908-09	..	..	..	..	..	..	..
1909-10	..	..	..	..	..	..	..
1910-11	..	..	..	..	..	..	..
1911-12	..	..	..	..	..	..	..
1912-13	..	..	..	..	..	..	..
1913-14	934	2,321	304	657	1,643	..	..
1914-15	..	..	..	..	..	616	1,519
1915-16	1,552	2,711	722	706	2,825	..	..
1916-17	..	..	..	..	.	1,964	2,594
1917-18	1,615	3,778	1,051	1,643	4,624	..	..
Total	4,101	8,810	2,077	3,006	9,092	2,580	4,113
Average for 10 years from 1908-09 to 1917-18.	1,367	2,937	692·3	1,002	3,030·6	1,290	2,056
1918-19	..	..	..	..	..	1,478	2,094
1919-20	1,466	3,170	790	1,386	2,628	..	..
1920-21	..	..	..	..	..	1,079	1,672
1921-22	1,306	3,613	392	452	1,642	..	..
1922-23	..	..	..	..	..	1,948	3,690
1923-24	1,521	3,531	704	651	1,191	..	..
1924-25	..	..	..	..	..	2,215	4,190
1925-26	874	1,396	460	1,347	3,203	..	..
1926-27	..	..	..	..	..	1,363	2,168
1927-28	1,166	3,572	345	805	1,642	..	..
Total	5,833	15,282	2,691	4,641	10,306	8,083	13,814
Average for 10 years from 1918-19 to 1927-28.	1,166·6	3,056·4	538·2	928·2	2,061·2	1,616·6	2,762·8
Total for 20 years	9,934	24,092	4,768	7,647	19,398	10,663	17,927
Average for 20 years	1,241·7	3,011·5	596	955·8	2,424·7	1,523·2	2,561

Statement showing the quantity of farmyard manure used in Plot No. 3 with the analysis and total ingredients found in farmyard manure No. 3 on the basis of which the mineral manures were calculated and applied during the last 20 years from 1908-09 to 1927-28.

Year	Farm-yard manure per acre in plot No. 3	ANALYSIS OF F. Y. MANURE			Total P_2O_5 per acre in plot No. 3 F. Y. M	Total K_2O_5 per acre in plot No. 3 (F. Y. M.)	REMARKS
		Percentage of nitrogen	Percentage of P_2O_5	Percentage of K_2O			
1908-09 . . .	3,226	·62	·41	·24	13·22	7·74	
1909-10 . . .	4,255	·47	·24	·68	10 21	28·93	
1910-11 . . .	4,167	·48	·28	·35	11·66	14·58	
1911-12 . . .	4,348	·40	·51	1·55	22·17	67·39	
1912-13 . . .	5,063	·395	·21	·52	10·63	26·32	
1913-14 . . .	5,000	·40	·22	·56	11·00	28·00	
1914-15 . . .	4,644	·43	·30	·74	13·93	34·36	
1915-16 . . .	4,255	·47	·308	·388	13·10	16·50	
1916-17 . . .	4,444	·45	·39	·77	17·33	34·21	
1917-18 . . .	5,000	·40	·27	·40	13·50	20·00	
1918-19 . . .	3,846	·52	·327	.692	12·57	26·21	
1919-20 . . .	2,899	·69	·48	1 01	13·91	29·27	
1920-21 . . .	2,667	·75	·37	·94	9·86	25·06	
1921-22 . . .	3,704	·54	·30	·73	11·11	27·03	
1922-23 . . .	4,158	·481	·304	·562	12·64	23·36	
1923-24 . . .	2,500	·80	31	·47	7·75	11·75	
1924-25 . . .	1,370	1·46	·742	2·57	10·16	35·20	
1925-26 . . .	2,500	·80	·38	·68	14·50	17·00	
1926-27 . . .	3,030	·66	·443	1·215	13·42	36·81	
1927-28 . . .	3,509	·57	·360	·91	12·63	31·93	
Total .	74,535	11·846	7·354	15·977	255·30	541·65	
Average of 20 years .	3,730	·59	·367	·798	12·76	27·80	

Cultivation charges of Punjab Permanent Manurial and Rotational Experiments at the current rate, taking the average yield of 20 years of Kharif and Rabi crops (1908-09 to 1927-28) for valuation.

Plot No	Valuation of produce per acre	Cost of cultivation per acre including seed and manure	Balance	Land rent	Profit per acre	REMARKS
	Rs A. P	Rs A P	Rs A. P.	Rs	Rs. A. P.	
1	78 12 0	32 8 6	46 3 6	12	34 3 6	
2	93 2 3	36 4 6	56 13 9	12	44 13 9	
3	105 12 6	40 0 6	65 12 0	12	53 12 0	
4	109 13 3	41 0 6	65 12 9	12	53 12 9	
5	93 1 3	46 10 6	46 9 9	12	34 9 9	
6	71 5 9	41 14 6	29 7 3	12	17 7 3	
7	63 11 9	38 6 6	25 5 3	12	13 5 3	
8	96 3 6	37 12 6	58 7 0	12	46 7 0	
9	91 8 9	43 2 6	48 6 3	12	36 6 3	
10	102 9 9	52 0 6	50 0 0	12	38 0 0	
11	53 3 3	37 13 0	15 6 3	12	3 6 3	
12	55 5 9	37 1 0	18 4 9	12	6 4 9	
13	67 0 9	32 8 6	34 8 0	12	22 8 0	
14	67 14 6	36 2 6	31 12 0	12	19 12 0	
15	61 12 9	31 12 6	33 0 3	12	21 0 3	
16*	98 5 9	37 0 6	61 5 3	12	49 5 3	15 years' average only

*This plot was added in 1913-14.

Cultivation charges of Permanent Manurial Rotation Experiments at the curren rates, taking the average yield of 15 years of Kharif and Rabi both (1913-1 to 1927-28) for valuation.

Plot No.	Valuation of produce per acre	Cost of cultivation per acre including manure, seed, etc	Balance	Land rent	Profit per acre	Treatment
	Rs A P	Rs A. P	Rs A P.	Rs.	Rs. A P.	
1	71 5 9	32 8 6	38 13 3	12	26 13 3	No manure.
3	101 4 3	40 0 6	61 3 9	12	49 3 9	(Farmyard manure 20 lb nitrogen)
4	107 12 6	44 0 6	63 12 0	12	51 12 0	(Farmyard manure 30 lb nitrogen)
13	61 1 9	32 8 6	28 9 3	12	16 9 3	No manure.
16	98 5 9	37 0 6	61 5 3	12	49 5 3	Super and green manure.
Average of 1 and 13	65 14 9	32 8 6	33 6 3	12	21 6 3	Average, no manure.

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