ANNUAL REPORT

OF THE

IMPERIAL DEPARTMENT OF AGRICULTURE

FOR THE YEAR

1904-05.

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TABLE OF CONTENTS.

Preface ............................................. v

PART I.—Report of the Officiating Inspector-General,
by Mr. F. G. Sly, I.C.S. .............................. 1—39

Paragraph,

1. Duties of the Inspector-General ....................... 1
2. Staff ............................................. 1
3. Tours ............................................. 2
4. Board of Agriculture ................................ 3
5. The Agricultural Research Institute, Pusa ............... 3
6. Agricultural Chemistry ................................ 5
7. " Saltpetre as manure ................................. 7
8. " Mineral Fertilizers ................................ 9
9. Mycology ............................................ 10
10. " Wheat Ruts ....................................... 12
11. " Ground-nut leaf disease ............................. 13
12. Entomology ......................................... 13
13. " The Bombay Locust ................................. 14
14. " Grasshoppers ...................................... 15
15. Cotton. Survey of indigenous varieties ............... 15
16. " Selection of Seed ................................ 17
17. " Hybridization ..................................... 17
18. " Trial of Exotics ................................. 18
19. " Tree Cottons ..................................... 19
20. " Improvement of methods of cultivation .......... 20
22. " Future expansion of cotton investigation ........ 21
23. Cotton seed oil industry ............................ 21
24. Tea ............................................... 22
25. Indigo ........................................... 24
26. Jute ............................................. 24
27. Juar ............................................... 26
28. Maize ............................................ 26
29. Soy Beans ......................................... 26
30. Tobacco ........................................... 27
31. Sweet Potatoes ..................................... 27
32. Irrigation ......................................... 27
33. Sericulture ........................................ 28
34. Agricultural Education .............................. 29
35. Distribution of seeds and implements ............... 30
**PART I.**—Report of the Officiating Inspector-General, 
by Mr. F. G. Sly, I.C.S.—contd.

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>36. Publications</td>
<td>32</td>
</tr>
<tr>
<td>37. Expenditure</td>
<td>32</td>
</tr>
<tr>
<td>38. Provincial Departments.</td>
<td>Bombay</td>
</tr>
<tr>
<td>39. Madras</td>
<td>34</td>
</tr>
<tr>
<td>40. United Provinces</td>
<td>34</td>
</tr>
<tr>
<td>41. Bengal</td>
<td>35</td>
</tr>
<tr>
<td>42. Punjab</td>
<td>36</td>
</tr>
<tr>
<td>43. Central Provinces</td>
<td>36</td>
</tr>
<tr>
<td>44. Assam</td>
<td>36</td>
</tr>
<tr>
<td>45. Burma</td>
<td>37</td>
</tr>
<tr>
<td>46. Native States</td>
<td>37</td>
</tr>
<tr>
<td>47. Proposals for future expansion</td>
<td>38</td>
</tr>
</tbody>
</table>

**PART II.**—Report of the Agricultural Research Institute, Pusa, 
by Mr. B. Coventry, Director. | 41—49 |

1. General History | 41 |
2. Objects and aims | 42 |
3. Board of Agriculture | 43 |
4. General features of year's work | 43 |
5. Public Works Department | 43 |
6. Buildings and other works. | 44 |
7. Departmental work | 44 |
8. The Farm. | 44 |
9. Cultivation | 45 |
10. Cotton experiments | 45 |
11. Cattle Farm | 46 |
12. Chemistry | 47 |
13. Botany | 47 |
14. Entomology | 47 |
15. Mycology | 48 |
16. Bacteriology | 48 |
17. Weather | 48 |
18. Accounts | 49 |

**PART III.**—Report of the Agricultural Chemist to the Government of India, by Dr. J. W. Leather, Ph.D., F.I.C., etc. | 51—70 |

1. Preliminary | 51 |
2. Tours | 51 |
3. Analysis of agricultural materials | 52 |
4. Analysis of soils | 52 |
5. Sampling soils | 53 |
6. Available plant food in soils | 53 |
7. Saline soils | 54 |
8. Use of saline soils | 54 |
9. Combined Nitrogen in Rain and Dew | 55 |
10. Drainage water at Cawnpore | 57 |
### Part III. Report of the Agricultural Chemist to the Government of India, by Dr. J. W. Leather, Ph.D., F.I.C., etc.—Contd.

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Well waters</td>
<td>58</td>
</tr>
<tr>
<td>17. Manures</td>
<td>59</td>
</tr>
<tr>
<td>18—21. Sewage</td>
<td>59</td>
</tr>
<tr>
<td>22. Canal silt and waters</td>
<td>61</td>
</tr>
<tr>
<td>23—24. Saltpetre</td>
<td>62</td>
</tr>
<tr>
<td>25. Food grains and fodders</td>
<td>63</td>
</tr>
<tr>
<td>26. Oil seeds</td>
<td>64</td>
</tr>
<tr>
<td>27—28. Poisonous plants</td>
<td>64</td>
</tr>
<tr>
<td>29—33. Sugar</td>
<td>66</td>
</tr>
<tr>
<td>34. Dairy produce—Milk</td>
<td>68</td>
</tr>
<tr>
<td>35. Analyses of Forest products</td>
<td>69</td>
</tr>
<tr>
<td>36—37. Lectures</td>
<td>69</td>
</tr>
<tr>
<td>38. Publications</td>
<td>69</td>
</tr>
<tr>
<td>39—41. Establishment</td>
<td>69</td>
</tr>
</tbody>
</table>

### Part IV. Report of the Cryptogamic Botanist to the Government of India, by Dr. E. J. Butler, M.B., F.L.S.

| 1—3. Prefatory | 71 |
| 4. Establishment | 72 |
| 5—8. Touring | 72 |
| 9. Provincial work in fungus diseases | 73 |
| 10. Epidemics of fungus diseases | 74 |
| 11. Treatment of fungus diseases | 75 |
| 12. Potato diseases | 76 |
| 13—14. Wheat rusts | 76 |
| 15. Other rusts | 78 |
| 16—20. Sugarcane diseases | 78 |
| 21. Spike disease of sandal | 79 |
| 22. Tea and Coffee diseases | 81 |
| 23. Tur wilt | 81 |
| 24—25. Pepper diseases | 82 |
| 26. Other wilt diseases | 83 |
| 27. Ground-nut leaf disease | 83 |
| 28. Oat smut | 84 |
| 29. Other smuts | 84 |
| 30. Sorghum diseases | 84 |
| 31. Green-ear disease of the bulrush millet | 85 |
| 32. Diseases of trees | 85 |
| 33. Vine diseases | 85 |
| 34—35. Betel palm diseases | 86 |
| 36. Kodra poisoning | 86 |
| 37. Mychoriza | 86 |
| 38. Nodule bacilli of Leguminosae | 87 |

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. Miscellaneous</td>
<td>87</td>
</tr>
<tr>
<td>40. Publications</td>
<td>88</td>
</tr>
</tbody>
</table>

**PART V.—Report of the Entomologist to the Government of India, by Mr. H. M. Leffroy, M.A., F.E.S., F.Z.S.**

| 1—3. Historical | 89 |
| 4. Investigation of crop pests | 90 |
| 5. Special inquiries | 91 |
| 6. Remedies | 91 |
| 7. Beneficial insects | 93 |
| 8. Collections | 93 |
| 9. Indian Museum | 94 |
| 10. Work at Pusa | 94 |
| 11. Field study of insect pests | 95 |
| 12. Publications | 96 |
| 13. Rural Education | 96 |
| 14. Future needs | 97 |

**APPENDIX A.—An account of the scientific investigations of Indigo which have been and are being conducted in India, by Mr. C. Bergtheil, Agricultural Bacteriologist to the Pusa Estate**

| | 99 |

**APPENDIX B.—Jute Experiments in Bengal, by Mr. R. S. Finlow, B. Sc., F.C.S., Jute Specialist to the Government of Bengal**

| | 105 |

**APPENDIX C.—Outline of the history and the work done by the Mysore State Department of Agriculture, by Dr. A. Lehmann, Ph. D., Agricultural Chemist to the Government of Mysore.**

| | 108 |

**APPENDIX D.—List of recent agricultural publications in India**

| | 110 |
PREFACE.

As this is the first annual report published by the Imperial Department of Agriculture, it includes not only an account of the work of the past year, but a summary of that done since the appointment of the Inspector General in 1901. The first part consists of the Report of the Inspector General, which gives a general account of the Department, a summary of the work done by the members of the scientific staff, an account of the special investigations made by or at the instance of the Imperial Department, a résumé of the work of the provincial departments, and finally an outline of the proposals for future expansion. The remaining parts are the annual reports of the scientific officers of the subordinate branches of the Imperial Department, namely those of the Director of the Pusa Institute, the Agricultural Chemist, the Cryptogamic Botanist and the Government Entomologist. The appendices include accounts of the special investigations of indigo and jute, a summary of the work of the Mysore State Department of Agriculture, and a list of recent publications relating to Indian agriculture.
ANNUAL REPORT

OF THE

IMPERIAL DEPARTMENT OF

AGRICULTURE

FOR

1904-05.

Part I.

REPORT OF THE INSPECTOR GENERAL OF AGRICULTURE.

1. Duties of the Inspector General.—The post of the Inspector General of Agriculture in India was created in October, 1901, to which Mr. J. Mollison, M.R.A.C., was appointed. He held it until November, 1904, when he proceeded on one year's leave, and Mr. F. G. Sly, I.C.S., was appointed to officiate for him. The Inspector General is the administrative head of the Imperial Department of Agriculture and the scientific adviser in agricultural matters to both the Imperial and Provincial Governments. It is his duty 'to guide and co-ordinate the experiments which are being made under the orders of Local Governments and to publish and criticise their results, to indicate new lines of experiments which they may profitably follow, and to respond to the requests of private investigators for assistance or advice.' He is not invested with any direct authority over provincial departments of agriculture, and the experience of the past four years shows that such authority is not required, for provincial Directors freely consult him and welcome such advice and assistance as he can give.

2. Staff.—When the appointment was created in 1901, two experts only were attached to the Imperial Staff,—the Agricultural Chemist and the Cryptogamic Botanist. There are now eleven appointments in the Imperial Department:—(1) Inspector General, (2) Assistant Inspector General, (3) Director, Pusa Institute, (4) Agricultural Chemist, (5)
Cryptogamic Botanist, (6) Entomologist, (7) Agri-Horticulturist, (8) Supernumerary Agriculturist, (9) Biological Botanist, (10) Agri-Bacteriologist, and (11) Second Entomologist. During the same period the expert staff of provincial departments has similarly been strengthened. Madras, Bombay and the United Provinces alone employed expert agriculturists as Deputy Directors, and the Economic Botanist in Madras was the sole representative of the specialized sciences. Now Deputy Directors have been appointed for Bengal, Punjab and the Central Provinces; an Economic Botanist, an agricultural chemist and a professor of agriculture have been added to the Bombay staff, an Economic Botanist to the United Provinces, and an Agricultural Chemist to the Central Provinces. The staff of experts employed by Government has thus increased from six to twenty-five during the past four years. The inspection tours of the Inspector General have persistently brought to notice the imperative necessity for the employment of scientific experts in guiding and controlling the work of agricultural departments, so that the main problem of the application of science to Indian agriculture may be properly investigated.

3. Tours.—The head-quarters of the Inspector General are located at Nagpur (Central Provinces), which is a convenient centre for inspection duty. The past four years have been spent in almost constant touring throughout India, all the provinces having been visited at least once, and most of them several times. These tours have enabled the Inspector General to make the close acquaintance of the provincial directors and their staff, with whom the maintenance of friendly relations is the first essential to success in his work. Secondly, he has studied on the spot the experiment stations and other lines of work in progress, which has enabled him to make recommendations for their improvement. Thirdly, he has obtained a general view of the agricultural conditions in each province, which has allowed him to prepare working schemes for the consideration of local officers. The more important action resulting from these tours will appear in the subsequent notice of the work of each provincial department, but I may refer to one great advantage which has accrued from the appointment of an Inspector General. All provincial departments have been brought more closely into touch with each other, thus removing the isolation of the work carried on in each province. In a similar direction much good resulted from a general tour to the experimental farms of the Bombay Presidency in 1903, which was made under the guidance of the Inspector General by the Directors of Bombay, Punjab and the Central
Provinces, the Deputy Director and the Economic Botanist of Madras, the Agricultural Chemist of the Mysore State, and the expert staff of the Bombay Department of Agriculture. It is desirable to arrange similar occasional tours in other provinces, if the officers can be spared to attend them.

4. **Board of Agriculture.**—Another advance in the same direction has been made by the creation of the Board of Agriculture which meets annually at Pusa. This Board consists of the Inspector General (who is the President) and the Imperial staff, the provincial Directors and their expert staffs, the Inspector General, Civil Veterinary Department, Director of the Botanical Survey and Director of Public Instruction, Bengal. It discusses the programmes of the imperial and provincial departments, and advises Government as to the action that should be taken for the improvement of Indian agriculture. This annual meeting thus affords to the agricultural experts working in different parts of India an opportunity of exchanging ideas with each other, of learning what is being done in the various provinces, of co-ordinating their work and of advising on agricultural administration generally. The recommendations of the Board are submitted to the Government of India for their consideration. The first meeting was held in January last and was attended by thirty members. The proceedings* of the Board have been separately published, the principal subjects that came under discussion being the year's programmes of the imperial and provincial departments, the improvement of cotton cultivation, the extension of jute cultivation, agricultural education, irrigation, cattle breeding, measures for regulating the relations between the imperial and provincial departments, measures for bringing the department into touch with cultivators, and publications. Several of the recommendations have been accepted by the Government of India, whilst others are still under their consideration. The universal opinion of the members was that the first meeting had proved of great utility.

5. **The Agricultural Research Institute, Pusa.**—A most important development of the imperial department occurred in 1903, when the Government of India sanctioned the establishment of an Imperial Agricultural Research Station and College, which includes fully equipped laboratories for research work, an experimental farm, a cattle breeding farm and a higher Agricultural College. This Institute is located on a Government estate of 1,358 acres at Pusa in Behar, the most thickly

populated agricultural tract of India, which will be the head-quarters of the Imperial scientific staff. Apart from the value of the estate, the buildings will cost some Rs 6 4 lakhs ( £110,000), towards which has been applied a portion of the magnificent donation of £30,000 made by Mr. Phipps, an American gentleman, who during a visit to India placed this gift at the disposal of His Excellency the Viceroy, Lord Curzon. The main building will include fully equipped laboratories for all the specialists, herbarium, museum and library, together with hall, lecture rooms and laboratories for the students of the College. The farm will provide experimental cultivation for the research work and for the training of the students; it is hoped that it will serve as a model for similar stations under provincial departments. The Agricultural College, with a full staff of professors and assistants, will provide a specialized post-graduate agricultural education in the hope that the best of the native students will be ultimately fit for the higher appointments in the agricultural departments. It will also give to students a good agricultural education to fit them for employment by Government in the revenue service and by land owners as estate agents and the like.

It is anticipated that the College will be ready to open about the end of 1907. The cattle farm is intended to provide a supply of good bulls for distribution to the adjoining tracts of Bengal for the improvement of the indigenous breed of cattle. It is thus intended that the expert staff of the Pusa Institute shall conduct higher lines of research work applicable to all India and beyond the capacity of provincial departments, guide and assist the provincial experts in their several branches, train young scientists for future employment as provincial experts and be the professors of the higher grade Agricultural College for all India. The Report of the Director (Part II of this report) shows the progress that has been made towards the realization of this scheme. Mr. B. Coventry took up the appointment of Director in April 1904, and the complete staff of specialists has now been recruited, although they are not yet all resident at Pusa. Substantial progress has been made with the erection of the necessary buildings. A large part of the farm land has been reclaimed from waste and brought under cultivation, but it must take some few years to bring the land into a suitable uniform condition for regular experimental work. During the past year a start has been made in the testing of different varieties of crops, whilst experiments have been tried with many varieties of cotton in order to discover a fine quality that will suit the agricultural conditions of Behar. These preliminary trials seem to repeat the result of
similar efforts in many other parts of India, that it is very difficult to introduce exotics successfully and that the most hopeful line of work is to breed a suitable variety from the indigenous races. Pending the opening of the College, some provincial candidates have been trained in practical agriculture and entomology, in order to qualify them for posts in provincial departments. This start met with such success that arrangements have now been made to train similar candidates in practical agriculture, agricultural chemistry, mycology and entomology. In view of the importance of securing quickly the nucleus of a staff of trained assistants in each province, this temporary arrangement should be of much utility to provincial departments.

6. Agricultural Chemistry.—In addition to a large number of analyses of agricultural materials (soils, manures, feeding stuffs, waters and the like) made at the instance of provincial departments, several special problems have been under investigation, an account of which is given in Dr. Leather's report (Part III). His relief from the duty of delivering courses of elementary lectures at Poona, Madras and Dehra Dun has given more time for specialized work. A large number of samples of Indian food-grains and fodders, many of which are foreign to European agriculture, have been analysed to determine their comparative value, and the results have been published in Agricultural Ledgers Nos. 10 of 1901 and 7 of 1904. A similar inquiry has been made to determine the amount of oil contained in different varieties of oil seeds, collected from all parts of India. These have given some most interesting results, which may prove of commercial importance, large variations being found in the oil-content of samples of oil seeds received from different parts, more particularly of earthnuts, sesamum, mustard and safflower. The inquiry has now to be carried to the second stage by the experimental cultivation of the best oil-yielding varieties, to test the comparative gross outturns and to see if the quality is dependent upon local conditions of soil, climate and cultivation, or is maintained after transfer to other surroundings. Dr. Leather has co-operated in the investigations made at the Manjri (Poona) Sewage Farm into the agricultural value of purified sewage, the best treatment needed for its purification, and the extent of land required to take the sewage from a given population; chemical inquiry has been made to ascertain the degree of purification effected, the size of septic tank suitable for definite quantities of sewage of different strengths, and the necessity for aerated beds. These experiments have necessarily been made under artificial conditions, which somewhat
detRACT FROM THE UTILITY OF THE RESULTS, BUT DEFINITE CONCLUSIONS HAVE BEEN ARRIVED AT AS REGARDS THE MANURIAL VALUE OF THE SEPTIC TANK EFFLUENT, THE KINDS OF CROPS MOST SUITED TO A SEWAGE FARM, THE BEST SYSTEM OF CULTIVATION AND THE AREA REQUIRED TO UTILIZE THE SEWAGE FROM A GIVEN POPULATION. THE AGRICULTURAL CHEMIST HAS SIMILARLY ASSISTED IN AN INQUIRY INTO THE SUGARCANE CULTIVATION OF THE CENTRAL PROVINCES, AN ASSISTANT BEING DEPUTED DURING THE HARVESTING SEASON IN ORDER TO ANALYSE THE DIFFERENT VARIETIES OF CANE. VERY MARKED DIFFERENCES IN THE QUALITY OF THE VARIETIES OF CANE HAVE BEEN FOUND, MOST OF THEM BEING POOR, BUT ONE VARIETY CONTAINED NO LESS THAN 22.40 PER CENT. OF CANE SUGAR, WHICH EQUALS THAT OF THE BEST CANES KNOWN TO BE IN CULTIVATION. OTHER IMPORTANT RESULTS HAVE BEEN OBTAINED FROM SUGAR EXPERIMENTS IN BOMBAY AND THE UNITED PROVINCES OF AGRA AND OUDH, WHICH ARE GIVEN IN DR. LEATHER'S REPORT (PART III). ATTEMPTS HAVE BEEN MADE TO DETERMINE VARIOUS CHEMICO-AGRICULTURAL QUESTIONS BY THE GROWTH OF PLANTS UNDER 'POT-CULTURE METHODS,' MORE PARTICULARLY IN REGARD TO THE SOIL REQUIREMENTS OF LIME, SULPHATES AND PHOSPHATES, ITS PHYSICAL NATURE, MOISTURE CONDITIONS AND OTHER MATTERS WHICH CANNOT BE DETERMINED BY CHEMICAL ANALYSIS ALONE. THIS BRANCH OF WORK HAS BEEN STARTED UNDER DIFFICULTIES BUT A PROPER POT-CULTURE HOUSE IS NOW UNDER CONSTRUCTION AT PUSA. THE PRELIMINARY INVESTIGATION INTO SALINE EARTHS HAS LARGELY BEEN COMPLETED, THE NATURE AND QUANTITY OF THE SALTS HAVING BEEN DETERMINED BY THE ANALYSIS OF NUMEROUS SAMPLES. THIS HAS ASSISTED THE EXPERIMENTS IN RECLAMATION IN PROGRESS IN THE UNITED PROVINCES AND MADRAS, BUT AT PRESENT THE COST OF ANY SUCCESSFUL KNOWN TREATMENT SEEMS TO EXCEED THE VALUE OF SUCH RECLAIMED LAND. AN INTERESTING INQUIRY HAS BEEN STARTED TO ASCERTAIN THE AMOUNT OF NITROGEN ADDED TO THE SOIL BY RAIN WATER AND DEW AND LOST TO IT BY DRAINAGE. THE AMOUNT OF COMBINED NITROGEN IN RAIN AND DEW HAS BEEN INVESTIGATED AT DEHRA DUN AND CAWNPORE, WHilst DRAIN-GAUGES HAVE BEEN ERECTED AT CAWNPORE TO DETERMINE THE LOSS OF NITROGEN BY DRAINAGE. IT IS HOPEP THAT THESE GAUGES WILL ALSO FURNISH INFORMATION OF INTEREST TO THE IRRIGATION DEPARTMENT IN REGARD TO THE VELOCITY OF PERCOLATION, THE AMOUNT OF EVAPORATION AND SUCH LIKE MATTERS. DR. LEATHER HAS WRITTEN A NOTE ON 'WATER IN THE SOIL,' WHICH GIVES SOME INTERESTING PRELIMINARY DEDUCTIONS ON THIS IMPORTANT SUBJECT. DR. LEATHER'S REPORT SHOWS THAT A VERY LARGE AMOUNT OF USEFUL WORK HAS BEEN DONE BY HIM DURING THE PAST FOUR YEARS, BUT AS IN OTHER BRANCHES OF SPECIALIZED SCIENCE MUCH OF IT HAS BEEN IN THE NATURE OF THE PRELIMINARY INVESTIGATION OF MANY IMPORTANT PROBLEMS. WITH THE NUMEROUS DEMANDS MADE UPON A SINGLE
chemist, it is impossible for him to concentrate his time upon a complete inquiry into a few definite problems, which again emphasises the necessity for a large increase in the number of specialists.

7. Saltpetre as manure.—Experiments to test the value of Indian saltpetre (nitrate of potash) as a manure have for many years been made at several provincial experiment stations. At Cawnpore, it has been found that crude saltpetre increases the yield per acre of maize from about 740 to 1,020 lbs. and of wheat from 1,270 to 1,710 lbs. (see North-West Provinces Bulletin No. 9 of 1900). At Nagpur, its use has increased the yield of wheat by 300 to 450 lbs. Similar results have been obtained at Dumraon. Extensive trials in the Bombay Presidency show that saltpetre gives a largely increased yield of rice under favourable conditions, but in porous soils much of this soluble manure is liable to be washed away unless applied at a suitable time. The best results have been obtained at Burdwan, where an application of bonemeal (3 maunds) and saltpetre (60 lbs.) has given an average yield of 4,350 lbs., of paddy as against 1,480 lbs. unmanured, giving an excess net profit of Rs 100 an acre. Crude saltpetre has thus almost universally proved itself a valuable manure for cereals. An inquiry was, therefore, started by the Inspector General of Agriculture to see if any practical measures could be devised to increase and cheapen the production of saltpetre and to extend its use amongst cultivators. An investigation into the manufacturing processes was made first by Mr. Hooper and later by Dr. Leather, the results of which will shortly be published as an Agricultural Ledger. No practical measures for improving these processes could be suggested, the workers already making the best use of the available materials within the economic limit of their surroundings. The production is controlled by the Salt Department under a system of licenses. An inquiry was made, in consultation with the Commissioner of Northern India Salt Revenue, to see if any modification of this license system could be devised which would lessen the amount of Government interference and cheapen the product. It is clearly impossible to abolish all supervision, for there are extensive tracts of salt earths in India, which have produced enormous quantities of salt in former years, and which would be worked again under the guise of saltpetre works. The methods of extracting saltpetre and salt from suitable earths are practically identical, so that any freeing of the former is impracticable so long as government controls the manufacture of salt. The workers, who separate the crude saltpetre from the nitrous earth, could easily separate an edible salt by the same
processes, but for the same reasons it is not possible to permit it. The present small license fees have no appreciable effect upon the price of saltpetre, which is regulated by the export trade, so that no reduction in the license fees would make any real difference in the price of saltpetre. The very small extra profit would be absorbed mostly by the landlord who leases the area of nitrous earth, and to a smaller extent by the crude saltpetre workers and the refiners. In order to lessen the supervision and consequent interference with the refineries, it was suggested that the license fee might be regulated by the number and size of the boiling pans employed, instead of levying a fixed duty on the refinery and a tax on all salt excised from it, but this system would prove unequal owing to the very varying amount of salt in the crude material. The imperial department of agriculture was, therefore, unable to make any practical proposals for cheapening saltpetre, although such a result would be of great benefit to Indian agriculture. At present prices it is not a cheap manure. The price of refined saltpetre is about £9 to £11 per ton in Calcutta, whilst Chili saltpetre (nitrate of soda) can be landed at about £11 per ton. The potash of Indian saltpetre has probably not a great manural value in India, whilst the price per unit of nitrogen is somewhat in favour of Chili saltpetre. Indian saltpetre (nitrate of potash) is more valuable in certain industries than Chili saltpetre (nitrate of soda), so that its present price is independent of agriculture. The present aim of the Inspector General is, therefore, limited to extending the use of saltpetre as a manure. Nitrous earth is used by cultivators in tracts where there is an available local supply more particularly for tobacco, wheat, potatoes and garden crops. The price of crude saltpetre is largely regulated by the price of the refined material. At ordinary prices, it is somewhat cheaper to use as manure near the source of supply, but the railway freight on this bulky material makes it less profitable at a distance. Demonstrations of the use of saltpetre as a manure have been made on an extensive scale in cultivators' fields in the Central Provinces and Bombay with promising results. This year a large free issue of bonemeal and saltpetre has been made out of funds supplied by the Inspector General to cultivators around Burdwan, where such excellent results have been secured from its use on the experimental farm. By such means, it is hoped in time to bring it into general use. Another subject, investigated during this inquiry, was the utilization of Sitta, or impure saltpetre salt, which is a by-product of the refineries. Experiments were made to test its suitability as a substitute for common salt in cattle food, by giving it
to cattle at several Government Cattle Farms. At some farms its use caused no ill effects, but at others it was followed by diarrhoea and abortion. It varies very largely in its composition, containing from 25 to 85 per cent, of sodium chloride. The safety clearly depends on its purity but it may generally be said that the mixture of potassium nitrate with some lime and magnesia makes it an unsafe food. In all cases it was found that the price (including freight) was equal to, if not in excess of, the price of common salt; and the quantity available is too small to make any real difference in the price of the salt required for cattle.

8. Mineral Fertilizers.—The possibility of encouraging the use of mineral fertilizers has been under consideration, the question having been raised by the Board of Scientific Advice. Phosphatic manures, mostly in the form of crushed bones and superphosphate, have been under trial for several years at some government farms. Their use has not generally been characterized by any great increase of crop yield except at the Burdwan farm (see paragraph 7 above). The high price of superphosphate in India prohibits its general use under existing agricultural conditions, whilst crushed bones act too slowly to be of use in most soils. The establishment of a sulphuric acid industry might alter these conditions, but phosphoric acid is not generally deficient in Indian soils except in the Gangetic alluvium. Phosphates occur in the form of apatite as a by-product of the mica mines of Chota Nagpur, but the output is too small to be of any importance. This phosphate has been tried on a small scale with poor results. Phosphatic nodules are found in large quantities at or near the surface in the Trichinopoly district of Madras. Analysis showed that the amount of phosphate of lime is fairly high comparing favourably with Carolina and English coprolites, but it is not well suited for the manufacture of superphosphate, as the quantities of carbonate of lime, iron and alumina are high, involving waste of sulphuric acid. It would thus probably pay neither to export nor to manufacture. It might be used as a slow acting fertilizer in a crushed state but the freight charges by road are very heavy. It is already worked on a small scale to provide manure for coffee estates. The phosphate of lime found in the Christmas Islands, which is shipped largely to Japan, Australia and Europe for use by artificial fertilizer manufacturers, can be landed in bulk at Calcutta at about £2-10-0 per ton, but in its raw state it could hardly compete with bones at their present prices, making allowance for the nitrogen in the bones. Christmas Island phosphates
might, however, be less costly than any indigenous material if a sulphuric acid industry could be established. The analysis of these materials is compared in the following table.

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<tr>
<th>Constituent</th>
<th>Apatite, Hazaribagh mine (a)</th>
<th>Trichinopoly phosphate (b)</th>
<th>Christmas Island phosphate (c)</th>
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<tbody>
<tr>
<td>Moisture</td>
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<td>2.71</td>
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<tr>
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<tr>
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<td>Alkalis, etc.</td>
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(a) Analysis made by Dr. Leather, Agricultural Chemist to the Government of India.
(b) Analysis supplied by the Director, Geological Survey of India.

Gypsum is found in large quantities in the Salt Range of northern India, and is locally obtainable in smaller quantity at several places. It deserves special notice because it is an antidote to certain classes of saline soils (*usar* or *reh*), but the cost of reclamation with gypsum is more than the value of the land owing to the heavy freight charges by road and rail. Nitrate of soda has lately been tried at several experiment stations, but the results are not definite. The use of artificial fertilizers seems to be coming nearer within the scope of Indian agriculture, and a regular series of trials upon cotton at government farms has been recommended by the Inspector General of Agriculture.

9. Mycology.—Since his appointment in 1902, Dr. Butler, Cryptogamic Botanist to the Government of India, has principally been employed upon a preliminary survey of the important fungus diseases of Indian crops, which has resulted in the collection of a mass of
material, much of which still remains to be worked up. The forming of a type collection of fungi and its detailed examination are the necessary preliminaries to work of a more directly economic nature. The investigation of several important fungus diseases has been carried through the first stage. Much attention has been given to the very serious wheat rusts, which are dealt with in the following paragraph. The fungus diseases of sugarcane have also been investigated, particularly red-rot, caused by *Colletotrichum falcatum*, which causes enormous losses in many parts of India. So far as this inquiry has proceeded, it seems probable that this disease is largely, if not solely, extended by the planting of diseased sets. If this is the case, every cultivator can easily control it by selecting only healthy unreddened sets for planting. A wilt disease of the pigeon pea (arhar or tur, *Cajanus indicus*), caused by a *Nectria* fungus, is very prevalent over Northern, Central and Western India. The same fungus is responsible for the serious outbreak of disease in the pepper vine gardens of Western India. No direct methods of attack have proved successful, and the only remedy seems to be to breed resistant varieties. This line of work has been taken up for pigeon pea at the Bombay farms, whilst the Madras department has started a special experiment station for pepper in Malabar. The ground-nut leaf disease is noticed in paragraph 11 below. Some of the smuts of cereals have been successfully combated by methods of steeping the seed. This treatment has been carried beyond the experimental stage in the Central Provinces, where demonstrations have been made over large areas with the result that it is being rapidly adopted by the cultivators for the eradication of smut in juar (*Andropogon sorghum*). Owing to the fact that the Agri-Bacteriologist has not yet joined the Imperial staff, Dr. Butler was directed to make some preliminary trials of Dr. Moore's methods of cultivating the nitrogen fixing bacilli of *leguminosae*. The nodule bacilli of the pigeon pea (*Cajanus indicus*) have been successfully cultivated by these methods. It yet remains to be seen whether such cultures will have much effect on crop out-turns in India. The system of growing pulses in rotation is so common as to make it improbable that there is a practical field for the use of such cultures, unless they prove much more virulent than the bacteria with which the soil is already impregnated. Similar work is being done by Mr. Bergtheil on indigo, and the whole subject will be taken up by him when he joins the Pusa staff as Bacteriologist. Much excellent work has been done by Dr. Butler, who single-handed has prepared
the way for the complete investigation of several important problems. Each important province requires a Mycologist on its staff before much rapid progress can be made. It seems improbable that direct methods of attack, such as spraying, can come into general use for the treatment of field crops in the present stage of Indian agriculture. Some good may result from less expensive methods, such as the steeping of seeds and the destruction of diseased plants, and there is undoubtedly a wide field for the introduction of preventive measures in the breeding of resistant varieties and the supply of disease-free seed.

10. Wheat Ruts.—A special investigation into the wheat cultivation of India is in progress, mainly with the object of securing a rust-resistant variety of good commercial value. The many cultivated varieties were collected by the Inspector General in 1902 and distributed to several Government farms for experimental cultivation in order to study their characters, to ascertain which possess rust-resisting qualities, and to commence cross-breeding from selected varieties in the endeavour to produce a rust-proof hybrid. These experiments are being conducted at Poona, Cawnpore, Nagpur and Lyallpur. As a result of the observations made on the many varieties under growth at Poona, Professor Gammie, Economic Botanist, issued in 1903 'A provisional classification of the Indian Wheats'. There was a bad outbreak of rust in 1902, which gave much information as to the rust-resisting qualities of the many varieties. It was generally noticed on the Bombay farms that the hard wheat varieties were more severely attacked than the soft varieties. It was also found that a variety which resists rust in one part is liable to attack in another climate, which shows that each province must work independently in this matter. Cross-breeding experiments are being systematically carried out at Poona and at Cawnpore, but the urgent need of an expert botanist to control these operations is felt everywhere. At Cawnpore the line of investigation includes sterilization and segregation experiments with wheat in order to test Eriksson's mycoplasma theory; endeavours to obtain germinating telutospores or resting spores, and to ascertain any possibility of transmission of the disease by these spores; testing the vitality of the uredospores and the possibility of the disease being carried over from one season to another by these spores; testing the possibility of transmitting wheat rust to other cereals and plants and vice versa. Dr. Butler, in co-operation with the provincial departments, has determined the several species of rust and is working out their life history. The general method of infection has yet to be
determined, but in some kinds of rust it seems doubtful whether any other plant has any influence on the spread of the disease. Climatic conditions are a most important factor. The preliminary results of Dr. Butler's investigation have been published in a note on 'The Indian Wheat Rust Problem, Part I,' as Bulletin No. 1 of 1903 of the imperial department of agriculture. India is rapidly assuming a most prominent position amongst the wheat-producing countries of the world and the crop demands special attention, not only in regard to the prevention of rust but to the improvement of the milling and baking qualities of the varieties cultivated for export. A special expert is required to guide and assist the experiments conducted throughout the several provinces.

11. Ground-nut Leaf Disease.—The important ground-nut (Arachis hypogaea) cultivation of the Bombay Presidency has rapidly declined of recent years mainly owing to a fungus disease (Septogloeum arachidis) locally known as tikka, a description of which is given in paragraph 27 of Dr. Butler's report (Part IV). This disease is also extending in the Madras Presidency. Spraying has not been successful, but if the surmise is correct that infection is carried in the seed, seed-treatment may be possible. Efforts have mainly been directed towards securing a disease-resistant variety. With this object varieties have been obtained from Japan, America, Africa, Spain and Mauritius. These are all being tested on the Bombay farms both for disease-resisting qualities and for yield in this country. A new farm has been started in South Arcot (Madras) as a ground-nut experiment station, where this disease will be fully investigated. The best of the foreign varieties were also distributed for trial in different parts of India. The cultivation at Pusa was a failure owing to the attacks of caterpillars. In other parts, the 'Virginian' and 'Pondicherry' varieties seem to have done the best. The oil-yielding quality has been determined by the Agricultural Chemist to the Government of India, who found that the percentage in the kernels varied from 40 to 50, the 'Mauritius' varieties grown in Madras generally giving the best results. The indigenous varieties contain from 39 to 44 per cent. of oil, 'Virginia' gave 44'33 per cent., and 'Japanese small' 49'75 per cent.

12. Entomology.—The work of the Government Entomologist may similarly be divided into two heads — the systematic survey of insect pests and special investigations. Since Mr. Lefroy was appointed Entomologist to the Government of India in April, 1903, he has done a great deal towards making a collection of insect pests, but much of the material yet remains to be worked up and identified by specialists.
in the several groups of insects. He has also made a complete field investigation of the insect pests of Guzerat and Behar, where his headquarters have been located. In his report (Part V), he rightly places the greatest importance upon the study of insect pests in the field. The training of a small number of provincial assistants to work as field-men in some provinces has been a most promising feature of his labours, for these men have done excellent work under his guidance. His remarks as to the necessity for a large expansion of this kind of establishment will doubtless receive the attention of provincial departments. Mr. Lefroy also indicates the lines upon which entomology should proceed in order to produce practical results upon the agriculture of the country. He points out that elaborate and expensive methods of attacking insect pests are not likely to be adopted by the Indian ryot, so that attention should be concentrated upon the simplification of such processes. It is improbable that the spraying of field crops with expensive mixtures will ever come into general use, but there are other remedies, mechanical and otherwise, which have considerable promise. The relations of the Government Entomologist with the Indian Museum (which possesses a large collection and which was previously responsible for entomological work) have been placed upon a satisfactory basis. Among special investigations the Bombay locust has been the most prominent subject of study, the results of which are given in the next paragraph. A special inquiry was also made into the insect pests of coffee, the results of which were published as bulletin No. 2 of 1903 of the Imperial Department of Agriculture. Mr. Lefroy's enthusiasm has overcome to a large extent the many difficulties with which he has had to contend and which are inherent in the starting of a new branch of scientific inquiry. The facilities that will be afforded by Pusa will remove all difficulties of importance. The imperative necessity for a considerable expansion of the staff of specialists, both Imperial and Provincial, is forcibly shown.

13. The Bombay Locust. — A plague of Bombay locusts (*Acridium succinctum*) caused considerable damage in the Bombay Presidency and the Central Provinces in the early part of 1904. In conjunction with officers of the Bombay Agricultural Department, a special inquiry was made into these important pests, and practical measures were undertaken for their destruction. The life history of the Bombay locust has now been completely worked out for the first time. Trials were made both in Bombay and in the Central Provinces of many methods for destroying these pests. The simpler methods proved the most successful,
such as the collection of the hoppers in suitable bags dragged by men over the young crops, the driving of hoppers into pans of kerosine oil, the destruction of locusts during the time of coupling, the collection of eggs and the like. The sum expended in this campaign amounted to some ₹2 lakhs in Bombay and ₹10,500 in the Central Provinces. Enormous numbers were destroyed, and the swarms that came to maturity were far smaller in number than in the previous year. Mr. Lefroy has prepared a report on the Bombay locust, which will shortly be published. In past years several trials have been made of Dr. Edington's South African fungus for the destruction of locusts. These trials were uniformly unsuccessful and were abandoned. The Kew authorities have recently suggested that the failure may be due to incorrect methods, so that it has been decided to make a careful test of the efficacy of the fungus cultures on a small scale under proper conditions of control by the Government Entomologist and Cryptogamic Botanist working together, which should finally settle whether this method is of any use in India.

14. Grasshoppers.—Large plagues of grasshoppers (Acrididae) have for some years caused much damage to the rice crop in parts of the Central Provinces. At the instance of the provincial department, the Inspector General of Agriculture arranged for the deputation of Mr. Stewart Stockman, Assistant to the Imperial Bacteriologist, for an inquiry into this pest in 1902. Mr. Stockman made a most careful investigation of this pest and tried many remedies, with the result that he devised a practical method for their destruction by the dragging of nets over the fields. This method has been worked on a large scale, and has been found to be most successful in clearing considerable tracts. It necessitates united action by all the cultivators in the same tract, so that the campaign must be organised and supervised by government officers. A full account of Mr. Stockman's inquiry has been published as Agricultural Ledger No. 3 of 1903.

15. Cotton:—Survey of indigenous varieties.—During the past four years measures for the improvement of Indian cotton have absorbed a very large proportion of the energies of the imperial and provincial departments. A full account of these measures has already been published in the proceedings of the Board of Agriculture so that this report will be confined to a general summary. In 1902 the Inspector General made a collection of the existing varieties of cotton cultivated in India. The percentage of lint to seed yielded by each variety was ascertained, and a valuation of the lint was made by trade
experts, which serves as a standard for future comparison. These varieties were distributed to Government experiment stations in the principal cotton-growing tracts to serve as a basis for botanical examination and identification and also to test the most suitable varieties for growth in each tract. As regards the botanical survey, a preliminary classification * was issued by Professor Gammie in 1903, and a second paper by him on the same subject is now in the press. This preliminary stage of the botanical survey is then completed for the present. Some interesting results have also been obtained by the growth of numerous varieties side by side in order to judge of their comparative values under varying conditions of soil and climate. These have been published in Mr. Mollison's two Notes on the Improvement of Indian Cotton, dated the 3rd February and 15th August, 1903. Field examination shows that the agricultural characters of different varieties are very much modified by transferring them from one tract to another. The modification may result in deterioration or the reverse, as regards vigour of growth, yield, quality of lint and proportion of lint to seed. A favourable season also affects the quality of the lint and its percentage to the seed. Most varieties have inherent characteristics that suit the local conditions. Varieties of the fine Broach type generally deteriorate when grown away from the genial influence of sea breezes. With their prolonged period of growth, they also require either deep moisture-holding soil or the assistance of irrigation. Extensive trials of the Broach variety were made in 1904, seed being distributed to Government farms and selected private persons. These proved almost universally a failure, being damaged in some parts by heavy monsoon rains and in others by winter cold. It may be that this type may succeed with early sowings under irrigation in the north of India, where very inferior varieties are at present grown. Early sowing is necessary so that the crop may be mature before the cold season arrests growth. The fine varieties of the Bani type come to early maturity, but are delicate and give a small yield with a low percentage of lint. Selection and cross-breeding to improve the yield and vigour of the plants is the most likely method of improvement. The coarse varieties of the Jari type are vigorous, hardy plants, giving a heavy yield and a high percentage of lint. The growth of this type is rapidly expanding and will not be ousted until a finer variety can be introduced which will give an equally large

* Note on the classification of Indian cottons at the Poona Farm by G. A. Gammie, F.L.S.
profit. The Jethi type is also extremely vigorous and prolific, but the lint is poor and its percentage to seed is small.

16. Selection of seed.—It seems probable that in most tracts improvement is more likely to result from working with the indigenous variety as a basis rather than the introduction of another variety. The two main methods of improvement are selection of seed and cross-breeding. In some tracts the cultivators practise no seed selection, whilst the increase of ginning factories has resulted in the mixture of seed and further deterioration in parts where the cultivators purchase their seed from such factories. Careful plant-to-plant selection upon scientific lines is proceeding at some government farms, which should result in future improvement. A proposal to start some large government seed farms has been negatived, but it has been decided to start an experiment station in each important cotton tract, which will contain a substantial area for seed selection and production. Efforts have been made to produce quicker results by a rougher method of selection. Under the instructions of the Government of India and with their financial support, provincial departments have arranged to help cultivators in securing the best seed of varieties known to be suitable to the local conditions, in the hope that this may result in the production of better cotton than is now produced by seed indiscriminately obtained from all sources. The methods followed have naturally varied with local conditions. In tracts where the cultivators obtain their seed from ginning factories, arrangements have been made with the owners to set aside the best lots of cotton purchased by them, to remove all stained lint and to gin separately for seed distribution. In other tracts, the best fields of cotton have been selected, from which all weakly plants and stray plants of other varieties are removed, and the best pickings taken for seed. An interesting trial of private seed farms is also being made in the Central Provinces by inducing some cultivators to grow cotton primarily for seed upon principles which differ somewhat from those followed in growing the crop for lint, with a government guarantee against loss and government assistance in trained supervision. It is clear that such generalized methods are only applicable to tracts where the cultivators themselves do not practise seed selection; the results have yet to be ascertained.

17. Hybridization.—The most hopeful line of work is plant-breeding, which is in progress on several farms, more particularly in the Bombay Presidency. This work was started in 1901, but it was
not till the following year that a regular programme was framed. Progress must necessarily be slow, but there is a distinct promise of some ultimate success. Everywhere the need of control by experts has been acutely felt. Crosses have been made of one indigenous variety with itself and with a second indigenous variety. The result of crossing inter se has generally been to produce a marked increase in the vigour of growth. This has been very marked at Surat and at Lyallpur, but no improvement is reported to have resulted from similar work in Madras. Crossing of one variety with another at first results in great variation of type. These hybrids are now undergoing a rigorous course of selection both for improved fibre and for improved yield. Several of the many hundreds of crosses have shown marked superiority over both parents. There are a few hybrids in cultivation on the Surat farm that can hardly fail to improve the Broach type. The work has received a sharp check from the very unfavourable season of last year when all that could be done was to save the crop by irrigation, but with two favourable years the provincial department should be in a position to distribute new varieties to cultivators. In other provinces the work is much less advanced or at a standstill owing to want of skilled supervision.

18. Trial of exotics.—Whilst attention has very largely been concentrated upon the improvement of indigenous varieties, the trial of exotics has not been neglected, although the persistent efforts of many years past have nearly always ended in failure. Exotics, even when acclimatized, are generally more delicate than indigenous varieties and deteriorate rapidly. In 1902 trials were made of a number of newly imported American and Egyptian varieties. They were sown as an ordinary monsoon crop, and failed everywhere on black soil. The small amount of lint produced was also found to have greatly deteriorated. The experiments were continued in 1903, the second year's crop being somewhat better than the previous one. Extensive trials of American and Egyptian varieties were made in 1904 in Behar and the Punjab. The Behar trials were generally a failure. Newly imported Americans and Egyptians were found to be risky to grow and did not thrive; the superior indigenous varieties matured so slowly that they were affected by the winter frost; acclimatized Americans did the best, but even these largely failed. The problem of cotton cultivation in Behar is still unsolved. In the Punjab a promising measure of success was obtained with some American varieties, both newly imported and acclimatized. Extended trials are being made during the current year. Still more
promising results have been secured by Mr. Fletcher, Deputy Director of Bombay, with Egyptian cotton in Sindh. Small trials in 1904 gave a good yield quite equal to that obtained in Egypt, whilst the growth of the plant appeared to be normal. The valuation showed that some deterioration had occurred in the quality of the lint. It yet remains to be seen whether such deterioration will gradually increase, or whether it is merely temporary on account of the sudden change from which the plant will recover. It is also possible that deterioration may be arrested by cross-fertilization. An area of 1,500 acres has been sown during the present year. It is altogether too early to pronounce any opinion upon these experiments, but it may safely be said that the first trials are promising. The introduction of exotics is not hopeless in the drier portions of India, where the monsoon rainfall is light and where irrigation is available for other periods. Deep alluvial soil with good natural drainage is much better suited to exotics than black cotton soil. Early sowing in April under irrigation has given the best results.

19. Tree cottons.—In the past few years considerable attention has been attracted to the perennial or tree cottons, some of which are known to produce fine lint. At present their cultivation is generally confined to a few stray plants in house gardens, the lint of which is used for weaving the sacred thread worn by high castes. A collection of the different varieties was made in 1904 by the Inspector General, preliminary trials being made at Poona and Pusa. The indigenous varieties with fuzzy seed nearly all yield lint of inferior quality, but some varieties of the rough Peruvian (naked seed) and Brazilian (clustered seed) types are more promising. These latter are probably the survival of foreign varieties introduced into India during the cotton experiments of the East India Company, which have become acclimatized and are much more immune to disease than newly imported seed. Large trials of tree cottons are being made by the Indian Long Staple Cotton Growing Syndicate (agents, Messrs. Shaw, Wallace & Co.) in Bengal, Assam and the Central Provinces. Towards the expenses of this pioneer work, the Government of India and the British Cotton Growing Association have agreed to contribute in equal shares a sum of £6,000. The Inspector General has assisted their work by exploring the different provinces of India for the collection of seed of the more promising varieties. This has thrown a considerable burden upon provincial departments, for it is most difficult to collect any quantity of seed from isolated plants in gardens scattered over very wide areas. Considerable quantities of seed of indigenous annuals have also been
supplied. The principal cotton farms of Messrs. Shaw, Wallace & Co. were inspected by the Inspector General, who wrote a note detailing the results and giving advice for the improvement of the methods of cultivation under trial. It is as yet too early to pronounce any opinion upon the possibilities of cultivating tree cotton as a field crop upon a commercial scale. Similar pioneer work is being conducted at Belgaum by Mr. Tytler with a rough Peruvian tree cotton. As some promising results were obtained by garden cultivation, Mr. Tytler has been assisted by Government in starting a plantation for experimental cultivation. Government has guaranteed half the actual net expenses after deducting the profits on sales, subject to a maximum payment of £5,000. There is some hope that this variety of tree cotton may prove suitable for cultivation on poor upland soil. Extensive trials of 'Caravonica' cottons (hybrid tree cottons raised by Mr. D. Thomatis of Queensland) were made in Assam and Behar. The results of the first trials are far from encouraging, the plants suffering from heavy rainfall, from frosts and from insect pests. Seed has now been distributed by the Inspector General to many government farms in order that this cotton may receive a fair trial throughout India.

20. Improvement of methods of cultivation.—Endeavours to improve the methods of cultivation have been made in several tracts, where it does not reach a high standard. The best cotton cultivators in India are the Guzeratis. Special parties of these trained cultivators with bullocks and implements were sent by the Inspector General to the Punjab and Behar in 1904, where they demonstrated proper methods of cultivation. This is reported to have given successful results. Similar efforts have, for a few years past, been made in the Central Provinces to improve the cotton cultivation in the backward parts of that province. Experiments in the manuring of cotton are in progress at several government farms. A circular letter to all provincial departments was also issued, recommending the trial not only of the local available manures, but also the chemical manures in general use in America.

21. Extension of cotton cultivation.—The possibilities of extending cotton cultivation in the Indian Empire have not been neglected. The experiments in the Punjab, Sindh, and Behar have been noticed above. In the Central Provinces cotton cultivation has extended to some new tracts, partly as the result of trials and demonstrations made by the provincial department. It has been suggested that Upper Burma is a suitable field for extension. This question has been examined by the Inspector General of Agriculture and by the Reporter on Economic
Products.* The circumstances of the small existing cotton cultivation were considered, but they do not seem to hold out much promise of a wide cultivation of fine varieties. The cotton now produced is inferior, the soil does not seem to be very suitable, transport is difficult, and there is a great scarcity of labour. Experimental trials must await the establishment of a provincial department of agriculture.

22. Future expansion of cotton investigation.—From the above account, it will be seen that a great deal of attention is being given by the departments of agriculture to the improvement of Indian cotton. In framing the programme, the Inspector General of Agriculture has received the assistance of the Board of Scientific Advice. This brief review of the cotton experiments may fittingly be closed by stating the principal recommendations of the Board of Agriculture for placing the department in a proper position to deal adequately with the problem. They include the appointment of an Imperial cotton expert to guide and correlate the experimental work throughout India; the strengthening of provincial departments by the employment of a full staff of experts, so as to permit of proper control of existing work and its future expansion; and the establishment of an experiment station in each important cotton tract, with a substantial area for seed selection and production.

23. Cotton seed oil industry.—The expansion of the cotton seed oil industry in America and England, coupled with a sudden large export of cotton seed from India, caused the Secretary of State to direct an inquiry into the possibility of encouraging the establishment of this industry in India. This question was referred to the Inspector General of Agriculture, who published the comprehensive information collected by him in Agricultural Ledger No. 9 of 1903. This dealt with the supply and prices of Indian cotton seed, the value of cotton seed as cattle food in India, feeding trials of undecorticated cake on Indian cattle, the percentage of oil, and other connected questions. A consignment of different varieties of cotton seed was sent to Hull, to test the adaptability of English machinery, the yield of oil and the feeding value of the cake. These tests were made under the supervision of Professor Gilchrist of Durham College, to whom the department is much indebted for assistance. The yield of oil from different varieties varied from 14.81 to 13.42 per cent. The feeding trials showed that Indian rough cotton-cake gave satisfactory results with

* 1. Report on cotton in Burma by Mr. I. H. Burkill, dated the 25th March 1904.
2. Report on the question of the possibility of extending cotton cultivation in Burma, by Mr. J. Mollison, dated the 15th August 1904.
stock fed indoors or on pasture, and that its high manurial value makes it a desirable manurial agent. Some further feeding experiments were made under the guidance of the Edinburgh College of Agriculture. Sheep and cattle were fed with several feeding stuffs with the result* that Bombay cotton-cake took the premier position in the sheep-feeding experiment and its right to that position was well supported by the results of the cattle-feeding experiment. These several trials have shown the suitability of English machinery for the treatment of Indian seed, the yield of oil that may be expected and the value of the cake as a feeding stuff. A considerable amount of information concerning the possibilities of this industry for India has thus been placed before the public, and the Government of India have decided that it is unnecessary for them to take any further action. Some cotton seed mills have indeed been established in India with varying results. Experience shows that whilst the oil can be sold in the country, the cake must be exported to Europe, because the Indian cultivator will not pay the price for this concentrated feeding stuff that can be obtained by exporting it. The success of a cotton seed mill largely depends upon the full and profitable utilization of all the by-products, which does not seem to be assured in India.

24. Tea.—The investigation of the scientific problems connected with the Tea industry is conducted by the Indian Tea Association with the support of an annual subsidy from Government. The Scientific Department was started in April 1900, when Dr. Harold Mann, D.Sc., was appointed Scientific Officer, his laboratory being at Calcutta. The department was expanded in 1904 by the appointment of a second scientific officer (Mr. C. M. Hutchinson) and the establishment of a Tea experiment station at Jorhat (Assam). The following short summary of the scientific work is prepared from materials courteously supplied by Dr. Mann. There have been four main lines of scientific work—the study of (1) the tea soils of north-east India, (2) the manufacturing processes, (3) the fungus diseases, and (4) the insect pests. A survey of the tea soils was made with a view to ascertain what connection exists between soil and quality of tea, and also the most remunerative methods of treatment. Some interesting results of this survey have been published in two pamphlets "The Tea Soils of Assam" and "The Tea Soils of Cachar and Sylhet." The tea soils of the Duars are now under investigation, and it has been found that they are

as a class richer than those of any district of north-east India with the exception of Darjeeling, and that with suitable methods they would probably yield a much higher quality tea than at present. The extreme importance of the physical texture of the land for tea culture is emphasised by this inquiry. An examination of the processes of tea manufacture was made in order to find out what actually takes place and the relation of each part of it to the production of high quality tea. The enzyme or unorganised ferment which is the principal agent of the changes, has been isolated and studied; the changes in its amount at various stages have been determined, with its effect upon the success of the process. These investigations have led to considerable improvements in the manufacture in several progressive factories. The results have been published in three pamphlets on "The Ferment of the Tea Leaf." An enquiry has been commenced into the changes in soluble matter and tannin which take place in tea during manufacture, which promises to furnish results of considerable importance. One of the most serious blights of the tea plant is that known as Red Rust, caused by an Alga (Cephalurosu virescens). An investigation of this alga and its effects has been made, with the result that the practical measures for preventing its growth and reducing the loss caused by it have been ascertained, including modifications in planting systems and direct methods of attack. Two bulletins have been published on Red Rust. The most serious insect pest of tea is the 'Mosquito Blight,' caused by a plant bug (Helopeltis theiovora). This has been under investigation during the past three years, and a method has been devised which, when the conditions are suitable for its application, has been successful in dealing with the blight. Two bulletins on 'The Mosquito Blight of Tea' have been published and a third is now in the press. At the Jorhat experiment station, tests are being made of the effect of manures on (a) the quality and (b) the yield of tea, the relative values of different green manures, methods of pruning, and methods of plucking for both quality and yield. These will in time give valuable results. The introduction of by-products on tea gardens has received a good deal of attention, including sisal hemp and rubber.

A description of the culture of the former plant, based on foreign information and an examination of young plantations in the tea districts, was written by Messrs. Mann and Hunter and published in 1904 as 'Sisal-Hemp Culture.' The area under this fibre now amounts to several thousand acres. Rubber extension proceeds gradually; advice
is constantly asked for, and the Forest Department have promised to publish an account of its experiments with Ficus elastica. The manufacture of caffeine, which was suggested by Dr. Mann, has for the first time this year been started on a commercial scale. The Scientific Department has thus already achieved many important results, which justify an expansion of its work. In particular, the services of an Entomologist are required to investigate the serious insect pests of tea.

25. Indigo.—The scientific investigation of the Indigo industry is similarly carried out by the Behar Planters' Indigo Association assisted by a subsidy of government funds. An account of this investigation is given in the note printed as Appendix A of this report, written by Mr. C. Bergtheil, Agri-Bacteriologist of the Pusa Institute, whose services have been lent to the Association. The decay of the industry, owing to the competition of the synthetic indigo, has caused government to give special support to the efforts to revive it. Much work has been done in the investigation of the cultivation and manufacturing processes of indigo. Some improvements have been effected in the manufacturing processes, the chemistry and bacteriology of which have been carefully worked out. New methods of oxidation have been adopted by many factories. The enquiry into the improvement of the cultivation has not yet been so complete, but it has resulted in one important change—the introduction of the Java-Natal variety. This variety (Indigofera arrecta) is hardy and vigorous, and yields a much higher amount of indigothan than the variety ordinarily cultivated (I. Summatrana, formerly erroneously named I. tinctoria). It is now coming into general cultivation and will in all probability oust completely the common variety. The difficulty of bad germination has been overcome by the invention of a suitable scarifying machine. Many competent planters hold that the introduction of this variety will be sufficient alone to arrest the further decay of the industry, if not to result in its resuscitation. Manurial experiments show that Behar soils are deficient in phosphoric acid and nitrogen, and that artificial manures can be economically applied. A list of recent publications dealing with scientific work on Indigo is given in Appendix C.

26. Jute.—The investigation of jute was started in 1900, owing to a representation from the Calcutta Daled Jute Association that the fibre had considerably deteriorated in recent years. The Dundee Jute
Importers' Association also addressed the Government of India in 1901 on the same subject. An inquiry was taken up by the Bengal Department of Agriculture under the guidance of the Inspector General, and later on a special officer, Mr. R. S. Finlow, B.Sc., F.C.S., was employed as Jute Specialist. A short report by him is published as Appendix B of this report. The botanical examination of jute, first started by Sir George Watt, indicated that there was greater variety in the treatment to which jute was subjected than variety in the races grown. Endeavours have been made to obtain pure seed of all local varieties, which have been grown at the Burdwan farm for comparative tests, the most important points for elucidation being whether the quality of the fibre varies with the kind of the jute sown; whether a well grown crop on good manured soil produces better fibre than an inferior crop; how the quality and outturn of fibre is affected by thick and thin sowing; the effect produced by sowing sound and matured seed, produced from healthy vigorous plants specially sown very thinly for seed, in comparison with seed obtained from an ordinary thickly sown crop grown for fibre. In addition experiments were started to test (a) manures, (b) cutting the fibre at different stages of growth, (c) selection of seed, and (d) spacing experiments. A careful botanical examination by the Reporter on Economic Products showed that whilst there were numerous agricultural races of jute, all were included in either Corchorus capsularis or C. Olitorius. The races of the former were found to be more numerous than those of the latter and were conspicuously wanting in permanency, due perhaps to free cross-fertilization. The main differences were in the date of flowering, height of plants, vigour of growth, and colour of stalks and leaves. These experiments were also referred to the Board of Scientific Advice, and the opinion expressed was that the deterioration of fibre is very largely, if not wholly, due to fraudulent watering of the prepared fibre in order to increase its weight. There was no evidence of degeneration in the jute plants. The advisability of legislation to prevent fraudulent adulteration has been under consideration, but the proposals have not met with general approval. The Board of Agriculture considered the possibility of extending jute cultivation, the most promising tracts being the delta areas of Madras, Lower Burma and the coast of Bombay. At the instance of the Inspector General, the Madras department of agriculture has started experimental trials in the Godaveri Delta. Trials have also been started in Chhattisgarh by the Central Provinces department of agriculture. An inquiry into the retting process has
shown that the quality of fibre is harmed by the use of dirty water and also that discoloration results from retting in water containing iron. The results of all these experiments have been published in the Report of the Board of Scientific Advice and in 'Selected Papers on Inquiry into Deterioration of Jute, 1903-1904.' The investigation is now being taken up on a larger scale by the Bengal department of agriculture, who are starting jute experiment stations in several localities. The retention of Mr. Finlow's services as Jute Specialist has been recommended.

27. Juar (Andropogon sorghum).—A collection of the very numerous varieties of Juar grown in different parts of India was made in order first to afford material for a botanical examination and second to test their respective qualities. They were grown on the Bombay farms in 1903, and 50 varieties were selected as worthy of further trial. These were distributed to Government farms in the Punjab, Bengal, Madras and the Central Provinces, with the result that some promising varieties are under trial with a view to their introduction in substitution of inferior local varieties. An extended trial of the 'Dharwar' variety is in progress in the Central Provinces. The botanical examination is still in the charge of Professor Gammie at Poona. Some samples of good red varieties were sent to the Transvaal, in order to test the possibility of an export trade from India to South Africa, where red juar is largely used for the production of beer. The samples were valued at Rs 8 per bag of 200 lbs. in South Africa.

28. Maize.—Trials were given in the United Provinces, Punjab, Bombay and the Central Provinces to some American maize imported by the Reverend Mr. Windsor of Sirur (Bombay). This seed did not give satisfactory results, the yield being everywhere poor. Some special varieties introduced by the Inspector General of Agriculture from America were more promising, but the sugar-corn varieties do not retain their qualities. The result of other trials tends to show that American varieties are not generally so suited to India as the indigenous stock.

29. Soy beans (Glycine soja).—Six varieties of soy beans were introduced from Japan by the Inspector General of Agriculture in 1902. These white or green seeded varieties are far superior to the black seeded varieties grown in the north of India. The trials were successful on the Siripur, Kirkee and Cawnpore farms. The beans and chaff were analysed by the Agricultural Chemist to the Government of India in order to determine their value for oil and feeding
stuff. Most of the samples were found rich in nitrogenous compounds with a very high percentage of oil. As these preliminary experiments gave promising results, a fresh supply of ten varieties was obtained from Japan in 1903, which are now under careful trial to see if they can be grown as profitably as the more common pulses. The highest percentage of oil in the beans was 24·87, whilst ten samples gave over 20 per cent., which may be compared with an average of about 17 per cent. obtained in the United States. The percentage of albuminoids in the chaff varied largely, the highest being 8·12. The chaff has undoubtedly a high feeding value.

30 Tobacco.—The Inspector General of Agriculture obtained from Java two varieties of tobacco known as 'Taloen' and 'Wilingi' and two true wrapper leaf varieties, 'Deli (P)' and 'Deli (D)' Four varieties known as Havanna, Spanish, Florida and Sumatra, which had been grown for some few years at Dalsingsarai (Behar) and two of the best indigenous varieties (Shamru and Peelio) of Bombay, were added to the collection, which was distributed for trial in Madras, Bombay, Bengal and Kolhapur. The trials in Madras were generally unsuccessful, but promising results are reported from Kolhapur. Havanna tobacco has successfully been introduced into general cultivation in Burma and can be grown well in Behar. Further progress is improbable until the problem of improving the methods of curing is taken up, which is a matter for an expert that demands attention. The employment of an expert in tobacco curing and a chemist for the improvement of tobacco has been recommended by the Board of Agriculture.

31. Sweet potatoes (*Ipomoea batatas*).—Three varieties were imported by the Inspector General of Agriculture from America. These did extremely well at Poona, with the result that cuttings and tubers were distributed throughout India, together with a leaflet describing the best methods of cultivation. A collection of the indigenous varieties was also made and grown for comparison at Poona. Only a few were found to equal, and none to excel, the American varieties. Three varieties were also obtained from the West Indies, but did not prove suitable.

32. Irrigation.—In accordance with the instructions of the Government of India, provincial departments have started hydraulic experiments in the irrigation of crops upon the lines recommended by the Irrigation Commission. The Inspector General of Agriculture twice gave evidence before this Commission and submitted notes on the extension of
irrigation in the Bombay Presidency and protective works in the Deccan. The Bengal department has opened a farm at Cuttack for irrigation experiments in rice, which are also being carried out at other existing farms. The Punjab department has arranged in conjunction with the Irrigation Department for experiments in the best methods of irrigating wheat. The Bombay department is conducting irrigation experiments at the Sindh cotton farm. Madras has started some stations in order to study the 'duty' of water for various crops and soils. Many useful tests have also been made in that Presidency of waterlifis, aermotors, oil-engines and the like, in consequence of which several oil-engines are now being worked by cultivators. These have shown that an oil-engine is a cheaper form of lift than the leather bucket with bullock-power in common use, provided that the well yields a full supply of water. An irrigation farm for pumping experiments is being started on the Hagari river in Bellary, which will include the irrigation of cotton as one of the principal experiments. The Central Provinces department has a series of irrigation experiments at its farms. The United Provinces contemplate the starting of an irrigation farm in the area watered by the Betwa canal. In this province much has been done towards the investigation of well irrigation, more particularly in testing different types of wells for use in tracts with sandy sub-soil, and in improving and cheapening the methods of making trial borings. These are matters of great importance to the well-irrigated tracts of the United Provinces and a new type of well now under trial promises to be successful. All these experiments were discussed by the Board of Agriculture (see items Nos. 23 to 27 of the Proceedings).

33. Sericulture.—Experiments in sericulture are in progress in several Provinces. The establishment of the large profitable silk industry of Cashmere is an instance of what can be achieved in this way. In Bengal efforts are made to induce the mulberry silk rearers to use only healthy seed examined by the microscope under the Pasteur system. An establishment is employed and classes are held at silk rearing depôts, the whole operations being under the management of the Bengal Silk Committee. A special grant was given by the Inspector General of Agriculture for the extension of this work, which is reported to have achieved some result, rearers now appreciating the necessity for healthy seed and the use of the microscope. Mulberry plantations are reported to be extending. In Assam some small experiments have been made with imported seed from France and Italy with successful results. Seed was also distributed to some rearers who obtained good
returns. Examination revealed the existence of *pebrine* and *flacherie* in the moths, so that reliance must be placed upon imported seed, until an arrangement is made for rearing healthy seed locally. A special inquiry was made by the Central Provinces department into indigenous tasar silk, Mr. Mukerjee of the Bengal department being deputed for the purpose. The decaying state of the tasar silk rearing industry was found to be mainly due to the prevalence of the *grasserie* disease, which has become widespread since the rearers have taken to using home-bred seed instead of collecting wild cocoons from the forests. Mr. Mukerjee's recommendations have been published in his report* on the subject. Some important work has been accomplished at Mr. Tata's private silk farm at Bangalore, which is in charge of a Japanese expert. The main object of this farm, which is an instance of the public spirit of the late Mr. J. N. Tata, has been to test the adaptability to India of Japanese methods of mulberry cultivation, silk worm rearing and silk reeling. The Inspector General of Agriculture, who visited the farm on several occasions, found that the results were promising. The farm has been good enough to train several men in the Japanese methods who were deputed from some provinces at the instance of the Inspector General. The Government of India have now sanctioned the establishment of a silk farm at Pusa, which will be managed on similar lines. An interesting trial was made at Bangalore to test the Japanese machinery for the reeling of tasar cocoons. With some modifications, this was successfully accomplished, silk of excellent quality being reeled. Arrangements are now being made in the Central Provinces to see if the simple Japanese reeling machines can be introduced into general use. The Bombay department also proposes to start some sericulture trials upon Japanese lines. The need for a silk expert to control these several experiments is greatly felt.

34. *Agricultural education.*—Agricultural colleges, with a three years' course of study, are maintained at Poona and Saidapet (Madras). Agricultural schools with a two years' course are established at Cawnpore, Nagpur, and Sibpur. The Inspector General of Agriculture was a member of a committee appointed to consider the course of training at Saidapet. He prepared a note strongly criticizing the existing management. The curriculum was unsuitable, the teaching staff wholly inadequate, and the practical work and management of the

farm inefficient. The Madras Government have since decided to abolish the college and to start a new one upon proper lines at Coimbatore. The Inspector General was also a member of a committee appointed to consider the arrangements for agricultural teaching at Poona. Their principal recommendations included the strengthening of the teaching staff by the appointment of European professors of agriculture and agricultural chemistry and improved arrangements for practical work. These recommendations have now been given effect to. Considerable improvement has been effected in the Cawnpore school, Trained teachers in botany, agricultural chemistry and veterinary science have been employed; an instruction farm has been opened; a hostel has been added; and the equipment of the laboratories improved. Excellent buildings, including laboratories, have been provided for the Nagpur school, but the teaching staff still requires strengthening and improving. The professorial staff at all agricultural educational institutions has hitherto been inadequate, so that their influence on agricultural improvement has been small. Their main result has been to turn out students, with some knowledge of agriculture, who have mostly been absorbed into the several branches of the Government revenue administration. One great defect of Indian agricultural teaching is the absence of suitable text books. European and American text books of the agricultural sciences are unsuitable because they deal with crops, methods of cultivation and other matters which are foreign to Indian agriculture, so that the students cannot appreciate the object lessons and illustrations given in explanation of general principles. Arrangements have consequently been made by the Inspector General of Agriculture, under which the Imperial experts will prepare Indian text books dealing with their respective sciences. The education of the rural classes, which is so closely connected with the improvement of agriculture, formed the subject of discussion at the Board of Agriculture. The Board emphasised the importance of conducting such instruction upon proper principles based upon the agricultural surroundings of the children. Proposals were subsequently made by the Inspector General of Agriculture for securing closer co-operation between the Education and Agricultural Departments in the training of rural school teachers and the preparation of suitable reading books for use in these schools.

35. Distribution of seeds and implements.—This is rapidly developing into an important branch of the work of the office of the Inspector General. In most field crops a large number of races,
agriculturally separate, is grown in different parts of India. Some of the races are much superior to others, and there is a wide field for the transfer of the best kinds from one tract to another. This must of course be cautiously done under proper experimental trial at the government farms. During the past four years numerous trials were arranged on several farms. In addition to the special trials recorded in the preceding paragraphs, the Inspector General distributed small quantities of seed of varieties of rice, bulrush millet, gram, oats, barley, onion, cardamom and others. Two instances may be given of successful results from this action. Several varieties of rice were sent for trial, with the result that both in Madras and Orissa, a variety known as 'Banko' from the Central Provinces gave excellent results. It is found to be suitable for high level land and to thrive with a minimum of water. Seed was distributed to cultivators and now there is a large demand for it. In Behar the 'Mozuffernagar' wheat of the United Provinces has succeeded and is rapidly ousting other varieties. Distribution on a considerable scale both to government farms and private persons has been made of seed of cotton, wheat, juar, rice, ground-nut and other crops. The amount of seed distributed approximates to 17 tons. Numerous requests for seed are received from private persons, which are met so far as is possible. The distribution of seed has brought into prominence the fact that it is difficult to introduce new crops or methods of cultivation unless the Inspector General can send to the tract trained subordinates, who can be trusted to carry out instructions. Numerous lots of seed have been sent in response to the request of foreign correspondents in the United States of America, Natal, East Africa, West Indies, Australia and Japan. The interchange between provinces of superior indigenous implements has been productive of some good results. Instances may be given of the Guzerat cotton cultivation implements, the Poona sugar boiling apparatus and the field hoe of the Deccan. Better results generally are secured by transferring indigenous implements rather than by the introduction of foreign ones, but considerable success has been achieved in Bombay and the Central Provinces in the distribution of iron ploughs and in the Central Provinces of winnowers and fodder cutters. Numerous inquiries are received from private persons for all imaginable kinds of information. These are answered as fully as possible, often involving much labour. In many cases it is evident that the labour is wasted, but the demand for information from all sides is a hopeful sign of the awakening of the country to the importance of agricultural improvement.
36. Publications.—Appendix C gives a list of recent publications relating to agriculture in India, including not only the work of members of the agricultural departments but important contributions by officers of other departments in India. The arrangements for publications by the imperial department have hitherto been in a very unsatisfactory state. This question was fully discussed by the Board of Agriculture, and their recommendations have now received the sanction of the Government of India. The imperial department will in future have two important publications—(1) A quarterly issue called 'The Agricultural Journal of India' containing articles on agricultural matters, intended for the information of the agriculturist and the general reader interested in agriculture; and (2) Scientific Memoirs for papers of a scientific or technical nature.

37. Expenditure.—The expenditure incurred in the imperial department of agriculture (apart from expenditure on buildings constructed by the Public Works Department) has been as follows:

<table>
<thead>
<tr>
<th>Section of Department</th>
<th>1903-04</th>
<th>1904-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspector General</td>
<td>21,849</td>
<td>56,956</td>
</tr>
<tr>
<td>Pusa</td>
<td>43,623</td>
<td>1,15,753</td>
</tr>
<tr>
<td>Agricultural Chemist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryptogamic Botanist</td>
<td>11,060</td>
<td>21,164</td>
</tr>
<tr>
<td>Government Entomologist</td>
<td></td>
<td>23,517</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>32,909</td>
<td>1,62,064</td>
</tr>
<tr>
<td></td>
<td>88,595</td>
<td>3,15,413</td>
</tr>
</tbody>
</table>

The increase shows how rapidly the department has expanded, but the provision is still inadequate to meet many important demands made upon it. In addition to the ordinary budget provisions, the Inspector General receives an annual grant for expenditure upon special investigations, improvements and the like, which he may desire to introduce. The principal objects to which this grant has been devoted in the past four years are enumerated below:

- Extensions of the Manjri (Poona) farm: 900
- Well irrigation at Surat: 1,000
- Fedder reserves at Chharodi cattle farm: 5,500
- Quarters for apprentices at Bombay farms: 4,270
- Cotton experiments: 15,000
Improvements to Nadiad farm 6,100
Irrigation scheme at Pusa 3,000
Improvement of irrigation at Nagpur farm 2,840
Improvement of irrigation at Hoshangabad and Raipur farms 10,000
Silk experiments in Bengal 8,000
Distribution of manures to cultivators around Burdwan 4,000
Tobacco curing experiments at Nadiad and tree cotton experiments at Belgaum 6,000

The power to give such provincial support is an important adjunct to the influence which the Inspector General of Agriculture can exercise over provincial schemes.

38. **Provincial Departments, Bombay.**—In the preceding portion of this report an account has been given of the principal investigations conducted both by the imperial and provincial departments of agriculture, and in the following paragraphs a short summary will be given of other work of a more general character done by each provincial department. The Bombay department is the most advanced in India, owing to the fact that for some years past it has employed some expert staff to control the work. Three additional European experts have now been appointed as Economic Botanist, Agricultural Chemist and Professor of Agriculture. The Upper subordinate establishment has also been strengthened. New experiment stations have been started; (1) Dharwar farm in the Southern Maratha Country, (2) Dhulia farm in the Khandesh District, and (3) Mirpurkhas farm in Sindh, at all of which cotton will be the principal crop. The existing farms have largely been utilized by the Inspector General for special investigations. They have also served as a good training ground for apprentices sent from Bengal, Madras and the Punjab. The Nadiad farm, which was the property of and managed by a private association, has been extended and re-organized under the guidance of the Inspector General, who makes an annual grant towards its maintenance on condition that the cropping scheme is approved by him and the farm controlled by the Bombay department. Its principal line of work is the study of tobacco cultivation. The Inspector General has also taken a lively interest in the management of the Northcote cattle farm at Chharodi, the most important improvement being provision for a reserve stock of fodder to guard against a famine year. At several farms important experiments are in progress in the manuring of cotton and other crops. At the Manjri farm the nitrogen requirements of sugarcane are being determined. Some successful trials have also been made of the
Broach type of cotton under irrigation. The Poona farm has largely been utilized for growing varieties of crops for botanical examination by the Economic Botanist. Cotton, wheat, juar, rice and tur are being worked out. The management of the Poona dairy farm has been improved. This serves as a model to the public, a training ground for students, and for experiments in the improvement of dairy breeds and in feeding and dairying operations. The Kirkee Botanical Garden has started some useful economic work in rubber, fibre plants, spices, and other plants. The Director, Mr. H. S. Lawrence, I.C.S., has controlled the department with conspicuous success.

39. Madras.—The permanent government farms at Bellary, Koilpatti and Samalkotta were all visited by the Inspector General. The two former are mainly devoted to experiments in tillage and manures under the control of Mr. Benson, M.R.A.C., Deputy Director. Deep tillage combined with surface interculture produced much better crops of cotton—at Koilpatti during the last year’s dry season than the local methods of cultivation. Some useful preliminary work has been done in testing varieties of cotton, juar and other millets. The Samalkotta farm is devoted to the study of sugarcane, mainly with the object of preventing the serious losses in the Godavari Delta caused by red rot (compare paragraph 16 of the Cryptogamic Botanist’s report, page 79). This is under the control of Mr. C. A. Barber, M.A., F.L.S., Economic Botanist. The testing of varieties has resulted in the distribution of two canes (white Mauritius and striped Mauritius), the demand for which is so great that it cannot be met in full. The experiments in methods of cultivation and manuring also promise to give practical results. New experiment stations have been started for ground-nut in South Arcot and pepper in Malabar, to study the serious fungus diseases from which these crops are suffering. The work in cotton has hitherto been preliminary only, and the need for strengthening the establishment in order to take this up is clearly apparent. Some experimental work in the improvement of tobacco cultivation and curing has commenced, but real progress must await the appointment of an agricultural chemist. The Agave fibre station at Hindupur is now beginning to yield results, sisal hemp promising to prove successful in the dry stony soil. Much interest has been shown in the starting of district agricultural associations, which are guided by a strong Central Committee formed in connection with the Victoria Technical Institute of Madras.

40. United Provinces.—An Economic Botanist (Mr. H. M. Leake,
M.A., F.L.S.) was added to the staff. A new experiment station has been started at Orai to serve the Bundelkhand country. The Inspector General assisted in drawing up a scheme of experiments in green manuring and rotations for the Cawnpore farm. The Deputy Director (Mr. J. M. Hayman) has continued his investigations of wheat rusts (see paragraph 10 above) and the insect pests of the Cawnpore farm. The study of the wheats of the province has progressed and the crossing of varieties with the object of obtaining a suitable strain for the Bundelkhand district. The study of the local varieties of juar and poppy has been started. The investigation of the Rohilkhand processes of sugar boiling has been practically completed, and some important modifications have been recommended for the improvement of the yield both in quantity and quality.* The Economic Botanist has started the general investigation of the cottons of the province and the production of hybrids, but his time is so occupied with his administrative duties as Superintendent of the Saharanpur Gardens that he has little opportunity for research work. Proposals have been made to remove this difficulty. The distribution of good seed to cultivators has been effected on a large scale, over 4,000 maunds being dealt with. The department has been most efficiently controlled by Mr. W. H. Moreland, C.I.E., I.C.S.

41. Bengal.—A Deputy Director (Mr. F. Smith, B. Sc.) has been appointed, but it is impossible for him alone to control the many experiment stations and other spheres of work of the department, which suffer from inadequate control and a poor subordinate establishment. After local inspection, the Inspector General drew up a revised scheme of experiments for the principal farms. Fieldmen were also sent to demonstrate improved methods of cultivation. A new farm has been started at Cuttack, mainly for experiments in the irrigation of rice. Another farm has also been started at Chittagong. The scientific inquiry into indigo and jute has been noticed in paragraphs 25 and 26 above. The trials of cotton have generally failed, but the season was unfavourable. An interesting attempt is being made to introduce into general use around Burdwan a manure for rice consisting of saltpetre and bonemeal. Tobacco experiments are in progress at Rangpur. An important provincial agricultural association has been started at Calcutta and some district associations have been formed under it.

* Improvements in native methods of sugar manufacture, by Mr. Syed Muhammad Hadi, M.R.A.C., Bulletin No. 19 of 1905, United Provinces Department of Agriculture.
42. **Punjab.**—The provincial department of agriculture is in its infancy. An experiment station was started at Lyallpur in 1901, for which the Inspector General drew up a detailed working scheme. There are special opportunities here for agricultural work, for this farm is situated in the Chenab Canal Colony, where the new settlers have no stereotyped system of cultivation and are willing to assimilate any improvements. A second farm has been started at Sargodha in the Jhelum Canal Colony mainly with the object of providing good seed for the colonists. An expert agriculturist (Mr. S. Milligan, B.Sc.) has been appointed Deputy Director. The promising results of the trials of exotic cottons have already been noticed (paragraph 18 above). Tests of many varieties of wheat are in progress to determine the most suitable varieties for the Colonies.

43. **Central Provinces.**—Appointments of Deputy Director and Agricultural Chemist have been created, but the department will still be undermanned." New experimental farms have been started at Hoshangabad (principally for wheat) and at Raipur (principally for rice), whilst the Nagpur farm will be mainly devoted to cotton and juar. With his head-quarters at Nagpur, the Inspector General has been able to watch carefully the work in the Central Provinces. The working schemes of all the farms were revised by him. The cotton experiments have not progressed much owing to the want of supervision by a botanist. The campaigns against locusts and grasshoppers have already been noticed (paragraphs 13 and 14 above). A special inquiry into sugarcane cultivation is in progress. The study of wheats and the breeding of new varieties for rust resistance has advanced. The distribution and sale of implements is increasing, more particularly of fodder cutters, winnowers and iron-ploughs. Much useful work has been done by demonstration farms and peripatetic work, for which there is much scope owing to the inferior methods of cultivation practised in the backward parts. Demonstrations of improved methods of cultivation are producing some results; the steeping of juar seed for the eradication of smut is coming into general use; the embanking of wheat land is spreading; and several improved varieties of crops have been introduced. The district agricultural associations continue to be an important agency in the spread of these and similar improvements. The vernacular monthly Agricultural Magazine maintains its popularity with a circulation of nearly two thousand copies.

44. **Assam.**—The provincial department maintains an experiment station at Shillong, principally for temperate fruits and vegetables, and
a second at Wahjain, principally for tropical fruits and plants. Some superior varieties of potatoes have been introduced into general cultivation. Methods of spraying for the prevention of the potato blight are under trial. The sericulture experiments have already been noticed in paragraph 33 above. A trial of American nitrogen-fixing culture on peas failed to give any result.

45. Burma.—A department of agriculture has not yet been organized in Burma. The Inspector General has submitted a scheme framed after a tour of inspection. Some successful results have been obtained by the distribution of seeds and plants. Potatoes, strawberries, and other fruits have been introduced into the Hill States. Havanna tobacco has been established in general cultivation in the Irrawaddy delta. Ground-nut is also being generally adopted.

46. Native States.—Apart from the departments of the provincial governments, some Native States maintain separate departments of agriculture, with which the Inspector General has no direct concern. He has, however, been in frequent communication with the departments of the Baroda and Mysore States. There has been no opportunity to visit Baroda, but some assistance has been given in the supply of seeds for experimental trials, in the training of assistants and in advice on several questions referred to him. Several visits have been made to Bangalore, which is the head-quarters of the department maintained by the progressive State of Mysore. An account of the work has been kindly furnished by Dr. A. Lehmann, Ph.D., Agricultural Chemist, which is printed as Appendix C of this report. Excellent laboratories have been constructed, and an experimental farm has now been started. Sanction has also recently been given to the appointment of a second scientific officer as Entomologist and Mycologist. Much attention has been given to coffee, which is the principal crop of Mysore. Investigation has been made into the soils, methods of cultivation, manuring and the like; suggestions have been made for improvement, but without a coffee experiment station it is difficult to make proper tests. In the laboratory efforts have been made to discover a test for quality in coffee, which seems to bear a close relation to the specific gravity. Sugarcane cultivation and the local processes of making jaggery have been examined; recommendations have been made for lessening the considerable loss that undoubtedly occurs in the local method of sugar boiling. Tests have been made of a large number of foreign grasses with the object of improving the fodder supply, but these have repeated the common experience
that the indigenous plants of India are more suitable than exotics. Much good has resulted from the analysis of samples of fertilizers, which have been shown to vary enormously in composition, the lesson of which is that they should only be purchased under a guarantee of quality. In the investigation of the important fungus diseases and insect pests of coffee, assistance has been given by the Cryptogamic Botanist and the Entomologist of the Imperial Department (See Parts IV and V of this report). Dr. Butler has been obliged to abandon the investigation of the obscure 'spike' disease of sandal-wood, because it would occupy the whole time of a mycologist for a long period. An annual report is published by the Agricultural Chemist of the Mysore State giving an account of each year's work.

47. Proposals for future expansion of the departments.—In the preceding paragraphs an account has been given of the working of the existing departments, and this report may suitably conclude with an outline of the proposals for their future expansion. In March last Government announced that they had decided to make an additional annual grant of Rs 20 lakhs (£133,000) for expenditure upon agricultural research, education and improvement. This grant will permit of a large expansion in the work of the departments. Proposals were framed by the Inspector General suggesting the general lines of expansion. These have been considered by Local Governments, who have prepared the provincial schemes. These naturally vary in order to suit the local requirements, but follow certain general lines. In the first place it is intended to provide an experiment station in each important distinct agricultural tract. The staff of specialists of each important province will ultimately be strengthened so as to include one or more Superintendents of Farms or Deputy Directors (expert agriculturists) as they have hitherto been named, an Agricultural Chemist, Economic Botanist, Mycologist and Entomologist. A further improvement, upon which great immediate stress is laid, is the establishment in each important province of an Agricultural College with a competent teaching staff and fully equipped laboratories. This will be located on the principal experimental and instruction farm which will also be the Central Research Station. The expert staff mentioned above will for the present be responsible for the teaching in addition to their research work, with the help of competent native assistant professors and a full subordinate staff. The course of instruction will last three years, after which it is hoped that a few of the best students will proceed to Pusa for a further post-graduate course
of two years in order to fit them to fill the higher appointments. It is hoped also to improve the means of introducing the results of research work into general agricultural practice. Temporary demonstration plots will be started; the formation of district agricultural associations will be encouraged; agricultural shows will be supported; the distribution of improved seed, implements and manures will be extended; popular publications in the vernacular will be encouraged. In order to control a large provincial department upon this scale, it has been decided to appoint a separate Director of Agriculture, who will be responsible for its general administration and discipline. As regards the imperial department, the first proposal is to appoint supernumeraries to each specialist, who after the completion of their college education in England will be posted to Pusa in order to undergo a further training under Indian conditions. They will be absorbed into the regular cadre of the provincial departments as vacancies occur. It is thus hoped to lessen the existing difficulties of recruiting in England suitable candidates of experience. It is also proposed to strengthen the imperial staff by the employment of specialists who can devote their whole time to the investigation of important special problems. The additional specialists at present proposed include a Cotton Expert to guide and correlate the experiments for the improvement of Indian cotton; a Wheat Expert, to investigate the special problems of the wheat crop, including the improvement of the milling and baking qualities of wheats grown for export; a Sugar Expert to investigate the problems of sugarcane cultivation; a Tobacco Expert to introduce improved methods of tobacco cultivation and curing; and a Fruit Expert to improve the fruit cultivation and the methods of packing and grading in the important fruit-growing temperate zone of north-west India. Such are the outlines of the general scheme for the expansion of the imperial and provincial departments, which has become possible with the increased grant for expenditure. This scheme has yet to receive the sanction of the Secretary of State, and must necessarily take some years before it can be introduced in its entirety. When it is completed, the Departments of Agriculture will for the first time be placed in a proper position to deal with the problems of India's greatest industry, which supports three-fourths of her population.

F. G. SLY, I.C.S.,

Officiating Inspector General of Agriculture in India.

Dated the 9th September, 1905.
ANNUAL REPORT OF THE AGRICULTURAL RESEARCH INSTITUTE, 
PUSA, FOR THE YEAR ENDING THE 30TH JUNE 1905.

I. GENERAL.

1. History.—The Government Estate of Pusa covering an area of 1,358 acres is situated in the district of Darbhanga, Bengal, 6 miles from the Waini station of the Tirhut State Railway. It was first acquired by Government in the year 1796, and was used as a Stud Farm until 1874. Horse breeding operations were then abandoned, and a part of the property was utilised as an experimental farm, special attention being devoted to the growth and curing of tobacco. In 1877 it was leased to Messrs. Begg, Dunlop & Co. of Calcutta as a tobacco estate and factory; they abandoned the enterprise in 1897, when the Bengal Government again assumed charge of the property. In 1902 a scheme was prepared for utilizing the estate as a cattle breeding and dairy farm, to which were added proposals for establishing an Agricultural Research Station and College. It was apparent that an undertaking of this magnitude concerned not only the province of Bengal but the whole of India, and it was eventually settled that the management should be placed under Imperial control. The munificent donation of £30,000 by Mr. Henry Phipps, an American citizen, placed at that time in the hands of His Excellency the Viceroy, assisted greatly to these conclusions, and the greater portion of this sum (£25,000), was set aside for the erection of the Institute and Laboratories. The scheme as finally approved by the Government of India was sanctioned by the Secretary of State, and on the 26th of December, 1903, the property was formally handed over by the Bengal Government to the Government of India.

2. On 1st January, 1904, Mr. Mollison, the Inspector General of Agriculture, brought his camp to Pusa, and immediately began the preliminary work of clearing and levelling. Farm buildings were commenced, work cattle purchased, and some of the land brought under cultivation. On the 1st April, 1904, I had the honour to enter upon my duties. Since then my principal duty has been to continue the work of laying out the estate. This has been much facilitated by the
co-operation of the Bengal Government, the Lieutenant-Governor, Sir Andrew Fraser, making a visit of three days in February, 1904, to pass the necessary orders concerning the disposition of the property, and the position which the Bengal Government would henceforth hold in relation to the Institute.

3. **Objects and aims.**—The scheme as sanctioned by the Secretary of State comprises:—

- (1) An Experimental Farm.
- (2) An Economic Botanical Garden.
- (3) A Research Institute.
- (4) An Agricultural College.
- (5) A Cattle Breeding Farm.

The farm will comprise some 300 acres of land under cultivation in the immediate charge of an expert agriculturist from England. The chief functions of the farm will be to afford a training ground for the students of the college, a means to the scientific experts of working out on a practical scale the many problems which await their investigations, and a distributing centre for improved seeds and plants. The Economic Botanical Gardens in charge of the Economic Botanist will be for the use of the scientific officers and the students, and will contain as far as possible a complete collection of the economic plants of India. The Research Institute will have spacious laboratories fitted with the best apparatus for scientific research, and will also contain a library of the most important works and periodicals allied to agriculture, as well as a museum and Therbarium. The publication of the work done at Pusa under the control of an Editorial Committee of the staff, is to be one of the most important undertakings of the institute, and it is intended that a central bureau of reliable information on agricultural subjects should thus be created for the whole of India. The College for the training of students will be attached to the institute and a hostel is being built to accommodate at first some 70 students. It is to be of the University type, for post-graduate candidates, and will be fed by the agricultural colleges of the provinces. In the latter, students will undergo a course of three years' training in general scientific and practical work, and the most successful candidates will pass out of the provincial college into Pusa, there to complete another two years of specialised training. By this method it is expected that it will be possible to supply for the agricultural departments in India scientific men of a high order, who, it is hoped, will be competent to fill the highest posts in professorial work, or become reliable specialists for
original research work, and thus supply one of the greatest needs of the country. The cattle breeding farm is composed of two parts; one in which local cattle of the best type will be bred for the supply of bulls to Bengal and Behar, and the other in which various approved herds will be kept for acclimatisation and use in these districts. Some 400 acres have been set aside for grazing.

4. **Board of Agriculture.**—On 6th January, 1905, the members of the Board of Agriculture appointed under Government of India Resolution No. 24—14-1 of the 20th September, 1904, met for the first time under the presidency of Mr. F. G. Sly, I.C.S., Officiating Inspector General of Agriculture, and were accommodated under canvas. The number of members present was 31 and the proceedings lasted five days.

5. **General features of year's work.**—The general features of the work of the past year have been the erection of buildings for the scientific staff and their establishments, the clearing and breaking up of lands for the use of the experimental farm, and the general reclamation of the whole estate, most of which since the close of the stud farm in 1874 had been allowed to lapse to jungle.

II. **BUILDINGS AND OTHER WORKS.**

6. **Public Works Department.**—Building operations under the Public Works Department commenced in the month of November last, and for a time made rapid progress, but in the months of February and March the work slackened off, which was explained as being due to the department being undermanned. The operations were then constituted an independent charge under Mr. Arnott as Superintendent of Works, and since his arrival, operations have progressed with renewed activity. Residences for the European officers and quarters for the subordinate staff are under construction, several having been already completed and occupied. The main college and research building, known as the Phipps' Laboratory, has also been commenced. The foundation stone was laid on the 1st April, 1905, by His Excellency Lord Curzon, Viceroy and Governor General of India, a large number of European and Indian gentlemen attending the ceremony at the invitation of Sir Andrew Fraser, the Lieutenant-Governor of Bengal. Important speeches explaining the nature and scope of the institute were made by His Excellency the Viceroy and Sir Denzil Ibbetson, K.C.S.I., Member of Council. Owing to the complicated nature of the design, it is not expected that the building will be completed under another two years.
and with the time it will take to supply the fittings it is calculated that it will not be ready for occupation before November, 1907.

7. Departmental work.—Among the buildings, the construction of which was undertaken departmentally, the farm buildings with machinery were finished in the month of October last at a total cost of Rs.60,350. In order to enable research work to commence, temporary laboratories are being erected, and should be completed by the month of October of the present year. An insectary for the use of the Entomologist, and a potculture house for pot experiments, are under construction, and will be soon ready. Sanction has been given for the building of houses for sericulture, and the accommodation of a Japanese silk expert.

8. The irrigation scheme sanctioned by the Government of India for the supply of water to the estate is near completion, and will be of the greatest utility for the experimental work.

III. THE FARM.

9. Cultivation.—Mr. E. Shearer, M.A., B.Sc., entered on his duties on the 19th November, 1904, as Agriculturist to the Institute. The work of the past year has been mainly the removal of old and useless buildings, the cutting of trees and jungle that had grown over the property, and the bringing into cultivation of the portion of the estate set aside for the farm. The total area brought under cultivation is 350 acres. Beyond the growing of varieties of crops for fodder and for the purpose of getting the land into normal culture, no experiments that can correctly bear that name have been carried out, if we except the growth of many varieties of cottons to which reference will be made later. Land, which has been abandoned to grass and jungle for a long period of time, cannot at once supply those conditions of uniformity and normality, which are absolutely required for the purpose of reliable and satisfactory agricultural tests. Indeed it must take time and practical experience, before we can ascertain whether the required conditions of soil have been reached. For these reasons the land of the farm can supply at present the requirements of no strict experiments as such, and it will take time before the agriculturist or myself will be able to say that it is fit for tests in which conditions of uniformity and normality in the soil are essential. I would, therefore, strongly deprecate the farm being pressed to do experiments, which at this moment cannot be carried out under the conditions required by the exigencies of scientific research. I have felt constrained to make these
remarks, as there appears a very widespread idea that the Pusa farm
is in a position to carry out most of the agricultural tests common to
experimental farms which are in full working order. To work on this
assumption will not only cause disappointment, but owing to the
varietal nature of the work such a proposition would entail, the lands
would have to be prematurely sub-divided into small plots and areas,
which would greatly hamper the initial work we have in hand, and
prevent the realization of uniformity in the soil which can only be
acquired by the cropping over large areas with only one crop at a time.
These remarks do not refer to most of the problems in Entomology,
Mycology and Economic Botany, and the initial investigations that are
required to be made by the Agricultural Chemist. They can be taken
in hand at once. It is only where the conditions of soil are required
to be uniform, normal and constant, such as in comparative manuring
tests, comparative modes of cultivation, and the like that these remarks
apply.

10. Cotton experiments.—I have made an exception in the case of
cotton to my statement that no experimental work has been carried out
on the farm in the past year. Nearly all known varieties, both indi-
genous and exotic, have been given a trial. These were divided into
two main heads (1) tree cottons, and (2) annual cottons. We can
dispense for the present with the tree cottons, which are perennials,
and take at least two to three years to establish themselves, so that any
remarks on the results so far obtained would be premature. Regard-
ing annual cottons the case is different, and although the results are by
no means conclusive, we are able to forecast the probabilities of suc-
cess and the lines on which the experiments should in future be con-
ducted. To aid us in our opinions we have besides the experiments
carried on at Pusa, those carried out by the planters in Behar over an
area of some 3,000 acres. The conclusions arrived at by the planters
themselves are that the growing of cotton with them has been a
complete failure, and that the soil and the climate of Behar are unsuitable
for its growth. From an industrial and commercial aspect I can but
agree with this statement, as far as the present time is concerned.
But from an experimental point of view, I think that it is possible and
even probable that a cotton may be bred to suit the Behar climate and
the requirements of the home market. This necessarily implies that
we have no cotton at present that suits, and that it will be necessary
to breed and acclimatise a plant for this purpose. By this I indicate
the lines upon which, in my opinion, the experiments should be
conducted. It is essentially a problem for the Economic Botanist to carry out, but which should be worked out at Pusa. It has generally been considered that an early flowering variety such as the American is the best, but I am entirely of the opposite opinion, and think that a late flowering variety will be found more adaptable. The reason for this is that if an early variety is sown at the only two normal seasonal periods of sowing, namely, June or October, the flowers and fruit from the first are either entirely spoilt by the heavy rains of the monsoon or the cold in the succeeding months, while plants from the second are too young to withstand the cold of the winter months. The only alternative which seems to present itself is to have a late flowering variety, which sown in June, will yield in the following March and April. This in fact is the only kind of cotton plant which is grown in Behar by the native cultivator. Its selection is doubtless the result of accumulated experience, for though the cotton is very inferior in quality, it is the only variety that will flourish in Behar, and is remarkably free from pests and disease. It, therefore, seems to me that in the face of the results obtained during the past season, this plant should form the foundation of our future work. Now that the Economic Botanist has arrived in the country, the whole question of cottons will be duly considered by him, and experiments laid out in accordance with his views.

11. Cattle farm.—I have to report but slow progress under this head. Forty-five cows and one bull of local breed were purchased for the farm by the Civil Veterinary Department, Bengal. Of these 25 were rejected by the Inspector General of Civil Veterinary Department in January last. We have, therefore, only 20 cows and 1 bull left, and are awaiting further purchases by the Superintendent, Civil Veterinary Department, Bengal. When the cattle first arrived at Pusa, they were in poor condition, and they did not improve with the abnormal cold which obtained in January and February. Since then a liberal ration of concentrated food has been prescribed, and the condition of the cattle at present is all that can be desired. The cost of this ration has added considerably to the outlay under this head, but it is expected that with the introduction of a more economical basis of feeding, expenditure will be reduced.

12. Fourteen Montgomery cows and one bull were introduced into the farm last year from the Punjab, with a view of testing their adaptability to these districts. One cow died and the rest are doing well, but their milking powers are not as great as we were led to anticipate,
the yield being from 5 to 8 seers per day, according to the cow. These cattle did not thrive well at first, but now appear to be acclimatised, and it is possible that an increase in milk may be expected from their next calf.

13. Some 400 acres of pasture have been reserved for the grazing of the cattle. A certain area of this has been put down to artificial pasture. Two of the old stables of the estate have been fitted up for the housing of the different herds and will accommodate 200 head of cattle.

IV. CHEMISTRY.

14. No work has been started yet under this branch, and Dr. J. W. Leather, Ph.D., F.I.C., F.C.S., at present Agricultural Chemist to the Government of India, the officer to be in charge of this section, is not expected before November. In the meantime temporary laboratories and a pot-culture house are being erected for his use, and will be ready by the date of his arrival, so that he need lose no time in commencing the work of many of the important problems which await his investigation.

V. BOTANY.

15. Mr. A. Howard, M.A., A.R.C.S., F.C.S., F.L.S., the Economic Botanist, has arrived in India, and will be able to commence his work here at once. Besides the various problems which await his attention with agricultural crops, the orchards and botanical gardens will be placed in his charge. Fruit trees of many varieties have already been collected and planted, and the botanical gardens are being laid out. It is proposed that besides making these to a limited extent ornamental, they should also be planted with as complete a collection of economic trees and plants as it is possible to collect. These will afford not only a means of studying on the spot the origins of most economic products, but will provide a training ground for the students, and the means of extended investigation for the scientist.

VI. ENTOMOLOGY.

16. Mr. H. Maxwell Lefroy, M.A., F.E.S., F.Z.S., the Entomologist appointed to be in charge of this department, took up his head-quarters at Pusa on 1st May, 1905. He had previously been at Pusa during the year and many of the crops have been treated for various pests, the results of which will be the subject of a separate
report from that officer. An insectary has been built and will very shortly be ready for his use.

VII. MYCOLOGY.

17. Dr. E. J. Butler, M.B., F.L.S., at present Cryptogamic Botanist to the Government of India, who is the officer to be appointed to this branch, has not yet removed his head-quarters to Pusa, but plans of his experiments have been received which are being duly carried out. Temporary laboratories are also in process of construction for his use. Owing to the injury which might result to the farm crops from the contagion or infection caught from diseased plants under investigation, it has been thought proper to isolate the experiments in the case of diseases which have a tendency to spread, and for this purpose a separate and isolated area has been reserved.

VIII. BACTERIOLOGY.

18. Mr. C. J. Bergtheil, the officer of this department, is at present on deputation to the Bengal Government for the carrying out of experiments in indigo manufacture. Facilities are however being given him here to initiate investigations appertaining to his branch. The bacteriological investigation of soil and manures will commence as soon as circumstances admit, and preparations are being made for experiments on the effects of nodule bacilli on the soils of Pusa.

IX. WEATHER.

19. The total amount of rain that fell in Pusa last season amounted to 45 inches, which may be taken as normal, but in many other respects the character of the weather was abnormal. The rains commenced late, and the quantities precipitated were small, but this shortness was made up in August by heavy falls, which injured many of the crops. On the other hand, the unusual late rains in October secured a very fair outturn of cold weather crops. In the end of January and beginning of February, cold weather of unprecedented severity was experienced, which damaged a number of crops, notably tobacco, linseed and sweet potatoes. With the exception of the rainfall, we have been unable up to date to take meteorological observations, but the instruments for this purpose have been received from the Meteorological office, and as soon as the observatory to hold them is ready, observations will be made in due course.
X. ACCOUNTS.

20. The total departmental expenditure incurred in the past year amounted to Rs.26,575, the principal items being Rs.15,750 for pay of gazetted officers, Rs.15,000 for irrigation scheme, Rs.30,000 for clearing and arable cultivation, and Rs.37,000 for buildings and machinery.

B. COVENTRY,
Director and Principal,
Agricultural Research Institute, Pusa.
Part III.

ANNUAL REPORT OF THE AGRICULTURAL CHEMIST TO THE GOVERNMENT OF INDIA FOR THE YEAR 1904-05.

I have the honour to submit my report on the work of this department for the year ending June the 30th, 1905. Included in it are, however, brief references to work of previous years, as directed in your letter No. 846—4-2, dated the 6th July, 1905.

2. I held charge during the whole of the year.

3. Tours.—I made the following tours:

**August 2nd to 15th, 1904.**—I visited Poona and Bombay principally to inspect the work which was being conducted by Mr. Price, one of the Assistants in this Laboratory, on the purification of sewage. I also visited the Matunga Leper Asylum, Bombay, where Mr. Carkeet James, Sanitary Engineer to the Municipality, showed the further development of his most useful sewage experiments. I was also able to meet the Director of Agriculture, Bombay, to discuss the work generally that was being done by this department in conjunction with his.

**January 2nd to 22nd, 1905.**—This tour was devoted principally to attendance at the meeting of the Board of Agriculture at Pusa, and a general consideration of the work of this office with Mr. Sly. A good deal of time was also devoted on this occasion to working out details for the publication of the Agricultural Journal and Memoirs. For the same purpose I visited Calcutta in company with Dr. Butler and Mr. Lefroy. In this month I also visited Benares to see some new chemical laboratories that have been built for the Central Hindu College.

**February 15th to 19th, 1905.**—I met Mr. Moreland, Director of Agriculture, United Provinces, at Aligarh on this occasion, to discuss with him the possibility of employing gypsum for Usar land on an extended scale. The Usar area at Gursikran was visited as also the dairy farm at the Cherat Usar.

**March 29th to April 16th, 1905.**—Pusa was visited on the occasion of the ceremony of laying the foundation stone. The arrangements for the Agricultural Journal, the library and the temporary laboratories at Pusa were brought under consideration by Mr. Sly. After
leaving Pusa I visited Pemberandah and discussed with Mr. R. S. Finlow the experiments which would be most suitable in relation to the jute enquiry. Thereafter I visited Mozafferapore and Saran in company with Mr. Nunn, Assistant Commissioner of the Salt Department, to inspect saltpetre factories and refineries.

May 7th to 10th, 1905.—This period was devoted to an examination of the methods used in saltpetre refineries at Farrukhabad, when Mr. Buckley, Assistant Commissioner of the Salt Department, accompanied me.

June 12th to 17th, 1905.—A brief visit to Cawnpore at this time was necessitated in order to obtain information as to the amount of water in the soil at the close of the hot weather.

Mr. B. B. Price, one of the Assistants, was deputed to Poona from July 22nd to October 2nd, 1904, to carry out a set of daily analyses of the sewage in the septic tank.

Mr. Price was also deputed to the Central Provinces from December 6th to February 5th to assist in the sugarcane experiments instituted by the Director of Agriculture. He then proceeded to Pusa, and analysed the sugarcane juice there on behalf of the Cryptogamic Botanist to the Government of India.

4. Analysis.—The nature of the work carried on in this department may be roughly divided under two heads, namely, the analysis of agricultural materials for, Local Governments, and investigations of a special nature.

The following list will illustrate the nature of the analytical work:

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521
5. Among investigations which have been in progress the following deserve reference.

6. Soils.—A very large number of soils have been examined since this chemical laboratory was fitted up in 1895. At first the examination extended only to the chief ingredients. No precise information existed regarding even the main chemical features of Indian soils, and attention was devoted, therefore, in the first instance to the determination of the amount of the chief constituents in some of the better defined soils, such as the Indo-Gangetic and other alluvial soil, the black cotton soils, laterite, etc. Space does not admit in this report of a detailed reference to this work. Of these soils the Indo-Gangetic alluvium and the Regur vary in composition only within comparatively narrow limits, whilst in most other classes the variation is considerably greater. The work was published as Agricultural Ledger No. 2 of 1898.

7. Sampling soils.—The most suitable method of selecting samples of soils was taken up in 1901. The method very commonly adopted in England is to take a portion of earth from either one or at most a very limited number of places in the field which it is desired to subject to chemical analysis. The value of such a specimen for the purpose in view depends entirely on whether the field is really uniform or not. Such a condition is obviously frequently not the case, and it appears only reasonable that in order to secure a truly representative specimen, portions should be taken from a number of places in the field. Even when this is done the difference between two samples is quite large enough. The results of this investigation were published before the London Chemical Society in 1902 (Trans. Vol. 81).

8. Available plant food in soils.—During later years attention has been given more particularly to the estimation of that part of the plant food in soils which may be considered readily available to plants. The methods suitable for this purpose which are at present known, are limited and are admittedly imperfect, and the more accurate estimation of this readily available plant food is perhaps one of the most urgent desiderata of the agricultural chemical laboratory. Considering the chief items involved it may be said that it will pay to employ nitro-benous manure on all soils situated in the plains; and even in hill soils, so far as I have acquaintance with them, the same rule is more commonly applicable than I at one time thought.

Two other important ingredients are potash and phosphates. For the estimation of the amount of the readily available quantity of either of
considerable tint. the cultures pn or for the purpose is that of Dyer, and it has been applied in this laboratory to a considerable number of soils. It is an empirical method, and in order to check its indications, cultivations have been carried out in a small pot-culture house attached to the laboratory. The number of cultivations has only been small up to the present, and the house is not well suited to the work, but there seems every reason to expect that Dyer's method will prove itself generally applicable to the purpose. At Pusa it will be possible to push this department more energetically than has been possible here.

Lime is another constituent of soils which is required not only by the ordinary crops, but also usually to maintain the soil in a sufficiently basic condition for the healthy growth of bacteria, especially those which produce nitrate. All soils contain lime in one or another form of chemical combination, but these cannot all be considered as equally available to plants. The amount of calcium carbonate is perhaps the best indication we possess at present of the relative value of lime from this point of view, and its quantity varies in soils very greatly indeed. It is intended to test this matter by means of pot-cultures in the near future.

The quantity of sulphate in Indian soils seems to vary more than in Europe, or at least it often falls to very small proportions, so small indeed that the adoption of special means has been frequently necessary in order to determine the amount present. There is no information as to how much sulphate a soil should possess for high fertility. It is probably only a very small quantity, but the intention is to include this subject also in the list of experiments.

9. Usar.—The nature of Usar land has been studied up to a certain point. The quantities of the pernicious saline ingredients are now known. These are usually sodium carbonate, bicarbonate or silicate, sulphate and chloride. Occasionally magnesium sulphate or chloride is also present. The quantities of these salts vary within considerable limits. If the amount be expressed as a percentage in the upper 6" or 12" of soil, there is not usually more than 1 or 2 per cent. and commonly much less than this. These salts are, however, generally concentrated at the surface of the soil, so that by scraping this off, much higher proportions will be found in the specimen. The effect of these salts on the soil and on the plant differs. Sodium carbonate causes an entire change in the physical state of the land, and natural drainage becomes impossible. The corrosive action of this salt on the cuticle
of the plant root is also so serious that a very small amount, such as \(0.1\) per cent., suffices to prevent vegetation altogether. The other salts do not usually deleteriously affect the physical state of the soil, and plants can struggle in the presence of \(0.1\) or \(0.2\) per cent. of either the sulphate or chloride. The cause of their presence is either that the sodium carbonate has rendered the soil almost impervious to water and stopped drainage, or that the rainfall is so light that there is not sufficient water to admit of any real drainage. Broadly speaking the former is the common cause in the United Provinces, and the latter in the western districts of the Punjab. Detailed information regarding the Usar in the United Provinces, Punjab and Bombay Presidency was published in Agricultural Ledger No. 13 of 1897. In addition a series of samples from the Madura district, in the Madras Presidency, have been reported on.

10. The actual reclamation of Usar land has not fallen within the province of my work. The only methods for this, which are at all feasible, are good cultivation coupled with heavy manuring, and the application of gypsum. Drainage systems have failed so far, because the water carries earth with it and rapidly stops up the pipes. Gypsum is so expensive at present that considerations of cost prevent the general application of this agent on really bad Usar land. The quantity required per acre would naturally vary, but would frequently amount to 100 or 150 maunds per acre, costing R1 per maund. At the same time I believe that it would pay to apply gypsum in fields, which though affected by Reh, are not infertile. Small quantities of the finely ground mineral applied to barren patches would not entail the great initial expense that the reclamation of entirely bad Usar would do.

11. The amount of combined nitrogen in rain and dew.—The rain water collected at Dehra and at Cawnpore has been examined over a period of twelve months and a record of the amount of ammonia and nitrate in it kept. The quantities found are set out in the subjoined statement:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches</td>
<td>As ammonia</td>
</tr>
<tr>
<td>Dehra Dun</td>
<td>87'45</td>
<td>2'178</td>
</tr>
<tr>
<td>Cawnpore</td>
<td>49'36</td>
<td>2'482</td>
</tr>
</tbody>
</table>
There is nothing novel or remarkable in these figures, and indeed the work was only undertaken in order to add to the evidence which already exists tending to show that the amount of such combined nitrogen which is brought into the surface soil with the rain is very nominal compared with that required by crops. It may be safely stated that the quantity is not more than 5 lbs. per acre per annum in all parts of the world.

12. Although the amount of ammonia and nitrate in the dew is generally much greater per unit volume than that in the rain, and was from 1 to 2 parts of "ammonia" nitrogen and a similar quantity of "nitric" nitrogen per 1,000,000 (million), the actual amount of dew precipitated is so small that when the figures are expressed as lbs. of nitrogen per acre, it becomes apparent how little this source of nitrogenous plant food can affect the question of the supply in the field. During last cold weather 0.055 lb. of "ammonia," nitrogen and 0.056 lb. of "nitric" nitrogen per acre were found in the dew at Cawnpore.

A point of interest is the fact that the amount of nitrate was relatively higher in the dew than in the rain; it usually equalled and sometimes exceeded the ammonia, whereas rain water rarely contains so high a proportion of "nitric" as of "ammonia" nitrogen, and usually the latter is considerably the greater. On the assumption that the ammonia in the atmosphere is derived from decaying vegetation, and might be thus expected to be in greater amount near the earth, whilst the nitric acid is formed by electrical discharges in the higher strata of the air, one would have expected rather the reverse result, for the dew precipitation is formed near the earth's surface, that is, in the region where the ammonia is supposed to be in comparative excess and the nitric acid if anything in deficiency.

13. During the hot weather of last year the dust which collected at Cawnpore almost daily on the large rain gauge, was removed carefully with a camel hair brush and a little distilled water, and weighed. The total amount found was (approximately) 28 grammes, the greater part of which settles at night. Considered from the point of view of addition of nitrogenous matter to the soil, this quantity is not great; the amount of dust per acre amounts to only 0.61 lb., and would not contain more than 1 per cent. or 0.00061 lb. of nitrogen, unless indeed it collected very considerable amounts of ammonia from the air, which appears impossible. Another point which I noticed in relation to this atmospheric dust was the irregularity with which it appeared in the rain water in the early stages of the monsoon at Dehra.
The first rainfall was very dirty as is usually the case. Then followed a period of clear atmosphere and rain water free from dust, but after this the rain water again became contaminated with dust without either any serious break in the rains or dust haze appearing in the atmosphere.

14. The drainage water at Cawnpore.—The last monsoon provided the first set of samples of drainage water from the gauges which were constructed at the Cawnpore farm in 1903. Percolation occurred in 1903 and was measured; No. 1 gauge yielded 11'12" and No. 3 11'97", but the water was not analysed. During 1904 a record (excepting for a period of ten days when the collecting vessels were under repair) of the amount of drainage was maintained. It is estimated that of 43'3" of rain which fell during the monsoon, 5" went to make up the loss which the soil sustained during the dry weather; 4" ran off the surface during an exceptionally heavy fall on September 9th, but all the rest soaked into the land. In July an interruption occurred in the measurements, and a correction has to be inserted in both rainfall and drainage. Thus of about 34'3" which remained, 25'7" is believed to have percolated, leaving less than 9" for evaporation during the monsoon. It is also to be noted that the amount of percolation was the same from the 3-foot gauge as from the 6-foot one, excepting on one occasion when a very heavy fall occurred.

It is proposed to construct similar gauges at Pusa, and it is certain that very interesting information will be obtained from these and the Cawnpore gauges. Among other items to be held in view are the actual velocity of percolation; the effect of one stratum on the percolation of another, such as an underlying bed of sand or clay; the effect of vegetation; the amount of evaporation during the dry and wet seasons.

15. The nitrate in the drainage water.—Samples of the drainage water from both gauges were kept and mixed once a fortnight in aliquot proportions of daily quantity. In these the amount of ammonia and nitrate was determined, and from these analyses the quantities per 1,000,000 (million) of water and per acre are readily calculated. The drainage was similar to that obtained at Rothamsted, in that the amount of ammonia was only nominal whilst that of nitrate was very large. A very small amount of percolate occurs throughout the dry season, but this contains only a small quantity of nitrate; in fact this constituent disappears at times. Then with the advent of the monsoon and recommencement of percolation, the quantity of nitrate rises very rapidly.
For instance, the first percolate of any consequence from the 6-foot gauge, that which followed the first ‘004”, contained 13.4 parts of nitric nitrogen per 1,000,000, and the corresponding figure from the 3-foot gauge was 22 parts, so that there seems to be a thin layer of water in the soil of the under surface of the gauge containing but little nitrate. The concentration of nitrate rose to a maximum of 30 parts of nitrogen per 1,000,000 (million) in the 6-foot gauge and to a maximum of 23.5 parts in the 3-foot gauge. These quantities, though large, are not greater than has been found at Rothamsted.

The total amount recorded for the monsoon period, which is synonymous with the whole year, was 56 lbs. of nitric nitrogen per acre from the 3-foot gauge, and 106.4 lbs. from the 6-foot gauge. These amounts are however below the truth, for drainage was lost in July which it is certain contained a very considerable amount of nitrate, and although any estimate of unrecorded quantities is open to possible criticism, still the amount of nitrate lost I estimate to be 16.4 lbs. of nitrogen from the 6-foot gauge, making a total of 122.8 lbs.; and 18.0 from the 3-foot gauge, bringing its total to 74 lbs. These are greater quantities than those recorded at Rothamsted, the largest there being (so far as I know) 59.62 lbs. per acre in 1880. But no records of the nitrate from the 20” gauge were maintained for seven years after these gauges were constructed, and there is every reason for supposing that the quantity was greater at first than later.

It is of first importance to recollect that these gauges are in each case kept free from vegetation, and that the presence of vegetation on them would probably very materially modify the quantities of water and nitrate passing away. In fact these gauges at present provide conditions of maximum loss. The intention is to keep some of the gauges at Cawnpore and at Pusa under the influence of vegetation, so that on the one hand a record of maximum loss of water and nitrate, and on the other hand the minimum loss may be obtained.

16. Waters.—Although a considerable number of well and canal waters have been examined for the several provincial agricultural departments, only two series of such specimens require notice here.

One had reference to the agricultural value of some wells in Gujarat, the water of which is highly prized for tobacco crops. It was readily shown that this value is due to the presence of high proportions of nitrates. Some of these waters contain, indeed, so much nitrate that they cannot be employed without previous dilution with other less salty water. The nitrate is not always the potash salt; indeed in those
samples which contained most, the nitrate was almost exclusively the sodium and lime salt. The details of the work were published as Agricultural Ledger No. 14 of 1895.

Another series of very saline waters from the Muttra District, United Provinces, was examined in 1901. Some of these likewise contained high proportions of nitrate, but the more pronounced characteristic was the presence of large quantities of other salts such as calcium, magnesium and sodium sulphates, and magnesium and sodium chlorides. The investigation was published in Trans. of the Chem. Soc., Volume 81.

17. Manures.—A very considerable number of samples of manures of all descriptions has been analysed, and the average composition of the principal kinds is now known. A ledger on this subject was published in 1897 (No. 8), and it will shortly be possible to publish a more complete paper of the same nature.

Experiments with manures have not so far been made independently by me; no experimental farm is attached to this office at Dehra Dun, and my province has been restricted to that of adviser at other farms. Sewage has been a subject of special investigation, and is dealt with in the succeeding paragraph.

Among experiments made at the farms, I submitted in 1899 those on the continuous growth of wheat and maize at Cawnpore to a comparison with the similar ones at Rothamsted and Woburn in England (vide North-Western Provinces and Oudh Bulletin No. 9 of 1900). A study of the figures is of considerable interest and illustrates well the value of manures, especially nitrogenous manures, in India.

18. Sewage.—A series of tests was carried out in 1903 and 1904 at the Manjri sewage farm near Poona in order to determine the rate at which domestic sewage of different strengths becomes purified. The experiments on the use of the septic tank and beds had been in progress for several years at Poona, but excepting for odd analyses made several days after the samples had been taken, little was known of the actual rates of purification. An assistant from this laboratory was, therefore, deputed to the sewage farm, and a series of daily tests of the sewage made during December 1902, January and February 1903, and August 1904. The details of the work of 1902-3 were published in the "Annual Report on the working of the Sewage Farm at Manjri for 1902-3"; those for 1904 have not so far been published.

The principal outcome of the investigation has been to indicate how fast the organic nitrogen becomes hydrolised in the septic tank. This
is best shown by the accompanying chart, from which it is seen that the rate of change is considerably greater when the concentration of this organic nitrogen is high than when it is low, and that for a strong sewage a relatively smaller tank would be required than for a weak sewage. Secondly, there seems to be a limit to the destruction of this organic matter, which fact is illustrated most perfectly by the curves of the weaker sewage; after the amount of this nitrogen had fallen to about 1 part per 100,000 (hundred thousand), no further diminution occurred, and it is probable that if the tank had been sufficiently large to admit of the strong sewage remaining in it longer, the amount of organic nitrogen would have become practically constant in this case also.

19. The corresponding work on the purification effected in the "Bacteria" or "Contact" beds showed that with septic tank effluent containing about 1 part of organic nitrogen and 1'7 part of ammonia per hundred thousand, three charges could be purified per day; with an effluent containing 2'8 parts of "organic" nitrogen and 4'6 of "ammonia" nitrogen the beds become foul when filled so often.

20. In addition to changes in the character of the compounds in the sewage which take place during bacterial treatment, an actual loss
of nitrogen invariably occurs, and this loss was recorded at Poona. It varies considerably. Out of every 100 parts of nitrogen in the fresh sewage, from 10 to 20 were lost in the septic tank, and a further 10 to 20 were lost in the bacteria bed treatment. The total loss experienced varied from 30 to 40 parts. The magnitude of this loss has not apparently any relation to the strength of the sewage, for it was nearly as great when the weak, as when the strong, sewage was being treated.

21. Since the effect of the bacteria beds is to increase this loss so much, it follows that from the agricultural point of view it would be preferable to run septic tank liquid on to land rather than to submit it to the extra purification. And some of the land at Manjri has been regularly irrigated with septic tank liquid in order to see whether this may be done year after year without harm. The last year's report has not yet been published, but my own opinion, formed after personal inspections of the Manjri land, is that this practice is perfectly feasible, provided of course the quantity of sewage employed be not altogether excessive. On the other hand, it is not good agricultural economy to apply sewage to the smallest area possible; the general aim should be to apply it over the largest area that circumstances will admit.

22. Canal silt and waters.—I devoted some little time in 1895 and 1896 to an estimate of the value of the silt which canal water carries with it, and the results were published as Agricultural Ledger No. 5 of 1897.

Samples of canal water were sent by the Executive Engineer from the Upper Eastern Jamma Canal for two years, and the amounts calculated for average quantities of water supplied to wheat, rice and sugarcane. The conclusions arrived at were as follows. (a) The silt during the monsoon period supplies considerable amounts of plant food: 32 lbs. of nitrogen and 41.7 lbs. of phosphoric acid per acre were estimated from one set of samples, and 31 and 42 lbs. respectively from another set; quantities which would be of material advantage to a rice crop. (b) During the cold weather the corresponding amounts of plant food were only very small; 3.8 lbs. of nitrogen and 5.2 lbs. of phosphoric acid were estimated from one set of samples, and only 5 lbs. and 1.1 lbs. respectively from another. Such quantities would not be of material service to the wheat crop. (c) The water supplied to sugarcane over the twelve months was estimated to bring about
8 lbs. of nitrogen, and 10 lbs. of phosphoric acid per acre on to the land, quantities which are quite trivial compared with the requirements of the crop. Naturally the value of silt will vary with the season, and will probably be characteristic of each canal, for it is well known that its nature varies, so far as the eye can tell, from one canal to another. But the investigation was of interest and deserves repetition in other cases.

23. Saltpetre.—I have had opportunities during the year to visit saltpetre factories and refineries. The few descriptions of the methods of manufacture, or as it should be styled “extraction,” of this salt from earth, speak of the earth being “lixivated” and “macerated” with water. No more unsuitable terms could be employed, because they imply the use of comparatively large quantities of liquid with the solid, and the inevitable result of this, if applied to Indian saltpetre earth, would be the production of weak liquors. Such indeed is the method employed in Chili when extracting sodium nitrate from the “caliche.” But the latter contains very high proportions, such as 30 to 50 per cent. of the salt, whereas Indian saltpetre earth contains but 3 or 4 per cent. As a matter of fact the Indian saltpetre worker employs a process of percolation by which a very strong, almost saturated, solution of the salts is obtained at first, and the weaker liquors which follow are simply thrown on the earth and allowed to dry up. By the employment of better percolators more of the concentrated liquor would be obtained, but it is a question whether it would pay to employ capital in this manner. Incidentally also I find that whilst ashes are said to be added to the earth to keep it open and porous, the real advantage lies simply in the fact that these earths generally contain some sodium and calcium nitrate, which are changed by the potash of the ashes to potassium nitrate.

24. Another matter related to this industry that I have had under consideration is the amount of potash salts present in “sitta,” a product of the refinery process. The process of refining saltpetre is a very simple one. A solution, a “mother liquor” in fact from a previous operation, is taken. This solution at the temperature of the air is saturated with both sodium chloride and potassium nitrate, the two salts which are chiefly involved. On raising its temperature however such a solution would dissolve much more (about eight times as much) potassium nitrate, but practically no more sodium chloride. Hence if crude saltpetre, containing, say, 60 per cent. of potassium nitrate and 30 per cent. sodium chloride, is added to such a liquor at
or near the boiling point, the potassium nitrate will dissolve but the sodium chloride will not. Together with the latter salt any sand and dirt and most of the sulphate of the crude saltpetre will remain. This mixture of salts, etc., is fished out of the pan and drained in baskets. It is called "sitta." It is to be observed that the liquid adhering to the sitta is a strong solution of saltpetre, and that the sitta, unless purified specially, must contain a rather high proportion of this salt. Thus I have found from 2 to 14 per cent. and Mr. Hooper met with even higher proportions. This constituent is far more valuable than either common salt or sodium sulphate. Its market value in the refined state is about R7 or R8 per maund, as against a few annas for the others. Consequently the refiner must regard sitta as more valuable on account of its nitrate than in any other sense. In Behar and the United Provinces where I had an opportunity of seeing the processes, sitta was simply treated as a source of saltpetre, but in other places I understand that it is used for skin curing and is possibly washed first in this case. Some samples of sitta also contain rather high proportions of potassium sulphate and chloride. At one time it seemed to me that this material might be considered as a source of these valuable salts, which indeed could be fairly easily separated on the manufacturing scale, but I am doubtful whether the whole quantity involved is very large, and it is certainly not large in any one place; and secondly, I am not sure whether this potash is not in reality required in the refinery to assist in changing the sodium and calcium nitrates of the nitre earth into the potassium salt.

24. The methods employed in the saltpetre industry, though perhaps less perfect than would be the case in a European factory, are nevertheless far more perfect than published descriptions lead one to suppose. The true value of the refinery earth (not the village nitre earth) is probably not what it is generally supposed. The common view is that it is a source of nitrate and that nitrate grows in it in fact, but this is perhaps doubtful.

25. Food grains and fodders.—Information of the chemical composition of Indian food grains and fodders has been gradually collected, and has been published in 1901 and 1903 as Agricultural Ledgers. The latter includes 255 analyses of the grain, straw, etc., of forty different crops.
26. **Oilseeds.**—During the last two years the amount of oil in a considerable number of oil seeds from all Provinces has been determined. The list includes the following:

<table>
<thead>
<tr>
<th>Sampling Code</th>
<th>Genus/Species</th>
<th>Percentage of Oil Varies from (to)</th>
</tr>
</thead>
<tbody>
<tr>
<td>52 samples</td>
<td>Sesamum indicum</td>
<td>45 (56)</td>
</tr>
<tr>
<td>61</td>
<td>Brassica (several varieties)</td>
<td>27 (49)</td>
</tr>
<tr>
<td>20</td>
<td>Eruc sativa</td>
<td>25 (36)</td>
</tr>
<tr>
<td>31</td>
<td>Guizotia abyssynica</td>
<td>36 (43)</td>
</tr>
<tr>
<td>54</td>
<td>Linum usitatissimum</td>
<td>35 (44)</td>
</tr>
<tr>
<td>30</td>
<td>Carthamus tinctorius</td>
<td>22 (33)</td>
</tr>
<tr>
<td>(i) 58</td>
<td>Arachis hypogea</td>
<td>39 (59)</td>
</tr>
<tr>
<td>100</td>
<td>Ricinus communis (kernel)</td>
<td>55 (71)</td>
</tr>
<tr>
<td>10</td>
<td>Poppy</td>
<td>44 (48)</td>
</tr>
<tr>
<td>(ii) 80</td>
<td>Cotton seed</td>
<td>15 (21)</td>
</tr>
<tr>
<td>10</td>
<td>Mohwa seed</td>
<td>46 (49)</td>
</tr>
</tbody>
</table>

In some cases the seed from a certain locality was distinctly superior. Thus samples of sesamum from Kanara contained appreciably more oil than those from most other localities. But considered as a whole, differences in the amount of oil are not readily traceable to locality.

As to the relation of variety to percentage of oil, the "Mauritius" earth-nuts from Madras districts contains 45 to 49 per cent. of oil against 40 to 45 in the "local" variety, a well marked difference. But the information supplied was usually quite insufficient to render differentiation on this point possible. Indeed the botanical separation of most crops is not perfect enough at the present time to admit of this. Information regarding the Madras earth-nuts was published in the Madras Agricultural Bulletin No. 41 of 1900. The results of the more recent and major part of this work has been supplied to all Directors of agricultural departments but has not been otherwise published.

27. **Poisonous plants.**—Under this head I referred to several cases of poisonous plants in my last report, all of which contain a cyanogenic glucoside or glucosides, from which prussic acid is readily produced by the action of a hydrolytic enzyme. The plants specially mentioned were cassava root and jowar (Andropogon sorghum). Early in 1904 I examined a series of cassava roots for both free hydrogen cyanide, which has been repeatedly stated to be present, and for a cyanogenic glucoside. By carrying out the experiments under conditions which would prevent enzymic action on any possible

(i) Done partly in 1900.
(ii) Done partly in 1902.
glucoside, I was able to prove the entire absence of prussic acid in the root. On the other hand, it was as readily ascertained that these roots invariably contain a glucoside, accompanied by an enzyme, and that when the roots are crushed prussic acid is rapidly formed. Tapioca roots from Cawnpore and Assam have also been examined, and none has been found free from this glucoside, though the quantity appears to vary much. The largest amount I have obtained from any roots was 1.25 grain of prussic acid per lb., and the smallest about 0.07 grain. The terms "sweet" and "bitter" cassava cannot properly be employed to indicate freedom or otherwise from this ingredient.

The glucoside is apparently situated to a great extent in the pith. Boiling the root destroys the enzyme and prevents the formation of prussic acid afterwards. In an experiment on this point, three roots were boiled for three hours, and two hours later a part of one was crushed with water, and distilled half an hour later. A very faint trace (estimated at 0.04 grain per lb.) of prussic acid was obtained. This is not surprising, because during the initial stages of heating it is quite possible for a small part of the glucoside to be acted upon by the enzyme when the cells become fractured and before the temperature has risen sufficiently to inhibit the action, though such opportunity for the action is extremely limited, and it is quite safe to eat the boiled root. On the other hand, I am not satisfied that roasting the sliced root, as is done in the West Indies, is quite safe. In my experiments I found that prussic acid is always found in small quantity by slicing the root, a circumstance to be expected, because the enzyme and glucoside are naturally thus brought in contact, and it does not follow necessarily that roasting would dissipate all the prussic acid formed. A misconception exists in the mind of some writers in newspapers on the subject. Because this acid is a volatile substance, therefore it is assumed that to merely expose the roots to the air is sufficient to provide for its dissipation, but this is a misapprehension, for it requires somewhat protracted distillation to effect this. In the preparation of starch, the prussic acid will naturally be formed, but will be effectively removed from the starch in the wash waters, so that here no danger exists.

28. In May 1904 a case of poisoning occurred among the work bullocks of the Manjri farm. This was readily traced to the glucoside dhurrin, which was present in a quite unusual quantity in the fodder. The specimen which reached me produced, when crushed
with water, 10 grain of prussic acid per lb. The presence of this glucoside in *Andropogon sorghum* is well known, but usually the quantity is only small.

Some of the seed of the sorghum which had been so fatal to work bullocks at Manjri was obtained and grown at Dehra, but although the glucoside was present in the leaves, the quantity never approached at any period of growth that which had been found in June. It is intended to try again at Pusa to detect under what conditions the glucoside is produced in largest amount.

Other materials which have been examined are Rangoon beans (*Phaseolus lunatus*), Val (*Dolichos lablab*) field peas, gram (*Cicer arietinum*) and Mung (*Phaseolus mungo*). Prussic acid was obtained from all these seeds in quantities varying from 1 up to 1 1 grain per pound. Soy bean (*Glycine Soya*) was found free from cyanogenetic glucoside.

29. *Sugar.*—The quality of the sugarcane crop in different parts of India is another subject on which much precise information has been ascertained. Commencing with an examination of the cane and *gur* at the Poona, Cawnpore, Dumraon and Burdwan farms, the operations have been gradually extended to other districts. In 1897 the canes in several of the Deccan districts were included, and more recently in 1903-04 and 1904-05 the canes of the Chhindwara, Betul and Balaghat districts of the Central Provinces were the subject of experiment. The result of this extensive work has been to show that the amount of cane sugar in the juice varies from about 10 up to more than 20 per cent. (grammes per 100 c.c.). The latter has been found in some cane of the Balaghat district and at Pusa, and shows what a high standard of cane India possesses, though it is not met with everywhere. Some of the cane at Samalkot is of a similarly high quality. (*Vide* Madras Bulletin No. 51.)

30. The investigations have also shown a considerable variation in the amount of juice expressible by the common iron mill, some canes yielding not more than 60 per cent., whilst from others 70 per cent. may be obtained. Broadly speaking the thick canes yield more juice than thin ones.

31. Again it has been demonstrated that excessive rain and irrigation or manuring tend to produce a juice containing less sucrose and more glucose than it would otherwise do. Whilst the crop is benefited by heavy manuring there is a limit which should not be exceeded. At Poona, manure containing such a large amount as 350 lbs. of
nitrogen per acre may be used economically, but at Cawnpore this quantity was found to be apparently excessive.

32. The quality of the "gur" varies very greatly indeed, as the following sufficiently illustrates:

<table>
<thead>
<tr>
<th></th>
<th>Fyzabad</th>
<th>Balaghat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>63.14</td>
<td>85.81</td>
</tr>
<tr>
<td>Glucose</td>
<td>9.91</td>
<td>6.49</td>
</tr>
<tr>
<td>Ash</td>
<td>3.65</td>
<td>...</td>
</tr>
<tr>
<td>Water</td>
<td>8.26</td>
<td>...</td>
</tr>
</tbody>
</table>

These are extreme cases it is true, and the more frequent variation might be stated as: 75 per cent. sucrose plus 10 per cent. glucose in better samples, against 65 per cent. sucrose plus 15 per cent. glucose in poorer samples.

32. A good deal, say, 5 to 15 parts, out of each 100 parts of sucrose in the juice, becomes changed to the non-crystallisable glucose during the boiling process. This change is effected by the acids naturally present in the juice, and attempts have been made, both by me as also by others, to neutralise these acids with lime, and so prevent their inverting action. The result has not been altogether a success. Among a few practically feasible substances which may be employed, lime is one, and at Cawnpore it was used effectively; but great difficulty is experienced in the field (and in the absence of special assistance) in avoiding the use of too much. In the latter case a dark coloured nearly black gur is obtained, which has no value in the bazar, although it may be better for the refiner than the usual article.

Greater success has attended the efforts of Syed Mohammad Hadi, Assistant Director of Agriculture, United Provinces, who has employed sodium bicarbonate. (Details regarding this will be found in the United Provinces Bulletin No. 19 of 1904.)

33. Success in the preparation of a better class of raw sugar is probably more readily attained by preparing the semi-liquid "jaggery" or "rab," and then separating the crystal from the molasses. For this purpose Messrs. Thomson and Mylne introduced a hand centrifugal separator some years ago, and from estimates which I made, more than half of the sugar in juice may be obtained as "brown" sugar containing over 92 per cent. of sucrose and about 2 per cent. of glucose; the molasses, containing the remainder of the sugar, may be then boiled down and produces an inferior gur of (say) 65 per cent. sucrose and 14 per cent. glucose. Syed Mohammad Hadi has likewise adopted a hand
centrifugal machine among his improvements, and the product is of
even better quality than my Behar samples, and contains upwards of 97
per cent. of sucrose plus only 15 per cent. of glucose. It is in this direc-
tion, as well as in that of good cane and good cultivation, that this
industry must be improved. It is true that of two million tons or so of
sugar produced in India nearly the whole is consumed as gur, and only
a small part is refined, still the demand for refined sugar steadily
increases; the imports of sugar have risen from about 100,000 or 150,000
to 250,000 tons in the last ten years. Great fluctuations have occurred,
but a survey of the statistics seems to leave no room for doubt that the
time is rapidly coming when a high proportion of the sugar produced
in India will be refined, and the gur of today is not well suited to this
purpose.

The preparation of brown sugar from rab by the cultivator has
several advantages over the more general system of sending cane
to the refinery. It means that far less has to be expended on transpor. The refinery has less molasses to deal with. Also both
parties are more independent. If a refinery buys cane, dependence is
placed on the cultivator to grow it and supply it within a certain small
radius, whilst conversely the cultivator is dependent on the refinery
to buy it. If however the cultivator crushes his own cane and prepares
"rab" and brown sugar of the quality I met with in Behar, he can
sell it in the open market, and at the same time the refiner is not
dependent on the cultivator in his immediate vicinity.

34. Dairy produce—Milk.—This subject has perhaps received less
attention than most others of an agricultural nature in India. Numer-
ous small dairies exist, but the whole subject of dairying has not
received a fraction of the attention in India that it does in Europe and
America. In these countries the whole of the milk and butter is
regularly examined chemically and a very exact knowledge gained of
their characteristics. In India this control is conspicuous by its absence.
I had one opportunity, when at Poona and Madras in 1899, of examin-
ing a series of samples of the milk of individual cows and buffaloes, and
this proved of considerable interest. The results were published before
the Society of Public Analysts, London, in 1901, and may be very
briefly summarised as follows:—(a) Indian cow's milk is not poor, but
as rich in butter fat as that of European cows, (b) that of buffaloes is
even richer, (c) the general composition of Indian cows' milk is precisely
similar to that of European cows, and the relation between the proteids,
sugar and mineral matters is the same, (d) that buffaloes' milk contained
rather more proteids than cows' milk, but the proportion of sugar and mineral matters corresponds closely to that of cows.

35. For the Forest Department a good many specimens of various kinds, e.g. barks, fruits, latex, paper, rosin have been annually examined.

36. Lectures.—For some years I delivered courses of lectures; at the College of Science, Poona, from 1898 to 1903; at the Agricultural College, Saidapet, from 1898 to 1904; and at the Imperial Forest School from 1898 to 1904. I have now been relieved of this duty as it was found to interfere seriously with the other work of the department.

37. From December 1904 until June 1905 Babu Har Narain Batham, M.A., of the Agricultural School, Cawnpore, was deputed to go through a special course of training in this laboratory.

38. Publications.—A list of publications will be found at the end of this report.

39. Establishment.—The establishment of this office has been gradually increased from one up to seven assistants for the chemical laboratory, and one clerk. Only five of the appointments are filled at present, and of these two are probationers. Among the former I have much pleasure in mentioning the following as having done good work: Mr. B. B. Price and Babu Subodh Chandra Kar, assistants in the laboratory, Muhammad Ziauddeen Hyder, the clerk, and Chandi Pershad, a laboratory servant.

40. During the year one of the older assistants died, and one of the probationers has resigned, as he found the work too hard. The new senior appointment has been filled by a probationer of whom I have great hopes; and one of the junior appointments is held by a probationer. There are at present two appointments vacant.

41. There has been and still is great difficulty in finding suitable assistants, and I refer to the matter here in the hope that the publication of the difficulty may aid in removing it. A book knowledge of chemistry is most useful and necessary, but taken by itself it is not sufficient. Young men, the recipients of the highest university honours, and after spending two or three years specially in the chemical laboratory, work with dirty vessels, are generally untidy, and are careless and inaccurate in simple arithmetic. Cleanliness, order and neatness should be a standing rule in any laboratory, and if students who did not comply with it were dismissed from the laboratory, a great advantage would be felt both by employers and employed in after life. Two of the assistants of whom I have had experience this year were both characterised by these grave faults, and they cast great discredit
on their universities. Since these qualifications are essential, it is useless to confirm any appointment until they are obtained.

J. WALTER LEATHER, Ph.D., F.I.C.,
Agricultural Chemist to the Govt. of India.

_Dated the 22nd July, 1905._
Part IV.


I. PREFATORY.

1. I joined the Department of Agriculture early in April 1902, and have held charge of the office of Cryptogamic Botany of the department since that time. A year previously was spent attached to the Botanical Survey of India in the Royal Botanic Gardens, Calcutta, but as the time was occupied in acquiring some knowledge of the conditions of mycological work in India and was not specially devoted to the agricultural aspect of the science, no reference to it will be contained in the following report.

2. The subject of Cryptogamic Botany includes all the non-seed-bearing plants, that is to say, the Algæ, Fungi, Mosses and Ferns and their allies. The chief group of agricultural importance is the fungi and my work has lain mostly with these plants, being such as is usually performed by a Mycologist. In a country of the size of India, with its differences of crops and climates, touring has naturally been of the utmost importance. By this means a knowledge has to be obtained of the principal diseases of crops induced by fungi. The information thus gained has to be worked out in the laboratory, life-histories studied and the general relations between host and parasite examined by laboratory methods. Field experiments under close observation are often required to complete the work and an experimental field of several acres was taken up for this purpose rather over a year ago.

3. The fungus flora of India has not been the object of many researches. Collections of fungi made by individuals have been sent to Europe for identification from time to time. The value of this may be gauged by the fact that on several occasions the same fungus sent to two different authorities has been differently determined. Two Mycologists have, however, actually worked in the country, Doctors Cunningham and Barclay, both medical officers in the employment of the
Government of India, and their work has been of the greatest value. Type collections, that is to say, specimens actually named by the authorities by whom they have been examined, are practically non-existent in the country. One of the first essentials is, therefore, to get together a herbarium of fungi collected in India and preserved for reference. Over a thousand specimens have been obtained and in part determined, and these are stored in the herbarium attached to the office. In addition nearly 900 specimens of parasitic fungi have been purchased from abroad for comparison with the indigenous species.

II. ESTABLISHMENT, TOURING AND GENERAL.

4. Establishment.—A clerk and two fieldmen were appointed in 1902-03. In 1903-04 two assistants were added and in the present year a third assistant and two more fieldmen. The difficulty of obtaining good men for the scientific posts has been sometimes acutely felt.

5. Touring.—I have travelled about 40,000 miles in India in the three years under review, 170 days were spent on tour in 1902-03, 127 in 1903-04 and 151 in 1904-05. The following are the principal tours which have been made and their general objects:—

1902-03.—I visited Coorg in July-August in connection with "spike" disease of sandal trees, Assam in August-September to study some tea diseases, and Bombay (Poona and Surat) in September-October for a preliminary examination of field crop diseases. A short time was spent in October at Nagpur in the investigation of the tur (Cajanus indicus) wilt disease. In November I visited Eehar where a serious outbreak of sugarcane disease had occurred. Several weeks were spent at Cawnpore farm in the spring of 1903 working at cereal rusts; and Hissar in the Punjab was visited for the same purpose in February and April.

6. 1903-04.—The Bombay government farms at Surat and Poona were visited in August and some experiments in the treatment of ground-nut and tur diseases conducted. After seeing the Government sugar station at Samalkot, and spending some days at the Government Botanist's office in Madras working through his collections of crop parasites, I toured in Mysore in September visiting some of the coffee districts and continuing the study of sandal spike disease. Several sugarcane diseases were investigated in Bengal in October and November. In January work was continued at Cawnpore on cereal rusts, and a visit was paid to Pusa in February to examine the sugarcane varieties there for disease at planting.
7. 1904-05.—A short visit was made to Saharanpur early in August to inspect the fruit trees in the Government gardens in order to decide on the freedom from disease of the grafts and seedlings required for the new fruit garden at Pusa. I spent some days at the Royal Botanic Gardens, Calcutta, in the same month, in the identification of specimens, and have to acknowledge my indebtedness to the staff both on this and on several other occasions for much assistance received. I subsequently investigated a fungus disease of the casuarina plantations at Chatrapur in the Ganjam district of Madras. In September I toured in Mysore in connection with the investigation of spike disease of sandal trees, and in the Coimbatore district of Madras for a preliminary examination of field crop diseases. Pepper vine disease in Malabar and Wynaad and tea and coffee diseases in the Droog range of the Nilgiris occupied most of October, and in the same month I also studied a disease of prickly pear in the Trichinopoli district which the Forest Department hoped might serve as an effective check to the extension of this troublesome plant. Three visits were made to Pusa, in January, February and April, in connection with the Board of Agriculture meeting, sugarcane diseases and the discussion of work connected with the institution with the Inspector General of Agriculture and the other members of the staff; and two to Calcutta, in January and May, in connection with the proposed publications of the department and other departmental matters. A preliminary investigation of some plant diseases in Assam was made in May and June, Shillong, Wajhain and several places in Sylhet having been visited.

8. Munshi Inayat Khan, fieldman, collected specimens in the United Provinces, the Central Provinces and Berars, Central India, Rajputana and the Mussoorie and Simla hills, in the spring of 1904, all primarily in connection with cereal rusts. He also visited Saharanpur in March 1905 in a search for disease-free sugarcane varieties. Mr. Mitra, third assistant, visited Lyallpur, Punjab, in March 1905 to make notes on an outbreak of wheat rust there. Mr. Basu, first assistant, worked in the Government Botanist's office, Madras, in May, 1905, chiefly in carrying out inoculations of pepper-vines with the pepper Nectria but was obliged to leave through ill-health before the work was completed.

9. Provincial work in fungus diseases.—It is satisfactory to record an increasing interest in the study of fungus diseases of plants in several provinces during the past few years. In Madras, the government farms at Samalkota (sugarcane), South Arcot (ground-nut, etc.), and Taliperamba, Malabar (pepper), the last two of which
have been started during the past year, are carrying out investigations in the diseases of these plants under the direction of the Government Botanist. The South Mysore Planters' Association has also determined this year to start an experimental garden, where the study of the behaviour of different varieties of coffee to disease will probably be one of the lines of work. In Bombay some experiments in the direction of finding varieties of tur resistant to the wilt disease are in progress at the Kirkee farm, and some work has also been done with the ground-nut disease. At Cawnpore the study of cereal rusts has been taken up by the Deputy Director of Agriculture, United Provinces, and a paper has been prepared in conjunction with myself detailing the results of our work up to 1904, to which has been added a note on the relations of the weather to rust in wheat by Mr. Moreland. The Board of Agriculture has recommended (Proceedings of meeting of January, 1905, paragraph 6) the commencement of work with a view to obtaining varieties of wheat resistant to this disease at a locality in the Punjab and at Hoshangabad in the Central Provinces. The treatment of smut on juar and wheat has been found successful at the Nagpur farm and the practice introduced to the cultivators. At Shillong experiments in spraying for potato blight have given a measure of success recorded in the last year's Report of the Department of Agriculture, Assam. A considerable correspondence has arisen in connection with these experiments and as a consequence of frequent enquiries from superintendents of farms, etc., regarding fungus diseases.

10. Epidemics of fungus diseases.—Plants are subject in the same measure as animals and man to outbreaks of epidemic disease. Several of these have come to my notice since I arrived in India. Potato blight, for instance, was first noticed in Lower Bengal in 1900 and reached epidemic violence in 1902. It had not previously been known in the plains, though frequently severe in the hills of various parts of India. The mysterious disease of sandal known as "spike" first received detailed mention in a Memorandum by the Deputy Conservator of Forests, Coorg, in 1899. Since then it has rapidly extended, a large part of the Mysore and some of the Madras sandal areas being now infected. The betel palm plague in Sylhet, first reported this year, has only been noticed within the past few years but has destroyed fifteen-sixteenths of the palms in some gardens visited. A mildew on tobacco, recently discovered, threatens an epidemic in Bengal, but has so far been reported from one district only. The
palmyra palm disease in the Godavery delta, apparently of recent origin, appears to have acquired an epidemic frequency this year. The coffee twig disease in the Nilgiris and Neliampatties investigated last year is stated to have appeared about three years ago. It has already done much damage in the infected districts. Of a somewhat different order are the cereal rusts and red-rot of sugarcane which are endemic but have their periods of maximum and minimum intensity. Of the natural laws governing these we have at least some indication. In the case of rusts climatic conditions are apparently all important, while the red-rot of sugarcane probably increases with the increasing number of diseased canes planted, and receives a check when a variety becomes so diseased as to oblige the cultivators to replace it with a less infected kind. The climatic influences in their relation to rust received an illustration last year, when conditions in the earlier part of the season being favourable, rust appeared extremely early. There was every indication of a bad attack resulting, but the disease seemed to receive a check from the great cold experienced this year in Northern India and a general outbreak was averted; though in parts of the United Provinces, in Behar and in Jubbulpore, where the conditions were less unfavourable, severe damage was caused.

11. Treatment of fungus disease.—The direct destruction of fungus parasites, in the way that insect pests are dealt with, is often impracticable with the means at present at our disposal. These minute parasitic plants usually occupy the interior of the tissues and cannot be reached by the substances employed without damage to the latter. But their reproductive bodies or spores are ordinarily formed on the surface and set free into the air or soil, and the extension or germination of these may sometimes be prevented. For this purpose spraying with fungicides or removal and burning of diseased parts are employed. But spraying, which is in its infancy even amongst the more highly educated farmers of Europe, is not likely to be adopted generally by the ryots in India for some time to come. And indeed the number of diseases that I have seen in India which are likely to repay spraying is small. Of the ordinary field-crop diseases, potato blight and ground-nut leaf-spot are the chief, and even in these reliable results from experiments in India are not yet available. No special attempts have, therefore, been made to introduce spraying into practice. The other method of preventing spore dissemination, the destruction of diseased parts, is capable of wide application in a number of cases, and this practice has several times been explained and recommended. A group of diseases, chiefly
those known as smuts, is conveyed on the seed. Disinfection here is often comparatively easy and cases of its practical application will be mentioned below. Another group of diseases, chief of which are potato blight and probably sugarcane red-rot, is transmitted by the use of internally affected seed, and the supply of healthy seed is the first requisite in these cases. But for many diseases, for cereal rusts, coffee leaf-disease, tur and pepper wilts, etc., the breeding of resistant varieties offers the chief hope of eventual success. I look forward to the time when private seedsmen or Government departments of agriculture will make the supply of resistant varieties and of disease-free seed one of their important lines of work.

III. INVESTIGATIONS OF CROP DISEASES.

12. Potato diseases.—An enquiry was made in 1902 into the diseases affecting potatoes, their prevalence and distribution. Potato blight caused by *Phytophthora infestans* was found generally present in the hills, being prevalent in the Himalayas from Bhutan on the east to beyond Simla on the west, in the Khasia hills and in the Nilgris. In the plains it is less common being obtained from Bengal only. "Bangdi" blight, characterised by blackening of the stems and tubers, is a serious disease in Bombay. It is allied to those potato diseases in other countries which have been ascribed to bacterial action. Other diseases of minor importance occur in various localities. An account of the history of these diseases, their causes, and the remedies suggested was published in the Agricultural Ledger series in 1903.

13. Wheat rusts.—The study of these, probably the most serious of any crop diseases of India, was commenced in 1903, and has continued each season. The species of rust fungi concerned, their life-history in relation to other plants and the behaviour of different varieties of wheat to their attacks required investigation, practically nothing being known on these points. Much of the work was done in conjunction with Mr. Hayman, Deputy Director of Agriculture, United Provinces, at the Cawnpore farm. A first paper was published in 1903, and a second, in collaboration with Mr. Hayman, has been in the printers' hands for many months, a delay having occurred in printing the plates. Three varieties of rust have been found, the black rust caused by *Puccinia graminis*, the yellow rust caused by *P. glumarum* and the orange rust caused by *P. triticina*. All three are known in Europe. Their distribution has been in part investigated, and search made for other plants on which a
part of the stages in the life-history may be passed. The aecidial stage of black rust, described by Barclay on Simla barberries, has not been found in the hills further east, nor in the Nilgiris. The barberry rusts of these localities are unconnected with wheat rust. This rust, too, was in 1904 the prevalent rust in the central parts of the country, at distances from the habitat of the barberry so great that it is impossible to suppose any connection to have existed. Yellow rust has been found on two grasses, *Phalaris minor* and *Brachypodium sylvaticum*, and Barclay mentions that black rust occurs on a grass, probably *Brachypodium distachyum*, at Simla. But, the rusts on the first and third of these do not readily pass to cereals. No other host has been found bearing any of the three rusts, the one remaining likely "intermediate host" *Launea asplenifolia*, the aecidium of which was described by Drs. Cunningham and Prain in 1896, and considered to be possibly connected with orange rust, having been shown experimentally to have no relationship. The conclusion has been arrived at, therefore, that the influence of other plants on the disease need not be taken into consideration. The means by which the disease persists from one wheat season to another are still unknown, the indications being that spore infection from the spores of the previous year's crop will not account for it. The alternative hypothesis put forward by Professor Eriksson of Sweden that disease germs are conveyed in the seed in the form of a protoplasm mingled with that of the wheat plant, has received no experimental support from our work, though it offers a more comprehensible explanation than any other. The experiments are still in progress and consist mainly in growing a few plants of wheat each year in germ-tight cases to determine if any of them will develop rust under conditions which prevent outside infection. The specialisation of the races of the parasite on wheat, barley, etc., *i.e.*, the degree to which the form on each species of host is confined to that host, was investigated. Both the black and yellow rusts of wheat were found capable of passing to barley in some cases. Attempts to produce the yellow rust of wheat from barley failed. Orange rust could not be inoculated on barley, and none of the three on oats. The specialisation of the yellow rust differs to some extent from that observed in Europe. Enquiries made in the Punjab and elsewhere indicate that rust is induced by cloudy moist weather at the season of rust prevalence. This is in harmony with the meteorological observations analysed by Mr. Moreland in their relation to rust in some selected districts of the United Provinces.
14. The chief experiments carried out in 1904-05 were the following. An attempt was made to determine if the first outbreak of rust would be in any way affected by submitting the seed to various degrees of heat before sowing. On Professor Eriksson's theory it was thought possible that a difference of a week or two might be apparent between the first cases in the treated and untreated plots, for it is possible that if any internal germ exist it may be destroyed by heating. In experiments on seed treatment against rust previously carried out in other countries no distinction has been made between the first outbreak, which is usually slight, and the secondary spread caused by spores from the first attacked plants. Yet it is certain that the two sets of cases have a different origin, for the earlier cases can only arise from infection carried over in some way not yet understood from the previous year's crop. Nothing was observed, however, which would lead one to hope that seed treatment by heat will affect even the first cases. An experiment was also made to determine the degree to which the susceptibility of a wheat to yellow rust is dependent on its liability to infection by uredospores produced on the first attacked plants. A tent of cloth sufficient to arrest the passage of air-borne spores was erected over a small plot before rust appeared. On opening, some weeks after the first outbreak, the marginal plants which were exposed to infection carried in by insects at the ground level were found considerably rusted, while those in the centre largely escaped; 160 rusted leaves being obtained from the marginal 78 square feet and only 24 in the internal 112 square feet. Hence in this case susceptibility evidently depended on the liability to secondary uredospore infection. Several determinations of the thermal death-point of the uredospores of yellow rust were made in February and March. Moist heat between 45° and 50°C. for five minutes was found to destroy the power of germination.

15. Other rusts.—Over 70 species of *Uredinae* parasitic on different plants have been identified. Several of these are serious parasites of cultivated crops. Amongst the more important are *juar* rust (*Puccinia purpurea*), *bajra* rust (*P. Pennisetii*), linseed rust (*Melamp. sora Lini*), rusts on indigo, lentil, lucerne, etc. (species of *Uromyces*), several members of the genus *Peridermium* on conifers, teak rust (*Uredo Tectonae*), castor oil rust (*Melampsorella Ricini*), etc. The *juar* and *bajra* rusts were considered identical by Barclay and described as *Puccinia Pennisetii*. They differ however in several important particulars and must be considered two distinct species. Information is
required regarding their life-histories and the extent of the damage caused by them. The linseed rust is very destructive. At Pusa this year it was confined to indigenous varieties and imported flaxes were entirely free. As botanically both plants belong to the same species this affords an indication that the breeding of a rust-resistant linseed is possible.

16. Sugarcane diseases.—The most important is red-rot, the disease induced by *Colletotrichum falcatum* which has been so destructive on the East Coast and in Bengal, and which is common elsewhere. Inoculation and field observations both point to the probability of the disease being conveyed chiefly in the canes used for planting and not primarily by spores. The field observations were carried out mainly in Behar where the recent development of sugar manufacture and planting in European hands has directed particular attention to it. In the localities where it was chiefly observed the disease was confined to one variety of cane. The fungus was found in the young plants of this variety and numerous cultures obtained from sets prepared for planting. Spore production was scanty in the fields, and it was found that other varieties could be planted in the diseased land provided that they came from healthy stock. This year inoculations from cultures grown on raw cane, and therefore not likely to have lost their virulence as a result of artificial culture, were tried both on sets at planting and on growing canes. No disease resulted though the canes were grown in boxes to maturity and the fungus preserved its vitality in the short length of cane tissue which it had been able to infect. Further experiments will be required to establish that the disease is seed-borne, and the work is being continued. The outlook is hopeful, for should this view be confirmed, treatment will resolve itself into the selection of unreddened sets for planting, a simple matter. The effects of a rigorous selection of healthy sets for planting on the resulting crop was apparent at Pusa, where 23 varieties from different parts of the country were grown in 1903-04 under somewhat unfavourable conditions. They gave on the whole excellent results, in spite of having had in several cases to undergo a long railway journey. The analyses, which were conducted by an assistant from the Agricultural Chemist's office kindly lent for the purpose, gave as an average of the 23 varieties 18·13 cane sugar and 498 glucose, while excluding six varieties grown under the shade of trees in unsuitable soil, the remaining varieties gave an average of 19·11 cane sugar and 380 glucose. As the object in view is to
establish a stand of healthy cane for future experiments at Pusa, an area of over 5 acres has been planted this year with these varieties submitted a second time to careful selection under my supervision.

17. A set-rotting fungus, *Sphaeronema adi posum*, was found in Behar and Dehra Dun in 1903-04. Its life-history, which possesses several points of interest, was followed and the relations of its different spore forms determined. Experiments to test the infection of sets in the field failed through an attack of white ants, but the fungus was found capable of rapidly rotting cut canes in the laboratory. An examination of failed sets obtained in the vicinity of Dehra Dun in 1904, gave this fungus as the apparent cause of the rotting in 61 cases, *Diplodia cacaoicola* in 6, *Schizophyllum commune* (a doubtful parasite) in 5 and white ants or rot from undetermined causes in 89 sets. Inoculations made in 1904 showed that this fungus does not readily attack growing canes.

18. The "pine-apple-disease" producing fungus, *Thielaviopsis ethaceticus*, which is very destructive to cut sets in other countries, has not been found indigenous in India, but two occasions have come to my notice of its introduction from Java and Mauritius in both of which I was able to obtain the destruction of the consignment. As the monetary loss in one of these cases was considerable, and as the danger of introducing into India cane diseases from other countries is a very real one, I made the following suggestions for Government action in 1903:—

(1) that cane imports for the purposes of field cultivation should be prohibited; (2) that importation for experimental cultivation should be permitted subject to the proviso that full information should be supplied to the department of agriculture and the cane be liable to inspection and to compulsory destruction should it be found diseased; and (3) that the departments of agriculture should be exempted from the action of these checks. Under case (2) the question of the advisability of providing compensation was raised. Government did not however consider that the time had come for such action, and it was decided only to issue through the press a warning against the introduction of diseased canes from Java and Mauritius.

19. Various other diseases of the leaf and stem of sugarcane were investigated in Bengal in 1902 and 1903, and a full illustrated account has been completed since May 1904, but the printing of the plates has delayed its publication.

20. Fermentation of cane sugar by fungi.—In June and July 1904, the effect produced by the two fungi *Colleiotrichum falcatum* and
Spharonema adiposum on solutions of cane sugar was investigated in conjunction with the Agricultural Chemist. The loss of crystallisable sugar caused by the red-rot disease, due to the first of these, is altogether out of proportion to the area of cane infected which is often only one or a few internodes. Proof was obtained that this results from the action of sugar-inverting ferments produced by the fungi, that of Spharonema being considerably the more active. It appeared probable from the experiments that the ferment is not diffusible but is formed and remains within the cells of the fungi.

21. Spike disease of sandal.—The sandal-growing areas in Mysore and Coorg infected with this disease were visited in 1902, 1903 and 1904. No parasitic cause was discovered. The other causes assigned, such as fire, poor soil, want of shade, the presence of the Lantana shrub, which has invaded a considerable portion of the infected area, etc., were found to be insufficient to account for the facts. Observations regarding the infective nature of the disease were made and its extension watched. A large number of inoculations with different parts of the diseased tissues were tried but all have failed to take. As the prosecution of the enquiry would entail prolonged investigation carried out on the spot, the disease being most obscure, and as my time is fully occupied elsewhere, I was obliged to abandon the work until a more favourable opportunity arises. A note was published in the Indian Forester in 1903 and a critical examination of the views expressed on the disease by the Conservator of Forests, Mysore State, in the same in 1904.

22. Tea and coffee diseases.—A number of these have been seen in Assam, Dehra Dun and South India. Red rust caused by the Alga, Cephaleuros virescens, is probably the most serious tea blight. It was found widely distributed on jungle trees and shrubs and can doubtless pass to tea from these. From its absorbent character it was considered probable that spraying with Bordeaux mixture would prove advantageous, and this practice has been recommended by the scientific officer of the Indian Tea Association as a result of his experiments with it on tea estates. Thread-blight which is prevalent on tea in some districts appears to spread mainly by the blowing about of attacked leaves, some experiments in 1902 indicating that it cannot attack the bushes from below as was suggested by the Kew authorities at one time. Stump-rot or root-rot caused by various members of the genus Resellinia is common on both tea and coffee estates. These diseases
ordinarily originate in old rotting jungle or shade tree stumps. Hence on cleared jungle land they may become alarmingly frequent. Where, however, the nature of the disease is understood and prompt measures are taken, the damage can often be checked. Certain trees only seem capable of starting the disease as they rot, and the destruction of the roots of these by uprooting or burning out, has in some places been found practicable. As the number of foci of disease is often small and as propagation normally occurs through the upper layers of the soil, surrounding diseased areas by a trench is almost always successful in preventing its extension. Spore-production is not common and probably plays no considerable part in the history of the disease. A short note on stump-rot in tea and coffee was prepared for the South Mysore Planters' Association and printed in their Proceedings in 1903. Another root disease of tea which has appeared in a few localities was investigated in 1902. It was found due to an undescribed fungus of the genus Diplodia. Recently a serious coffee disease has appeared in the Nilgiris and Nelliampatties. It is characterised by the dying back of the twigs, loss of leaves and rotting of the berries. It is constantly associated in the cases seen with a fungus (Glæosporium) to which the cause is assigned. Similar diseases are known to be produced by fungi of this genus and of the allied one Colletotrichum on orange and other trees. Experiments on spraying with Bordeaux mixture, the effect of wind belts, etc., are being carried out on an estate in the Nilgiris, but their result has not yet been reported. A number of other diseases was collected and an account of them will be published at a later date.

23. Tur wilt.—Cajanus indicus (tur or arhar) suffers commonly from a disease marked by the complete or partial drying up of the plant. It has been found over a large part of Northern India. The cause of the disease, which was first investigated in 1902, is a Nectria fungus which laboratory study has shown possesses four distinct spore-forms. Numerous experiments have been made in order to trace its mode of action. It is principally soil borne but also carried by the wind and possibly on the seed. Inoculations, chiefly made in 1904-05, have given very irregular results, the best being 20 per cent. of successes, while several series altogether failed. No explanation is available of this behaviour.

24. Pepper diseases.—The pepper vine disease in Malabar which has caused very great losses in the Wynaad and appears to be endemic on the Malabar coast was found constantly associated with a Nectria
which on cultivation in the laboratory proved to be indistinguishable from that of the *tur* wilt above-mentioned. As the causal connection has been proved by inoculation in the latter case, and as the two diseases are entirely similar in their pathological aspects, little doubt remains that they are identical. Arrangements were made for inoculation on pepper vines grown for the purpose by the Government Botanist, Madras, but the illness of Mr. Basu, who was deputed to carry them out, obliged their abandonment while still unfinished. Delays and difficulties of this character are inseparable from work attempted at a distance from head-quarters. The treatment of these wilt diseases resolves itself into the attempt to obtain resistant varieties, for they are not amenable to direct treatment. In the case of an annual like *tur* this should not be too difficult and varieties have been got together for the purpose at Kirkee and other farms. In a slow growing plant like pepper it becomes a formidable problem. The newly established pepper station in Malabar will no doubt be able to devote attention to this subject.

25. A second pepper vine disease has been known for a number of years in the Mysore ghat tracts. Instead of mere drying up of the vine without injury to the standard or living tree on which it grows, as in the case of the Wynaad disease, vines and standards are killed out in patches in this other form. The examination of a large number of specimens sent to Dehra showed the disease to be caused by one of the root rotting parasites of the genus *Rosellinia*. The particular species proved to be *R. bunodes* which has not previously been noted as a parasite. Treatment is hopeful in this case as the number of foci of disease is usually small and propagation can probably be checked by trenching as in the case of the similar diseases of tea and coffee.

26. Other wilt diseases.—Similar diseases to the pepper and *tur* wilts have been observed in Deccan hemp, soy bean and fennel, but the *Nectria* stage was not found. A gram wilt is also prevalent at Poona but the fungus concerned has not been isolated.

27. Ground-nut leaf disease.—A disease known in Bombay as *tikka* disease is a cause of much damage to the ground-nut crop in Bombay and Madras. It is caused by the fungus *Septoglæum Arachidis* first described from Java in 1898, and found also in German East Africa. The leaves are attacked and become covered with dark spots surrounded by a yellow areola, later on falling off. Nuts produced on badly attacked plants are shrivelled and worthless. Spraying with Bordeaux Mixture was tried at the Kirkee farm in 1903, but the results
were not conclusive. An experiment was made in 1904 to test the conveyance of the disease in the seed or in soil. Seed from Poona where the disease is common was sown in Dehra Dun where the crop is unknown and where the danger of air-borne infection might be neglected. Some plots were sown without further treatment while to others was added soil from a field at the Kirkee farm which had borne a diseased crop the previous year. All the plots took the disease indicating a probability that infection can be transmitted by the seed. Seed treatment is being tried this year at Pusa on the seed obtained from this diseased crop. As the amount of damage caused varies with the degree to which the nuts have formed before the attack begins, an attempt has been made this year by sowing a couple of months before the rains to produce an early crop.

28. Oat smut.—Treatment of oat seed with formaline and copper sulphate against smut was tested in 1904-05 at Dehra Dun. The plots were about \( \frac{1}{2} \) bigha in size. On the untreated plot 172,495 smutted ears to the acre were found. On the formaline plot, treated by soaking the seed for 4 hours in 1 per cent. formaldehyde, 1,092 smutted ears only appeared, while the two copper sulphate plots, treated respectively with \( \frac{1}{2} \) per cent. and 1 per cent. by soaking for 24 hours, gave 2,115 and 1,069 smutted ears. The prolonged treatment with copper sulphate injured germination considerably especially with the 1 per cent. solution, while giving no better results than the formaline which was not injurious. The latter is, therefore, considered the more satisfactory. As smut is very bad in Dehra Dun, affecting about 10 per cent. of the ears, an attempt will be made this season to introduce the treatment into practice. It is extremely simple in application.

29. Other smuts.—Smuts of wheat (Ustilago Triticci), barley (U. Hordei), rice (U. virens), sawan millet (U. Panici-frumentacei), etc., have been frequently obtained and indications for treatment given.

30. Sorghum diseases.—Juar suffers from a number of fungus diseases. Besides rust, already mentioned, the following have been investigated:—Smut: two varieties are common, caused by different fungi, Ustilago Sorghi and U. Reiliana. The former can be successfully treated with copper sulphate and experiments are in progress to determine at what stage infection occurs and to compare formaline and copper sulphate treatments. The germination of the spores has also been followed as a preliminary to tracing the complete life history. Collectotrichum Lincoln is a common cause of a leaf-disease and Phyllosticta sorghina has been found causing a somewhat similar
affection. A curious leaf shredding disease has also been observed but the fungus associated with it has not yet been determined.

31. Green ear disease of the bulrush millet.—A common condition of the bajra millet, in which the whole ear becomes converted into a brush-like head with transformation of the floral leaflets into small distorted foliage leaves and no formation of grain, has been noticed in Bombay, the Punjab and Madras. The cause was determined last year to be an undescribed fungus of the genus Sclerospora, other members of which similarly affect various cereals. The life-history of this fungus remains to be worked out, and treatment cannot be suggested until it is known how it originally attacks the plant.

32. Diseases of trees.—A large number of diseases of fruit and forest trees have been investigated in the past three years. The deodar forests in Jaunsar are much damaged by the root fungus Fomes annosus. Its mode of action was studied and extension found to depend largely on the production of rhizomorphs or organised strands of fungal tissue. Their occurrence in this species was not previously known and influences considerations regarding treatment. The effect of the fungus on deodar wood was also examined. An account was published in the Indian Forester in 1903. A second disease caused by the rust Peridermium Cedri has recently been obtained on the same tree, and is said to cause much damage to young plants. Pinus excelsa is attacked by Trametes Pini near Simla, specimens having been received in 1904. It was not previously known to exist in India though a serious pest in German forests. A babul disease has been reported to be destructive in the Berars. Its cause has been ascertained to be Fomes Pappianus, a fungus not previously reported as a cause of disease, but found in Abyssinia on acacias. The casuarina plantations on the East Coast are attacked by a disease in some places. The cause was found on examination at Chatrapur in 1904 to be an undescribed fungus of the genus Trichosporium which attacks the base of the tree. A description has been drawn up including some suggestions for treatment and communicated to the Madras Government and the Forest officers concerned. It has been incorporated in some notes on Indian forest fungi which have been sent for publication in the Indian Forester and will contain a description of a number of forest pests. Peach leaf-curl caused by Exoascus deformans, and leaf diseases of mango, loquat and other fruit trees have been obtained from various localities.

33. Vine diseases.—Powdery mildew caused by the vine Oidium
and anthracnose due to *Sphaceloma ampelinum* were seen at Poona, Shillong, and elsewhere and remedial measures carried out.

34. **Betel palm diseases.**—Two serious diseases of this valuable palm have been investigated. In Mysore a disease known as Koleroga was seen in 1903, and its probable cause ascertained to be a *Phytophthora*. Further enquiry has not been possible. In Sylhet the disease known as plague is causing great ravages, and was studied locally in May, 1905. It is of recent origin and due to a fungus which attacks the base of the tree. Its treatment is likely to be extremely difficult and a total loss of many of the gardens is to be feared. The nature of the fungus has not yet been ascertained with certainty.

35. In addition to the above a large number of other diseases of cultivated crops has been received for examination or seen on my various tours. Wherever possible recommendations for treatment have been given.

~ IV. OTHER INVESTIGATIONS.~

36. **Kodra poisoning.**—The poisonous properties often possessed by the grain of kodra (*Paspalum scrobiculatum*), a cereal much grown by the poorer classes in various parts of India, have been more than once referred to some abnormal condition produced by a disease of the plant. Several specimens were obtained from Bombay and the presence of a fungus detected in the seed coats and less frequently in the endosperm. A sample of grain which had actually produced poisoning was obtained in Behar in 1903. Grown in Dehra Dun in 1904 the resulting grain was found to produce the peculiar symptoms of vertigo, etc., in man when eaten. Thirty-seven per cent. of the seeds were found to contain the fungus. Experiments were made with rabbits and rats but neither appeared to suffer from eating the poisonous grain. They are being continued, but until a suitable animal is found for experiment the influence of the fungus cannot be determined. An analogous case, that of *Lolium temulentum* which appears to owe its poisonous properties to a fungus inhabiting the seed coats, and which is at present the subject of investigation from this point of view in Europe, gives an indication that we are on the right track.

37. **Mycorrhiza.**—It has long been known that a number of plants live in combination with a fungus which inhabits their roots. To the combination the name mycorrhiza has been given. In many cases the fungus occupies the interior of the root and a large number of such “endotrophic” mycorhizas has been examined in the past three years.
The case of the nodule bacilli of the *Leguminosae* and the evident fact that the plant does not suffer from the association suggests that such mycorrhizas play a part in plant nutrition. Experiments to investigate this have been in progress for some time. The fungus has been found in all the cases examined (over 50) to be identical. It refuses to grow satisfactorily in artificial cultures and has never been observed to produce spores. Its handling is, therefore, a matter of much difficulty, and the experiments in progress have not yielded results of much value. It has not been possible to attack the problem seriously owing to constant touring, and the work so far has been mostly preliminary.

38. **Nodule bacilli of Leguminosae.**—Experiments were started in April, 1905, at the instance of the Inspector General of Agriculture, to determine the effect of inoculation of leguminous crops with bacilli in the manner recently recommended by the United States' Department of Agriculture. The principal departure in this method from those already adopted with varying success in other countries consists in growing the bacilli on non-nitrogenous culture media. In a preliminary test three lots of 30 seedlings each of *tur* (*Cajanus indicus*) were grown in sterilised soil. One lot was inoculated with bacilli prepared according to the method advocated by the United States Department, a second with bacilli grown on media containing nitrogen and the third left uninoculated. Examined after five weeks 404 nodules were found on the first lot, 32 on the second and one on the third. No conclusions can be drawn from a single experiment of this nature. Field tests are being carried out both at Dehra Dun and Pusa, and their results should be of considerable interest. In the case of a widely grown crop like *tur* no great advantage can be expected to result from the practice since the bacilli are doubtless present in the soil in which it is habitually grown, unless it should prove to be the case that bacilli starved of nitrogen are more virulent than those normally present in the soil. The further enquiry is in the hands of the Agricultural Bacteriologist.

39. **Miscellaneous.**—A commencement has been made this year in the collection of the edible fungi of India, which are very little known. A collection of mildews, caused by lower forms of the *Eryiphaceae* whose identification is very difficult, has been recently sent to Mr. E. S. Salmon at Kew who is monographing the group. Several collections of members of the interesting family of the *Gasteromycetes* have been sent for identification to Professor Lloyd of Cincinnati, who proposes to issue a monograph of the Indian forms. Some fungi
probably concerned in the retting of jute were received from the Special Jute Expert to the Bengal Government in 1905 and their identity determined.

40. A list of publications will be found at the end of this report.

E. J. BUTLER, M.B., F.L.S.,

_Cryptogamic Botanist to the Government of India._

_Dated the 13th July, 1905._
Part V.

REPORT OF THE ENTOMOLOGIST TO THE GOVERNMENT OF INDIA.

1. Historical.—The study of Economic Entomology in India may be said to have commenced in 1888, when E. C. Cotes, in charge of the Entomological Section of the Indian Museum, Calcutta, commenced the investigation of economic insects and inaugurated the publication which later on became Indian Museum Notes. Prior to that date there had been a small collection of insects at the Indian Museum under the care of Wood Mason, Neville and De Nicéville successively. The economic work of this section of the Museum was later extended so as to include the identification of such injurious insects as were sent to the Museum by the Directors of Agriculture from all parts of India. The reports which accompanied these insects, as well as the identifications of the insects, were published in Indian Museum Notes at irregular intervals up to 1901. At that date the Indian Museum possessed a large collection of insects partly of economic interest, which were gradually being identified and named by the co-operation of specialists in Europe; four complete volumes of Indian Museum Notes and a part of a fifth had been published, containing a heterogeneous mass of information and identification of numerous common Indian insects. The field study of pests had not been possible, and the published information served no useful practical purpose to the general public. In January, 1901, Mr. De Nicéville was appointed Entomologist to the Government of India, with head-quarters at the Indian Museum, where he was in charge of the entomological section, but with liberty to conduct his inquiries in the field in all parts of India. The work was terminated by his death after less than one year's service; the valuable results of his inquiries were published in the last number of the fifth volume of Indian Museum Notes. In April, 1903, the present writer was appointed Entomologist to the Government of India; the intimate connection with the Indian Museum was severed and the Entomologist placed on the staff of the Imperial Department of Agriculture. The issue of Indian Museum Notes has ceased.

2. The present Entomologist commenced work in India in April, 1903, and this report covers a period slightly exceeding two years.
Having spent six weeks in preliminary work in the Indian Museum, the Entomologist's temporary head-quarters were placed at Surat; they were transferred to Muzafferpur in October, 1904, and to the Agricultural Research Institute, Pusa, in May, 1905. Some time was spent in securing the equipment and necessary staff, and a considerable amount of time was expended in training the latter, there being no qualified assistants available in India at that time. At the present time the staff includes one special assistant undergoing training, two assistants who are capable of doing useful work, one fully trained fieldman capable of doing independent work in the field, three fieldmen undergoing training, and a trained setter. It has been a matter of considerable difficulty to obtain suitable candidates for these posts, the work being of a character wholly new to India.

3. The Directors of Agriculture in the several provinces of India have assisted the Entomologist by sending specimens of insects injurious to crops together with reports; a large number of such insects has been received not for identification alone, but for preservation in the office and also to enable information to be sent of any practical steps possible to check the pest. As a rule it is not possible to advise any action; such specimens are chiefly valuable as an indication of what the crop pests of India are, though the reports that accompany them are naturally of very unequal merit. It has not been found possible for the Entomologist to visit all localities which are reported to be infested with pests, and this form of assistance will only be possible when there are trained assistants stationed throughout India capable of giving practical advice. Many specimens have also been received from planters, from the Superintendents of Botanic Gardens and from others interested in agriculture and horticulture. The replies sent to such inquiries are regarded as an important part of the work of Entomologist, but they naturally entail a large amount of work. They serve the purpose of bringing the Entomologist in touch with the various phases of agricultural activity in India.

4. Investigation of crop pests.—As much time as possible is allotted to the investigation in the fields of the insect pests of crops. It is impossible to do more than carry this on in localities representative of large areas, and special attention has been devoted to the pests of the more important crops. The long periods spent in South Gujarat and in Behar have permitted a careful study of pests and conditions in these areas; this has been supplemented by tours and by.
investigation on the government farms. Judging from the records of Indian Museum Notes, the principal pests of crops in the plains of India have thus been under observation and new ones have been discovered which had not been reported. Whilst a very small amount of inquiry in the fields is far more valuable than any investigation conducted solely in a museum, this work cannot be said to be progressing adequately. It is impossible for one observer, with a mass of other duties, to study adequately pests in so large a continent as India. A careful study has been made of the insect pests of cotton, and also of the principal pests of rice, sugarcane, maize, jowari and other millets, pigeon pea, tobacco, mustard and rape. Individual pests of almost every other field crop of the plains have been studied and the pests of garden cultivation observed. In view of the many inquiries received, it has been necessary to become familiar with as many of the more general pests as possible, including all recorded in the Indian Museum Notes; the detailed study of these pests must be a matter of years and is carried on as circumstances permit. At present there are in the collections specimens of almost every known injurious crop pest with a more or less complete amount of information regarding the life-history of the insect; its local occurrence and the best methods of checking it will be investigated as opportunities of touring occur or when assistants can be sent to various agricultural tracts. The basis of this work must lie in the classified collection of injurious insects and the work of the past two years has largely consisted in preparing this basis.

5. Special inquiries.—The insect pests of the coffee plant have been the subject of special inquiry in Mysore and the Nilgiris. The Entomologist’s familiarity with the same pests in the West Indies has simplified this inquiry which has now been concluded.

The outbreak of the Bombay locust in Western India was also the subject of special inquiry, in co-operation with the Directors of Agriculture in Bombay and the Central Provinces. A considerable amount of assistance was given and the inquiry has now been concluded.

6. Remedies.—Every opportunity has been taken of testing remedies that are in use in other parts of the world. This investigation is possible only when injurious insects are met with in sufficient number, and cannot be carried on continuously. The conditions under which agriculture is practised in India differ so much from those of countries where these remedies have been discovered that any attempt to introduce European and American methods must be preceded by exhaustive
trial. Whilst this has not been neglected, the elaboration of simpler methods, suitable to the limited resources of the ryot, has occupied more attention. The experience of other countries is almost useless in India; methods which appeal to highly trained farmers accustomed to machinery and to scientific devices are viewed with suspicion by the agricultural masses of India and are not always within their reach. At the same time, the ryot is shrewd enough to put aside his scruples if he can be shown that any method pays in practice; it is only necessary to remember that everything must be demonstrated and that the arguments which appeal to a planter, when backed with what he regards as competent knowledge, have no weight with the ryot. The necessity of actually demonstrating every artificial method of checking pests makes progress very slow, and it is doubtful if methods based, for instance, on changes in agricultural practice, will ever appeal to him. The experiments in insecticides have shown that these have as great a value in India as elsewhere; it is to be hoped that they will be more freely used on experimental farms as a preliminary to their general use by the cultivators. What may be described as mechanical methods have also great value; the hopper bag used in the operations against the Bombay locust is an instrument capable of extended use, and this simple method, if generally used, would save an enormous loss caused by certain pests in India. Methods based on changes in the present agricultural practice should be tested on experimental farms, but even when successful will be very slowly, if ever, accepted by the agricultural classes at large. Finally, what may be termed common-sense remedies appear to be largely unknown in India, but there seems no reason why they should not be generally adopted after repeated demonstration. The attitude of the ryot to such methods appears to be blank indifference supported by religious prejudice. The market gardener who laboriously collects the caterpillars from his cabbages, and liberates them in a corner of his field, evidently regards the destruction of his pests from a point of view not in sympathy with more wholesale methods of slaughter. So too the ryot who collects the cotton plants which are infested with the stem borer but leaves them in neat heaps throughout his field, with the natural result that the beetles inside presently emerge and work havoc in his field. It will be a laborious matter to demonstrate such matters so clearly that he will be convinced it means money to him. These considerations must be borne in mind in estimating the progress that has been made which is, perhaps, as great as has been possible.
7. Beneficial insects.—A phase of modern entomology is the increasing study of beneficial insects and the continued efforts made to utilize them more directly in the destruction of insect pests. Unfortunately the principles which underlie this branch of biology have in most cases been neglected; the plausible hope that one insect could be made to live on another and so keep it in check has appealed especially to the newspapers and the general public, but there is only a limited application to this attractive principle, and in India this application is very small. The study of the parasites of Indian pests has formed part of the work of this period and will be continued. No immediately practical results can be expected from the study of beneficial insects, not solely on account of the inadequate study of these insects but from the nature of the pests of Indian crops and the conditions under which they live. Time has not permitted the investigation of useful insects, such as silk insects, lac insects, bees, etc. These are special inquiries that should be in the hands of a staff with full time to devote to each of them.

8. Collections.—In the course of investigation, specimens of all stages of the lives of injurious insects are collected and preserved. This forms the valuable ‘Economic Collection’ which is constantly growing. There has also been made a ‘General Collection’ consisting of specimens of all kinds, preserved and properly stored. This collection is now large and is constantly being added to. It is necessary primarily for teaching purposes, but also as an adjunct to the Economic Collection. The general collection will ultimately serve another purpose, that of assisting the identification of economic insects. There is a lamentable lack of interest on the part of naturalists and entomologists in all the insects of the Indian region except butterflies and moths. The result is that while these latter insects have been to a large extent classified and named, it is impossible to identify any other insect. Not only are there no books on the subject, but it is not even possible to induce European Systematists to undertake the examination of Indian insects. This difficulty can be adequately met only by the appointment of entomologists in India for this work; pending this, it is hoped that European Entomologists may be induced to do some portion of it when they can be provided with really large collections of properly preserved insects. General collections are thus made as large as possible in the hope that this will eventually facilitate the identification of economic insects. The difficulty is not an important one except in regard to publications
and has unfortunately been aggravated by the consignment to European specialists of numbers of badly preserved insects from the Indian Museum collections. The formation of the general collection is also carried on as part of the work of the Insect Survey of India originally started by the Indian Museum.

9. **Indian Museum.**—The new relations with the Indian Museum have been settled, and the Entomologist has been able to advise the Superintendent on matters that concern this section, whilst having no direct supervision over the work of the staff. A special assistant has been appointed in the Museum and trained by the Entomologist to work in the Museum under his general guidance. The collections of the Museum are being re-arranged and put in good order. It is unfortunate that these collections are of very slight value in the identification of Indian insects; the collections are considerable, but ill-arranged and not fully identified. The climate of Calcutta is extremely adverse to the preservation of pinned insect and it is probably only a question of time before these specimens will be ruined and valueless. It has been arranged that duplicates of insects not already in the Museum collections, which are collected in the General Collection, shall be sent to the Museum; this is necessary so long as the large reference collections are maintained in the Museum, but it would be advisable to transfer these to a locality where there is a prolonged period of dry weather during the year. The inevitable result of the present policy will be an increasingly large and valuable collection in good preservation at Pusa, and collections at Calcutta, now valuable, but from year to year deteriorating owing to the adverse climate. Should there ever be sufficient accommodation at Pusa it would be advisable to transfer the reference collections from the Indian Museum to Pusa, leaving the exhibit collections in the Museum and making arrangements to renew these from Pusa as they deteriorated.

10. **Work at Pusa.**—The Entomologist is now stationed at the Agricultural Research Institute, Pusa, where work was actually commenced in October, 1904. The farm affords an opportunity of testing remedies in the field under the best possible conditions and allows of the field study of insect pests. It is hoped that the work may be extended on better lines as soon as buildings are available at Pusa for laboratories and the like. An important part of the Entomologist's work will consist in preserving the crops grown at Pusa from the attacks of injurious insects which would render useless comparative
experiments of the value of manures and make the trials of varieties increasingly difficult. The work at present carried on at Pusa consists in checking pests on a fairly large scale with the object of ascertaining the actual cost in practice of remedies suggested. The best possible test of remedies is to carry them out on a reasonable scale, ascertaining, when possible, not only the actual cost but also the increased yield assured by the treatment; this is not always possible but the farm at Pusa actually represents an estate on which all that science suggests is carried out and the actual cost and value ascertained.

11. **Field study of insect pests.**—The great need at the present time is the more extended field study of insect pests in all districts of India. This is work requiring principally a knowledge of agriculture and local conditions, some training in entomology and the possession of certain faculties of observation. The first of these will be found only in natives of the different agricultural tracts of India; an attempt has been made to secure men with this knowledge, who have also the faculty of observation and who can be trained in entomology. Three such men have been trained, at the request of the Departments of Agriculture of the Punjab, the Central Provinces and Baroda. They have commenced independent work, as subordinates of these departments, under the general control of the Entomologist. The experiment has been one of great interest and has given excellent results. Further apprentices are undergoing training for work in Bengal and Bombay. The successful issue of this experiment has largely been due to the initiative and keenness of the men selected for training; the actual training cannot be properly attended to by the Entomologist under the present conditions. Undoubtedly, men can be found who are peculiarly adapted to this work. If the results of entomological inquiry are ever to reach the ryot, it will be through the agency of such men, and it may be urged that this feature is the most promising one in the present work. Entomological investigation is a matter of observation and common sense; first rate entomological assistants can be found in India, and, provided they are not selected from too highly educated men, these men can be trained to do excellent work in the field. This applies to entomology far more than to other branches of agricultural inquiry, and I would urge that there should be a very large development in this direction. The large annual losses from preventible pests in India, the excellent work that is done by trained agriculturists, the fact that such men alone can appeal to the ryot and show him that simple
methods of checking pests are within his reach, such considerations justify the statement that, if entomological science is to be properly brought to bear on Indian agriculture, it must be through the medium of such men; the number required is very large and at least five should be trained yearly for each province. At present the organization for training and utilising these men does not exist, but a small amount of supervision is all that is required, and a single European Entomologist in each province can easily give this for a large number of trained men. I would most strongly urge that a far larger number of men should be trained and set to work; the cost of such men will be far more than met if they are able only to check a single pest in one crop. There should be one such man first in every large tract, then in smaller divisions of large tracts. At the present time there is not even one for some large provinces. It is to this form of extension that I look for the practical results that will eventually spring from the scientific study of entomology, and I trust that it may be possible to extend this over the whole of the Indian Empire.

12. Publications.—No medium exists at present for the dissemination of useful information; a great deal has been done by the replies sent to inquiries but this is laborious and far less effective than any form of periodical publication. The results of scientific investigation should be published in a form suitable to those who are in need of such information. The results of the inquiry into pests of coffee were published as a Bulletin. A second bulletin was issued on Cotton Pests in Behar. A series of leaflets was commenced dealing with Insecticides, Spraying machines, Common Pests, and kindred matters. These were printed largely with the object of lessening the number of letters that have to be written in answer to inquiry; whenever possible a leaflet is sent instead of a letter. The issue of further leaflets has now ceased as the information to be contained in them is to be embodied in a book. Two bulletins have been printed dealing with technical matters for the use of apprentices and the staff.

13. Rural education.—At the desire of the Officiating Inspector General of Agriculture, the lessons on insects in the Primers used in schools were obtained and carefully examined, with a view to improving the nature of the teaching given in schools throughout India. This is an important question, as it reacts on the agricultural classes and any improvement in the teaching may eventually make the ryot more receptive of suggestion as to the destruction of pests. It has been impossible to take up this question adequately, and the preparation of object-
lessons on Insect Life will require the very greatest care. An attempt is being made to exhibit specimens of injurious insects on the experiment farms, at the offices of the Directors of Agriculture and in other suitable places. The proposal has been welcomed by the Directors, and every effort is being made to cope with the demand for specimens. Some time must elapse before this can be put on a good basis and the present staff is inadequate for the increased work. A beginning will be made very shortly and, even if progress be slow, the exhibition of specimens with suitable leaflets will probably prove to be a very valuable medium for disseminating useful information.

14. Future needs.—The above paragraphs summarise the progress that has been made during the short period under review. The most valuable developments have been the actual field study of pests and the beginning made in the training of suitable native assistants who have an intimate knowledge of the country and of its needs. Good progress will be made so long as these main principles govern the work—the necessity of actual field study, the value of native assistants in influencing the ryot and bringing actual practical results to him. On the other hand, the work has been and is carried on under very great difficulties; the lack of suitable laboratories is a very great handicap that is felt daily and hourly; the constant heart-breaking difficulty of preserving delicate and valuable collections in totally unsuitable buildings and under very adverse conditions is keenly felt. The work has naturally expanded far beyond the adequate control of a single officer with a small staff; the work of the Entomologist includes (1) the routine work of head-quarters, including a large correspondence in answer to inquiries, (2) supervision of the work of the staff and the training of most of them, (3) training of apprentices, (4) the treatment of insect pests at Pusa, (5) tours to the provinces at the request of the provincial departments of agriculture, (6) the care and classification of the economic and general collections at head-quarters, and their transmission to European specialists for identification, (7) the direction of the work of provincial assistants, (8) the investigation into injurious insects. At the present time there is also much work to be done in the organization of the Agricultural Research Institute. Item (8) alone should occupy the whole time of the Entomologist but has to be done as opportunity permits when routine work is over. The routine work is unnecessarily heavy since it is governed by the rules that apply to executive and administrative branches of Government; it is impossible to conduct a scientific section under the same rules as govern
these branches as has now to be done. Freedom to obtain stores from England direct, at any time and without the present excessive delay, would remove one source of difficulty; the power to carry over unexpended grants from year to year would admit of greater elasticity in the expenditure and of less waste (this is permitted to the Indian Museum); freedom to transfer sums from one head to another would remove one further difficulty since it is impossible to foresee the requirements of each head. At present the work done is limited by the grants allotted, regardless of the fluctuating demands of scientific inquiry which cannot come within the usual control; what is required is greater freedom to adjust the various sums to the necessities of work, while not exceeding the gross sum allotted.

15. The preliminary work has now been completed, the work is progressing smoothly, and the practical results should be extended first to the experimental farms and later to the cultivator. This cannot be hoped for under the present circumstances; it is impossible for the present staff to supervise experiments on farms all over India nor is it possible to expect provincial departments to make experiments without a full knowledge of their nature and objects. A large increase in the trained native staff of the provincial departments is the first necessity; a suitable medium for publication is the second; with these it will be possible to carry out experimental and regular control of insect pests on the farms, and gradually to extend the knowledge of this work to the cultivator, which is the ultimate aim of this section, one that is steadily kept in view and will be gradually attained. In addition it is hoped that the provision of suitable accommodation at Pusa will also enable the work to proceed more smoothly and rapidly, and will permit of the inception of methods of inquiry that are at present impossible. In conclusion I wish to record the excellent work done by the members of the staff who have shared the difficulties under which the work has been carried on and done their utmost to assist me.

H. MAXWELL LEFROY, M.A., F.E.S., F.Z.S., 
Entomologist to the Government of India.

Dated the 7th August, 1905.
APPENDIX A.

An account of the scientific investigations on indigo which have been, and are being, conducted in India.

Scientific work connected with indigo commenced in India in 1898. During 1897 a marked drop in the prices of natural indigo took place owing to the commercial production and competition of synthetic indigo, and a body called the Indigo Defence Association was formed by some of the proprietors of indigo concerns in Behar to protect their interests. This body was subsequently amalgamated with the Behar Indigo Planters' Association. They decided to obtain the best scientific advice possible, and their choice fell upon Mr. Christopher Rawson of Bradford. This gentleman arrived in India in June 1898 and commenced his experimental work in a small laboratory which had been fitted up at the Tirhoot Planters' Club in Muzaffarpur. The outcome of the work of that season resulted in an arrangement being entered into with Messrs. Collingridge, and a laboratory and experimental vats were built at their factory Mosheri, and the work was carried on there by Mr. Rawson during the manufacturing seasons of 1899 and 1900.

During these same years (1898-1900) certain Behar planters formed the "Indigo Improvements' Syndicate" whose object was to conduct experiments in the cultivation of indigo and other crops of interest to the indigo planter. An agricultural chemist, Mr. Hancock, was retained, and he worked at Dalsing Serai under the auspices of Mr. Bernard Coventry.

The Government of Bengal first rendered monetary assistance to these enterprises in November 1900 when a grant of £500 per annum for three years was made to the Behar Indigo Planters' Association to provide the services of a bacteriologist. In 1901 both the Behar Indigo Planters' Association and the Indigo Improvements' Syndicate asked Government for aid in their work, and a grant of Rs.50,000 per annum for a period of three years was made on the condition that the planters found a sum of Rs.75,000 yearly for the same period, and that the work was conducted by the Behar Planters' Association and the Indigo Improvements' Syndicate jointly. These two bodies accordingly amalgamated during 1901, and Mr. Rawson removed to Peeprah, a large factory in the Champaran District, where a new laboratory and an experimental factory had been arranged for him, whilst work was carried on at Dalsing Serai by Mr. Hancock with the assistance of a biologist, Mr. H. M. Leake.

In 1902 the present writer joined Mr. Rawson as bacteriologist at Peeprah, and extensive experiments bearing on indigo manufacture were conducted there; meanwhile Mr. Leake, the biologist, was alone at Dalsing Serai, Mr. Hancock having left India at the end of 1901. In March 1903, Mr. Rawson left India, and the present writer returned to Mosheri, where Mr. Rawson's early experiments had been conducted until March 1904. The laboratory there had, however, been dismantled in the meanwhile, and work had to be conducted in a small godown.

During 1903, the Bengal Government gave their grant of Rs.50,000 to Mr. Bernard Coventry to further the work he had been conducting at Dalsing Serai. Professor
Bloxam was engaged and carried on work there together with Mr. Leake until March 1904, when both of these gentlemen left India. In 1904 the grant of Rs 50,000 was again made to the Behar Indigo Planters' Association, but unconditionally. An effort was made once again to resume work at Mosheri Factory, but a satisfactory arrangement could not be entered into with the proprietors. A lease was, therefore, taken of a disused and dismantled factory at Sirsiah near Muzaffarpur, and an experimental factory, laboratory, etc., have been under construction there during the past year. All the fittings, apparatus, etc., purchased by the Behar Indigo Planters' Association and the Indigo Improvements' Syndicate, both independently and under grants from Government, have been removed to Sirsiah, and work is at present in progress there.

Much valuable information has been obtained during the seven years these investigations have been in progress, but the work as a whole has naturally suffered from lack of continuity and co-operation on the part of the workers. The object of all the work has of course been to increase the amount of indigo obtainable from a unit area of land, and it has naturally divided itself into two main sections, the first dealing with the purely agricultural aspect of the case, such as the increase of plant obtainable from the unit area of land or the production of a plant richer in potential colouring-matter, and the second with questions involved in the manufacture of the finished product from the plant. During his five years' work Mr. Rawson dealt with both aspects of the case, and the main results of his investigations are summarised in his final report to the Behar Indigo Planters' Association published in 1904. On the agricultural side much useful information was obtained as to the composition of Behar soils and their response to manurial treatment. As a general rule the soils examined were found to be deficient in available phosphoric acid and to respond remuneratively to treatment with superphosphate, bonemeal or other phosphatic manures. Nitrogenous manures were generally found useful when applied in conjunction with phosphates. These same conclusions were arrived at by Mr. Hancock working under Mr. Bernard Coventry at Dalsing Serai in 1901 (vide Indigo Report to Indigo Improvements Syndicate by Mr. B. Coventry for season 1901). Mr. Rawson lays stress on the anomalies which occur in the results of the manurial experiments carried out both by himself and by Mr. Hancock (plots taken in the same field giving in several cases entirely different results under one manurial treatment), and expresses the opinion that "much more work is still needed before one can be justified in drawing general conclusions as to the kind and quantity of manures to be applied in order to obtain remunerative returns." The manurial value of the refuse plant or "seet" obtained in the manufacture of indigo was very thoroughly investigated by Mr. Rawson, and the conclusion arrived at was that in many cases it was as valuable as the indigo produced by a factory or even more so, an opinion shared by most planters in Behar to-day. A method was also devised by Mr. Rawson for determining analytically the potential colouring-matter in the plant and several facts of value were established by its use. It was shown that the leaves were the only portion of the plant from which an appreciable amount of dye can be obtained, and the stage of growth of the plant at which the content of the leaves in the dye-yielding principle is at its highest was established. The leaves of several indigo-bearing plants were analysed, and it was conclusively shown that
those of the Java variety of indigo contain more potential colouring-matter than do those of the plant ordinarily cultivated in Behar.

On the manufacturing side Mr. Rawson’s experiments were most complete. Every stage of the process was investigated from the purification of the water used in steeping to the drying of the finished indigo. His recommendations are summarised in the report referred to above and details cannot be gone into here. In the writer’s opinion, if Mr. Rawson’s recommendations are followed, there can be nothing further to be desired in the purification of water, the oxidising process, and the after-treatment of the crude indigo. In the steeping process there may still be scope for improvement, and this will be touched upon later. As a conclusion to his final report, Mr. Rawson remarks as follows:—“Finally, any further aid (from a technical point of view) to improve the position of the indigo industry can only come, in my opinion, from improvement of the plant by natural selection or by the introduction of some other species (such as Natal plant) capable of yielding a greater amount of colouring-matter.”

From this last quarter aid has already come. The Java plant, which was first brought prominently to the notice of planters by H. Bailey, who visited Java on behalf of the Indigo Improvements’ Syndicate in 1899, has proved itself of the greatest value to the Behar planter, and its cultivation is spreading as rapidly as the seed supply forthcoming will permit. In a very few years this plant will, no doubt, have almost entirely replaced the variety formerly grown in Behar. It was first grown on an extended scale by Mr. Bernard Coventry at Dalsing Serai, and its advantages were apparent immediately certain difficulties in its cultivation had been overcome. The chief of these was the possession of a hard coat by the seed of the plant, which rendered germination very difficult. It was suggested by the writer in 1902 that this difficulty might be overcome by suitably scarifying the seed in a similar manner to that practised on clover and other hard seeds in other countries. The idea was taken up and proved feasible by Mr. H. Leake, the biologist to the Indigo Improvements’ Syndicate, and a machine has now been invented and patented by Mr. G. F. Watson of Messrs. Arthur Butler & Co., Muzaffarpur, by which the operation may be performed on a large scale with perfect success.

Mr. Leake’s work at Dalsing Serai was mainly devoted to an enquiry into the sources of supply of the indigo seed ordinarily used in Behar. Much valuable information was obtained on this point which should serve as a guide for any future work on the selection of seed and the control of the supply for Behar. Mr. Leake also carried out an investigation on the localization of the indigo-yielding substance in the plant which, though at present mainly of academic interest, may prove of the utmost value in conducting researches into the physiology of indigo-yielding plants, which must be carried out before the full story of the production of indigo can be told.

Finally, in summing up the history of the past researches on indigo mention must be made of the work of Professor Popplewell Bloxam carried out at Dalsing Serai during 1903-04. The period over which Professor Bloxam’s work extended was too short to permit of his arriving at any definite results. An account of it as far as he went is, however, given in his report to the Government of Bengal, dated 1905.
In the course of this report several manurial experiments are described, their chief feature being the supply of various carbonaceous materials to indigo soils with the idea of promoting the growth of the nodule bacteria. The value of the methods proposed remains to be seen, but from the facts that the manures were applied at an unsuitable season of the year, and that the results obtained are quite anomalous, no conclusion can be drawn from the experiments described. In the chemical part of the report bearing on indigo manufacture, the methods in vogue of analysing indigo are severely criticised and several statements made which are open to criticism and which further experience would probably have led the writer to modify. Mr. Leake's work on the germination of Java indigo seed and on the seed-supply of Behar, referred to above, are also embodied in Professor Bloxam's report, as well as two interesting papers by the same author (Mr. H. M. Leake) on "the soil in its relation to moisture" and "an investigation of soil temperatures."

The present work at Sirsiiah can hardly yet be said to have made a beginning. The buildings, etc., have been under construction there since November last, and a crop of indigo has been grown on the lands leased. The laboratories at Dalsing Serai were dismantled in May last, and the removal of their contents to Sirsiiah and the re-fitting there has occupied much time. From August 1904 until May of this year, the present writer worked in the laboratory at Dalsing Serai, and the line of investigation which was being followed, as well as the future work to be undertaken, was described in a preliminary report to the Behar Indigo Planters' Association in January last. On the manufacturing side it is pointed out that, contrary to Mr. Rawson's opinion, there may still be scope for improvement since the efficiency of the ordinary process as determined by him was founded on a method of analysis of leaf which has since been proved erroneous. If this is so, the fault must lie in the steeping process, since there is no doubt that, granted the precautions suggested by Mr. Rawson are taken, the oxidising process is as perfect as possible. The writer's researches into the modus operandi of the steeping process were begun at Peeprah in 1902 and continued at Mosheri in 1903, and the results of this work were embodied in a paper communicated to the Chemical Society of London in June 1904 (vide Journal of the Chemical Society, 1904, volume 85, p. 870). As a result of these researches it was concluded that the only possibility of improvement in the process lay in the direction of employing water at an elevated temperature. This has been frequently tried, and most recently by Mr. Rawson. He came to the conclusion that the hot water system offered "no advantage over the ordinary steeping process when the latter is carried out under the most favourable conditions; but in wet weather the process would repay the cost of steam." Mr. Rawson's experiments were however conducted at one fixed temperature and for one fixed period of steeping.

A preliminary series of laboratory experiments has shown that the exact temperature of the water employed and the exact period of steeping have a very profound effect on the result obtained, and it seemed worth while conducting a series of experiments on a manufacturing scale with the object of determining the optimum combination of time of steeping and temperature of water for the steeping process. This will necessitate at least one whole mahai being devoted to this end, and it will form the main object of the experiments carried out both at Sirsiiah and at Pusa this year. It may prove that no improvement of economic value can be made in this way, but
this can only be determined by manufacturing experiments. An endeavour will also be made at Sirsiah this year to conduct some trials on new modes of drying and packing indigo and perhaps also of refining. There seems scope for improvement in all these directions. Laboratory work will, of course, accompany all these experiments, and certain researches with a more or less direct bearing on indigo problems, both agricultural and manufacturing, will be undertaken. An investigation is at present in progress having for its object a critical examination of all the established methods of indigo analysis. It is hoped that the points raised by Professor Bloxam may be cleared up once and for all thereby.

On the agricultural side little has yet been done at Sirsiah. It is proposed to carry out experiments on the selection and hybridisation of varieties of indigo, but it is doubtful whether much can be done at this until a trained botanist is made a member of the staff. As has been frequently pointed out this is a most important aspect of the work, and perhaps the direction in which the chief hope of permanent assistance to the industry lies. Certain experiments in growing selected seed were started at Sirsiah, but were unfortunately destroyed by caterpillars. It is proposed to sow an area of Java plant in October, and experiments both in methods of cultivating it for manufacture and for seed production will be started. Manurial experiments will also be undertaken on a somewhat new plan with the idea of endeavouring to remove the anomalies in the experiments hitherto conducted and determining definitely if there is any substance that can be profitably employed to increase the production of indigo from a unit area of land. Certain agricultural experiments have also been started and are in progress at Pusa.

Another piece of work of an agricultural nature which is being undertaken at Sirsiah is an endeavour to prepare cultures of the nodule bacteria peculiar to indigo on the lines which have recently been advocated by Dr. Moore of the United States Department of Agriculture, with a view to carrying out inoculation experiments on indigo lands.

Lastly, mention must be made of a seed farm which is being conducted by the Behar Indigo Planters' Association under their grant from Government at Dasna near Delhi. The farm is supervised by Mr. Flavell, the Manager of the Zamindari in which it is situated. The object with which the farm was started was the production of Java seed for use in Behar. It has however proved that no advantage whatever arises from growing the seed in the north-west districts, and in the writer's opinion, the cultivation of seed there should be discontinued, and seed farms started in Behar. The cultivation of a limited amount of the seed of the Summatrana variety might however be conducted in the north-west with advantage, since it will probably be always necessary to grow a certain amount of the plant in Behar and by having their own farm, planters will be able to control the selection of the seed and be assured of a pure supply. The advantage arising out of such a system of seed production has been apparent at Sirsiah this year, where land sown with seed carefully grown and harvested at Dasna has given far better crops than similar land sown with the seed bought in open market. Experiments in methods of cultivation of indigo seed started at Dasna this year were unfortunately rendered useless by becoming overgrown with weeds, delay in the receipt of money from Government having rendered weeding impossible until too late. There will be a good supply of Java seed forthcoming from Dasna this year, however, if all goes well. Some experiments
in seed cultivation are in progress at Pusa, and others will be carried out at Sirsiah this year.

C. BERGTHEIL,

Agricultural Bacteriologist to the Govt. of India.

Sirsiah;

Dated the 14th August, 1905.
APPENDIX B.

Jute Experiments in Bengal.

The production of jute in Bengal has, ever since exportation of the fibre commenced in 1828, expanded so rapidly and apparently with so little effort, that until quite recently, little or no serious attention has been paid to its scientific development. During the last few years, however, jute merchants have come to the conclusion that the quality of the fibre which is now produced is deteriorating and in 1901 a request was made to the Bengal agricultural department to make the matter a subject for investigation. This has been done by carrying out agricultural experiments at Burdwan and elsewhere under the guidance of the Inspector General of Agriculture. The objects of these experiments may be summarized as follows:

(a) to compare the respective fibres produced from different varieties of jute, both as regards weight of outturn and quality of fibre;

(b) to determine the stage of growth at which it is best to cut the plant;

(c) improvement of varieties by selection;

(d) manuring experiments;

(e) relative merits of thick and thin sowing;

(f) retting.

As yet, no very definite conclusions have been come to as to which variety or varieties are the best, and when this has been established for Burdwan, it will have to be proved to hold equally well for other districts, before distributing the seed indiscriminately.

As regards the stage of growth at which the plant should be cut,—there seems little doubt that if cut when dead ripe, the yield of fibre is rather greater than if cut earlier; but it also seems equally certain that the quality of the fibre from the late cut plant is not so good as that obtained from the plant cut at an earlier stage. These experiments are being continued, and it is hoped that it may be possible in future to supplement the results by subjecting the samples of fibre produced to chemical and other tests in the laboratory.

The manuring experiments tend to show the superiority of cowdung and castor cake over other fertilizers. Cowdung is the best and cheapest manure when it can be obtained, but castor cake and even a mixture of bonemeal and saltpetre appear to justify their application by yielding an increased net profit. These experiments will doubtless be continued, as the results, if borne out by others, are important. There is much land in the jute districts, especially in places which receive no annual deposit of silt, which responds readily to manure, as one can see at a glance by comparing the crops near the homestead with those a little distance away. The advantage is very much with the former, doubtless on account of the extra manure they receive. If this state of things is to be changed, the raiyat will have to be taught to supplement his scanty supply of cowdung with manures like castor and other cakes which often give results out of all proportion to their present cost.

As regards the improvement of varieties by selection, the Bengal agricultural department has this year taken over plots of land in Faridpur, Mymensing and Rangpur, on which typical varieties of jute, local and otherwise, are being cultivated.
for seed alone. It is hoped that by encouraging a vigorous growth of the plants, by allowing them plenty of room, and by sacrificing the fibre for the sake of the seed, an improved strain of plant will be the result. If this scheme proves successful on a small scale—the plots are about 20 acres in extent,—it is proposed to start a system of distribution of seed, obtained in this way, on a large scale.

Retting.—Under this heading may be included all the operations which the plant undergoes during the separation of the fibre from the rest of the plant. After the plants have been cut, they are tied up into bundles and immersed in water, where they are allowed to remain until the fibre comes away easily from the woody portion of the stem. This is brought about by a fermentation during which the tissue in which the fibres are imbedded is softened or dissolved. It is apparently the result of the work of a particular bacterial organism, and sterilized stems of jute inoculated with what are believed to be pure cultures of this organism ret rapidly. A most interesting observation has been made, viz., that if small amounts of ammonia salts and salts of phosphoric acid be added to the water in which the retting takes place, the fermentation proceeds far more rapidly than in pure water. This may prove to be of value commercially. There can be little doubt that a prolonged immersion in water weakens the jute fibre. If, therefore, the time of retting could be materially shortened, a superior fibre would presumably be the result. It is impossible, however, to say anything definite until experiments have been conducted on a larger scale than is possible in the laboratory.

In the course of the investigation into the retting of jute, it was discovered that various moulds, when allowed to grow upon the stems kept in a moist condition, have the power of dissolving or softening the tissue in which the fibres are imbedded, in other words of performing the retting process. This is no doubt the rationale of "dew retting" of flax in Europe but with regard to jute it is of scientific rather than economic interest.

It is most essential for the production of fibre of good colour that the retting water should be clean, i.e., free not only from much suspended earth, but free as possible also from traces of iron in solution. If the water is muddy, the fibre loses its lustre and becomes greyish in colour, and experiments have proved that a brown fibre results from retting in water containing iron. Unfortunately the raiyat cannot always choose his water for retting. A good crop of jute when green weighs between 300 and 400 maunds per acre and it would not pay him to cart such a weight far, even if suitable water were available at a distance. It should always be possible, however, to wash the separated fibre in clean water.

Deterioration.—The possible causes of the deterioration which, it is generally admitted, has taken place of late years in the quality of jute fibre may be enumerated thus:—

1. The plants grown for the sake of the fibre have actually degenerated.
2. Lands not suited to the growth of jute have been planted with it, thus producing inferior fibre.
3. Kinds of jute are cultivated which are unsuitable for the particular locality in which they are grown.
4. Lands growing jute are becoming exhausted owing to insufficient manuring and lack of application of the principle of rotation of crops.
5. Retting is not now performed with the same care as formerly.
6. The deterioration is due to the practice of fraudulent watering of the fibre to increase its weight before bringing it into the market.

The sub-committee of the Board of Scientific Advice pronounce unhesitatingly against the idea of degeneration in the jute plants. They say "the best kinds now as then if cultivated liberally yield excellent crops and their fibre if properly extracted is also excellent."

The second, third and fourth causes undoubtedly account for the appearance in the market of fibre of inferior length and fineness. The experiments at Burdwan, Faridpur, Mymensingh and Rangpore mentioned above, deal with these questions and are to be looked to for a remedy.

Carelessness in separating and washing the fibre after retting is complete is the cause of sticky, dirty fibre. In isolated cases, the raiyat having more than he can do properly may not clean his fibre properly; but this is by no means generally the case.

One of the principal causes of the deterioration of jute fibre is undoubtedly the practice of adding water and sometimes sand to the fibre to increase its weight before bringing it into the market. This practice of fraudulent watering only commenced a comparatively short time ago, but it is now almost universal. Accurate estimations have been made of the amount of water in a number of samples of watered jute. The percentages of water calculated on the wet sample, dried at a temperature of 100°C, varied from 21 per cent. to over 55 per cent. On the other hand estimations have been made of the amount of moisture taken up by jute fibre from a saturated atmosphere at about the temperature of the rainy season. The results, which are fairly consistent, place the maximum of hygroscopic moisture below twenty per cent. under the most favourable conditions.

The balers have to dry the wet jute in the sun before baling it, for jute is a fibre which is exceedingly sensitive to the action of water, and if it is baled or even rolled into "drums" in the wet condition, it soon begins to heat after which rotting of the fibre takes place in an astonishingly short time. There is a very strong probability that of recent years a good deal of fibre which has been wetted has been baled for export before being properly dried. There is little doubt that such fibre would be quite rotten and therefore useless from a spinning point of view when it reaches its destination. It is easy to see from this how impressions have got abroad concerning the deterioration of the jute plant, whereas all the deterioration has really taken place after the fibre has left the hands of the cultivators.

Extension of the area under jute cultivation.—According to the annual returns, the area under jute cultivation and the weight of fibre produced are continually expanding. Nevertheless, the demand continues equal to the supply. In view of the fact that more and more persistent efforts are being made to grow jute in other countries, e.g., in Java, French Indo-China, and West Africa (where £3,000 is said to have been spent last year in experiments) it is advisable to consider whether the area of cultivation cannot be extended from Bengal to Madras, Bombay and Burma, in each of which provinces it has been suggested there are tracts suitable for this purpose.

ROBERT S. FINLOW, F.C.S.,

Jute Specialist to the Government of Bengal.

Dated the 11th September, 1905.
APPENDIX C.

Outline of the history and the work done by the Mysore State Department of Agriculture.

Complying with a request from the United Planters’ Association for Southern India, the Mysore Government appointed an Agricultural Chemist (who arrived in January 1899) to investigate agricultural problems in Mysore and to do all in his power to help the agriculturists of the State. The following year a plan to use the building in which the Geological Department had been doing their chemical work, as part of an entirely new Chemical Laboratory for both the Geological and Agricultural Departments, was sanctioned. The Agricultural Chemist undertook to fit up and take charge of the new laboratories, and began chemical work with two Geological assistants in February 1901 in a part of the building. A year and a half later, all the laboratories housed in a building a little over 100 feet square were practically finished and work has been carried on uninterruptedly in them ever since.

For nearly three years a part of the laboratory compound has been used as a small experimental field, and this year an “Experimental Farm” of about 39 acres has been laid out and has been sown with a preliminary test crop to judge of the uniformity of the soil. On this Experimental Farm are nearly 10 acres of wet land under a permanent tank; the remainder is dry land.

A pot-culture house is being built in the laboratory compound.

The first assistant chemist to the Agricultural Department was appointed in January 1902, and out of four further assistants which have been sanctioned two have just been appointed. A Mycologist and Entomologist was recently appointed but was granted 18 months’ leave to work in laboratories in America and Europe so as to get a wider experience in laboratory practice before coming out to India.

The work of the Department is to be confined at present to soils and their crops. Sugarcane and its manufacture into jaggery (Gur) and raw centrifugalled sugars have received most attention so far. The sugarcane of Mysore is of particularly good quality. One sample analysed contained less than $\frac{1}{2}$ per cent. glucose and over $21\frac{1}{2}$ per cent. sucrose, and to find a sucrose content of 17, 18 and 19 per cent. is quite common. In fact if it contains appreciably less than 17 per cent. it is probably either not ripe or over ripe. From a refiner’s or sugarmaker’s standpoint, the extraction and boiling of the sugarcane juice are very defective. The extraction is generally between 50 to 70 per cent. on the weight of the cane, and a large percentage of the sugar in the juice is lost by fermentation after milling and by inversion during boiling, the latter on account of insufficient liming, the former on account of want of cleanliness. In one case over 13 per cent. of the total cane sugar in the juice was inverted and an average of one extensive set of experiments conducted in one of the best sugar boiling districts (Tumkur) indicated that over 7 per cent. of the total sugar extracted from the cane was inverted before or during the boiling of the juice. Taking that one pound of inverted sugar prevents two
pounds of cane sugar from crystallising, this implies that if these jaggeries are refined there is an average loss in the refinable sugar of 21 per cent. and that in the one experiment quoted above there would be a loss of 39 per cent. of the total sugar extracted in the juice. The inversion caused by overheating on account of boiling over a direct fire instead of by steam seems, if judged by the experiments conducted here, not as great as is generally believed, for in many cases where juice was limed to neutrality, absolutely no inversion could be detected though the boiling was done in an open native iron pan over a direct fire.

The analyses of commercial fertilizers largely used by coffee planters, is another line of work which has received considerable attention since the laboratories were opened. This was done to show the great differences which exist in fertilizers bearing the same name and the advisability of buying and selling fertilizers with a guarantee as to their composition. In nearly all the various oil cakes used as fertilizers by the planters of this State, the maximum nitrogen contents were about double that of the minimum and in safflower cake nearly three times as much, the minimum being below 3 per cent. and the maximum above 8 per cent. In dried fish and other manures similar variations exist. Even bonemeal was by no means uniform in composition.

Preliminary manurial experiments with ragi and with different depths of cultivation have been made on a small scale, showing that ragi responds well to liberal treatment, when grown on poor soil. Manurial experiments with coffee conducted for four years have so far only shown that the soil on which these experiments were conducted had enough plant food not to require manuring for four years, as none of the fertilizers, though applied liberally, gave any noticeable increase in crop.

A series of experiments with various English grasses and a number of "drought resisting" grasses supplied by the Department of Agriculture at Washington failed completely in this climate in two successive seasons.

A series of analyses has been made of 51 samples of coffee from different parts of the globe with a view of finding out, if possible, a method by which coffee could be judged as to quality in the chemical laboratory. Thus far the specific gravities of the raw coffee beans (of the same variety and from the same district) have been found to agree fairly well with the market price of the samples tested, and at present the specific gravity of the raw beans appears to be the best index for comparing the quality of the crops from different plots of the same experimental fields at our disposal.

The ripe leaves of twelve of the best varieties of trees used as shade for coffee were analysed to judge of the manurial value of the mulch produced by them. These are reported in the third Annual Report and the nitrogen contents of thirty-one so-called famine foods are to be found in the fifth Annual Report.

A. LEHMANN, Ph.D.,
Agricultural Chemist to the Mysore State.

Dated the 7th September, 1905.
### APPENDIX D.

#### List of recent Agricultural Publications in India.

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<th>Serial No.</th>
<th>Title</th>
<th>Author</th>
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<td>3</td>
<td>Note on Improvement of Indian Cotton, 1902-03.</td>
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<td>5</td>
<td>Note on Cotton in Bhainsi, Nizam's Dominions.</td>
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<td>8</td>
<td>Cultivation of Longer stapled-cottons at the Cawnpur Experiment Station.</td>
<td>P. Subbiah, Principal, Cawnpur Agricultural School.</td>
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<td>9</td>
<td>Experimental cultivation of Egyptian cotton at the Nagpur Experimental Farm.</td>
<td>R. S. Joshi, I. Ag., Assistant Director of Agriculture, Central Provinces.</td>
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<tr>
<td>10</td>
<td>The Cotton seed oil Industry</td>
<td>F. G. Sliy, I.C.S., Commissioner of Settlements and Agriculture, Central Provinces.</td>
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<td>Dr. J. W. Leather, Ph.D., F.C.S., Agricultural Chemist to the Government of India.</td>
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<td>C. K. Subba Rao, B.A., Sub-Assistant Director of Agriculture, Madras.</td>
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List of recent Agricultural Publications in India—continued.

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<td>26</td>
<td>Papers on Jute, 1902-03</td>
<td>Department of Agriculture, Bengal</td>
<td>Bengal Secretariat Press, Calcutta.</td>
</tr>
<tr>
<td>27</td>
<td>Selected Papers on enquiry into Deterioration of Jute, 1903-04.</td>
<td>Ditto</td>
<td>Ditto</td>
</tr>
</tbody>
</table>
## List of recent Agricultural Publications in India—continued.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Title</th>
<th>Author</th>
<th>Where published</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Title</td>
<td>Author/Issuer</td>
<td>Price</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>40</td>
<td><em>Paspalum dilatatum.</em> A new fodder grass for India.</td>
<td>Department of Agriculture, Central Provinces.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Urocolia esculenta</em> in Burma.</td>
<td>Department of Land Records and Agriculture, Assam.</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Rhubarb</td>
<td>Ditto Ditto</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>The Spanish chestnut</td>
<td>Ditto Ditto</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Award on the competition for prizes for silos in the Khasi Hills, 1904-05.</td>
<td>Ditto Ditto</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Shillong Government Farm</td>
<td>Ditto Ditto</td>
<td></td>
</tr>
</tbody>
</table>

**Agricultural Ledger No. 1 of 1901. Government Printing, India, Calcutta. Price 2 annas.**

**Bulletin No. 7 of 1902. Department of Agriculture, Nagpur Secretariat Press. Price 1 anna.**


**Agricultural Ledger No. 10 of 1903. Government Printing, India, Calcutta. Price 2 annas.**

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**Bulletin No. 10 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.**
List of recent Agricultural Publications in India—continued.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Title</th>
<th>Author</th>
<th>Where published</th>
</tr>
</thead>
</table>
Different systems of Housing Cattle and conserving manure in the United Provinces.
The utilization of night-soil as manure.
Proceedings of the Board of Agriculture.
Annual Report of the Board of Scientific Advice.
Agricultural Statistics of British India, 1902-03.
Agricultural Statistics of Native States.
Area and yield of certain principal crops in India.
The Agriculture of the United Provinces.
Annual Report of the Department of Agriculture, Bengal.
Annual Report of the Department of Agriculture, United Provinces.

P. V. Subbiah, Principal, Cawnpur Agricultural School.
R. S. Joshi, L. Ag., Assistant Director of Agriculture, Central Provinces.


Pioneer Press, Allahabad, 1904.

List of recent Agricultural Publications in India—continued.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Title.</th>
<th>Author.</th>
<th>Where published.</th>
</tr>
</thead>
</table>

**Agricultural Chemistry.**

| 2 | Reclamation of Reh or Usar-land. | Ditto | Ditto | Agricultural Ledger No. 7 of 1897. Government Printing, India, Calcutta. |
| 5 | Manure Farm Yard | Ditto | Ditto | Agricultural Ledger No. 3 of 1894. Government Printing, India, Calcutta. |
### List of recent Agricultural Publications in India—continued.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Title</th>
<th>Author</th>
<th>Where published</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Experiments at the Cawnpore Farm on the growth of wheat (a) with green manuring, and (b) in rotation with leguminous crops</td>
<td>Ditto ditto</td>
<td>Bulletin No. 10 of 1990, Government Printing Press, Allahabad.</td>
</tr>
<tr>
<td>16</td>
<td>Ditto</td>
<td>Ditto ditto</td>
<td>Agricultural Ledger No. 19 of 1896.</td>
</tr>
<tr>
<td>Title</td>
<td>Author</td>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>The composition of Indian Cows' and Buffaloes' milk</td>
<td>Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India</td>
<td>The Analyst, 1901.</td>
<td></td>
</tr>
<tr>
<td>Procedure to be adopted in the systematic examination of varieties of crops</td>
<td>Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India</td>
<td>Bulletin No. 8 of 1900.</td>
<td></td>
</tr>
<tr>
<td>Some recent investigations in the Chemistry of Agriculture.</td>
<td>Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>The Tea soils of Assam</td>
<td>Ditto</td>
<td>Ditto</td>
<td></td>
</tr>
<tr>
<td>Ferment of the Tea Leaf, Parts I-III</td>
<td>Ditto</td>
<td>Ditto</td>
<td></td>
</tr>
<tr>
<td>Serial No.</td>
<td>Title</td>
<td>Author</td>
<td></td>
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<td>-----------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Agricultural Chemistry—concluded.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Note on Provisional Classification of Indian wheats cultivated during 1901-03 at the Poona and Manjri Farms, Bombay.</td>
<td>Professor G. A. Gammie, F.L.S., College of Science, Poona.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Note on the Classification of Indian Cottons (tentative) and cross-breeding experiments at the Poona Farm, 1901-03.</td>
<td>Ditto ditto</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The Indian Cottons</td>
<td>Ditto ditto</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Potato Diseases in India</td>
<td>Dr. E. J. Butler, M.B., F.L.S., Cryptogamic Botanist to the Government of India.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The Indian Wheat Rust Problem, Part I.</td>
<td>Ditto ditto</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Botany.</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Government Central Press, Mysore, Bangalore.

Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.

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Imperial Department of Agriculture, Bulletin No. 1 of 1903. Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.
<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>A Deodar Disease in Juansar.</td>
<td>Ditto ditto</td>
</tr>
<tr>
<td>9</td>
<td>Pilzkrankheiten in Indien im Jahre 1903</td>
<td>Ditto ditto</td>
</tr>
<tr>
<td>Serial No.</td>
<td>Title</td>
<td>Author</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>Variation in Indigofera sawadra Gneti, as induced by climatic conditions.</td>
<td>Professor G. A. Gammie, F.L.S., College of Science, Poona.</td>
</tr>
<tr>
<td>17</td>
<td>A Note on the plants used for food during families and periods of scarcity.</td>
<td>H. M. Leed, M.A., F.L.S., F.Z.S., Entomologist to the Government of India.</td>
</tr>
<tr>
<td>2</td>
<td>Instructions for destroying Hoppers.</td>
<td>Ditto</td>
</tr>
<tr>
<td>3</td>
<td>The six-spotted Lady Bird Beetle.</td>
<td>Ditto</td>
</tr>
<tr>
<td>4</td>
<td>The Red Cotton Bug.</td>
<td>Ditto</td>
</tr>
<tr>
<td>5</td>
<td>The Cotton Leaf Hopper.</td>
<td>Ditto</td>
</tr>
<tr>
<td>6</td>
<td>The Dusky Cotton Bug.</td>
<td>Ditto</td>
</tr>
<tr>
<td>No.</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>7</td>
<td>The Success Knapsack Sprayer</td>
<td>Ditto</td>
</tr>
<tr>
<td>8</td>
<td>Insects attacking Cotton</td>
<td>Ditto</td>
</tr>
<tr>
<td>9</td>
<td>Kerosine Emulsion</td>
<td>Ditto</td>
</tr>
<tr>
<td>10</td>
<td>Rosin washes as Insecticides</td>
<td>Ditto</td>
</tr>
<tr>
<td>11</td>
<td>Lead Arseniate</td>
<td>Ditto</td>
</tr>
<tr>
<td>12</td>
<td>Crude Oil Emulsion</td>
<td>Ditto</td>
</tr>
<tr>
<td>13</td>
<td>How to rear caterpillars that attack crops</td>
<td>Ditto</td>
</tr>
<tr>
<td>14</td>
<td>Note on Cotton in Behar</td>
<td>Ditto</td>
</tr>
<tr>
<td>15</td>
<td>Insect Pests of Coffee</td>
<td>Ditto</td>
</tr>
<tr>
<td>16</td>
<td>Classification of Insects</td>
<td>Ditto</td>
</tr>
<tr>
<td>17</td>
<td>Simple spraying apparatus</td>
<td>Ditto</td>
</tr>
<tr>
<td>18</td>
<td>Fumigation of seeds</td>
<td>Ditto</td>
</tr>
<tr>
<td>19</td>
<td>Insects injuring sugarcane</td>
<td>Ditto</td>
</tr>
<tr>
<td>20</td>
<td>Notes on the work of Assistants</td>
<td>Ditto</td>
</tr>
<tr>
<td>21</td>
<td>Report on an enquiry into the state of Tasar Silk Industry in Bengal and the Central Provinces.</td>
<td>Ditto</td>
</tr>
</tbody>
</table>


Occasional Bulletin, No. 1, Pusa.

Imperial Department of Agriculture Bulletin No. 2 of 1903. Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.


The Bengal Secretariat Book Depot. Price Rs. 2.
List of recent Agricultural Publications in India—concluded.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Title.</th>
<th>Author.</th>
<th>Where published.</th>
</tr>
</thead>
</table>
REPORT

OF THE

IMPERIAL DEPARTMENT OF

AGRICULTURE

FOR THE YEARS

1905-06 and 1906-07.
REPORT

OF THE

IMPERIAL DEPARTMENT OF AGRICULTURE

FOR THE YEARS

1905-06 and 1906-07.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1908
# TABLE OF CONTENTS.

## Part I.—Report of the Inspector-General of Agriculture in India,

by J. Mollison, M.R.A.C.

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General duties</td>
<td>1</td>
</tr>
<tr>
<td>2. Staff and means for agricultural improvement in India</td>
<td>1</td>
</tr>
<tr>
<td>3. Rules for appointment in the Indian agricultural service</td>
<td>4</td>
</tr>
<tr>
<td>4. Tours</td>
<td>4</td>
</tr>
<tr>
<td>5. Board of Agriculture</td>
<td>5</td>
</tr>
<tr>
<td>6. The Agricultural Research Institute, Pusa</td>
<td>6</td>
</tr>
<tr>
<td>7. Agriculture</td>
<td>7</td>
</tr>
<tr>
<td>8. Cotton</td>
<td>8</td>
</tr>
<tr>
<td>9. Sugarcane</td>
<td>8</td>
</tr>
<tr>
<td>10. Agricultural Chemistry</td>
<td>9</td>
</tr>
<tr>
<td>11. Mycology</td>
<td>9</td>
</tr>
<tr>
<td>12. Entomology</td>
<td>10</td>
</tr>
<tr>
<td>13. Botany</td>
<td>11</td>
</tr>
<tr>
<td>15. Selection of cotton seed</td>
<td>12</td>
</tr>
<tr>
<td>16. Cotton hybridization</td>
<td>13</td>
</tr>
<tr>
<td>17. Trial of exotics</td>
<td>14</td>
</tr>
<tr>
<td>18. Tree cottons</td>
<td>14</td>
</tr>
<tr>
<td>19. Extension of cotton cultivation</td>
<td>15</td>
</tr>
<tr>
<td>20. Tea</td>
<td>16</td>
</tr>
<tr>
<td>21. Indigo</td>
<td>16</td>
</tr>
<tr>
<td>22. Jute</td>
<td>17</td>
</tr>
<tr>
<td>23. Flax</td>
<td>18</td>
</tr>
<tr>
<td>24. Other fibres</td>
<td>19</td>
</tr>
<tr>
<td>25. Tobacco</td>
<td>19</td>
</tr>
<tr>
<td>26. Wheat</td>
<td>19</td>
</tr>
<tr>
<td>27. Groundnut</td>
<td>20</td>
</tr>
<tr>
<td>28. Artificial fertilizers</td>
<td>20</td>
</tr>
<tr>
<td>29. Irrigation</td>
<td>21</td>
</tr>
<tr>
<td>30. Sericulture</td>
<td>23</td>
</tr>
<tr>
<td>31. Agricultural education</td>
<td>24</td>
</tr>
<tr>
<td>32. Distribution of seeds and implements</td>
<td>25</td>
</tr>
<tr>
<td>33. Publications</td>
<td>25</td>
</tr>
<tr>
<td>34. Expenditure</td>
<td>26</td>
</tr>
<tr>
<td>35. Provincial Departments of Agriculture</td>
<td>27</td>
</tr>
<tr>
<td>Bombay</td>
<td>27</td>
</tr>
<tr>
<td>Madras</td>
<td>28</td>
</tr>
<tr>
<td>United Provinces</td>
<td>28</td>
</tr>
<tr>
<td>Bengal</td>
<td>28</td>
</tr>
</tbody>
</table>

Paragraph. Page.
40. Provincial Departments of Punjab 29
41. " " Central Provinces 30
42. " " Eastern Bengal and Assam 30
43. " Burma 30
44. Expansion of the Department 30

PART II.—Report of the Officiating Director, Agricultural Research Institute, Pusa, by J. Walter Leather, Ph.D., F.I.C., F.C.S.

1. Charge of Office 33
2. General work of the Institute 33
3. Buildings 33
4. Roads, etc. 33
5. Medical 33
6. Training 34
7. Library 34
8. Publications 34
9. Accounts 34


1. Charge of Office 34
2. Laboratory 35
3. General Analytical work 35
4. Potculture house 35
5. Available plant food in soils 35
6. Pusa soils 36
7. Meteorology 36
8. Rain and Dew 36
9. Drain gauges 36
10. Loss of water from soil 36
11. Saltpetre 37
12. Sugarcane 37
13. Cyanogenetic glucosides 37
14. Establishment 37

PART IV.—Report of the Imperial Mycologist, by Dr. E. J. Butler, M.B., F.L.S.

1. Prefatory 39
2. Investigations of plant diseases 40
3. Sugarcane diseases 41
4. Cereal rusts 41
5. Groundnut leaf diseases 42
6. Wilt diseases 42
### Part IV.

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Green-ear disease of cereals</td>
<td>42</td>
</tr>
<tr>
<td>8. Mango diseases</td>
<td>42</td>
</tr>
<tr>
<td>9. Other diseases</td>
<td>43</td>
</tr>
<tr>
<td>10. Soil inoculation for legumes</td>
<td>43</td>
</tr>
<tr>
<td>11. Fungus diseases of injurious insects</td>
<td>43</td>
</tr>
<tr>
<td>12. Soil fungi</td>
<td>44</td>
</tr>
<tr>
<td>13. Systematic Mycology</td>
<td>44</td>
</tr>
<tr>
<td>14. Text-book</td>
<td>44</td>
</tr>
<tr>
<td>15. Training</td>
<td>44</td>
</tr>
<tr>
<td>16. Establishment</td>
<td>45</td>
</tr>
</tbody>
</table>

### Part V.
*Report of the Imperial Entomologist*, by Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.

| 1. Training                                                             | 47   |
| 2. Establishment                                                        | 47   |
| 3. Buildings                                                            | 47   |
| 4. Provincial work                                                      | 47   |
| 5. Correspondence                                                       | 48   |
| 6. Research                                                             | 48   |
| 7. Insect survey                                                        | 49   |
| 8. Summary                                                              | 49   |
| 9. Publications                                                         | 49   |

### Part VI.
*Summary of the Report of the Imperial Agriculturist.*

| 1. Staff                                                                 | 51   |
| 2. Historical                                                            | 51   |
| 3. Training                                                              | 51   |
| 4. Cropping                                                              | 51   |
| 5. Cotton                                                                | 51   |
| 6. Sugarcane                                                             | 52   |
| 7. Jute                                                                  | 52   |
| 8. Flax                                                                  | 52   |
| 9. Mangel wurzels                                                        | 52   |
| 10. Green manuring                                                       | 52   |
| 11. Trial of new pasture grasses                                         | 52   |
| 12. Breeding herds                                                       | 52   |
| 13. Establishment                                                        | 52   |

### Part VII.
*Summary of the Report of the Imperial Economic Botanist.*

| 1. Prefatory                                                             | 53   |
| 2. Wheat investigation                                                   | 53   |
| 3. Tobacco                                                               | 54   |
| 4. Barleys                                                               | 54   |
| 5. Ganja                                                                 | 54   |

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Library Catalogue</td>
<td>54</td>
</tr>
<tr>
<td>7. Tours</td>
<td>54</td>
</tr>
<tr>
<td>8. Staff</td>
<td>54</td>
</tr>
<tr>
<td><strong>Appendix A.</strong> A short account of recent work in Behar in Indigo Research</td>
<td>55</td>
</tr>
<tr>
<td><strong>Appendix B.</strong> A short account of experiments with Jute and other Fibres</td>
<td>56</td>
</tr>
<tr>
<td><strong>Appendix C.</strong> List of recent agricultural publications in India</td>
<td>59</td>
</tr>
</tbody>
</table>
REPORT

OF THE

IMPERIAL DEPARTMENT OF AGRICULTURE

FOR THE YEARS

1905-06 and 1906-07.

PART I.

REPORT OF THE INSPECTOR-GENERAL OF AGRICULTURE.

1. General duties.—The duties of the Inspector-General are advisory as regards agricultural investigations which are being carried out in each Province, but they are direct as regards the work carried on at the Government of India Research Institute at Pusa. The Provincial Directors have consulted him freely, and have also readily accepted advice. They have co-operated very freely with each other. Good arrangements have been made for continuity of work in each Province and there is no special overlapping of work. Mr. F. G. Sly, I.C.S., held charge of the office of the Inspector-General of Agriculture in India until 26th February 1907, when after over two years’ leave, Mr. J. Mollison, M.R.A.C., permanent incumbent of the post, again took over charge. As the work of the Imperial Department of Agriculture developed it was considered necessary to appoint an assistant to the Inspector-General. Mr. T. F. Main, B.Sc., was appointed in August 1905. His chief work has been to collect information regarding ordinary field and garden crops, agricultural implements, agricultural practices and the like. He was recently specially employed to make full enquiries regarding Coffee and Pepper cultivation in Southern India, to study the methods of keeping Farm accounts in all Provinces in order to offer suggestions to improve them and on an enquiry regarding the natural grasses and pasture plants of India. General work of this kind will be continued. One or two enquiries at a time will be taken up and fully dealt with.
2. The staff and means for agricultural improvement in India.—The proposals made to the Secretary of State for India for the expansion of the Agricultural Department have been generally sanctioned excepting those which refer to a third Entomologist and Crop Specialists for Tobacco, Sugarcane, Wheat, Rice and Fruit and Mycological and Entomological Experts in each Province. The appointment of a Cotton Expert has been sanctioned and is likely to be filled soon by a very experienced officer. A fibre expert has been appointed and now works under the Government of Eastern Bengal and Assam. His headquarters and laboratories and experimental plots are at Pusa. His work in regard to the extension of jute cultivation and other fibres extends all over India, but his chief field experiments are at present arranged for at Pusa.

There are now eighteen appointments in the Imperial Department of Agriculture, viz.:

1. Inspector-General of Agriculture.—J. Mollison, M.R.A.C.
2. Assistant Inspector-General of Agriculture.—T. F. Main, B.Sc.
3. Director of the Agricultural Research Institute and Principal of the Agricultural College, Pusa.—Bernard Coventry.
4. Imperial Agricultural Chemist.—J. W. Leather, Ph.D., F.I.C., F.C.S.
5. Imperial Mycologist.—E. J. Butler, M.B., F.L.S.
6. Imperial Entomologist.—H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.
7. Second Entomologist.—F. M. Howlett, B.A.
8. Imperial Bacteriologist.—C. J. Bergtheil.
9. Imperial Agriculturist.—E. Shearer, M.A., B.Sc.
10. Imperial Economic Botanist.—A. Howard, M.A., A.R.C.S.
11. Imperial Cotton Specialist.—Vacant.
14. Supernumerary Agriculturist.—G. H. Garrad, N.D.A.
15. Supernumerary Specialist.—C. W. Mason (Entomologist).
18. Supernumerary Specialist.—W. MacRae, M.A., B.Sc. (Mycologist).

The Imperial Bacteriologist has been employed by the Bengal Government in Indigo Research work. He will be able to continue this work when he takes up his permanent appointment at Pusa in April next, but there is much other work which requires his special attention at Pusa. We have found considerable difficulty in getting experienced
Agricultural Experts for particular sections. Therefore, young supernumerary officers have been appointed who are being trained at Pusa and by deputation to various Provinces. The second Entomologist and the supernumerary Mycologist have been selected, but have not yet arrived in India. The former is specializing in work which will be of value to India. The latter has gone to Germany for special studies. In each Province a great advance has been made in the organisation of its Agricultural Department. Each has a nucleus staff consisting in most cases of the Principal of the Agricultural College, a Chemist, a Botanist and one or more all-round practical Agriculturists. There are in all 38 sanctioned appointments for the Provinces as shown in the following table:

<table>
<thead>
<tr>
<th>Province</th>
<th>Deputy Director of Agriculture</th>
<th>Second Deputy Director of Agriculture</th>
<th>Principal, Provincial College</th>
<th>Botanist</th>
<th>Chemist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengal</td>
<td>F. Smith, B.Sc.</td>
<td>(not provided)</td>
<td>H. H. Corbin, B.Sc.</td>
<td>W. R. Buttershaw, M.A., B.Sc.</td>
<td>Vacant</td>
</tr>
<tr>
<td>Eastern Bengal and Assam</td>
<td>Rai Bahadur B. C. Basu, M.R.A.C.</td>
<td>(to be filled locally in October)</td>
<td>(not provided)</td>
<td>(required in October 1907)</td>
<td></td>
</tr>
<tr>
<td>North-West Frontier Province</td>
<td>(vacant)</td>
<td>(not provided)</td>
<td></td>
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*Note.*—Postings made subsequent to June 1907 have not been included in this statement.
Eight of these officers have not yet arrived in India. The sanctioned posts will probably all be filled before the end of the financial year. The Mysore, Baroda and Kashmir States are developing their Agricultural Departments and have each done a great deal to improve Horticulture. The larger public gardens in India are doing much to improve our fruit orchards and are making other improvements. The Planters' Associations in Behar and Southern India have been active in advancing their industries. The Indian Tea Association and Indigo Planters' Association have each a staff of Agricultural Experts.

3. Rules of Service.—Uniform rules have been laid down for the appointment in the agricultural service. Local allowances for certain officers of the Imperial Department of Agriculture and Principals of Provincial Colleges have been sanctioned. Separate Departments of Agriculture, distinct from the Land Records Departments, have been formed in nearly all Provinces and are placed in charge of officers of the Indian Civil Service as Directors of Agriculture. The restriction limiting the total emoluments of the Directors of Agriculture to the pay of the Collectors of the highest grade as a maximum has been withdrawn. Definite orders have been issued by the Government of India regarding the authority which can be exercised by the Imperial Experts over Provincial work. This authority is purely advisory. The Imperial Experts can freely communicate direct with Provincial Experts regarding lines of work already sanctioned, and their advice is also very freely taken advantage of in executive duties.

4. Tours.—In 1905 Mr. Sly attended the Educational Conference held at Simla and read a paper on rural education. During the period under report the Inspector-General visited all the Provinces once or several times. The main objects of the tours were to inspect various Government Farms and to confer with the local officers regarding the work done on these Farms, and regarding the extension of experimental work of proved value into local districts and of good methods of cultivation or good varieties of crops into other parts of India. A visit was paid to Burma early in 1905 when a detailed scheme for the organisation of the Agricultural Department of the Province was framed in consultation with the Director. On this tour endeavours were made to ascertain the possibilities of cotton cultivation in the Province. These were not found to be particularly hopeful because the profitable cultivation of cotton requires much labour, and in Burma labour is both scarce and dear. In Madras the Provincial Agricultural Stations and the general agriculture of the Province were seen, and in more particular detail the sugarcane experiments at Samalkota, the Agave plantations at Hindupur and the system of rice irrigation under tanks supplemented by wells. This system can probably be adopted with advantage in many parts of Peninsular India and should be generally known. On
the same tour Mr. Tata’s Silk Factory at Bangalore was inspected. Three visits were paid to the Bombay Presidency. The extensive work in the Bombay Agricultural Department was inspected and the possibilities for its extension in numerous directions discussed. The tree cotton experiments made by Mr. Tytler at Belgaum were seen, also the experiments with Egyptian cotton in Sind. The Chharodi Cattle Farm was inspected in company with the Inspector-General, Civil Veterinary Department, and the Bombay Director of Agriculture. It was decided to continue breeding operations on very definite lines and to breed from the very best cattle only. This Farm has been transferred to the Civil Veterinary Department. The Baroda State was visited, and the farms and sericulture experiments there were inspected. In the United Provinces the extensive work initiated by Mr. Moreland in wheat improvement by hybridization and selection was studied, also the general and very varied work of the Department, especially the storing and distribution of good varieties of seed. A conference was held regarding the extension of the Department. The North-West Frontier Province was visited. An area for an experimental farm was selected and general enquiries made as regards agricultural improvements in the Province. On the same tour the Lyallpur Farm and the agricultural conditions of the Chenab Colony in the Punjab were seen. In Bengal Mr. Sly advised regarding the site for the Provincial College and its Farm and also saw the experimental areas under tree cottons which are managed by Messrs. Shaw, Wallace & Co. helped by funds from the Government of India and the British Cotton Growing Association. The agricultural experiments and the general agriculture of the Central Provinces were kept well in review as the head-quarters of the Department are at Nagpur. In February 1906, Mr. Sly went to Eastern Bengal and Assam and conferred with His Honour the Lieutenant-Governor, the Director and Mr. Finlow on the organisation of the Agricultural Department and the cultivation of jute in the Province. He visited with Dr. H. H. Mann, Heeleeka, the principal experimental station of the Indian Tea Association, some tea plantations and the Sisal Hemp plantation at Daurachera.

5. Board of Agriculture.—The constitution of the Board of Agriculture, its duties and objects were described in the last Report of the Department. Since then, it has done most useful work in giving advice to Government in general agricultural experimental work and in other connected matters. The Board has now held three annual meetings attended respectively by 32, 35 and 48 members. The increased number of members indicates progress. The influence of these conferences greatly affects the advancement of agricultural science and practice in India. The second meeting of the Board was held at Pusa. It was attended by members from all Provinces except Burma, also by representatives from Mysore and Baroda. The subjects for general discussion
were (1) the programmes of work of the Imperial and Provincial Departments, (2) means of improving Indian wheat and tobacco, (3) the use of artificial fertilizers in India and control of the trade, (4) the provision of fodder for cattle in times of famine, (5) a syllabus for the principal branches of agricultural education. The Proceedings of the Board have been separately published. The proposals as regards the syllabus for scientific agricultural education may have to be modified before they can be accepted for general application. In fact the syllabus as framed for general agricultural education should only be taken as a guide for the agricultural course in any particular Provincial College. A sub-committee consisting of the Pusa staff and several other scientific experts proposed, in general terms, a scheme of experimental work for the Pusa Institute and the Farm. The scheme recommends that fundamental principles applicable to tropical and sub-tropical agriculture only should be dealt with at Pusa. Before we can, however, apply science to practice in the field a complete knowledge of ordinary field practices is required, and it is just as essential to study these practices at Pusa as at Provincial Research Stations. It was decided that the meeting of the Board should, in alternate years, be held at Pusa and in one or other of the Provinces. The third meeting of the Board was accordingly held at Cawnpore in February 1907. In addition to the ordinary members Sir Edward Buck, K.C.S.I., and Major Atkinson, R.E., were visitors, and made valuable contributions to the proceedings. The chief discussions referred to the programmes of work of the various Agricultural Departments, the Indian Sugar Industry, Cotton Improvement, Artificial Fertilizers and the Unification of Laboratory Methods employed by Agricultural Chemists. The question of legislation for the control of artificial fertilizers was again considered. The Board decided that such legislation though desirable is not ripe for introduction, but that trade developments should be closely watched. Sir Edward Buck introduced discussion on two very important subjects. The first was the utilization of river silt in India, the second was the employment of Agricultural Engineers in India. The discussion elicited many facts of general interest. The Board of Agriculture has grown unwieldy as regards the number of members. Its future constitution is being considered. It is proposed to reduce the number of members and to specially invite officers experienced in Agriculture.

6. The Agricultural Research Institute, Pusa.—The Director, Mr. B. Coventry, held charge until February 1907, when he proceeded on leave. Dr. J. W. Leather has been officiating for him. All branches of the Institute except Agricultural Bacteriology are now located at Pusa and consist of Agriculture, Chemistry, Mycology, Entomology, Bacteriology and Botany. The Imperial Bacteriologist, Mr. C. Bergtheil, is still on deputation with the Government of Bengal. The general work in
each section is described by the head of that section, and the report of each is added hereto as an appendix. Some reports being lengthy had to be summarised.

The College and Research building are nearly complete and will be opened for work by the end of April 1908. All other buildings are complete; they include eight bungalows for European officers, quarters for six European probationers, a rest-house, hospital, veterinary dispensary, a hostel for seventy students, quarters for thirteen teachers, the farm buildings, general office, temporary chemical, biological, entomological and botanical laboratories, an insectary and a potculture house. The whole estate has been practically cleared of jungle and put in order and the roads and avenues have been greatly improved. The compounds of bungalows and other buildings are in trim order except the compound of the College building which is not yet finished. The Pusa estate, like other parts of Behar, is liable to be suddenly flooded owing to heavy continuous rain. It has, therefore, been found necessary to form embankments to exclude from the experimental areas flooding in occasional years. It is impossible to make full arrangements for the equipment of the Institute until its construction is complete; but nucleus collections for the library and for other sections are being gathered. The museums of economic products, mycology and entomology, will be filled by specimens which have been collected or will be collected in the near future. Until the Provincial Agricultural Colleges are all in working order, we propose to teach at Pusa specially selected agricultural students who will each get a scholarship of sufficient value for support during the course of instruction. The chief object of instruction is to prepare natives of the country for practical work in scientific agriculture. Experienced highly educated natives are not now easily obtainable to supervise field experiments in a reliable way because practically trained men are not available. Eventually Pusa, by giving a post-graduate course, will, it is hoped, produce native specialists in particular lines of agricultural work such as in Agricultural Chemistry, Entomology, Mycology and Agriculture.

7. Agriculture.—Mr. E. Shearer, the Imperial Agriculturist, had charge of the Farm and all cultivation experiments during the period under review. The Pusa property extends over 1,300 acres, and the greater portion is intended for work-a-day methods. The clearing, levelling and reclamation of good arable land from jungle is nearly complete and preparations are being made on a small section of the property for scientific experiments which will probably benefit large areas in India. In framing the lines of experiments, the testing of varieties of crops, indigenous methods, available manures and such like, on land similar to that reserved for experimental plots, is likely to lead to useful results and this has been undertaken. In order to prepare for permanent
experiments, the uniformity of particular areas on the farm is being determined. The chief crops grown experimentally were cotton, sugar-cane, jute and flax. Exceptional floods damaged the whole estate in 1905 and 1906. Precautions have been taken to prevent this damage in future. A detailed account of jute and flax cultivation is given under separate headings.

8. Cotton.—Imported and acclimatised American, indigenous and Egyptian varieties and perennial tree cottons were tried on the farm. After three years' experience general results indicate that many other crops are much more profitable in Behar than any description of cotton. The exotic annual cottons and even the acclimatised perennial tree cottons are liable to severe damage by boll-worm and other pests which are difficult to control.

9. Sugarcane.—Twenty-five varieties of sugarcane were planted in 1905. The general results are shortly dealt with in part six of this report.

Green manuring with *Sunn* hemp gave good results on newly broken up poor land. Two pasture grasses, *Chloris virgata* and *Chloris gayana* which flourish in Australia and South Africa were tried and being promising will be tried on a larger scale next year. The pasture area of the Pusa estate is now laid out. Manurial and other experiments on grass and pasture land in England have yielded very valuable and definite results. It has been arranged to start similar experiments at Pusa and to determine whether our pasture land can be improved. Mr. Shearer has framed a scheme of manuring and other experiments which is fully described in the Agricultural Journal of India, Vol. 2, Part 3. Breeding herds of local and Montgomery cattle are kept on the farm, the former with the object of distributing good bulls throughout particular districts in Bengal, the latter chiefly with the object of testing the milking quality of the breed and of supplying the Pusa establishment with milk. Montgomery cattle are probably the best milk-breed in India and apparently can be acclimatised easily in almost any other Indian district. This herd is doing very well at Pusa. The Superintendent, Civil Veterinary Department, Bengal, gives advice and takes a keen interest regarding these breeding herds. The rejection and distribution of bulls for district work is practically left in his hands. We have begun poultry breeding and bee-keeping at Pusa from stocks imported from England, but indigenous stocks will not be neglected.

10. Agricultural Chemistry.—Dr. J. W. Leather held charge of the section except during three months' leave when Mr. R. S. Finlow acted for him. He has now a European Assistant. Numerous analyses of soils, waters, silts, manures, feeding stuffs, oil-seeds,
sugarcanes, etc., were made and several special problems were investigated. The miscellaneous work which Dr. Leather has hitherto undertaken will decrease as the posting of Chemists to each Province is completed. He will have more time for original research and for definite large investigations. Such large investigations are now essential because the work of the department has developed. During the period under report Indian commerce has been helped by the work of the Chemical Section. The value of rain and dew in adding manurial elements to the soil is under investigation. Pusa has a well-equipped potculture house which has already given practical results regarding the manures required for particular Indian soils. Dr. Leather has described the potculture house in Memoir No. 3 of 1907, Chemical Series. He is endeavouring to popularise his potculture results by practical application in the field among Behar Indigo Planters. Meteorological records are being kept. Four drain gauges have been constructed and the chemical and other effects of the passage of water through the soil are under investigation. Dr. Leather is determining the conditions under which Cyanogenic Glucosides are formed in certain agricultural plants, but there are yet no definite results to report.

11. **Mycology.**—The head-quarters of the Imperial Mycologist were transferred to Pusa in November 1905. Dr. Butler’s practical work will be greatly facilitated by a complete reference herbarium collection of fungus diseases which affect Indian agricultural crops. The specimens are gradually being collected. His work cannot easily be applied in practice until preliminary enquiries, which take time are worked out. He is single-handed and has more agricultural crop diseases to deal with than in any country in the world. He requires a European assistant in addition to the supernumerary who has been appointed but has not yet joined. Dr. Butler was absent in Europe on leave for three months and then enlisted the co-operation of scientific workers in Paris, Berlin, and Kew. For Mycological work, the training of native assistants has been undertaken at Pusa as far as possible for every Province and will be continued. At Pusa and Poona experiments were continued to study the groundnut leaf disease. The wheat rust problem was also continued. An account of the varieties and distribution of Indian rusts has been published in the Botanical Memoir, Vol. 1, No. 2, July 1906. The wilts of pigeonpea, cotton, gram, jute, sesamum and indigo have also been under study. The knowledge so far gained indicates that the United States Cotton Wilt Fungus (*Neocosmospora vasinfecta*) which is widely distributed in India, is the probable cause. A parasite (*Sclerospora graminicola*) causes the green-ear disease of *bajra*, *jowar*, Italian millets and other cereals. A published Scientific Memoir deals with this parasite (Vol.
II, No. 1 of 1907, Botanical series). In the mycological laboratory numerous specimens of affected agricultural crops, fruit trees, and other economic plants were examined and remedies likely to prove useful were suggested. Field experiments were made at Dehra Dun and Pusa to test the value of soil inoculation recommended by the United States Department of Agriculture. They resulted in no appreciable gains. These methods probably do not generally suit the soils in India because the system of rotation usually practised includes numerous leguminous crops and the bacilli which produce the nodules on the roots of these crops and which add nitrogen in an organic form to the soil are probably numerous in every field. The study of the fungi which help to decompose the organic matter in soil has been commenced. Dr. Butler is giving special attention to the diseases of palm trees, sugarcane and mangoes. The spread of palm-tree disease from the Godavari delta threatens the extinction of palmyra, Coconut and betelnut palms in many parts of Madras. Dr. Butler toured through infected areas in August 1905 and March 1907. A large campaign to stamp out this disease is guided by Dr. Butler’s advice, and the executive part of the work is being carried out vigorously by the Madras Agricultural Department.

A detailed account of this disease is given in the Agricultural Journal of October 1906 and a technical description of the parasite in the Scientific Memoir, Vol. I, No. 5, Botanical Series.

At Pusa investigation of the “Red Rot,” “Black Rot,” “Smut” and the “Red Leaf Spot,” some of the chief diseases of sugarcane has been made. A simple and efficient method of checking “Red Rot,” the most serious of these, has been discovered. The treatment and check of other sugarcane diseases are under investigation.

Dr. Butler visited Malda (Bengal) in 1905 to investigate the disease which is destroying the valuable mango orchards of the district. This enquiry will probably require incisive investigation. Dr. Butler is preparing a text-book regarding the fungus diseases of Indian plants for the use of Indian students.

12. Entomology.—Mr. Lefroy held charge of his section during the period under report. A supernumerary Entomologist joined in December 1906. Mr. Howlett as Second Entomologist will take up his appointment in December 1907. He is now specialising in England in preparation for work in India. The work of this section has progressed on very definite lines. The practical results of Mr. Lefroy’s enquiries have already been of immense value to India. The entomological work in each Province is carried out by Indian assistants who have been trained at Pusa and who work more or less under the guidance of the Imperial Entomologist. They meet annually at Pusa, discuss with Mr. Lefroy the year’s work and compare notes.
These meetings are extremely useful. The time of the Entomologist is largely taken up in identifying insects, reporting on them, and in satisfying enquiries. Steady progress has been made in investigating the life histories of insects injurious to agriculture. Specialists in Europe and America have helped this work. Pusa has now a large reference collection of injurious and other insects. Insecticides fatal to destructive insects but not to domesticated animals have been discovered. The insecticide experiments have reached the stage of field trials. An enquiry has been started regarding the prevalence in India of biting flies and their effects as carriers of disease. This subject is important in medical and veterinary science. The cultivation of Eri silk has been taken up to determine whether the worms can survive the dry hot weather and are likely to be acclimatised to heat in various districts. Lac was also introduced at Pusa as there is a likely field for this industry on existing trees in Behar. A severe outbreak of cotton boll-worm in the Punjab was controlled to some extent by measures described under cotton. Mr. Lefroy and Dr. Butler jointly tested the method of destroying locusts by the fungus which was reported to have been tried with success in South Africa. Healthy specimens of Bombay, North-West migratory locusts and some species of grasshopper were inoculated with pure culture of fungus in various ways. No successful results were obtained presumably because it has been found that the true natural locust parasite in South Africa is a different fungus (*Empusa grylli*) from that which has been distributed from Africa under this name (*Mucor ekiteosus*). A book on Entomology entitled "Indian Insect Pests" has been published. This book gives a summary of the facts relating to insect and insect life, origin of insect pests, their preventives and remedies and refers to the chief pests of the staple crops of India. The book has been widely appreciated in India. Mr. Lefroy is also recording general information regarding the insects of the cultivated areas. This as a text-book will be published soon to help advanced agricultural students and for general information.

13. *Botany.*—Mr. Howard took charge of the office of the Imperial Economic Botanist in 1905. At first he toured to acquaint himself with the agricultural conditions of various parts of India and the Botanical work carried on in the Provinces. A supernumerary Botanist has been added to his staff during the current year. Mr. Howard has in his charge at Pusa a large area which is partly devoted to orchards of many varieties of fruit, and partly to a botanical garden which will be chiefly planted with economic plants. The rest is really a field laboratory in which varieties of imported Indian crops are tested in small plots from which botanical descriptions and other data are obtained. The crops which have been chiefly dealt
with are wheat, barley, flax, tobacco, and fibre plants. Mr. Howard has given special attention at Pusa and in the Punjab to wheat and, I believe, has separated type specimens of all or nearly all Indian varieties from the mixed crops usually grown. This is really the first step towards the improvement of varieties. Cross-breeding and selection, and distribution of seed absolutely true to variety will follow. The general results of Mr. Howard’s work with wheat will appear in a monograph which he is preparing and which will be freely illustrated with type specimens of numerous varieties. The study of various kinds of tobacco grown in India was also undertaken. Seed of tobacco was obtained from various parts of India and grown at Pusa. Much of the preliminary classification is now complete, and seed has been collected for further study this year. We have not yet got beyond the field study of varieties of tobacco, but the way has been paved for experiments in curing and also for producing fine qualities of tobacco which may command high prices for export.

14. Cotton—Survey of indigenous varieties.—A botanical survey of the cultivated forms of Indian cottons has been practically completed by Professor Gammie, the Bombay Economic Botanist, who has been helped by the Reporter on Economic Products to the Government of India and by experts of the Agricultural Department in each Province. The results have been published in his “Note on Indian Cottons”. The report deals with the species and varieties of cotton known in India, their distribution in particular areas, the degree to which hybridization naturally occurs, the quality of lint and other particulars. A revised illustrated classification by Professor Gammie of Indian annual cottons is now in the press and will shortly be issued as a Scientific Memoir of this Department. A provisional classification of perennial or tree cottons found in India has also been prepared by him, but it is not yet sufficiently complete for publication. The Provincial Departments of Agriculture are testing on Government farms the varieties most suited to each cotton tract.

15. Selection of cotton seed.—The distribution of seed from selected fields of the varieties ordinarily grown received considerable attention in the Provinces; but this line of work is difficult because every cotton field practically contains several varieties. In India, improvement of ordinary varieties should begin by separating types and can be continued by plant-to-plant selection of seed. This work has been seriously undertaken by the Provincial Agriculturists and Botanists, and will tend slowly but with certainty towards improvement. The only other methods of improvement are (a) cross-breeding and subsequent selection, (b) the introduction of exotic varieties. These methods are being fairly and fully tried. The problem of cotton improvement in India is extremely difficult. Special trade
demands require special kinds of lint. The chief and most paying
demand at present is for coarse cotton to mix with wool for the manufacture of cheap warm cloth. If this demand is likely to be permanent, we ought to endeavour to increase the outturn of our so-called "inferior" cottons which are ordinarily grown with profit and without risk. The cotton farms have been extended in almost all Provinces, where it is proposed to raise on a sufficiently large scale for distribution to ryots, seed of such varieties of cotton as have been tried and found successful. A large cotton farm has been started at Surat in the Bombay Presidency for the improvement of the indigenous variety by selection of seed. Attempts to improve the indigenous Kumpta variety of Bombay by selection alone appeared to promise well. The various varieties of the Khandesh mixture have been isolated in order to compare the yields and quality of the produce of each. Some 30 tons of seed of the Lalio variety selected by the Department of Agriculture, Bombay, were distributed in the Ahmedabad District with successful results. One farm has been started in the Central Provinces for the improvement by continuous seed selection of (1) the coarse Jari variety and (2) of the finer Bani variety. Efforts have also been made to extend the area of pure crop of the Karanganni variety in Madras by special offers of rewards to cultivators.

16. Cotton Hybridization.—Experiments are in progress at several centres to improve the superior indigenous varieties by hybridization. The best results have been obtained in Bombay, Central Provinces and Madras. Practical results have been obtained by the Bombay Department of Agriculture by producing three crosses of fixed type which are superior to local cotton and which are suitable for the Surat-Broach tract which hitherto has produced the best cotton exported from India. One of these crosses can, it is believed, be grown over the whole of the Surat-Broach tract and may add immensely to the value of outturn. The other two indigenous crosses with proper treatment are expected to improve considerably. A cross between Bourbon (tree) cotton and Egyptian is also very promising; but requires experimental trial for two or three years longer. In other Provinces cross breeding results are promising, but are not yet sufficiently definite to describe.

17. Trial of exotic cotton.—Exotic varieties are under trial on Government farms and in cultivators' fields. Acclimatised American varieties may possibly be successfully introduced on an extensive scale in the United Provinces and in the irrigated areas of the Punjab, but they may in time deteriorate. The seed of Dharwar-American was distributed to planters along with seed of Allens Hybrid (New American), Yennovitch (Egyptian), Caravonica, Broach and Buri.
The trials were unsuccessful, except in the cases of Dharwar-American and Brui, both of which gave in unfavourable seasons fairly promising results in many places. The latter variety is of American Upland type. It is a fairly prolific and long-stapled cotton and may possibly be found suitable in Singhbum and Sonthal Parganas (Bengal). It gave in the Central Provinces a large outturn of very good cotton, and it will be there tested on an extensive scale. In the United Provinces the acclimatised Dharwar-American variety was not particularly successful. The cotton produced was equal to the best Broach, but the outturns were not uniformly good. In order to encourage the cultivation of these exotics which should be sown in the North of India with irrigation before the rains, the canal rate for this crop has been reduced. The cultivation of American-Dharwar cotton has increased in the Punjab, in spite of the heavy damage done by boll-worm in 1905. The area under this variety rose considerably in 1906. Experiments with Egyptian cottons indicate that they are well worth further trial in the South-Western districts of the Punjab. A farm has been started in the Province chiefly to grow exotic cottons under irrigation. Egyptian cotton in Sind occupied over 5,000 acres in 1906. The cultivation will probably extend largely, but boll-worm has done much damage. This damage can probably be controlled. The extension of this cultivation is restricted by inferior tillage which will improve as labourers are attracted to these new Canal Colonies, where labour is at present scarce and very dear. In Madras, American, Egyptian and Caravonica, varieties were tried, but there were no useful results. In Eastern Bengal and Assam, Spence tree cotton, Caravonica, Dharwar-American, King’s Improved and Buri have done well on an Upland private estate. Caravonica cotton may succeed as a field crop in Assam. The Burma experiments with tree cottons were fairly successful and should be persevered with. The general experimental results indicate that exotic varieties of cotton producing fine lint may be extensively introduced into the Indo-Gangetic plain and particularly into the new Canal Colonies of the Punjab and Sind, provided we can overcome the traditions of the people and the ravages of boll-worm. The latter are more virulent on exotics than on indigenous varieties.

18. Tree Cottons.—Experiments with tree cottons are in progress in various Provinces. The results are generally unfavourable. All known varieties previously grown in India have been collected and have been cultivated under various conditions of soil and climate. The numerous varieties, grown on the Poona farm in 1904, were classified by Professor Gammie. The experiments undertaken by a syndicate with Messrs. Shaw, Wallace & Co, as Managers are still in their experimental stage, but this stage has so far been unsuccessful.
I have nothing, therefore, very definite to report regarding perennial cottons, but I am strongly convinced that they will never enter into regular cultivation in India. The British Cotton Growing Association and the Government of India, however, each contributed Rs. 10,000 towards the losses incurred by floods and otherwise on these syndicate plantations. The firm of Messrs. Shaw, Wallace & Co., has transferred their operations to some extent to Mourbhanj, where it is proposed to plant out about 500 acres chiefly with a particular variety of clustered-seed perennial cotton. The best sample of lint of this cotton was valued at 9d. per pound. The syndicate have now got about 294 acres under cultivation in different places.

Mr. Tytler, who was assisted by Government in starting a tree cotton plantation at Belgaum had no particular success in his experimental trials (without irrigation). His experiments suffered from the bad season of 1905-06. He has since formed a syndicate for the cultivation of tree cottons on an extensive scale with irrigation at Belgaum. Experiments by Provincial Departments of Agriculture with tree cottons have given conflicting results. *Caravonica* cotton gave promising results in Assam. Experiments have recently been started under irrigation by Mr. Spence at Deesa (Bombay) with a tree cotton which yields superior lint. These trials are in their experimental stage as the trees are yet young. The greatest risk in growing tree cottons is that they are very susceptible to insect pests which once established are difficult to get rid of because the trees are perennial.

19. Extension of Cotton cultivation.—The possibility of extending cotton cultivation in India has received a good deal of attention. The area under cotton has considerably increased in recent years chiefly owing to higher prices. The extension of railway systems and particularly of branch lines has materially helped this increase. The British Cotton Growing Association have made a large grant of £10,000 to be spread over four years for the improvement of the quality of Indian cottons and for the introduction and extension of the finer varieties of cotton in India. This grant has been used chiefly in providing seed of good varieties, in safe-guarding cultivators against loss in experimental trials and in obtaining through dealers an adequate price for superior cotton grown by individual land-owners. A sum of Rs. 28,500 was paid as subsidy in 1906-07. Out of this Rs. 10,000 were paid to the Indian Long-stapled Cotton Growing Syndicate to compensate against loss by floods. From the remaining sum of Rs. 18,500, the Provincial Departments of Agriculture spent Rs. 4,025 only during 1906-07. Rs. 10,000 are allotted for expenditure during 1907-08. The Provincial Directors of Agriculture have been consulted regarding the utilization of the grant in future years. Our Agricultural experts in every Province are almost unanimously of opinion that the agricultural
prosperity of India will be benefited less by improving the quality of Indian cottons than by improving the outturn, cultivation and trade practices of the ordinary indigenous varieties. Cotton experiments are likely to greatly expand. A Cotton Expert will be very shortly appointed. He will tour through the Provinces, co-ordinate the cotton experimental work and give in each Province, advice based upon his wider experience gained throughout India.

20. Tea.—The Indian Tea Association in its scientific and practical investigations was assisted by a subsidy of Rs. 15,000 from the Imperial Government and with Rs. 13,500 jointly from the Governments of Bengal and Eastern Bengal and Assam. This Department was strengthened by the appointment of an Entomologist (Mr. C. B. Antram), whose head-quarters are at Cachar. He has been provided with a laboratory and insectary. A survey of the tea soils of North-East India has been completed. Experiments have been made to determine the flavour of tea by quantitative analysis. The results have been published as a pamphlet on “Factors determining the quality of Tea.” The general characters of many kinds of tea have been studied. The use of green manures and of bones in various forms has been tested in a general way. The different systems of cultivation are under systematic observation. Experiments regarding pruning and plucking promised to give useful results and will be continued till definite issues are obtained. Fungal parasites have been dealt with in a practical way. The causes, the means of infection and of prevention of the disease known as “Blister Blight” of tea plants were ascertained; the results have been published as Bulletin No. 3 of 1906 (Blister Blight of Tea Plant). A Bulletin on the “Mosquito Blight” (Indian Tea Association, Scientific Series, 1905, No. 1), has been published. Other investigations indicate methods of eradicating various insect pests including the “Bark eating Borer,” the “Looper,” the “Sandwich” and the “Red Slug Caterpillars” and of preventing damage done by “green fly” and the “white ant.”

21. Indigo.—Scientific investigations were continued and controlled by Mr. C. J. Bergtheil whose services were lent to the Bengal Government for the purpose. The work done is described in appendix A of this report. The improvement of indigo manufacture has received a good deal of attention from specialists and others for many years. Little has yet however been done to improve the plant by selection. The Behar Planters’ Association have recently appointed an Economic Botanist. He will have great scope for useful work in systematic field selection and in watching the results of cross fertilization. The superiority of the Java variety under very varying conditions of soil and climate is now generally recognised. There is very little doubt that its cultivation could, with advantage, be greatly extended in India.
Mr. Bergtheil in his report of the Indigo Research Station, Sirsiah, 1906-07, however, states that the Sumatrana plant can be grown in Behar on certain classes of soil which are unsuitable for the Java variety. The ordinary field crops grown from Sumatrana or Java seed produce plants of great variety of type. The first step towards real improvement is to isolate type specimens and subsequently determine the economic value of each. As the economic value of a pure type depends upon leaf percentage and indigotin content, it is clear that the field work of an Economic Botanist should be in close touch with chemical laboratory investigations. The importance of an enquiry of this sort and the value of ultimate results to the indigo growers cannot be questioned. Mr. Bergtheil states that a preliminary step has been taken by growing and examining sub-varieties which were identified in 1903. The work of the Economic Botanist will help Indigo Planters when type plants of superior merit are grown and when sufficient seed is available for demonstration areas. The Behar Indigo Planters' Association have established seed farms in Behar. A seed farm has also been opened at Dasna in the United Provinces. The first crop of Java seed was bought by planters at a very high price. Recently at Cawnpore, important tests were carried out to determine the relative dyeing values of synthetic and natural indigo. The results were in favour of the natural product, as regards depth of colour and in other ways. It is conjectured that the impurities in natural indigo have something to do with these results.

22. Jute.—Though the area under jute very considerably increased during the two years under review, the demand for the fibre exceeded the supply. Prices remained high. The increasing demand shows the necessity of extending its cultivation outside Bengal. Madras, Burma and parts of Assam appear to offer very favourable physical and climatic conditions for its cultivation. The extension of jute cultivation is being investigated, and preliminary results have been published in Bulletin No. 3 of 1906. Trials with jute were made at the Samalkota Experimental Station (Madras), Ganeshkhind Gardens (Bombay) and at Nagpur and Raipur (Central Provinces). The results at the first two stations were fairly promising. Indigo Planters in Behar took up the cultivation, and their example was successfully followed by their tenants. Extensive tracts in the Assam Valley were for the first time brought under jute and yielded very fine crops. The cultivation is rapidly extending in the plains of Assam, but the lack of labour prevents extensive development. On the Lyallpur Farm (Punjab), jute was also successfully grown this season, but in the Chenab or other Canal Colonies of this Province, scarcity of labour will make extensive cultivation impossible. It has been suggested that the extension of jute cultivation may reduce food supplies for men and cattle in the congested districts
in Bengal and perhaps elsewhere. The experiments on Burdwan and Cuttack Farms clearly indicate that a crop of jute and a good crop of winter paddy can be got from the same field in one year provided the land is sufficiently manured and properly dealt with. Great developments in the jute trade are likely to occur in Burma when the Agricultural Department of that Province gets into full working order which will happen shortly. The crop will also extend largely in Eastern Bengal and Assam and probably in the delta areas of Madras. The scientific enquiries which have been made are described fully in the Agricultural Journal of India, Volume II, Part 2. With the co-operation of Mr. Finlow, forty-four so-called varieties of jute were grown at Pusa with the object of determining their characteristics and to gain knowledge regarding the differences in quality of fibre produced in different districts. Definite results have not yet been arrived at, and the experiments will be continued. A very practical aspect of the jute enquiry relates to improvement of varieties, manuring and cultivation. This is being fully dealt with. In particular, type specimens of each of the numerous races have been separated, and we are now able to supply pure seed of such races as are considered by our Botanists to be distinct. Mr. Finlow and Messrs. Cross and Bevan of London are collaboration in a bacteriological investigation regarding the alleged deterioration of Indian jute, but at present there is no evidence that the plant or its fibre have in any way deteriorated. Deterioration in the fibre is unquestionably due to malpractices in the trade after the crops are grown and retted. The Governments of Bengal and the Eastern Bengal and Assam have declined to undertake legislation to prevent fraudulent adulteration of jute.

23. Flax.—The possibility of cultivating flax in India as a paying fibre crop was recently revived by Sir Lewis Hay and the Dundee Chamber of Commerce. The Board of Scientific Advice published a Report on experiments with flax. The subject was referred to in an article issued in Volume I, Part III, of the Agricultural Journal of India. The Dooriah Indigo Factory in Behar, in which Sir Lewis Hay has an interest, carried out experiments which gave promising results. In 1906-07, a quantity of Russian (Riga) seed was distributed through the Department of Agriculture, Bengal. At Pusa and Bankipore, the results were promising, elsewhere they were not. At Bankipore the outturn of green plant was 2\frac{1}{4} tons per acre. The Pusa experiments indicated that fibre as well as seed might be profitably obtained in India by introducing the best kinds of Russian, Belgian and Irish seed. At Pusa we have arranged for fibre-extracting machinery suitable for flax. The Government of Bengal made a special grant to the Behar Indigo Planters’ Association in 1906-07, to help them to procure the services of an expert from Europe and to instruct them in the methods of steeping, retting,
scutching and placing the fibre on the market. He has been appointed and has arrived. He is engaged in supervising experiments at Dooriah and in giving general advice. \(\text{(Vide appendix B)}\)

24. Other Fibres.—The cultivation of Sunn-hemp (Crotolaria juncea) and Hibiscus cannabinus largely increased during the period under report. Formerly they were produced chiefly for use in India, but they are now exported to some extent as substitutes for jute. An investigation regarding possible jute substitutes has been undertaken by Mr. Finlow.

25. Tobacco.—Tobacco is a specially important crop in Bengal, Madras and in parts of the Bombay Presidency. Experiments at Pusa and in the Provinces have been undertaken in testing indigenous and exotic varieties, in hybridization and in methods of cultivation. These experiments will gradually lead up to the testing of methods of fermentation and curing. Fairly complete arrangements for these lines of work have been made at Pusa, but I do not anticipate any very special advance in our work until a Tobacco Expert is appointed, as no one in the Department has a specific knowledge of the work which should be done. Some foreign varieties have given good results in growth and apparently also in texture of leaf. Some experiments were conducted by Messrs. Spencer & Co. of Dindigul (Madras) to determine whether Indian grown tobacco could produce a good wrapper leaf when properly cured. The results were not indefinite. The Peninsular Tobacco Company, Limited, have started manufactories at Monghyr and Karachi and are producing cigarettes which, I believe, are superior to those previously produced in India. The fungoid and insect pests of tobacco are under investigation by Dr. Butler and Mr. Lefroy, and a certain amount of advice has been given to Planters.

26. Wheat.—The improvement of Indian wheat was fully discussed at the second meeting of the Board of Agriculture. The Provincial experts described the experiments which were being carried out in their respective areas. This information was epitomised by Mr. Howard. Dr. Butler and Mr. Lefroy prepared notes on the fungus and insect enemies of the crop. The Board of Agriculture considered in detail the suggestions and made proposals. The improvement of the Indian wheat trade requires numerous investigations specially as regards facilities for transport and also notably in regard to the separation of varieties, their improvement by selection of seed and by cross-breeding, the provision to cultivators of pure seed of varieties which can be grown without risk and which are suitable for export. The best means of storage in India requires investigation, also the milling and baking qualities of particular varieties. In the Canal Colonies of the Punjab, wheat has been grown year after year on the same land, and this system will certainly become unprofitable in time, even on the highly fertile soil of
these Colonies. The Muzaffarnagar wheat which has been distributed in large quantities from the Cawnpore Farm seed-stores for many years, continues to increase in popularity. In Bengal, this variety has given encouraging results. Pure samples of wheat which are suitable for export are being distributed by Provincial Departments of Agriculture. Rust resistance experiments are in progress on several Government Farms and are everywhere of very great importance. An account of the Indian wheat rusts has been published by Dr. Butler and Mr. J. M. Hayman as a Botanical Memoir, Volume I, No. II of 1906.

27. Groundnut.—The most important centres of groundnut cultivation in India are Madras and Bombay. During recent years there has been a marked decline, particularly in the Bombay Presidency in groundnut cultivation and a consequent falling off in the export trade. The causes of the decrease in Bombay cannot be definitely stated but are partially due to a fungoid disease locally known as Ticca and also to recent seasons of deficient rainfall. The Imperial Mycologist has shown that this disease which is due both to infected seed and infected soil can be combated by spraying. The chief damage is done late in the monsoon, and therefore early ripening varieties are to some extent exempt. Many foreign varieties have been introduced, and some of these practically escape damage by disease on account of their short period of growth. The most successful introductions in this respect have been Spanish and Japanese groundnuts. The indigenous varieties, however, command a higher price than any one of the Foreign varieties, for reasons which at present are difficult to understand. In Madras, the disease has been so disastrous that a special Government farm has been recently started at Palur in South Arcot for groundnut. There has been a keen demand for sound seed from many parts of the Presidency. Elsewhere also Provincial Departments of Agriculture have distributed sound seed. The groundnut area is rapidly extending in Burma and is likely to expand in the Central Provinces and Bengal and in the irrigated areas of Sind.

28. Artificial Fertilizers.—This subject is beginning to attract the general attention of agriculturists in India. It was considered by the Boards of Agriculture and Scientific Advice, and it has been recommended that various Agricultural Departments should undertake experiments to test such manures of this class as are available. A series of experiments are in progress on cotton with various artificial manures, and similar experiments will be extended to wheat, sugarcane and other valuable crops. The Board of Scientific Advice recommended that special attention should be given to the trial of sulphate of ammonia in sugarcane cultivation. This fertilizer is very largely used for sugarcane in Java and Mauritius, both of which countries are importing into India an increasing amount of sugar. When the Tata Iron and Steel manufac-
ing project is in operation, the output of Ammonia Sulphate will greatly increase and be cheaply available for use in this country. The new artificial manures of Basic Nitrate, Calcium Nitrate and Calcium Cyanamide are under trial and will be tested on several Government Farms, although their prime cost in India for experimental trial is much beyond their worth in practical agriculture. Messrs. Phirozsha B. Petit & Co., Bombay, have, however, proposed to establish a factory in Kashmir for the manufacture of Nitrate of Calcium. At the instance of the Madras Agricultural Department, the Inspector-General of Agriculture referred to the Board of Agriculture at its second meeting, the question whether it was advisable for the Agricultural Departments to undertake the inspection and control of commercial fertilizers in India. Suggestions for legislation on the lines of those adopted in the United States and other foreign countries were also considered. After very careful consideration it was decided that the time was not ripe for the introduction into India of legislation on commercial fertilizers, but the Board considered it desirable to keep special watch over the developments of the trade.

29. Irrigation.—This subject, in relation to the improvement of agriculture, was fully discussed by the Board of Agriculture at its first meeting in January 1905 (Items Nos. 23—27 of the Proceedings). In pursuance of the recommendations of the Indian Irrigation Commission, hydraulic experiments in the irrigation of crops have been undertaken in most of the Provinces. In Bengal, the Agricultural Department started hydraulic experiments at Burdwan, Dumraon and elsewhere. These experiments, for the present, have been stopped owing to difficulties connected with reliable supervision. Mr. N. N. Banerji was placed on special duty to enquire into the possibility of extending well-irrigation in Behar and in Chhota-Nagpur. The results of his enquiry have been published as a separate report. The United Provinces have continued the investigations regarding general well irrigation and percolation wells. Well boring experiments are now a permanent feature in the work of the Department of Agriculture of this Province. Government provides the tools and supervision. The land-owners provide labour. Well sinking is also encouraged by giving advances. It is established that perforated cylinders provide the best casing for percolation wells. The Agricultural Department is also making experiments to solve the problem of sinking wells in the rocky parts of the Province and to protect the tracts of deep water level by tube wells worked by a central plant. In the Punjab, hydraulic experiments for irrigating wheat were conducted with the object of (1) determining the least number of waterings required and (2) the quantity of water required in each watering. These experiments will have to be continued for a number of years before definite results can be expected. The local Department of Agri-
culture is considering the question of employing an expert staff to report and prepare maps showing the possibilities of irrigation in each district, to improve the water supply of existing wells, to make trial borings and to generally aid the small proprietors to improve the irrigation of their fields. Hydraulic experiments for irrigating crops have been in progress for some time in Bombay. An oil engine and a pump is at work at the Nadiad Farm in Guzarat. The wells in this tract are deep, and their supplies of water are not easily exhausted. The cost of irrigation by oil-engine and pump is about half the cost by bullock power. The Department has arranged to maintain in each division a small staff of well borers. Boring trials will indicate where wells can be sunk with advantage. It is proposed to place an officer of the Public Works Department on special duty to enquire into the extension of irrigation from rivers by means of oil engines and pumps and to advise and assist land-owners in the erection and management of such machinery. Experiments in boring wells on the Japanese system were carried out in 1905 in the Bhavnagar State, Kathiawar. In all, five borings were made. The Japanese expert well sinker had his implements made locally. The depth reached in one case was 110 feet. The boring implements stuck at a certain depth before water was found and the boring had to be abandoned in each trial. The failure is partly attributed to the difficulty of making the Japanese expert and the labourers understand each other. The total cost of these experiments amounted to Rs. 5,500. Probably better and cheaper results would have been obtained by ordinary boring appliances. Madras has made very useful experiments on an extensive scale in pumping water with oil engines and centrifugal pumps under the supervision of Mr. A. Chatterton, Director of Industrial and Technical Enquiries. His report for 1905-06 fully describes his results. It embodies information in regard to (1) the actual cost of raising water under different conditions; (2) the amount of irrigation water required under varying conditions as regards crop, soil and rainfall; (3) the advantage of employing small oil engines and pumps for the irrigation of intensive cultivation such as that of garden crops on small areas; (4) the quantity of water available for lift irrigation throughout the year from various sources of supply; (5) the distribution of underground water in various parts of the Presidency and practical means of making larger use of it than at present; (6) the efficiency of different oil engines and centrifugal pumps, the practical methods and the precautions to be taken in using them; (7) the general arrangement of installations. In various parts of India intensive cultivation is practised and sugarcane, tobacco, ginger, turmeric, and many other crops are grown with extraordinary success. For this intensive cultivation, expensive well irrigation by bullocks and ordinary leather bags is very commonly used. This irrigation costs not less than Rs. 100 per acre per annum. The experiments of the last three
years have conclusively proved that there is great economy in using oil engines and pumps if there is a sufficient water supply in the wells. Oil engines can be worked fairly satisfactorily by native drivers on wages of Rs. 10 to 15 per month. In the Central Provinces a series of irrigation experiments with wheat and rice are being conducted on the Government Farms with the object of discovering the duty of water in various classes of soil, the maximum intervals between waterings and the like. In 1906, these Provinces were helped by a grant of Rs. 3,500 from the Imperial Department for experiments with oil engines and pumps. The Burma Agricultural Department is arranging to carry on experiments at Mandalay with irrigated paddy and also with a number of crops grown in the dry zone.

30. Sericulture.—Experiments in sericulture are in progress in several Provinces. The Bengal Silk Committee, with the support of annual subsidies from the Governments of Bengal and Eastern Bengal and Assam, continued to do useful work. Several model-rearing houses have now been constructed by the Committee. Microscopes and disinfectants were distributed to rearers. The necessity for these is gradually being appreciated by rearers particularly in Birbhum. The principal firms interested in the silk industry made a representation to the Government of Bengal showing a marked decline in the industry. A small Committee was appointed to make inquiries, and certain remedial measures were suggested. The late Mr. N. G. Mukerji, known as a Silk Expert, was deputed to Kashmir and Bangalore to report on methods of rearing, reeling, etc. He returned with the belief that the Bengal system of reeling could not be much improved and that inferiority in quality of silk was due to inferior cocoons. He was also deputed to the Baroda State, where Mulberry silk experiments have recently been started. After enquiry in the Central Provinces he also made recommendations for the improvement of the Tussar silk industry in that province. Sericultural experiments in the rearing of Univoltine silk in Eastern Bengal and Assam have, for the last three years, been giving successful results. In Hoshiarpore (Punjab) there has been a small but successful experiment. The raw silk produced in Kashmir in 1905 yielded a very high profit of £28,139 or 58½ per cent. on invested capital. The profits of 1906 are expected to exceed those of the previous year. The Kashmir industry gives employment to nearly 70,000 persons. A great success has already been achieved in establishing the silk industry at Mustang in the Kalat State (Baluchistan). The silk produced is equal in quality to Kashmir silk. Experiments in rearing Eri silk were started by the Imperial Entomologist at Pusa. Between April and November, five broods aggregating 150,000 worms were fed on the leaves of castor plants. The silk produced was valued in Calcutta at Rs. 80 per maund.
31. Agricultural Education.—The scheme sanctioned by the Secretary of State for higher agricultural education provides for seven Provincial Agricultural Colleges. In each of the larger Provinces except Eastern Bengal and Assam a site has been selected, and for experiments acquired and considerable progress made in construction of buildings. In most Provinces, the Colleges will be in working order within the next two years. The Madras College will be established at Coimbatore and the Bombay College near Poona. The Agricultural Schools at Nagpur (Central Provinces) and Cawnpore (United Provinces) will be each raised to the status of an Agricultural College. The needs of the Punjab and the North-Western Frontier Province will be met by a new Agricultural College at Lyallpur. The Agricultural Branch of the Sibpur (Calcutta) Engineering College will be closed as soon as the new Agricultural College at Bhagalpur is ready. The Burma Agricultural College is being built at Mandalay. The provision of Provincial Agricultural Colleges has modified the original aim of the Pusa Agricultural College. It will provide a post graduate course extending over two years to qualify graduates of Provincial Colleges as Experts in specialized branches of Agricultural Research. Pending the completion of the provincial Colleges selected students have been sent to Cambridge and America to complete their higher training in Agriculture. Four Bombay students are specializing in Sciences connected with Agriculture at Cambridge. Similarly the Government of Bengal have sent six students to America to graduate in Agriculture and specialize in particular lines of Agricultural work. Twenty-two probationers from various Provinces were under training at Pusa. Some were found unfit and rejected. Thirteen completed their training and were qualified for Provincial service. Three were trained in general agriculture, two in Agricultural Chemistry, two in Mycology and six in Entomology. Two probationers are still under training in Agriculture and Mycology. Besides these, six men were trained for field work in Entomology and one in Entomological drawing. The most pressing requirements of Provincial Departments are thus met; but the real development of agricultural improvement hinges on the completion of the Provincial Agricultural Colleges and the Pusa Institute. When these are ready, arrangements will be made to give full agricultural training, and the necessity of sending students to foreign countries will cease. Questions relating to educational qualifications necessary for admission, scholarships, the curriculum of studies and the degree to be conferred on passed students have practically been settled.

32. Distribution of seeds and implements.—This branch of work engaged much attention during the past two years. The demand for pure and selected seed has increased, and a number of seed depôts have been started by the Provincial Departments of Agriculture. The distribution has not, however, been successful in all directions particularly in regard
to indigenous varieties of cotton. For distribution in the Central Provinces cotton seed was obtained from particularly selected fields of good crop, but this selection was really no selection at all, because every field in the Central Provinces grows a very mixed crop of cotton. We have to begin much more humbly, go slow and be quite sure that we are really distributing seed which is true to a particular type. This principle is the beginning of seed selection, and the sooner this is fully recognised in every Province in India, the better for the country. In some of the other Provinces, the cotton seed distributed was truer to kind. Besides cotton, seed of other crops such as wheat, ground-nut, jowar, jute, tobacco, indigo, mustard, etc., was distributed to Government Farms or private persons, the object being to introduce new and superior varieties. Mention may be made of the successful results obtained at the Dumraon Farm by the introduction in 1902 of Jubbulpore and Raipur mustard. These varieties have been found superior to the local variety not only in the quantity of yield but also in the quality of oil. The Provincial Agricultural Departments have mostly established seed farms on a sufficiently large scale to grow seed of such varieties of crops as have been tried and found successful. We have had numerous indents from foreign countries for seeds and plants, and we get an adequate return in kind. We have sent abroad, in small parcels, a total of nearly four tons of seed during the last two years.

The interchange between Provinces of superior indigenous implements was as satisfactory as in the previous years. The agricultural exhibitions and shows which are becoming important features of the Provincial activities have greatly helped this work. There has been a marked increase in the demand for iron ploughs in some of the Provinces; winnowers and fodder cutters are gaining favour among cultivators. The Poona sugar boiling apparatus and the plant used in Mr. Hadi’s process of sugar making have become widely known to cultivators, and the demand for these is steadily increasing. The merits of new implements are fully tested on Government Farms, and demonstrations are made to show the advantages of those which suit local conditions. Owing to scarcity of labour in the Canal Colonies of the Punjab, bullock-power reapers and steam threshers are coming into use, because, the enormous irrigated wheat crop of these Colonies must be handled expeditiously.

33. *Publications.*—At the suggestion of the Board of Agriculture of 1905 (Item 43 of the Proceedings) the Annual Reports of the Experimental Farms and the Departments of Agriculture have been improved. These reports will be issued hereafter in uniform size and at uniform dates. The work of each experimental station will be described in the form of a continuous record which will include any positive action taken to make the station and its teachings known to agriculturists generally. Accounts of experiments which have yielded very definite
results in experimental plots and demonstration areas will be published in Bulletin form. These Bulletins will be translated in simple vernacular for the information of native cultivators.

The Imperial Department of Agriculture now issues two important publications (1) the Agricultural Journal of India—a quarterly Journal, intended for the use of educated Indian Agriculturists and general readers interested in agriculture, and (2) the Scientific Memoirs of the Department of Agriculture, which are papers of a scientific or technical nature and are published occasionally. These publications are widely distributed in India and to learned societies and interested individuals in all countries. The free distribution is more extensive than the sale list. An adequate return is, however, obtained in free copies of publications which are indispensable to the Department. Moreover, advertisement is essential for new publications. The Journal and Scientific Memoirs are liberally supported by contributed articles from the Imperial and Provincial Experts of the Department and also from other Government officials and private individuals. Articles on original work in India can be published quicker in the Memoirs than in any home journal. This is a matter of importance to scientific men working for the Indian Agricultural Departments and is fully appreciated. A good many Bulletins have been published during the year by the various Agricultural Departments. They deal with definite results of agricultural experiments. All the agricultural publications issued in India during the past two years are given in the list of publications (Appendix C).

34. Expenditure.—The expenditure incurred in the Imperial Department of Agriculture (apart from expenditure on buildings constructed by the Public Works Department) has been as follows:

<table>
<thead>
<tr>
<th>Section of Department</th>
<th>1906-07.</th>
<th>1905-06.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspector-General of Agriculture in India</td>
<td>90,235</td>
<td>1,03,360</td>
</tr>
<tr>
<td>Director, Pusa</td>
<td>1,06,300</td>
<td>60,655</td>
</tr>
<tr>
<td>Chemical Section</td>
<td>28,268</td>
<td>28,694</td>
</tr>
<tr>
<td>Mycological Section</td>
<td>25,382</td>
<td>24,055</td>
</tr>
<tr>
<td>Entomological Section</td>
<td>28,588</td>
<td>32,056</td>
</tr>
<tr>
<td>Bacteriological Section</td>
<td>2,500</td>
<td>900</td>
</tr>
<tr>
<td>Agricultural Section</td>
<td>99,248</td>
<td>63,692</td>
</tr>
<tr>
<td>Botanical Section</td>
<td>19,743</td>
<td>21,503</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,00,264</td>
<td>3,34,925</td>
</tr>
</tbody>
</table>
The figures for 1905-06 include Rs. 99,572 for the initial expenditure under the following heads:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of Departmental Buildings and Machinery</td>
<td>Rs. 59,747</td>
</tr>
<tr>
<td>Equipment of the Pusa Library</td>
<td>Rs. 18,825</td>
</tr>
<tr>
<td>Laying out roads</td>
<td>Rs. 15,000</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Rs. 15,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99,572</strong></td>
</tr>
</tbody>
</table>

Deducting this amount from Rs. 4,00,264 we get a net recurring expenditure of Rs. 3,00,692 for 1905-06. The expenditure of 1906-07 is larger than that of 1905-06. The increase in 1906-07 is due to the expansion of the Department. In addition to the ordinary budget provision, the Inspector-General of Agriculture in India receives an annual grant for expenditure upon special investigations, improvements and the like, which he may desire to introduce. The principal objects to which this grant has been devoted in the past two years are as follows:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Grants-in-aid of the Department of Agriculture, Bombay</td>
<td>Rs. 12,000</td>
</tr>
<tr>
<td>(1) For Mr. Tytler's cotton experiment at Belgaum</td>
<td>Rs. 5,000*</td>
</tr>
<tr>
<td>(2) For Sugarcane Power Crusher for Manjri Farm</td>
<td>Rs. 5,000</td>
</tr>
<tr>
<td>(3) For sugarcane experiments in Sind and for demonstration of improved Poona method of juicing at the Ahmedabad Exhibition</td>
<td>Rs. 1,200</td>
</tr>
<tr>
<td>(4) Contribution to the Nadiad Farm</td>
<td>Rs. 800</td>
</tr>
<tr>
<td>3. Grants-in-aid of the Department of Agriculture, Bengal, for distribution of seed of the <em>Aces</em> variety of Central Provinces paddy in the Chota Nagpur District</td>
<td>Rs. 350</td>
</tr>
<tr>
<td>4. Grants-in-aid of the Department of Agriculture, Central Provinces, for expenditure upon experiments with an oil engine and a pump in the Central Provinces</td>
<td>Rs. 8,200</td>
</tr>
<tr>
<td>5. Paid to the Secretary to the Chief Commissioner, Coorg, for agricultural improvements in Coorg and for experiments with Carvonica cotton</td>
<td>Rs. 3,000</td>
</tr>
<tr>
<td>6. Grants to the Indian Tea Association</td>
<td>Rs. 30,000</td>
</tr>
<tr>
<td>7. Purchase of seeds, implements and other requirements for agricultural experiments</td>
<td>Rs. 2,680†</td>
</tr>
<tr>
<td>8. Extension of Botanical Garden at Pusa</td>
<td>Rs. 4,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,00,239</strong></td>
</tr>
</tbody>
</table>

* Recovered from Mr. Tytler owing to his having formed a syndicate.
† The main heads of expenditure under this item are (1) Supply of jute seed to the Colonial Office, London, for trial in West Africa; (2) Purchase of Arlington ploughs for trial in India; (3) Supply of Indian cotton gins to the Crown Agents for Colonies, Whitehall Gardens, London, for transmission to Lagos; (4) Purchase of sugar boiling pans, for trial in the Central Provinces; (5) Purchase of Hodgkinson's cotton hand-gins for trial; (6) cost of date palm off-sets and tree cotton seeds; (7) Sugarcane cuttings supplied to Samaikota Experimental Station.

35. Provincial Departments of Agriculture.—It is unnecessary to give details of work done in each Province because each Department publishes its own report. I may, however, give the following information.

36. Bombay.—The Department has five European Experts, a large staff of well-trained Indian assistants, an Agricultural College and
twelve experimental stations. The College is at present the only one that teaches up to a degree standard in Agriculture. It is at present located in a hired bungalow. The classes for the three years' course are large. The permanent building for teaching and research work is being built. One hundred and forty-three acres of land have been acquired for the College Farm. An Industrial and Agricultural Exhibition was held at Surat in 1906. The Department sent 722 exhibits. The Department holds annually an Agricultural Conference chiefly to obtain the views of practical business men regarding agricultural improvements. The Conference was held in Bombay in 1905, in Surat in 1906 and will be held at Ahmedabad in November 1907. Similar conferences if held regularly in other Provinces would also be of great value.

37. Madras.—The Expert European staff of the Department now consists of the Principal of the College, an Agricultural Chemist, Economic Botanist and two Deputy Directors of Agriculture. Mr. Chatterton, Director of Industrial and Technical Inquiries, helps the work of the Agricultural Department in many ways. His long experience in India is invaluable. There are now ten experimental stations in Madras which are devoted to general agricultural problems, also to particular enquiries regarding sugarcane, pepper, jute, groundnut, agaves, rice and cotton. Groundnut has received prominent attention, and there is a high demand for sound seed. The need is felt for practical Indian subordinates who can properly supervise field work. The new Agricultural College and the head-quarters of most of the expert staff will be at Coimbatore. Agricultural Shows and Associations are a marked feature in the useful work of the Department.

38. United Provinces.—The Director, Mr. W. H. Moreland, C.I.E., after a visit to Australia began the first work in wheat improvement by cross-breeding in India. This work continues to be a very important enquiry in his Department. His expert staff of European specialists is being gradually recruited, and the old Cawnpore School of Agriculture is advancing to the status of a college. Four agricultural stations are now at work, and the Province has been mapped out into four divisions, to each of which an all-round agricultural expert will be appointed. The methods adopted for storing and distributing good seed of particular crops could, with great advantage, be carried out in other Provinces. The method devised by the Assistant Director, Khan Bahadur H. M. Hadi, M.R.A.C., for refining sugar, has attracted much attention. Boring experiments for well water have been very successful. A superior method for constructing percolation wells has been devised.

39. Bengal.—The work of the Department of Agriculture was separated from that of Land Records towards the end of the year 1905-06. The expert staff sanctioned for this Province consists of Deputy Director of
Agriculture, Principal of the College, Economic Botanist and Agricultural Chemist. The last two places are still vacant. Indian assistants trained at Pusa have been appointed for such Entomological and Mycological work as can be done by them under the guidance of the Pusa staff. There are six agricultural stations at Dumraon, Burdwan, Sripur, Cuttack, Bankipore and Sabour near Bhagalpore. The first three stations are maintained at the cost of the Dumraon, Burdwan and Hathwa Rajs, respectively. The Bankipore (210 acres) and Sabour (340 acres) Agricultural Stations are being organised. A farm of 200 acres will be opened at Chinsura on the East Indian Railway line for the deltaic alluvium. The Department has opened a seed, implement and manure store which is increasing in usefulness. It is proposed to open such stores at each Agricultural Station. A Committee, with the Director as President, was appointed to enquire into the present decline of silk industry and to suggest remedial measures. The improvement of jute as regards agricultural and trade aspects has received much attention by the Department. The cultivation of imported varieties of flax is likely to lead to a new profitable fibre industry. The value of the Rhea industry which was boomed in Bengal some years ago, may now be discounted. The Bengal Government has continued to make an annual grant of Rs. 50,000 to the Behar Indigo Planters' Association for research work in indigo. The services of Mr. Bergtheil have been placed at the disposal of the Association. A very short summary of the research work done by him and his assistants at Sirsiah is given in Appendix A. The details of work done cannot be conveniently described here, but I consider that Mr. Bergtheil should continue his present investigations when he takes up his permanent appointment at Pusa and also as far as possible guide by advice the scientific work of the Behar Planters' Association. Pending the completion of the Provincial and Pusa Colleges, the Department has sent six passed students of the Sibpur College to America for higher agricultural training. The report of the progress of these students is satisfactory.

40. Punjab.—A separate Department of Agriculture has been formed in the Punjab as in other Provinces. The expert staff at present consists of the Principal of the Agricultural College and Research Institute, the Deputy Director of Agriculture and the Agricultural Chemist. An Economic Botanist will join shortly. The extraordinary fertility of the new Canal Colonies and the enterprise of the cultivators offer exceptional chances for agricultural improvement. The Punjab agricultural experts have thus unusual opportunities of improving the agriculture of the Province. The scarcity and dearness of labour in the Punjab will probably require the introduction of labour-saving machinery for the wheat crop. There are very large exports of wheat from the Punjab, and prompt harvesting and disposal of the crop is very important,
I suggest that it is extremely important that railway and other facilities for export should be improved.

41. Central Provinces.—The Department of Agriculture is now separated from that of Land Records and Settlements. Two Deputy Directors of Agriculture, an Agricultural Chemist, a Principal of the College and an Economic Botanist have been sanctioned. There are four experimental farms at Nagpur, Raipur, Hoshangabad and Akola. The Nagpur Farm deals chiefly with cotton, wheat and rotation experiments and the Raipur Farm with rice. The Hoshangabad Farm is specially intended for wheat experiments and the Akola Farm for experiments with cotton. The Department has particularly demonstrated in the districts the advantages of drilling particular crops and of using particular implements, specially winnowers, chaffcutters, iron-ploughs and sugar-making appliances. A good deal of useful work has been done in the sanitary disposal of sewage on cultivated fields on the Meagher System. The method of applying sulphate of copper to jauar (Sorghum vulgare) seed to prevent smut has been extensively demonstrated. The distribution of selected seed was extended. The Nagpur Agricultural School has been raised to a College with a three years’ course. The Agricultural Gazette which is published in vernacular has maintained its circulation. Several Agricultural Associations have been formed.

42. Eastern Bengal and Assam.—The expert staff of the Department consists of the Assistant Director and the Fibre Expert. The posts of Economic Botanist, Agricultural Chemist and the second Deputy Director of Agriculture have been sanctioned, but are not yet filled. The College and Laboratories are under construction at Dacca, and land has been acquired for a College Farm. The experimental stations are at Rangpur, Rajshahi, Jorhat, Upper Shillong and Wahjain, and land for a tobacco station at Burihat is being acquired. Important jute experiments are in progress. Bengali cultivators, to demonstrate the proper method of cultivation and of extracting the fibre, have been employed. The Rajshahi Sericultural School has been taken over by Government and remodelled on a popular basis.

43. Burma.—The Agricultural Department has now been fairly organised. The Land Records and Agricultural Departments have been separated. The expert staff consists of an all-round Agriculturist, as Principal of the College, Deputy Director of Agriculture, Agricultural Chemist and Botanist. Arrangements have been made to start three agricultural stations—one at Mandalay as College Farm, one at Hmawbi chiefly for the study of paddy and a third in the dry zone of Burma.

44. Expansion of the Department.—The general expansion of the Agricultural Departments in India outlined in the last report has progressed. The experimental stations and demonstration plots in each Province have increased in number. I have already referred to the strength-
ened staff of European Specialists. I am hopeful that the Indian staff will be improved by better rates of pay and prospects. The work of the Department will be much extended by the Provincial Agricultural Colleges, Agricultural Associations, Agricultural Shows and the establishment of cattle-breeding farms. Efforts are being made to provide improved seed, good manures and better implements. In the Provinces, the Departments of Agriculture have been separated from the Departments of Land Records in order to enable the Directors to devote undivided attention to the improvement of agriculture. There is, in fact, a general advance which need not be further particularised, but which is an advance for progress.

J. MOLLISON, M.R.A.C.,
Inspector-General of
Agriculture in India.

Simla, E.,
The 17th October 1907.
1. Charge of Office.—Mr. B. Coventry held charge of the office of Director until February 20th, 1907, when he proceeded on leave and I was appointed to act for him in addition to my own duties.

2. General work of the Institute.—The Institute consists of six sections, namely, Agriculture, Chemistry, Botany, Entomology, Mycology and Bacteriology. The agricultural, entomological and botanical sections have been located at Pusa during the whole two years; the chemical and mycological sections were transferred from Dehra Dun in 1905; whilst the bacteriological section remains to be opened. Excepting Agriculture, the sections which are already at Pusa are accommodated in temporary buildings pending the completion of the new laboratories. The nature of the work is fully explained by myself and my colleagues in the following sectional reports.

The extensive laboratories which have been under construction for three years will be ready for occupation by the end of April 1908.

3. Buildings.—Quarters for the European and native establishments, students’ hostel, rest house, hospital and veterinary dispensary have been completed. The Farm buildings, Farm Office, Botanical and Entomological minor laboratories, Insectary, Fumigating House, and Potculture House were constructed departmentally.

4. Roads, etc.—The estate is liable to inundation from two sides and during the monsoon of 1905 and 1906 a large area of land was under water on this account. Three protective embankments became necessary, two of which have been completed and the third will be so shortly.

The roads of the estate have been made. The avenues have been thinned or new trees planted where necessary and generally improvements introduced. In some cases areas of jungle have been cleared for cultivation and pasture land.

Most of the compounds of the completed buildings have been laid out, but that of the large laboratories cannot be dealt with until the building is completed.

5. Medical.—A Military Assistant Surgeon was appointed in September 1906 but reverted almost immediately to military duty. He was succeeded by Mr. J. R. Foy in November 1906. The average number of cases in hospital has been 2·66 per day since the hospital was opened and the average number of out-door patients has been 13·11. In the
opinion of the European staff at Pusa the present medical arrangements are unsatisfactory.

6. Training.—Some students have undergone periods of training in special subjects. The courses of instruction will be much amplified when the Institute laboratories are complete.

7. Library.—The Library of the Institute consists of about 4,000 volumes, many of which are very valuable. It has been arranged to lend books to officers of the provincial departments under certain conditions. The catalogue is about to be issued.

8. Publications.—The publications of the Institute comprise (1) The Agricultural Journal of India, published quarterly, (2) Scientific Memoirs of the Department of Agriculture in India, (3) Bulletins which deal with matter in process of investigation, (4) Leaflets in English or the vernacular are issued at intervals.

The Inspector-General of Agriculture in India is the Editor and is assisted by advice from the staff. The grant is Rs. 25,000 per annum.

The preparation of these publications takes up much time. The Artist's work is supervised by Mr. Lefroy and the Photography is in my charge. These duties are by no means nominal and absorb much time. An Assistant Editor is urgently required.

9. Accounts.—The whole of the accounts pass through the Director's office. The total current cost of the Institute may be summarised as follows:

<table>
<thead>
<tr>
<th></th>
<th>1905-06.</th>
<th>1906-07.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay and travelling allowances</td>
<td>Rs. 1,16,500</td>
<td>Rs. 1,31,900</td>
</tr>
<tr>
<td>Publications</td>
<td>Rs. 15,000</td>
<td>Rs. 25,000</td>
</tr>
<tr>
<td>Farm expenditure and Scientific apparatus buildings, sanitation, etc., and contingencies</td>
<td>Rs. 1,78,500</td>
<td>Rs. 74,700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Rs. 3,10,000</td>
<td>Rs. 2,31,600</td>
</tr>
</tbody>
</table>

J. WALTER LEATHER,

*Officiating Director, Agricultural Research Institute, Pusa.*

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEARS 1905-06 AND 1906-07.

1. Charge of Office.—I held charge of this branch of the Institute until April 11th, 1906, when I proceeded on privilege leave until July
2nd and Mr. R. S. Finlow officiated for me; I again held charge throughout the following 12 months.

2. *Laboratory.*—The laboratory was transferred from Dehra Dun to Pusa in November 1905 where it has been accommodated in a temporary building pending the completion of the permanent laboratory.

3. *General analytical work.*—In past years a large part of the energies of the establishment have been absorbed by the examination of specimens sent by provincial departments. With the appointment of provincial chemists a material change has been effected in the character of the work undertaken, and investigations of a more special nature have been taken up.

The following statement shows the number of samples analysed in each of the two years:

<table>
<thead>
<tr>
<th></th>
<th>1905-06</th>
<th>1906-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils</td>
<td>244</td>
<td>255</td>
</tr>
<tr>
<td>River water and silt</td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>Waters</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Manures</td>
<td>229</td>
<td>124</td>
</tr>
<tr>
<td>Feeding stuffs and oil-seeds</td>
<td>63</td>
<td>51</td>
</tr>
<tr>
<td>Sugars and sugarcane</td>
<td>46</td>
<td>132</td>
</tr>
<tr>
<td>Plants examined for gluco side</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Rubbers</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Gum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>637</td>
<td>749</td>
</tr>
</tbody>
</table>

4. *Potculture House.*—A very well-equipped house for experiment on plants and soils by potculture methods has been erected at Pusa and a description of it published as Memoir No. 3 of the Chemical Series. The nature of the work carried on here is explained in paragraphs dealing with plant food in soils and cyanogenetic glucosides.

5. *Available plant food in soils.*—For several years a good deal of attention has been given to a study of available plant food in soils. The earlier work consisted in comparative tests of the validity of Dyer’s method for the estimation of a soil’s requirements in phosphates or potash and the principal results obtained have been published as Memoir No. 4, Chemical Series. As a practical adjunct to this work, a series of field experiments on the value of superphosphate in Behar, where the soil seems to be generally, within certain geological limits, deficient in available phosphate, has been commenced.

The investigation on available plant food in soils has more recently been directed to a more exact knowledge of the precise state in which
these compounds exist, in the hope that more accurate methods of soil examination may be evolved.

6. Pusa soils.—In 1906 samples of the surface and sub-soils of all the fields within the arable area at Pusa were taken; they were subsequently analysed and, in addition, specimens of each were stored for possible future examination.

7. Meteorology.—The usual meteorological records are maintained and the Institute is a reporting station of the meteorological department.

8. Rain and Dew.—A record of the amount of Nitrogen compounds in rain and dew was maintained last year at Pusa to provide a confirmation of that which was obtained by the examination of rain water and dew at Cawnpore and Dehra Dun (Memoir No. 1, Chemical Series) and the newer data agree with these in demonstrating the smallness of the total amount of these compounds in the annual rain and dew.

9. Drain gauges.—During the hot weather of 1906 four gauges were constructed at this Institute for observing the nature of percolation during wet weather. They are similar to those at Rothamsted in England and at Cawnpore and each consists of a block of earth 1—1000 acre in area which has been isolated in the undisturbed state. In two, the earth is three feet deep, and in the other two it is 6 feet deep. Rain water falling on them may either soak into the soil, or if the fall is very heavy it may also overflow. Arrangements are made for measuring the amount of water which percolates, the velocity of percolation, the chemical characteristics of the drainage water, and for measuring any water which overflows at 2", 3" or 4" above the ground level, as may be desired. The construction was carried out by Mr. M. H. Arnott, Superintending Engineer, Public Works Department, to whom we are much indebted for the care and interest that he devoted to this work. We shall thus have two records in India regarding the nature and quantity of percolation. Of those at Pusa it is proposed to keep one six-foot and one three-foot gauge entirely bare fallow, and on the other two vegetation, either grass or other plants, throughout the year, in order to determine the difference between the amount of drainage in the two cases.

10. Loss of water from soil.—Information as to the rate at which water is lost from soil during periods of dry weather and the amount of movement through the soil naturally forms the counterpart to a knowledge of drainage conditions, and records have been kept, in the first instance in bare fallow land, for this purpose. The first year's results have been considered of sufficient interest to merit publication and will appear shortly.
It will be evident that information regarding the movement of water through the soil during wet and dry weather respectively in India, important as it is when considered alone, is enhanced by the fact that it at the same time assists the formation of an opinion as to possible movements of plant food through the soil.

11. Saltpetre.—A reference was made in my last report to the saltpetre industry. Experiments were made to ascertain the manner in which the salts are removed from the nitre-earth during the percolating process so universally employed, and these demonstrated that the nitrates and chlorides pass out first, the major part of the sulphate remaining, in the ordinary course of the work, in the soil; and that the effect of the ashes which are so commonly added is to convert some of the nitrates of soda and lime into the potash salt. It was also ascertained that the common belief in the formation of nitrate in the refinery earths has no foundation in fact.

12. Sugarcane.—An assistant of this laboratory was again deputed during 1906 to analyse sugarcane in the Balaghat district.

The composition of the juice of the varieties of sugarcane at Pusa has been ascertained each year, and latterly this has been done periodically during the whole ripening period in order to ascertain what changes occur at this time.

13. Cyanogenetic glucosides.—Various plants, jowar, linseed, have been grown under varying conditions in order to try to determine the conditions under which their peculiar cyanogenetic glucosides are formed in large amount. It has been found that this is not a feature of the variety, for instances of the same variety forming much glucoside, or none at all respectively, have been met with. It is hoped that by carefully controlling the conditions of growth, the cause of formation may be isolated, and the work has met with a certain measure of success.

14. Establishment.—Mr. H. E. Annett, Supernumerary Chemist, arrived in May 1907. Mr. W. Roberts, Supernumerary Agriculturist, has been detailed to this section for experimental work on Behar soils. Four of the Indian assistants, who have served for some years in this section, are doing good work. Four of the provincial chemists spent some months at Pusa in order to acquaint themselves with the general work which is in progress.

In December 1905 three probationers, one each from Bengal, Madras, and the Central Provinces, were sent to this Institute for a period of training in the chemical section. Of these one resigned : the other two
remained until March 1907 and then returned to appointments in their respective provinces. The sanctioned scale of pay is insufficient to secure the best men, and only attracts probationers possessed of very limited qualifications. Much more than this is required if any particular progress is to be made in Agricultural Chemistry in India.

J. WALTER LEATHER,

*Imperial Agricultural Chemist*

Pusa.
PART IV.

REPORT OF THE IMPERIAL MYCOLOGIST.

1. I held charge of my section during the period under review, with the exception of three months from the 9th of August 1906, when I took privilege leave and Mr. S. K. Basu, Senior Assistant, took charge.

My laboratory was transferred from Dehra Dun to Pusa, in November 1905. It now occupies a temporary building. Considerable difficulties have been caused by damp and dust. Though these will be largely obviated when the main building is ready for occupation, still the experience of the past two seasons has shown that certain classes of work will always be carried on at a disadvantage in the warm, moist climate of Pusa.

My section will have two distinct functions to fulfil. One, common to all similar sections of Agricultural Departments everywhere, is the investigation of plant diseases and the study of fungi concerned in them, or otherwise agriculturally important. The other, usually separated or, indeed, in the older departments often unnecessary, is the accumulation of a representative collection of fungi for consultation. A large general fungus herbarium is not usually considered a necessary part of the equipment of an agricultural mycologist's laboratory. Such a collection is generally available elsewhere and in cases of difficulty the services of competent systematists near at hand can be obtained for the identification of species. As a matter of fact, however, in Europe at least and in a measure in the United States, cases of difficulty rarely arise. The fungus flora of these areas is well known and the identity of the species parasitic on particular plants can be determined with considerable ease. In India circumstances are different. It is probably the least known, excepting China, of any large area in the civilised world as regards the fungus flora. Almost the only important group of parasitic fungi which has been studied in India is the "rusts". Hence, though many of the commoner crop diseases of Northern India are known and have been studied in Europe, cases constantly occur of diseases which have not been previously investigated. In order to deal with these it is necessary to have the means of identifying the parasites concerned. The co-operation of other workers is not always available, and though I have to acknowledge generous assistance from outside India it is essential that the Mycological section at Pusa should eventually reach a position in which it will be able to deal with work of this nature. Further, one of the important duties at Pusa will be to assist
other Mycologists in India in determining their species and for this purpose good consulting collections are necessary.

Much time has been given to organising the sectional library and collections for ready reference to meet this demand. Card indices of the collections both parasites and host plants, and of all fungi hitherto described from India, have been prepared.

When on leave in Europe, I visited Kew, Paris and Berlin to secure assistance in naming and describing my collections of Indian fungi. I was fortunate enough to obtain the co-operation of Messrs. H. and P. Sydow of Berlin, and technical descriptions of Indian fungi will appear from time to time in their Journal, the "Annales Mycologici", one of the chief organs of systematic Mycology.

During the period under review, I collected specimens in Central Bengal, Behar, Godaveri, Belgaum, Bassein, Kumaon and Lyallpur. A very useful collection was made by Mr. S. N. Mitra, 3rd Assistant, in parts of the Bombay Presidency. Munshi Inayat Khan collected in Bundelkhand and Kumaon. Specimens have been presented by Mr. I. H. Burkhill, Mr. J. M. Hayman, Mr. C. A. Barber, Professor Gammie, Mr. Sundararaman, Mr. R. S. Hole, Mr. R. S. Troup, in India and by Dr. Walter Busse, Berlin, Mr. E. W. Holway, University of Minnesota, Mr. C. G. Lloyd of Cincinnati, Professor Jakob Eriksson, Stockholm, and Herr H. Sydow, Berlin, to all of whom I am much indebted.

The main lines of research work which it is proposed to follow at Pusa, were submitted to the Committee of the Board of Agriculture appointed to advise on the scientific work of the Institute at the second meeting of the Board held in January 1906, and were approved of.

2. Investigations of Plant Diseases.—Palm diseases. A serious disease of cultivated palms has broken out within the past few years in the Godaveri Delta. It is spreading slowly in a continuous area. Palmyra palms are chiefly attacked, but coconut and probably betelnut palms are also destroyed. In many villages over eighty per cent. of the palms have been killed. I visited the diseased area in August 1905 and March 1907. Proposals were made for an organised campaign to endeavour to stamp it out before the very valuable coconut forests further south were infected. A sum of Rs. 5,000 was sanctioned by the Madras Government, in 1906, for experimental measures for its control in a small area. This was increased by Rs. 26,000 in 1907, for the treatment of the whole area affected. The present operations are under the control of an Assistant Collector with a supervising staff from the Madras Department of Agriculture and two assistants from Pusa. The working parties are composed of palm climbers (toddy drawers) under several Revenue Inspectors. The cause of the disease is a fungus which chiefly attacks the leaf sheaths, and spreads gradually through
successive sheaths until the central bud is reached and the tree is killed. An account of it was given in the Agricultural Journal for October 1906, and a technical description of the parasite in the Memoirs, Volume I, No. 5, February 1907.

3. *Sugarcane diseases*.—The chief sugarcane diseases studied were red rot, smut, black rot and red leaf spot. Experiments with the former extending over two seasons show that the chief mode of conveyance is by the use of cuttings already containing the fungus. As this view is not in accord with the ideas prevailing in other countries where the disease has been a cause of loss, it required very full testing. The result has been to leave no doubt as to its substantial correctness in the more severe forms of the disease. Two distinct types of disease, however, occur and have been the cause of the misconception. In the milder first type air-borne spores gain access to the standing cane, being assisted by anything which tends to weaken the latter, such as the attacks of borers or leaf-hoppers. Individual canes become diseased, but the whole stool is not as a rule affected. The use of such infected canes as cuttings for seed leads to the second and (in Northern India) much the more severe type. The living fungus is planted out inside the cuttings and the resulting stool is attacked from below and eventually killed. The first form was active in the Pusa crop in the season of 1906-07, following on an epidemic of leaf-hopper. By carefully excluding all canes with recognisable symptoms of infection in selecting seed cane, the more serious type of disease can be, as a rule, eliminated. The practical conclusions to be drawn are that while it is impossible to avoid completely the first type of disease, it may probably be much diminished by checking pests and is not in any case likely to lead to very severe loss. Most of the loss caused by this disease is due to the use of infected seed and this loss can be avoided by discarding such seed in planting, without great difficulty. "Ratooning" varieties subject to the disease (as most of the thick canes) is liable to result in loss, which may be entire or almost entire if the ratooned crop had any large proportion of diseased canes the previous year. Further experiments are in progress to determine how far the fungus can exist in a cane without causing discoloration, whether soil infection ever occurs, the co-existence of other fungi in red rot, its connection with borers and some other points. Experiments with smut have been commenced this season. Black rot is primarily a disease of cuttings and is not at present a serious disease, though a near ally, the "pine apple" disease, is a cause of much loss in other countries. The latter was detected in newly imported cane and the consignment was destroyed. Accounts of these and other diseases of cane were published in the Memoirs, Volume I, No. 3, July 1906, and in a paper on the selection of sugarcane cuttings in the Agricultural Journal in April 1907.
4. Cereal rusts.—Experiments have been carried on in conjunction with Mr. J. M. Hayman, Deputy Director of Agriculture, United Provinces at Cawnpore in growing wheat in rust proof cases to test the validity of the "hereditary" theory of the disease. About 180 plants have been thus grown and two pustules of rust occurred in two cases this year. On the whole the evidence is against this being a frequent occurrence and it is possible that accidental contamination took place. A preliminary enquiry into the degree of resistance and susceptibility to rust was carried out at Lyallpur and Pusa, but it has been considered advisable to postpone taking this up in detail until pure races of Indian varieties have been separated. An account of the experiments and of the varieties, distribution, etc., of Indian rusts was published in conjunction with Mr. J. M. Hayman in the Memoirs, Volume I, No. 2, July 1906.

5. Ground-nut leaf disease.—Failure to establish this disease at Pusa has led to the abandonment of local experiments in its treatment. At Poona, steeping and spraying experiments are in progress, without as yet, any definite results.

6. Wilt diseases.—An area was reserved on the Poona Farm for an attempt to produce a resistant strain of pigeon pea by selection. Last year's results were promising. A similar experiment commenced at Pusa was destroyed by floods. Biological work with wilt-producing fungi absorbed much time but the conditions of infection are not yet determined. Wilts of cotton, gram, Bimlipatam-jute (Hibiscus cannabinus), sesamum and indigo have also been under study and it is probable that the majority of these diseases are caused by the United States cotton-wilt fungus (Neocosmospora vasinflecta) which was discovered to be widely distributed in India this year. A paper describing the pigeon pea wilt was published in the Journal in January 1906.

7. Green-ear disease of cereals.—Bajra, jowar, Italian millet and Euchlaena luxurians are all attacked in India by a parasite, Sclerospora graminicola, previously known on Italian millet and wild grasses only. An account of its life history and effects was published in the Memoirs, Volume II, No. 1, March 1907. This should enable practical methods of treatment to be employed in localities where it causes loss.

8. Mango diseases.—I visited Malda in August 1905, at the request of the Bengal Agricultural Department, to enquire into a disease which was reported to be damaging the valuable mango orchards of the district. The cause was found to be an alga already known as the cause of "red rust" of tea, one of the worst blights of this crop. The features of the disease correspond closely with those observed on tea and, like the latter, serious loss appears to be confined to certain districts, though the alga is widely distributed all over India. The conditions determining viru-
lence are not clearly known but they are evidently local, and prolonged investigation on the spot would be necessary before any suggestion for treatment could be made. This is not possible at present. Other minor diseases of the mango have also been studied.

9. Other diseases.—A large number of other diseases of plants, including most of the cultivated crops of the plains and several fruit and economic plants, were examined. A proportion of these are specimens sent in by Superintendents of Farms and other persons interested in agriculture, and reports are issued giving such recommendations for prevention or remedy as are likely to prove most useful. Others are collected by the establishment. Information regarding these is steadily accumulated, cultures obtained, the life histories studied and inoculations tried as opportunity permits. When necessary, a personal visit is made to the locality reporting the disease, or an assistant is deputed for local investigation. It will be years before we have anything like a comprehensive knowledge of Indian plant parasites and every occasion is utilised towards this end. This may be taken as the routine work of the Laboratory at present. It is essential to acquire information regarding the characters, distribution and effects of the diseases of important crops in India as rapidly as possible. A few only can be selected for further investigation at any one time. Such are, at present, the cereal rusts, sugarcane diseases, wilts of Leguminosee, and Malvacee, and palm diseases. In some cases simple preventive or remedial measures suggest themselves at once, and detailed study can be left over. A commencement has been made in expanding work through the medium of trained native assistants in the Provincial Departments. These men will be able to inculcate simple measures of improved sanitation, the selection of disease-free seed, the destruction of infective matter and the like; they will also assist largely in the crop disease survey. Larger measures of dealing with severe outbreaks of disease must be, as far as can be judged at present, left to Government agency. Government can also take an active part in checking imports of disease and in providing disease-free seed through seed farms. Further progress in the general control of plant diseases depends on the education of the cultivators.

10. Soil inoculation for legumes.—Field experiments with cultures of the bacilli obtained from pigeon pea, grown and applied after the methods recommended by the United States Department of Agriculture were carried out at Dehra Dun and Pusa. The Dehra Dun experiments, which alone were satisfactory, showed that no appreciable gain resulted from the application. The probable explanation is that bacilli, capable of forming nodules on this commonly grown pulse, must have been present in the field even though the crop itself had not recently been grown there.
11. *Fungus diseases of injurious insects.*—A joint investigation of the possibilities of this method of destroying locusts was carried out with the Imperial Entomologist. The locust fungus is a parasite which is capable of causing epidemic disease in certain locusts. Healthy specimens of the Bombay and North-West Migratory locusts and some species of grasshoppers were inoculated with pure cultures of the fungus, in various ways. Everything was done to increase the chances of infection. The results showed that for the species tested, the method is not likely to be of the slightest use. A Bulletin (No. 5 of 1907) giving details of the experiments and results is now printed. A supposed parasite of the green coffee bug was imported by the United Planters' Association of Southern India and forwarded to Pusa for cultivation. Repeated attempts were made to obtain a strong growth, but it failed to thrive and reports from South India indicate that no cases of infection occurred even with the freshly imported material, so that nothing is to be expected from this method of fighting the pest. These results are in harmony with the general experience of other countries, where the claims of those who advocate this line of work have not as a rule borne full enquiry.

12. *Soil fungi.*—A commencement has been made in the study of the soil fungi which assist in the decomposition of organic matter and help to render it available for plant food. The necessary preliminary to this is a knowledge of the species which are most constantly present in a given soil. This work has been in the hands of Mr. S. K. Basu, M.A., 1st Assistant, who has isolated and determined a number of the commoner soil forms at Pusa.

13. *Systematic Mycology.*—A monograph of the genus Pythium, an imperfectly known group of lower fungi to which the "damping off" and palm rot parasites belong, was published in the Memoirs, Volume I, No. 5, February 1907. To this was added a description of its parasites and some allied fungi. The first part of a systematic account of the fungi in the Herbarium at Pusa, entitled "Fungi Indic Orientalis", was published in conjunction with Messrs. H. and P. Sydow in the Annales Mycologici for October 1906. A second part is in preparation. Part of the collections of fungi, chiefly the larger woody forms, was sent to Kew, and descriptions of the new species published by Mr. G. Massee in the Kew Bulletin.

14. *Text-book.*—Some progress has been made in the preparation of a text-book of Indian diseases of plants. It is hoped to complete this during the coming year. Nothing of the sort is available for students of tropical and sub-tropical plant diseases.

15. *Training.*—The training of probationary assistants for the Central Provinces and Bengal was completed in April 1907. A pro-
bationer for the United Provinces has been under training since the 4th March 1907.

16. Establishment.—The staff has been strengthened by the recent appointment in England of Mr. W. McRae, M.A., B.Sc., as Supernumerary Mycologist. This officer has not yet, however, joined in India. Mr. J. H. Mitter, B.Sc., was appointed 2nd Assistant in July 1906. Babu R. R. Sen was appointed 3rd fieldman in August 1905, and N. C. S. Gupta, 4th fieldman, in December 1905, but transferred on deputation to the office of the Director, Pusa, in June 1906. All have worked satisfactorily, particularly Mr. S. K. Basu, Senior Assistant, Munshi Inayat Khan, 1st fieldman, and Babu Rameshwar Dayal, Clerk.

E. J. BUTLER,

Imperial Mycologist.

PUSA.

The 18th August 1907.
PART V.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

1. Training.—Entomological Assistants were given a full course of training for the Agricultural Departments of Bombay, Bengal, United Provinces, Madras and Assam. A short course of training was given to the Entomological Lecturer, Poona Agricultural College, to a Farm Overseer undergoing a general Agricultural training for Bengal, and to six Agricultural Assistants who had completed their agricultural course at the Cawnpore Agricultural College for the Punjab Agricultural Department.

2. Establishment.—The Supernumerary Entomologist, Mr. C. W. Mason, arrived in December 1906. In anticipation of the appointment of the Second Entomologist, the staff allotted to this officer was appointed. The post of First Assistant to the Imperial Entomologist was held by C. S. Misra who is directly engaged in training the probationers sent to Pusa. The second Assistant, C. C. Ghosh, has had charge of the insectary. One Assistant, T. V. R. Aiyar, was transferred to Madras as Entomological Assistant. P. G. Patel has been specially employed to work at biting flies. The other assistants are now being trained. The artist staff appointed for the Institute and for the Journal worked under my guidance.

3. Buildings.—The insectary was occupied in July 1905; the insecticide godown has been used as a laboratory since June 1906 and a large part of the staff still work in the old barn. Lack of light and of working accommodation have caused great difficulties in carrying out Laboratory work. The full work of my section can only be entered into when the permanent Laboratory is complete.

4. Provincial work.—Trained Assistants are now employed in each Province and, in most cases, the Imperial Entomologist suggests and guides the year's programme of work. Progress has been made in the general study of injurious insects. In the Punjab, the severe outbreak of boll-worm required special measures which are reported to have given good results. The three principal measures were:

(1) Removal and burning of the old plants in January.

(2) The cultivation of bhinda (Hibiscus esculentus) as a trap crop.

(3) The reintroduction of the parasite of the boll-worm.

The first did good generally, but the second was a general failure except in such localities as depended on well irrigation and where
the people understood how to grow the plant. The third measure was an apparent success. Damage estimated in 1905 at two to three crores of rupees was very greatly reduced in 1906 by these measures and in 1907 the crop is reported to be normal, the parasite being abundant generally. In Sind, the loss in 1906 was as bad as in 1907, but the parasite was reintroduced in April-May 1907 from Pusa and is now re-established there. The Bombay Entomological Assistant has given special attention to the outbreak of Potato Moth, an imported pest. In the Central Provinces, good progress has been made in investigating the general pests and a good course of practical entomology is being framed for the college. In Madras and Bengal good progress has also been made in general investigation regarding injurious insects.

The Provincial Entomological Assistants meet at Pusa in January of each year to discuss the year's programme, see the progress made at Pusa and compare notes. Real progress regarding Entomological enquiries is being made in the various Provinces and useful information about the injurious crop pests can without difficulty be diffused.

5. Correspondence.—Reports of injury to crops with specimens of the insects are received from the District officials and when possible a report is sent back at once. These district reports show when insects are doing injury and would be extremely valuable if more frequently sent; damage by insects is constantly reported in the weekly crop reports, but no report with specimens is sent to Pusa. I receive numerous enquiries from Farm Superintendents, Superintendents of the State Gardens, and from other official sources; from commercial firms, planters, zemindars and other private individuals. These enquiries cover a wide range and I have to devote much attention to answering them. A considerable part of my work is devoted to acquire the information necessary to answer such enquiries.

6. Research.—Progress has been steadily made in the investigation of the life histories and habits of injurious insects. A detailed study has been made or is being made of the most important insects, but for numerous destructive insects a full enquiry must wait until we have more time. For each injurious insect all observations are recorded and will in time be worked up. Every stage of the insect's life is recorded pictorially by an artist and the "plate" to illustrate each insect is brought to completion. When particular insects begin to do damage to crops, methods of treatment are experimented with. In co-operation with Mr. R. S. Finlow, a special investigation into insecticides was made, in the hope of finding a substance poisonous to insects but not poisonous to cattle, which could be applied profitably in the field. This investigation has reached the stage of field trials. Other subjects under enquiry, as time allows, are the
influence of climatic phenomena on insects, the utilisation of benefi-
cial insects and the value of trap crops in Indian Agriculture. In collabora-
tion with the Imperial Mycologist an enquiry was made into locust fungus and its value.

The cultivation of "Eri" silk was taken up to determine whether the worms will survive the dry hot weather or can be acclimatised to it. Lac was also introduced under cultivation, as there is a large field for lac culture on existing trees in Behar.

7. Insect survey.—In addition to work of a purely economic nature, provision has to be made for teaching, both in the shape of a collection of the common insects of India and of facts concerning them. The general collection of insects at Pusa has accordingly been made as large as possible. The insects collected are, when necessary, sent to specialists in Europe or America for identification and are then classified. Large collections have been sent to England for the use of authors of prospective volumes of the Fauna of India; I have received the greatest help from the Editor of the Fauna, Colonel Bingham, and our collection owes much to the generous help of Mr. H. E. Andrewes, in sending named specimens of beetles.

It has also been necessary to gather together all the recorded information about insects as the basis of teaching and to supplement this by observation and research. This has been done and the text of a volume on the insects of the cultivated areas of India has been prepared. This will serve as a basis for teaching or, if published, will be an advanced student's text-book and a manual for all workers in Entomology in India. No such work exists at present and its preparation has taken much time. Mr. F. M. Howlett, who will take up the work of the Second Imperial Entomologist in November has collaborated. He has been working at Indian Diptera in England.

8. Summary.—The chief work of the past two years has been a continuation of the preliminary work commenced in 1903, the chief object being the study of the injurious insects of this country with a view to recommend measures to check them or at least to give reliable information about them. The publication of this information is important to the agricultural classes. Practical instruction in entomology can be more effectively carried out when the Provincial Agricultural Colleges and the permanent Laboratories at Pusa are opened.

9. Publications.—"Indian Insect Pests" is the most important item and its publication and wide circulation in India has already produced marked effects. The publication of the Journal and Memoirs has given me heavy work. I have had to supervise the preparation of illustrations for all sections of the Institute including the reproduction of the plates and illustrations of the Journal and Memoirs. I have acquired technical knowledge of printing processes, under some
difficulties. The publishers have introduced the "Three Colour Process," and other improvements and illustration work in India is being vastly improved. Although the work of Messrs. Thacker, Spink & Co. is excellent, we have great need for an Assistant Editor skilled in printing processes and who can bring the work of illustrating to the highest possible level without increased cost. I consider that an Assistant Editor for our publications is urgently required.

H. MAXWELL-LEFROY,

Imperial Entomologist.

Pusa;
The 12th August 1907.
PART VI.

SUMMARY OF THE REPORT OF THE IMPERIAL AGRICULTURIST.

1. Staff.—Mr. E. Shearer was in charge of the section for the whole period. Mr. R. W. B. C. Wood joined as supernumerary in October 1905. In May 1906, he was appointed Deputy Director of Agriculture in Madras. Mr. A. G. Birt and Mr. W. Roberts joined each as a supernumerary in October 1906, and Mr. G. Garrad, in December 1906. Mr. Garrad was deputed to Bombay in May 1907 and Mr. Roberts to the Imperial Agricultural Chemist, each for special agricultural work which will probably give them some experience necessary for Provincial appointments.

2. Historical.—The Pusa estate of over 1,300 acres was largely occupied by jungle when first taken in charge by the Agricultural Department and the work of clearing the good land for arable cultivation has been extensive and costly. The work is not complete and apart from agriculture the amenities of the estate in this section still require considerable improvement.

3. Training.—Two probationers from Bengal completed two years' training in April 1906, and were respectively appointed overseers on the Bankipur and Sabour Farms. A probationer from the Central Provinces completed eighteen months' training in March 1907, and was appointed overseer on the Akola Farm. A probationer from Bengal was, after six months' training, appointed in December 1906, Travelling Inspector of Agriculture in the Orissa Division of Bengal. Another from Eastern Bengal and Assam continues under training.

4. Cropping.—The crops on particular selected fields were grown with the intention to determine how far the fields are uniform in character so that they may be eventually devoted to permanent experiments. The produce from each acre of these fields has been weighed separately. Information regarding the suitability of particular areas for particular experiments is required and a decision on this point will be come to shortly. So far, the indications are that, while large areas are not uniform, considerable blocks will be suitable for accurate experimental work.

5. Cotton.—Extensive trials began in 1904 and included the following:—

(a) Selected indigenous (annual and tree varieties).
(b) Newly imported American.
(c) Acclimatised American.
(d) Egyptian.
The general results have been unsatisfactory. It has been therefore decided that other crops are more profitable in Behar. In consultation with the Inspector-General of Agriculture, it has been further decided that these experiments should be abandoned. The varieties of tree cotton have given particularly unsatisfactory results at Pusa.

6. Sugarcane.—Twenty-five varieties were tested as regards methods of cultivation, manuring, irrigation, susceptibility to disease, outturn, etc. Damage was done particularly to thick soft varieties by white ants, borers, leaf hoppers, jackals and pigs. Fungus diseases caused considerable damage. Dr. Butler deals with the last-named troubles and Mr. Lefroy with insect attacks.

7. Jute.—Forty-four varieties of jute were grown in 1906, forty-two of C. capsularis and two of C. olitorius. The results are described in a general way by the Fibre Expert.

8. Flax.—Experiments with this crop have been carried on since 1904 for seed and fibre but chiefly for the production of fibre. The various varieties imported from Russia, Belgium and Ireland grew very well. An estimate of their value for fibre does not belong to my Department.

9. Mangel wurzels.—Mangel wurzels, as well as turnips, are grown to a limited extent in Northern India. The former was grown at Pusa in the rabi season of 1906 on well manured irrigated land and yielded just under 20 tons per acre. This crop will probably supply in part very suitable food for our cattle and sheep in the hot weather.

10. Green manuring.—The advantage of green manuring with San-hemp was tested and, in newly broken land, proved very profitable.

11. Trial of new pasture grasses.—The seeds of Chloris virgata (known in South Africa as "Rhodes grass") and Chloris gayana were received from New South Wales. They grew well and will be tried again on a larger scale.

12. Breeding herds.—Montgomery cattle continued to do well. The best of them give eight to nine sers* of milk a day when in full profit but this yield is less than in their own country. These cattle have remained healthy.

A herd of local cattle was started with the object of distributing bulls to improve Bengal cattle and the management is practically supervised by the Bengal Civil Veterinary Department. This breed is kept at Pusa to supply Provincial requirements but under present circumstances could possibly be more correctly controlled on a farm managed by officers of the Bengal Government.

13. Establishment.—The staff have worked well especially the two Farm Overseers, Mr. Gulabbai Desai and Mr. Mohammed Ikram-uddin, and Mr. Judah Hyam, the Veterinary Overseer, who is in charge of the breeding herds.

* Ser = 2 lbs.
PART VII.

SUMMARY OF THE REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

1. Mr. A. Howard took up appointment in India in May 1905. During the first three months he saw a good deal of the work carried on by the Agricultural Departments in various Provinces. The area under his charge at Pusa contains a fruit orchard and also a Botanical Garden which is in part devoted to such crops as he is studying. The area is securely fenced and laid out conveniently with paths and in plots. The Botanical Garden of Economic plants is only now being laid out as funds were not available until this year. The want of a laboratory and apparatus greatly impeded his work at Pusa during the first year. Convenient buildings have since been erected. One building is provided with north light and is quite suitable for laboratory work.

Extensive orchards have been planted and these comprise plots of peaches, figs, mangoes, litchis, guavas, loquats, plums and citrus fruits. The experimental scheme refers to pruning, cultivation, irrigation, manuring, planting and the influence of stocks on the scion. The whole is commanded by irrigation from the river and drainage has been arranged for. An account of this work has been published as Bulletin No. 4 of the Agricultural Research Institute, Pusa. The fruit trees are yet all young. They have, however, grown well and all are likely to succeed as they were selected as suitable for the soil and climate of Pusa. Some trees have already fruited. The fruit from the peach trees was notably perfect.

2. Wheat investigation.—In 1905, Mr. Howard collected many samples of seed in the wheat-growing districts. These samples mostly contained mixed seed. The different varieties had to be sorted out and their botanical characters and agricultural values studied. He has obtained a representative collection of Indian wheats through the Agricultural Departments, the Reporter on Economic Products, the Superintendent, Botanical Survey of India, and from other sources. He has undertaken a detailed study of the Punjab wheats at the request of the Punjab Director of Agriculture. A preliminary classification was made in 1906. By extensive field studies a classification of all wheats grown in the various Provinces has been nearly finished. He started cross-breeding wheat experiments in the Punjab and at Pusa. On account of favourable climatic conditions the former are
likely to be the most productive. The cross-breeding wheat experiments in the United Provinces and in Bombay have been conducted by local officers for a number of years. Mr. Howard is preparing a book of reference regarding Indian wheats. The work has been more laborious than he expected. He hopes to finish it soon.

3. Tobacco.—The study of the numerous varieties grown in India has been commenced. Exotic varieties likely to grow well in India have been collected. A classification of various types is a necessary preliminary to work on improvement. This classification has been undertaken.

4. Barleys.—A survey of the barleys grown in India is being made with the aim of improving this crop by cross-breeding and selection of seed. Many varieties were grown at Pusa in 1906-07.

5. Ganja (Cannabis sativa).—The attention of the Imperial Economic Botanist has been drawn to the need of a biological study of the ganja plant, but at present he is fully employed on other and more important work and a general enquiry must wait. He has, however, started minor enquiries regarding this crop at Pusa.

6. Library Catalogue.—A complete revision of the Library catalogue was found necessary and was undertaken in 1907.

7. Tours.—Mr. Howard toured extensively to become acquainted with the agricultural conditions of various parts of India, to see the general agricultural and experimental work which is being carried out in the Provinces, and to gain special information regarding his work on wheat.

8. Staff.—Mr. R. J. D. Graham, M.A., B.Sc., has been appointed Supernumerary Economic Botanist, and arrived in May 1907. Mr. Howard has found difficulty in obtaining a sufficient staff, because neither pay nor prospects are at present attractive.
APPENDIX A.

A SHORT ACCOUNT OF RECENT WORK IN BEHAR IN INDIGO RESEARCH.

In continuation of the far more extensive work of the previous years experiments in manufacture have been carried out at Pusa and at the Bengal Research Station (Sirseah), but chiefly at the latter place.

The Java and Sumatrana varieties yielded the largest outturns of dye by steeping in water at a temperature of 104° F. for 7 hours. These results require confirmation. Extra expense is incurred by using water at a high temperature but water which is too low in temperature is frequently employed with loss on cold and wet days at the beginning and at the end of the manufacturing season. The value of the plant at various stages of growth has been investigated and the study of the fermentation process has been further extended. It is recommended that the conditions of time and temperature mentioned above should be rigidly adhered to. There are inevitable losses of indigotin in the seed water and also in boiling, straining and pressing; but it is believed that an increase of outturn can be usually obtained between the oxidizing process and the finished product. This is under investigation. Attention has been directed to drying indigo in the form of powder as indigo cakes have to be reduced to powder for dyeing purposes. The agricultural and laboratory tests have clearly proved the superiority of the Java plant over the old Sumatrana variety. The difficulties connected with the poor germination of Java seed have been overcome. Treatment with sulphuric acid is effective. The idea was suggested by Dr. Butler and the treatment is successful because the outer tough coat of the seed is weakened and germination in the ordinary moisture of Indian soils is thereby facilitated. The Java plant is a perennial. It should be sown in October-November and cut back in the spring in order to multiply branches and increase leaf growth. There are divided opinions regarding the effect of pruning in subsequent years and the question requires further investigation. As regards manurial experiments no very definite results can yet be reported. The inoculation of Indian soils with a culture of the appropriate nodule bacteria has produced no advantageous results in Behar, presumably because the soils of this district are already sufficiently stocked with such bacteria. Considerable advance has been made in supplying good seed of both Java and Sumatrana varieties to Indigo Planters from established seed farms.

The Behar Indigo Planters' Association have appointed a Botanist and further advancement in indigo research in India will greatly depend upon his work. Nothing has yet been done to separate the best types of plants of any particular variety. The indigo industry is by no means yet dead in India and may yet become again very prosperous by seed selection on rational lines and by other agricultural improvements which are quite feasible. Much less attention has been given to the agricultural improvement of the crop than to chemical and other enquiries regarding the best means of extracting the dye.

Samples of known indigotin content sent to various analysts for examination showed considerable discrepancy in their results. A uniform method of trade analysis for indicating the true indigotin content of the samples dealt with has, therefore, been attained and its use by the leading analysts of Calcutta and England secured. The relative dyeing values of synthetic and natural indigo have been tested by Mr. Berghtheil and very interesting results were obtained. Further trials are probably necessary, but as far as the tests at Cawnpore go natural indigo gave a better depth of colour than synthetic indigo and was pronounced a better dye for ordinary Indian cloths. Mr. Berghtheil is, at present, on leave in England. When he returns from leave his research work regarding indigo will be continued at Pusa where complete arrangements have been made for manufacture and research. We may thus help European Planters in Behar, but we are still more likely to help the backward methods of manufacture in the United Provinces and Madras where cultivation has recently extended.
APPENDIX B.

A SHORT ACCOUNT OF EXPERIMENTS WITH JUTE AND OTHER FIBRES.

JUTE.

For several years the jute trade has been in a critical condition but it has been generally profitable to Indian cultivators and dealers. There has been a large expansion in its cultivation. The demand for the fibre increased so rapidly that supplies began to run short during 1905, with the result that prices had doubled. In 1906 and 1907 the areas under this crop expanded considerably with the result that in 1907 prices have fallen steadily and in time will probably become more normal.

*Jute Extension.*—Mr. Finlow, the Fibre Expert, has published a full report (Agricultural Research Institute Bulletin No. 3 of 1906) which deals with the possibilities of extending jute cultivation in various Provinces. This report has been supplemented by the report of Mr. F. Smith, published in the Agricultural Journal of India, Vol. 11, Part 2, April 1907, which refers particularly to the results of the experiment in Bengal. Outside Bengal, Madras appears to offer more favourable opportunities for jute cultivation than any other part of India. The climate of the Malabar Coast is distinctly similar to that of Bengal, although the hilly nature of some parts indicates unsuitability at first sight. Trials with jute have been conducted in the Godavari delta, at the Samalkota Experimental Station, since 1905, by Mr. Barber, the Madras Government Botanist. The results of the experiments in 1905 were not successful, but in 1906, owing to better experience regarding the necessary agricultural conditions, they were much more satisfactory. These experiments have been continued at the Samalkota Farm in 1907 and seed has been distributed to a number of cultivators in the district, who have received advice from the Agricultural Department regarding the proper method of cultivation. In 1907, jute experiments are also being carried out in other parts of Madras, notably at Tanjore in the Godavari delta on the Malabar Coast. In Bombay, trials were carried out in 1906 at the Ganeshkhind Gardens, Poona, by Professor Gammie on manured land but without irrigation. A yield of over 7½ maunds of fibre per acre was obtained, the value in Calcutta being Rs. 10-4-0 per maund. A larger area has been put down this year. Experiments at the Poona and Manjri Farms—at the latter with irrigation—are also being continued. Conditions in the rice districts of Bombay are not so favourable as in Madras owing to the want of early rains. The Central Provinces commenced trials with jute in 1905 at Nagpur and at Raipur, which were continued in 1906; the results were not satisfactory, chiefly because there are usually no premonsoon showers and the seed cannot, therefore, be sown early enough under favourable circumstances. This season (1907), however, sowings were made at Raipur on manured land in April with well irrigation and the results are reported to be much more promising. Well irrigation early in the season is very expensive and it is extremely doubtful whether it will pay even with a valuable crop like jute in the Chhattisgarh district where rice is practically the only crop at present. Behar and the Assam Valley, where jute had not hitherto been cultivated to any large extent, will probably produce very fine crops as experience is gained by cultivators. In 1904, Behar Indigo Planters began to get interested in jute and their tenants are now growing the crop to a considerable extent. In this tract, about 8,500 acres are under cultivation in the Mozafferpore and Champaran Districts this season (1907). Jute cultivation will probably extend largely into the plains of Assam because physical and climatic conditions are suitable. During the months of March, April and May of the present year, Mr. Finlow made a prolonged tour through the districts north and south of the Brahmaputra, including Cachar. The land near the river on both banks of Brahmaputra is in some places subject to deep inundation in the rainy season, but in others the banks are
practically, if not entirely, above flood level. Away from the river, there are large areas of rich land, much of it virgin and covered with dense reed jungle which, when brought under cultivation, may yield large crops of jute. The cultivation of jute is extending rapidly in the western end of Assam Valley where the acreage is estimated at 60,000 acres this year (1907) as against 33,700 acres in 1906. Many tea planters are interested, but the lack of labour will prevent rapid development. Forty-four varieties of jute were grown at Pusa in 1906, with two objects—(a) to commence plant to plant selection of seed, (b) to study the botanical characteristics of the different races and their agricultural values. Our observations tend to show that the Bengal jutes can be generally classified into (a) green stemmed races, (b) red stemmed races, (c) early maturing races, and (d) late maturing races. Different districts do produce fibre of different qualities and we are enquiring into the reasons. A full report on the experiments made at the Burdwan and Cuttack Farms has been published by Mr. F. Smith in Agricultural Journal, Vol. II, Part 2, April 1907.

Seed Distribution.—The Bengal Agricultural Department in 1906 distributed about 300 maunds of seed of jute from crops grown specially for the purpose. The Eastern Bengal Department of Agriculture also distributed 75 maunds of seed grown at the Rajshahi Farm, a considerable proportion of the latter was distributed in small quantities free of charge to intending cultivators chiefly in Assam. Part of the seed was also used for experimental purposes in other parts of India.

Jute substitutes.—The question of utilizing the various fibre plants which are possible substitutes for jute is assuming increasing importance. Both San-hemp (Crotalaria juncea) and Hibiscus cannabinus are grown throughout India chiefly for home use but to a considerable extent for export. Madras had nearly 70,000 acres of Hibiscus cannabinus in 1906 (the acreage for 1905 was probably less than 45,000) grown for export, or for gunny bags made in the mills at Bimilatam. Seventy thousand acres of San-hemp were grown in the plateau districts of the Central Provinces in 1905. The crop is also fairly important in Madras, the Punjab, Bombay and Bengal.

While these and other fibres have not all the peculiar properties of jute, they are superior to it in some respects and can be used for purposes for which jute is not suitable.

Other jute investigations.—Mr. Finlow has made arrangements with Messrs. Cross and Bevan of London, the well-known authorities on cellulose, to collaborate with them in certain scientific investigations regarding fibres. The first of these investigations is an attempt to find out the cause of the alleged deterioration which has occurred in jute during recent years. It is hoped that the Calcutta Baled Jute Association will co-operate in the enquiry which will, in the first instance, be chiefly bacteriological.

Diseases.—During the present season the crops of jute over a large part of Bengal have been attacked by insects; but serious damage has not been done except in a few instances. The Imperial Entomologist is dealing with these pests.

Fraudulent watering of jute is a common practice among small dealers and leads to much damage to baled jute during transport to Europe. Repressive legislation which was regarded as essential by a considerable section of the commercial community was declined by the Governments of Bengal and Eastern Bengal and Assam on various grounds.

Scientific work.—A temporary laboratory has been equipped at Pusa and work has been carried on during the last three months. At present the investigations are devoted chiefly to a chemical and microscopical examination of numbers of samples of fibre with the object of establishing data to assist the selection experiments in the field. Other problems will be taken up as opportunity offers.

Flax.

Experiments in cultivating flax in India as a fibre crop began as early as 1840 but no definite results were obtained. Experiments have again recently been started chiefly by Sir Lewis Hay, Bart., who, together with his manager Mr. Cameron, has
commenced operations on a large scale at Dooriah, Behar. The results of these experiments were considered by the Government of Bengal to justify assistance and an expert flax cultivator, M. Vandekerkhove, from Belgium, was appointed in February 1907. He will have to gain experience of Indian conditions of cultivation before he can give reliable advice on all points regarding the prospects of the crop. He states, however, that the weight of the rippled straw at present obtained in India is only about half of the yield obtained in Europe. He considers that this return would not be sufficiently remunerative to induce cultivators to take up flax; but he is quite sanguine that better results can be obtained by increasing the yield of straw per acre and by more expert manipulation in the extraction of the fibre. The retting process should be carried out in the fair season not in the rains. The hot weather is too dry for the breaking and scutching processes. Six varieties of imported flax were grown at Pusa during the rabi season of 1906-07; both for fibre and for seed. The yields of straw rippled (threshed), unrippled and seed were fairly satisfactory. Unfortunately, part of the machinery obtained from Europe for extracting the fibre arrived in broken condition so that it is impossible to give yields of fibre at present. The best plots gave about 25 maunds of rippled straw per acre. The European yield is from 40 to 50 maunds per acre. The cultivation expenses in Europe are higher than in India and acclimatization of seed may tend to increase the yield in India. The experiments will be continued until definite issues are obtained and a note will be published regarding results as soon as full experience on the prospects of the crop has been gained. In considering the value of a flax crop account must be taken of the seed, as the straw need not be cut for fibre until the seed is approaching ripeness. The average yield of seed from each of four plots at Pusa was worth about Rs. 17 per acre.

Mr. Finlow hopes in time to show, as regards Bengal and Eastern Bengal and Assam, (a) the best varieties of fibre plants to grow, (b) the best methods of cultivation, (c) the best means to produce the best fibre for the market, (d) the best means of getting full value for good fibre, and (e) the best way of growing seed on a large scale for distribution. He also hopes to be able to show to which areas jute cultivation can be profitably extended, where jute substitutes can be profitably grown and in which parts other profitable fibre plants can be introduced.
## APPENDIX C

**List of Agricultural Publications in India during 1905-06 and 1906-07.**

<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>Author</th>
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<tbody>
<tr>
<td>7</td>
<td>Agricultural Statistics of Native States, 1904-05. Price Rs. 3.</td>
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<tr>
<td>8</td>
<td>Area and yield of certain crops in India, 1905-06. Price 5 annas.</td>
<td>Department of Commerce and Industry</td>
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## List of Agricultural Publications in India during 1905-06 and 1906-07—contd.

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<tr>
<td>10</td>
<td>Agricultural Journal of India. Vol. II. Parts I to IV. Price Rs. 6</td>
<td>Agricultural Research Institute, Pusa</td>
<td>Messrs. Thacker, Spink &amp; Co., Calcutta.</td>
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<td>15</td>
<td>Phoenix Daedylifera Linn. (The Date Palm). Part I. Notes on Date Palm cultivation in countries other than India. Agriculture Ledger No. 1 of 1906. Price 3 annas.</td>
<td>F. Fletcher, M.A., B.Sc., Deputy Director of Agriculture, Bombay Presidency.</td>
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<td>17</td>
<td>Report of the Agricultural Department, Bengal, for the period of 15 months from 1st April 1905 to 30th June 1906. Price 8 annas.</td>
<td>Department of Agriculture</td>
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<tr>
<td>18</td>
<td>Report on the Administration of the Department of Agriculture of the United Provinces of Agra and Oudh for the year ending 30th June 1906. Price 8 annas.</td>
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<td>19</td>
<td>Report on the operations of the Department of Land Records and Agriculture, Punjab, for the year ending 30th September 1905. Price 5 annas.</td>
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<td>Report on the operations of the Department of Agriculture, Punjab, for the year ending 30th June 1906. Price 4 annas.</td>
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<td>21</td>
<td>Annual Report of the Department of Agriculture, Bombay Presidency, for the year 1905-06.</td>
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<td>Report on the working of the Department of Agriculture of the Central Provinces, during the year ending 31st March 1906. Price Re. 1.</td>
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<td>23</td>
<td>Report on the operations of the Department of Agriculture, Madras Presidency, for the official year 1905-06. Price 6 annas.</td>
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<td>24</td>
<td>Burma Land Records Administration Report for the year ending 30th June 1906. Price Re. 1.</td>
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<td>29</td>
<td>Annual Report of the Cuttack Experiment Station for the year 1905-06. Price 2 annas.</td>
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<td>31</td>
<td>Report on the Agricultural Station, Orai, Jalaun, of the United Provinces of Agra and Oudh, for the year ending 30th June 1906. Price 8 annas.</td>
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<td>Annual Report of the Government Experiment Farm, Lyallpur (Punjab), for the</td>
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<td>Kharif and Rabi Seasons, 1905-06.</td>
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<td>34</td>
<td>Annual Report of the Agricultural and Botanical Stations in the Bombay</td>
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<td>Presidency for the year 1905-06. Price Re. 1-2.</td>
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<td>Report on the Agricultural Stations in the Central Provinces for the year</td>
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<td>Annual Report on the Agricultural Stations in Eastern Bengal and Assam for</td>
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<td>Annual Report of the Tropical Plantation at Wahjain for the year ending</td>
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<td>Annual Report of the Jorhat Agricultural Station for the year ending 30th</td>
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<td>Annual Report of the Rangpur Agricultural Station for the year ending 30th</td>
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<td>Annual Report of the Rajshahi Agricultural Station for the year ending 30th</td>
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<td>Annual Report of the Shillong Fruit Gardens for the year ending 30th June</td>
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<td>Scientific Report of the Attur Agricultural Station for the official year</td>
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Government Central Press, Bombay.
Secretariat Press, Nagpur.
Eastern Bengal and Assam Secretariat Press, Shillong.
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Government Press, Madras.
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<td>Scientific Report of the Koilpatti Agricultural Station for the official year 1905-06.</td>
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<td>47</td>
<td>Report of the Indigo Research Station, Sirsiiah, for the year 1905-06.</td>
<td>C. J. Bergtheil, Imperial Bacteriologist</td>
<td>Behar Planters' Association, Mozufferpore.</td>
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<td>50</td>
<td>The cultivation of Ficus Elastica. Price Re. 1-6-0.</td>
<td>Claud Bald</td>
<td>Messrs. Thacker, Spink &amp; Co.</td>
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<td>51</td>
<td>The Objects and Plan of the Heeleka Experimental Station.</td>
<td>Harold H. Mann, D.Sc., Scientific Officer to the Indian Tea Association; and C. M. Hutchinson, Assistant Scientific Officer to the Indian Tea Association.</td>
<td>Indian Tea Association, Calcutta.</td>
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<td>52</td>
<td>Green Manuring in Tea Culture in India</td>
<td>Ditto</td>
<td>Ditto.</td>
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<td>53</td>
<td>Factors determining the Quality of Tea</td>
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<td>54</td>
<td>Experiments in Heavy Pruning</td>
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<td>56</td>
<td>Report on Sugar Mill at Benipur Factory</td>
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<td>Ditto.</td>
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<td>57</td>
<td>A note on the results obtained with Java Indigo</td>
<td>C. J. Bergtheil, Imperial Bacteriologist</td>
<td>Behar Planters' Association, Mozafferpore.</td>
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<td>58</td>
<td>A note on Testing the germinating capacity of Seeds</td>
<td>Percy Jones</td>
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<td>59</td>
<td>A note on Harvesting Java Indigo Seed</td>
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<td>60</td>
<td>A note on the Treatment of Java Indigo Seed with Sulphuric Acid to promote germination.</td>
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<td>A note on Pruning Java Indigo</td>
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<tr>
<td>62</td>
<td>Jute in rotation, with Paddy in the same year. Leaflet No. 1 of 1907</td>
<td>F. Smith, B.Sc., Deputy Director of Agriculture, Bengal</td>
<td>Department of Agriculture, Bengal.</td>
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<td>63</td>
<td>Groundnut. Leaflet No. 2 of 1907</td>
<td>Ditto</td>
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<td>64</td>
<td>Winter Rice. Leaflet No. 3 of 1907</td>
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<td>65</td>
<td>Potatoes at Burdwan. Leaflet No. 4 of 1907</td>
<td>Ditto</td>
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<td>66</td>
<td>Potatoes in rotation with Jute. Leaflet No. 5 of 1907</td>
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<tr>
<td>67</td>
<td>Variety Experiment on Mustard at Dumraon Agricultural Station. Leaflet No. 6 of 1907</td>
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<td>72</td>
<td>Notes on indigenous breeds of Cattle in the Punjab</td>
<td>Major H. T. Pease, I.C.V.D.</td>
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<td>78</td>
<td>The Bombay Cottons, bulletin No. 29 of 1906. Department of Agriculture, Bombay. 10 annas.</td>
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<tr>
<td>80</td>
<td>The Elements of Agriculture of the Bombay Presidency. Re. 1-4.</td>
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<tr>
<td>81</td>
<td>Cultivation of Borsim or Egyptian Clover (intended for cultivation in Sind only).</td>
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<tr>
<td>82</td>
<td>Instructions for the sowing and after cultivation of Egyptian cotton (without ridging).</td>
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<tr>
<td>83</td>
<td>First Book of Agriculture. 12 annas.</td>
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<td>84</td>
<td>Lift Irrigation. Rs. 2</td>
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<td>85</td>
<td>Report on Experiments in pumping with Oil Engines and Centrifugal Pumps in 1905-06.</td>
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<td>87</td>
<td>The Agathi Plant. Its growth in connection with the cultivation of the Betel vine which is trained thereon. Bulletin No. 52 of 1905. Madras Department of Agriculture. 9 pies.</td>
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<td>89</td>
<td>Note on Irrigation by pumping from a well at Melrosapuram. Bulletin No. 54 of 1905, Madras Department of Agriculture. Price 3 annas.</td>
<td>Alfred Chatterton, Professor of Engineering, Madras</td>
<td>Ditto</td>
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<td>91</td>
<td>The Sunflower. Price 1 anna 6 pies.</td>
<td>Department of Agriculture, Madras</td>
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<td>Book</td>
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<td>96</td>
<td>Journal of the Agri-Horticultural Society of Western India (Quarterly, 1906).</td>
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<tr>
<td>98</td>
<td>List of the Principal Economic Plants grown in Bengal. Price 7 annas.</td>
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<td>99</td>
<td>Manual of Arboriculture</td>
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<td>100</td>
<td>Report on the Sugarcane Industry of Bengal.</td>
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<tr>
<td>102</td>
<td>Note on the Production of Coffee in India in the year 1906. Price 4 annas.</td>
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<td>103</td>
<td>Production of Tea in India, 1906. Price 8 annas.</td>
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<td>104</td>
<td>Note on the cotton failure on account of boll-worm in the Central and South-West Punjab in 1905 and on the results of the measures taken to prevent a recurrence in 1906. Bulletin No. 1 of 1907. Price 2 annas.</td>
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<td>105</td>
<td>Jute. Leaflet No. 1 of 1906</td>
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<td>106</td>
<td>Note on Agricultural Experiments suitable for the Bhagalpur Division. Leaflet No. 2 of 1906.</td>
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<td>107</td>
<td>Suggestions on the Cultivation of Cotton. Leaflet No. 3 of 1906.</td>
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<td>Honorary Secretaries, Poona</td>
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<td>F. Smith, B.Sc., Deputy Director of Agriculture, Bengal.</td>
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<td>W. Renouf, C.S., Director of Agriculture, Punjab.</td>
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<td>N. G. Mukerji, M.A., M.R.A.C., Assistant Director of Agriculture, Bengal.</td>
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<td>Superintendent, Government Printing, India, Calcutta.</td>
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<td>109</td>
<td>Short Note on Cotton for the use of Cultivators. Leaflet No. 6 of 1906.</td>
<td>Ditto</td>
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<td>110</td>
<td>Simple instructions for the destruction of Insects attacking Jute. Leaflet No. 7 of 1906.</td>
<td>Ditto</td>
<td>Ditto</td>
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<td>111</td>
<td>Instructions in regard to Cotton Picking. Leaflet No. 8 of 1906.</td>
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<td>112</td>
<td>Short Note on Potato Cultivation for cultivators. Leaflet No. 9 of 1906.</td>
<td>Ditto</td>
<td>Ditto</td>
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<td>113</td>
<td>Teaching of Experiment work at the Burdwan Station. Leaflet No. 10 of 1906.</td>
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<td>Ditto</td>
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<td>114</td>
<td>A simple method of destroying the Red Cotton Bug which is now found in large quantities on the Cotton near Jamtara. Leaflet No. 11 of 1906.</td>
<td>Ditto</td>
<td>Ditto</td>
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<td>115</td>
<td>Jute Experiment, Cuttack, 1906</td>
<td>F. Smith, B.Sc., Deputy Director of Agriculture, Bengal.</td>
<td>Ditto</td>
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<td>7</td>
<td>The Agricultural Research Institute, Pusa.</td>
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### List of Agricultural Publications in India during 1905-06 and 1906-07—contd.

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### List of Agricultural Publications in India during 1905-06 and 1906-07—contd.

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List of Agricultural Publications in India during 1905-06 and 1906-07—concl.

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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist)

1907-09

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1909
# TABLE OF CONTENTS.

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Introductory</strong></td>
<td></td>
</tr>
<tr>
<td>1. Agriculture</td>
<td>1</td>
</tr>
<tr>
<td>2. Botany</td>
<td>4</td>
</tr>
<tr>
<td>3. Agricultural Chemistry</td>
<td>6</td>
</tr>
<tr>
<td>4. Mycology</td>
<td>7</td>
</tr>
<tr>
<td>5. Entomology</td>
<td>8</td>
</tr>
<tr>
<td>6. Cotton</td>
<td>10</td>
</tr>
<tr>
<td>(a) Selection and Distribution of Seed</td>
<td>13</td>
</tr>
<tr>
<td>(b) Introduction of Superior Indigenous Varieties and Better Methods of Cultivation</td>
<td>14</td>
</tr>
<tr>
<td>(c) Hybridization</td>
<td>15</td>
</tr>
<tr>
<td>(d) Trials of Exotic Varieties</td>
<td>16</td>
</tr>
<tr>
<td>7. Tree Cottons</td>
<td>18</td>
</tr>
<tr>
<td><strong>II.—Report of the Director, Agricultural Research Institute, Pusa</strong></td>
<td></td>
</tr>
<tr>
<td>1. Charge</td>
<td>19</td>
</tr>
<tr>
<td>2. Staff</td>
<td>19</td>
</tr>
<tr>
<td>3. Scientific Work</td>
<td>19</td>
</tr>
<tr>
<td>4. College, Grounds, Roads, etc.</td>
<td>20</td>
</tr>
<tr>
<td>5. Students</td>
<td>20</td>
</tr>
<tr>
<td>6. Publications</td>
<td>20</td>
</tr>
<tr>
<td>7. Library</td>
<td>21</td>
</tr>
<tr>
<td>8. General Health of the Station</td>
<td>21</td>
</tr>
<tr>
<td><strong>III. Report of the Imperial Agriculturist</strong></td>
<td></td>
</tr>
<tr>
<td>1. Charge and Establishment</td>
<td>23</td>
</tr>
<tr>
<td>2. Training</td>
<td>23</td>
</tr>
<tr>
<td>3. Cropping and Character of the Seasons</td>
<td>23</td>
</tr>
<tr>
<td>4. Special Crops under Experiment</td>
<td>23</td>
</tr>
<tr>
<td>(a) Sugarcane</td>
<td>25</td>
</tr>
<tr>
<td>(b) Jute</td>
<td>25</td>
</tr>
<tr>
<td>(c) Flax</td>
<td>25</td>
</tr>
<tr>
<td>(d) Tobacco</td>
<td>25</td>
</tr>
<tr>
<td>5. Manurial Experiments on Wheat</td>
<td>25</td>
</tr>
<tr>
<td>6. Green Manuring</td>
<td>25</td>
</tr>
</tbody>
</table>
7. Permanent Manurial and Rotation Experiments 27
8. Permanent Pasture Experiments 27
9. Breeding 28
10. General Improvement of the Estate 29
11. Programme for 1909-10 29

IV. Report of the Imperial Economic Botanist 31
1. Charge of Office 31
2. Teaching and Training 31
3. Wheat Investigations 32
4. Fruit 35
5. Fibres 35
6. Oil Seeds 35
7. Minor Investigations 35
8. Tobacco 35
9. Programme for 1909-10 36
   (1) Training 36
   (2) Plant Breeding and Plant Improvement 36
   (3) Fruit Experiments 37
   (4) Minor Investigations 37

V. Report of the Imperial Agricultural Chemist 39
1. Charge 39
2. Introductory 39
3. Meteorology 39
4. Rainfall 39
5. Evaporation 39
6. Drainage 40
7. Loss of Water from Soil 41
8. Water required by Plants 42
9. Available Plant Food in Soils 42
10. Soil Gases 43
11. Black Cotton Soil 43
12. Other Investigations 43
13. General Analytical Work 43
14. Students 44
15. Establishment 44
16. Programme for 1909-10 44

VI. Report of the Imperial Entomologist 47
1. Training 47
2. Establishment 47
3. Buildings 48
4. Provincial Work ........................................ 48
5. Correspondence ......................................... 49
6. Research .................................................. 49
7. Sericulture .............................................. 51
8. Lac .......................................................... 52
9. Insect Survey ............................................ 52
10. Demonstration ........................................... 53
11. Publications ............................................. 54
12. Conclusion ............................................... 55
13. Programme for 1909-10 ................................ 55

VII. Report of the Second Imperial Entomologist ........ 57
1. Charge and Establishment ................................ 57
2. Training .................................................... 57
3. Work on Publications .................................... 58
4. Entomological Work ..................................... 58
5. Correspondence .......................................... 61
6. Conclusion ................................................ 61
7. Programme for 1909-10 .................................. 62

VIII. Report of the Imperial Mycologist ................... 63
1. Charge and Establishment ................................ 63
2. Laboratory ................................................. 63
3. Training .................................................... 63
4. Organisation .............................................. 64
5. Research Work ............................................ 65
6. Sugarcane Disease ....................................... 65
7. Palm Disease ............................................. 65
8. Disease of Citrus Fruits ................................. 66
9. Wilt Disease ............................................... 66
10. Mulberry Disease of Kashmir ........................... 67
11. Ginger Disease ........................................... 67
12. Other Diseases of Plants ............................... 67
13. Silkworm Disease ........................................ 67
14. Programme for 1909-10 ................................ 67

IX. Report of the Imperial Cotton Specialist ............ 69
1. Charge ....................................................... 69
2. Tours ........................................................ 69
3. Collection of Varieties ................................... 77
4. Distribution of Seed ..................................... 77
5. Identification and Valuation ............................ 77
6. Programme for 1909-10 ................................ 78
REPORT
OF THE
Agricultural Research Institute and College, Pusa
(Including Report of the Imperial Cotton Specialist)
1907-09

INTRODUCTORY.

The reports of the Director and heads of sections of the Agricultural Research Institute, Pusa, and of the Cotton Specialist for the years 1907-09, are herewith published. The period ends on the 30th June 1909.

The Institute was opened for advanced students only in July 1908. Before this 22 probationers came from various provinces for technical training in various sections, to adapt them for work of a very practical kind in the provinces concerned.

It has been definitely settled that Pusa shall chiefly be a higher teaching institution with post-graduate studies principally for selected graduates of provincial agricultural colleges and distinguished science graduates of Indian universities. Arrangements have, however, been made, for the time being, to give in agriculture, economic botany and entomology, short courses particularly in regard to the practical application of these sciences to every-day agriculture or horticulture in India. I attach great value
to these practical courses. A prospectus of the Pusa College has, for general information, been published.

Before I review in short detail the work done at Pusa, there are a few features of this Institute which I wish to clearly define. The first refers to the general suitability of Pusa for the central research and experimental station for the whole of India. Pusa is a magnificent estate of over 1,300 acres, bounded on three sides by a loop of the little Gundak river. The soil is deep alluvial and is capable of growing successfully nearly every rain crop which can be grown in the plains of India. With irrigation from wells or from the river, it can grow successfully the majority of the more important garden crops. We have arranged for all necessary means of irrigation from the river and from wells, also for dealing with many important crops. The rainfall of Pusa and of Behar is generally secure; otherwise the district could not maintain its population of 900 to 1,100 per square mile. Pusa is situated in the heart of intensive agriculture which is largely controlled by a community of indigo planters: Agricultural improvements through their influence, can be brought to the notice of ordinary cultivators in a manner which is unique for other parts of India. This was one reason why Pusa was selected as the central research station. Mr. Coventry, an experienced indigo planter and an extensive experimenter in agricultural problems, was selected as the Director. He has very particular opportunities of spreading very far afield the results of the research work and of the practical field enquiries which are undertaken at Pusa.

We have at Pusa the Phipps' laboratory, a two-storied building, well-equipped with a laboratory for each branch of agricultural science and a physical laboratory. The main building also includes a library, museums for the various sections and the necessary lecture rooms. Quarters have been provided for the European and Indian staffs. There are recreation grounds, and I am glad to
say that the European staff, assistants and students are keen on sports. A hostel with accommodation for 70 students is provided, also a well-equipped hospital and dispensary.

All sections were very badly housed at Pusa in temporary laboratories for some time. The head of each section now rejoices in having a well-equipped laboratory with all necessary fittings and apparatus. The Institute is served by water-power and electric installations.

The amenities of the estate have been much improved in many ways. A new approach avenue to the Institute has been constructed, and the lawns surrounding the college building have been laid out under irrigation and sparsely planted parklike with trees and ornamental shrubs. The scrub and jungle growth on the estate has been mostly cleared, thus making preparation for bringing waste land under cultivation. The unsightly brick-fields near the entrance to the estate, have been levelled and are now under cultivation with suitable ordinary crops. An area of some 150 acres has been reclaimed for arable cultivation. Practically the whole of the estate is now under grass or cultivation.

It has been proved in the past that the Pusa estate is capable of growing very fine timber trees in the avenues and elsewhere; consequently we are endeavouring to improve the attractiveness of the estate by planting and protecting young trees in the pasture areas, along the frontage of the river and in the avenues. The existing teak, shishum, bamboo, and mahogany avenues are an object lesson to many parts of India. We even expect to improve upon these. The fruit orchards and botanical area are now attractive features. A large vegetable garden is maintained. Many suitable trees on the riverside land have been inoculated with lac.

Nineteen students in all the various sections were admitted for training in 1908-09. In regard to the scientific and practical teaching in the lecture rooms, in the laboratories and in the fields at Pusa, my chief desire is that it
should be a means of helping, in a very practical way, the ordinary or improved agriculture of this country. I wish, therefore, to attract, from provincial agricultural colleges and from other colleges, students of high class ability who have been reared on the land.

Many of such students are usually poor and cannot afford the expense of an advanced course in research work. Government have spent of late years large sums on the development of agriculture, and I am confident that Indian gentlemen generally interested in the work will do their share. There is perhaps no direction in which there is more scope for liberality of the most useful kind than in the founding of scholarships for students at Pusa.

I refer below to some of the work done in each section at Pusa and by the Cotton Specialist. A full review of each report is not required here.

Agriculture.—Mr. E. Shearer, Imperial Agriculturist, has done much useful work for the Department. He was absent on privilege leave from 2nd July to 30th September 1908, when his duties were carried on by the Director.

Permanent manurial and rotation experiments were laid down last year on two blocks of 9 acres each. The land selected for these experiments has been tested and found sufficiently uniform for the purpose.

Permanent pasture experiments were laid down in the monsoon of 1907. It is very important to know the best conditions in various parts of India under which pastures can, on practical lines, be properly established and improved. This is the aim of the Pusa experiments, and it is believed that the results will be of very wide application, especially as similar grass experiments have been undertaken in some provinces. Already there is a decided change in the character of the herbage in some of the manured plots at Pusa.

Arable areas which are likely to be suitable for the extension of experimental work in the future, are being treated uniformly in regard to cultivation and cropping.
The more important crops under trial at Pusa include wheat, barley, oats, maize, rice, various pulses, oil-seeds, sugarcane, jute, flax, and tobacco. Efforts are being made to obtain and acclimatise the best indigenous and foreign varieties of these crops. Cotton varieties have been given up, as nearly all are unsuitable to Behar.

Perhaps the most important line of work in the Agricultural Section at Pusa, refers to the breeding and rearing of farm live stock. A very select herd of Montgomery cattle, the premier milk breed of India, is maintained. A record of the milk yield of each cow is kept. It is hoped to raise the milking standard (which is now very high) by selection on the basis of these records, and to breed these cattle of one colour and of one type. I draw attention to an interesting illustrated note which will appear in the October number of the *Agricultural Journal of India* for 1909. It refers to a large and remunerative export trade in Indian cattle which has recently arisen. Probably no Indian breed will meet the requirements of this foreign demand better than Montgomery cattle. They are useful for milk, for work and for beef, and in South Africa, in the Southern States of America and in the Straits Settlements they must prove useful, because pure and half-bred Indian cattle have been found to thrive well in these parts and are not affected by flies and ticks in the same disastrous way as local cattle.

Last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. They are being crossed by *dumba* rams to give them hardiness and obtain improvement in the crosses as mutton and wool sheep.

Poultry breeding is now conducted on a fairly large scale. During the last year 19 breeding pens of fowls representing 10 pure breeds and 3 crosses, have been maintained including turkeys, geese and ducks. The experience so far gained indicates that the breed of fowl fully suited to India will have to be developed by crossing.
With this aim in view various experiments are being tried at Pusa. Many enquiries are received for pure bred birds and for eggs for hatching. The farms in several provinces have been supplied with birds, and large orders are being booked from private individuals, chiefly in Madras and Burma. Some of the pure and cross breeds reared at Pusa are being tried experimentally in the hills to determine how they stand the climate.

**Botany.**—Mr. Howard has done a great deal of useful work for the agriculture and horticulture of India.

He continued to be in charge of his section at Pusa except when he was on leave for six months from August 8th, 1907, to February 8th, 1908, when Mr. R. J. D. Graham, Supernumerary Economic Botanist, carried on the work of the section.

The most important work done by Mr. Howard during the period under report is in relation to wheat. He has nearly completed the botanical survey of the wheats of India. The results are given in the first section of his book, *Monograph on Indian Wheats*, now in the press. Samples of wheat were sent to Mr. Humphries in England for milling and baking tests, the results of which are published in a bulletin. At Pusa several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities.

The plant-breeding work in wheat is now being conducted on a fairly large scale, and the separate cultures, many hundreds in number, extend over several acres. The main objects of this hybridization work are to improve the grain, straw and rust resistance of the Indian wheats. Considerable progress has been made in the investigation into the influence of soil, climate and moisture on the character of the grain in wheat.

Fruit cultivation on an extensive scale has been successfully established. Most of the fruit trees are coming into bearing. The fruit experiments at Pusa have already
yielded results of considerable practical importance. They have proved the suitability of the soil and climate in Behar for growing certain important varieties of fruit.

Preliminary experiments with high class fruit regarding sun-drying, evaporating and refrigerating, have been carried out. A method was devised and successfully tested for sending peaches long distances by rail in India.

During the past year a considerable amount of preliminary work was accomplished by Mr. Howard on oil seeds of the genus *Brassica*, and a general study of the oil seeds of India will be undertaken.

The races of both *Nicotiana rustica* and *Nicotiana tabacum* isolated at Pusa, have been studied. Arrangements have been made with the Peninsular Tobacco Company of Monghyr to conduct experiments at Pusa to ascertain the best varieties and the best means of growing tobacco suitable for the manufacture of cigarettes.

Selection experiments with flax, *Hibiscus canabinus* and *Crotalaria juncea*, were continued, and some promising races isolated.

Three varieties of sisal hemp (*Agave rigida sisalana*) have been established on a small scale.

Progress has been made in the investigation work with barley, *ganja* and opium. The study of the varieties of cassava has been completed, and Mr. Hector is preparing a final report on this subject.

*Agricultural Chemistry.*—Dr. Leather held charge of this section till 14th April 1909, when he went on leave, and the Supernumerary Agricultural Chemist, Mr. Annett, was appointed to officiate for him. Very few samples of agricultural materials are now sent up by provincial departments for analyses, as these departments have now their own chemists. An appreciable reduction has also taken place in the number of samples received from Native States, the Forest and Irrigation Departments and private persons. Dr. Leather had, therefore, more time for
original research and for larger investigations of importance to Indian agriculture generally.

The work in the pot-culture house has led to important field experiments, the results of which are likely to benefit cultivators at least in Behar in a very substantial way. These field experiments are devised to show that phosphatic manure can with economy and great advantage, be used for certain soils and many crops, particularly in parts of the Gangetic alluvium and especially in Behar.

The Imperial Agricultural Chemist has a very important investigation in progress on the effect of soil or manure on the composition of certain seeds. The results already obtained are remarkable. In conjunction with the Imperial Entomologist, Dr. Leather is investigating the prevention of injury by weevils to wheat and other grains when stored in bulk. This enquiry is of great importance, particularly as it is probable that the American "elevator system" of storing grain may be introduced into India at least on an experimental scale. Mr. Annett has conducted an interesting enquiry into the cause of the dark colour of the black cotton soil. The results of this enquiry are about to be published.

Mycology.—Dr. Butler held charge of this section till 31st March 1909, when the Supernumerary Mycologist, Mr. W. McRae, M.A., B.Sc., was appointed to officiate for him. Mr. McRae arrived in India after deputation for six months to the laboratory of Professor von Tubeuf at Munich. The transfer of the laboratories to the Phipps' building has greatly facilitated the work of this section.

Dr. Butler should be congratulated in regard to the practical application of his work to the ordinary conditions of Indian agriculture.

The requirements of provincial departments still continue to make heavy calls upon the time of the Imperial Mycologist. Collections are being accumulated and worked out with such voluntary assistance as can be got outside
India. Duplicate collections will be as far as possible supplied to provincial departments which already have mycological assistants.

The fungi hitherto recorded from India have been in great part identified, and the information has been made readily accessible.

The research work includes the examination of the life-history and general biology of parasites and their effects on the attacked plants.

The wilt diseases of cotton, indigo, pigeon pea and gram were selected for special study, and the results already obtained will largely help Indian agriculture. A memoir on the work is now in the press. The experiments at the Poona farm to raise a strain of pigeon pea resistant to the wilt disease, have been in progress for four years and are promising well.

Renewed experiments were made to elucidate the methods of infection of the red-rot disease of sugarcane which in India has been for a considerable period a very disastrous disease to this important crop. It is hoped that the new results will be published during the year, and advice of importance given. The study of the life-history of other sugarcane parasites has not yet reached the publication stage.

Dr. Butler inspected the palm disease operations in the Godavari delta in September and December 1907 and in January 1909. Successful inoculations with the parasite were secured during 1908, and a further study of its life-history was made. The campaign against this disease has been particularly successful, and is still being prosecuted earnestly by means of the special staff sanctioned by the Madras Government. I must note the fact that the results of this enquiry by Dr. Butler are so valuable to India that they are equivalent to saving the cost of his section to India for many years to come.

The Imperial Mycologist visited Travancore in September and October 1907 to investigate the cocoanut palm
disease that had broken out in that State. A report on that disease has been published.

The Imperial Mycologist visited Kashmir in 1908 during the months of July, August and September, and enquired into diseases of mulberry and of imported fruit trees. The result of part of this work has been published, and recommendations made for dealing with mulberry diseases. The problem is very important, as many poor people in Kashmir derive much benefit from the silk operations and from the cultivation of good kinds of fruit.

Dr. Butler will complete in a short time the text of a book on Indian plant diseases. It will be of great value to students of agriculture in India.

*Entomology.*—Mr. Lefroy held charge of this section during the period under report. His indomitable energy appears throughout the work of his section. He continued to direct the work of entomological assistants in the provinces, but their number is still only 13, which is quite inadequate to make an appreciable impression upon the agriculture of India. A beginning only has been made.

The teaching of entomology at the provincial agricultural colleges and also at demonstrations and at shows has made fair progress.

Attention has been given in provinces to the study of the life-histories and habits of injurious insects.

In the Punjab the effects of cotton boll-worm and its parasites has been closely watched.

The work on the insects of the plains of India was continued.

Assistance was given to firms dealing with *mohwa*, with brush-making and with cheroots in regard to insects damaging these articles.

Valuable results have been obtained in the cultivation of *eri*-silk during the past year on a small scale at Pusa, and it is intended to continue this as the basis of a small cottage industry in several parts of India. This industry
is being taken up in Tirhoot and Gujarat. The purely experimental work on *eri*-silk is almost completed. The cultivation of mulberry silk has been taken up.

The question of *tussar* silk is also being investigated.

The cultivation of lac was continued at Pusa as a demonstration to students and for much wider practical application in villages. Some owners of indigo factories in Behar have taken up lac cultivation on a fairly large scale. These men were supplied with seed and information, and their assistants were trained in lac culture. Assistance was also given to the Bikanir State in regard to the possibilities of lac culture there.

Mr. Lefroy has started apiculture with a few stocks of European bees to determine how far they thrive in the plains of India.

The Supernumerary Entomologist, Mr. Mason, visited the various centres at which army stores are baled and stored, to investigate the occurrence in clothing, etc., of the destructive insect *Anthrenus vorax*. On the completion of this enquiry recommendations were made for better baling. Mr. Mason continued the enquiry into the value of insect eating birds.

The general collection of insects of India apart from the purely economic one, has been completely arranged.

Enquiry into the question of preventing the introduction of fungus and insect pests by importation of plants and seeds was made in order to devise remedial measures.

The text-book on *Indian Insect Pests* continues to increase in popularity. Its translation in Bengali has been prepared.

Mr. Lefroy's great work on *Indian Insect Life* has been issued.

A series of excellent coloured plates with short printed explanations illustrating injurious insects, have been issued for use in agricultural colleges, museums and farms and at
exhibitions and shows. This series will be continued and will cover silk, lac, bees and beneficial insects.

The best methods of preparing exhibits of injurious insects for shows are also being tested with a view to find out the class of exhibits that most appeal to the public. Further, a series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows.

Mr. Howlett, Second Imperial Entomologist, arrived at Pusa in December 1907. He has undertaken the investigation of those biting flies of whose habits little or nothing has been hitherto known in India. With a view to obtain materials for this enquiry, sets of apparatus and copies of the bulletin on biting flies, have been issued to persons and associations likely to render help. In this connection Mr. Howlett is in complete touch with special officers of the medical and veterinary departments. He arranged in February 1909 an exhibition of all kinds of blood-sucking and parasitic insects for the pathological section of the Bombay Medical Congress, and read a paper on the habits of sand flies. He has ascertained the life-histories of nearly all the mosquitoes which occur in Pusa, and has found two species of fish which are capable of destroying large numbers of anopheles larvæ. A report on the natural enemies of mosquitoes was furnished to the Director of Agriculture, Bengal.

A comprehensive investigation of the several species of fruit flies which attack mangoes, peaches, etc., is in progress. The life-histories of several of these have been worked out, and methods of destroying the mango fly have been tested with success. An attempt to check the annual attack of these pests on the peaches grown at Pusa, was so far successful this year that the period of severity was postponed; thus the Imperial Economic Botanist was able to complete certain experiments.

Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908, to obtain informa-
tion regarding the fruit flies in India, the Australian fruit flies being related to those found in India. Specimens have, therefore, been supplied to him.

Arrangements have also been made with Professor Silvestri to supply parasites of some of the South Indian species in the hope that they may be utilized against the olive fruit fly, a species which inflicts great damage in Italy.

Specimens have been lent to the Indian Museum, Calcutta, in connection with the revision of nomenclature of various groups of Indian diptera. A large representative collection of tabanidæ has also been lent to the British Museum to assist in like manner the revision of that family now in progress.

Mr. Howlett contributed to Indian Insect Life the portions relating to Diptera and the sections on Mallophaga, anoplura and cimicidæ.

A memoir on sand flies is under preparation in collaboration with Dr. Annandale of the Indian Museum.

Mr. Howlett controls the work of the artists at Pusa and is endeavouring to raise the standard of illustration work which is a most valuable part of the publications of the Imperial department.

Cotton.—Cotton continued to receive a great deal of attention from the agricultural departments. Mr. G. A. Gammie who has done much useful work in cotton, was appointed Imperial Cotton Specialist in December 1907. His report is separately published with those of the heads of sections at Pusa. It is unnecessary to minutely review it here. The co-ordination of the experiments that are being conducted on this crop, will now be possible, and Mr. Gammie's advice in the improvement of cotton ought to prove of great help to the department. The principal lines of improvement attempted have been (a) selection and distribution of cotton seed, (b) introduction of superior indigenous varieties and better methods of cultivation, (c) hybridization and (d) trial of exotic varieties.
(a) Selection and Distribution of Seed.—The distribution of seed of selected pickings from cultivators' fields, has been in progress for more than four years in several provinces, but without any marked result. This is hardly surprising, for such selection, while no doubt supplying sound seed, is, properly speaking, no selection at all, since the fields ordinarily contain many varieties mixed together. It is by separating types and continued plant-to-plant selection that real improvement can be effected. This line of work is now being followed on Government experimental stations with very encouraging results. On the Surat farm, the different types found mixed in Khandesh cotton have been isolated and have been sown separately to determine the comparative value of each. Similar experiments are in progress in Madras. At Akola in the Central Provinces promising work is in progress in the separate cultivation of the four distinct varieties of cotton which are now grown mixed by the ryots under the names jari and kati vilayati. Of these the malvensis seems to be a distinctly superior variety, and special attention is being directed towards selection from it.

Eight cotton seed farms were worked by private agencies in the Central Provinces in 1908 under the guarantee of the provincial department against loss. Such farms have been in existence for the last four years. They grow the ordinary jari and bani varieties of cotton, but are situated in districts which have special reputation for the high quality of their cotton. The seed of first and second pickings is purchased by the provincial department at more than market rates for distribution. In course of time when the selection now going on at the experimental stations has borne fruit, these farms will become useful agencies for the distribution of improved strains of seed. The ultimate object is to establish a number of such farms independent of the department, but receiving, when required, assistance in the provision of seed, trained staff or advice. In the Punjab, Bengal and United Provinces, selection of cotton seed is in progress.
(b) Introduction of Superior Indigenous Varieties and Better Methods of Cultivation.—There has been a marked extension of this line of work, especially in Bombay and Madras. The introduction of Broach cotton into the Dharwar district has been attended with considerable success. This cotton is superior to the locally grown Kampta variety not only in quality, but also apparently in average yield per acre and in lint percentage. In 1908 sixteen thousand pounds seed of Broach cotton from Navsari were sown in these parts in addition to some of the seed of this crop grown locally in 1907. Steps are being taken to get the people to cultivate it properly and to adopt a cleaner system of picking. Some efforts were made to introduce Broach cotton under irrigation in the Deccan, but owing to faulty cultivation and irrigation on the part of the cultivators, the experiments were not successful. Attempts have been made to improve the quality of Broach cotton in northern Gujarat by introducing seed of the superior Navsari variety from the south of the district. In the Tinnevelly district of Madras the karungani variety has been found to be superior in quality and yield to the uppam variety. Arrangements were, therefore, made by the provincial department to sell pure karungani seed sufficient to sow about 8,000 acres in 1908. This work was partly helped by the grant from the British Cotton Growing Association. The Madras Agricultural Department has also made successful efforts to improve the ryots' methods of cotton cultivation. Expert cultivators are sent to teach the use of the country drill and bullock-hoe and to demonstrate the value of improved cultivation. Implements are supplied free of cost and expert labourers are sent to help the growers. The advantages of the drill are becoming widely appreciated, and in all 1,000 acres of private land were sown with the drill last year, and many ryots have learned to use the drill.

(c) Hybridization.—Experiments in hybridization were continued at several centres. They have brought to light
some new ideas which, however, require confirmation. The crosses at the Surat farm have been found to be undergoing considerable variation. Although their lints have a relative advantage in quality over the ordinary Surat cotton, the ginning percentage is steadily falling. (The percentage has fallen from 36·9 to 30·3 during the last five years.) The crosses have not yet been grown on a sufficiently large scale to properly test the outturn per acre. The lints of 21 hybrids grown on the Surat station were valued from 5 to 10 per cent. above fine Broach. At Dharwar some encouraging results have been obtained by crossing inter se newly introduced varieties from America and Egypt. Work on similar lines is being done in the Central Provinces and Madras, but until the hybrids show greater stability it is impossible to estimate their value.

(d) Trials of Exotic Varieties.—Trials of exotic varieties on Government farms and in cultivators’ fields were continued. It is disappointing to have to record a set-back in the expectations previously formed regarding Egyptian cotton in Sind. Up to 1907 the area under this cotton was increasing, but last year, owing to the short supply of water till long after the proper sowing season, the area decreased, and the quantity and quality of the produce much deteriorated. Further, on account of faulty methods of cultivation, careless picking and admixture of leaves and dirt, the produce was so inferior that great difficulty was experienced in disposing of it. There were no bidders at the three auctions held in November, December and January last. The cotton was ultimately sold to a Bombay firm who wanted it for a particular trade purpose and paid only Rs. 9 per maund for abassi and Rs. 8·6-0 for metafifi as against a minimum of Rs. 11 per maund secured in the previous year.

The average outturn per acre of Egyptian cotton in Sind has been during the last four years much lower than that of the hardier indigenous variety and much less than was originally expected. This is mainly due to bad
cultivation on the part of the ryots who do not follow the instructions of the agricultural department. Unless cultivation is improved and sufficient flow irrigation is obtained as early as March-April, there is no likelihood of Egyptian cotton being established as a general field crop in Sind. The Government of Bombay are taking steps to secure these conditions. It is disappointing, however, to record that this year (1909) no sowings in Sind of Egyptian cotton have been made on account of the difficulties of water supply.

Some promising results have been obtained from the trials of American and Cambodia cottons in parts of the Southern Maratha country.

The area sown with American cotton in the Jhelum colony of the Punjab increased in 1907, but on account of the scarcity of labour due to the epidemic of plague, the area was restricted last year. There has been, however, no large decrease in the number of cultivators growing this cotton. Arrangements were made last winter to dispose of the produce by auction as is done with Sind-grown Egyptian cotton, and the results were most satisfactory, the cultivators obtaining an adequate price for their produce. The trials with Egyptian cotton in the Punjab have not yielded any satisfactory results. The Economic Botanist has now imported a new variety which he considers better suited to the Punjab.

Acclimatised American cotton was successfully grown in 1907 by many cultivators in the Aligarh district of the United Provinces, and there was a large increase in the demand for seed for the next year's crop. It is anticipated that the quantity of this cotton will soon be sufficient for putting it on the market on a commercial scale and the prices offered will determine whether it will be permanently established in these provinces.

In the Central Provinces and Bengal burhi cotton (an acclimatised variety of American type) has continued to give successful results. Efforts are being made to extend
the area under this cotton and to improve the quality and outturn by selection. In the Central Provinces arrangements were made during 1908-09 to secure a large supply of seed for distribution. It is a good cropper in districts of fairly heavy rainfall, yields a high percentage of lint of good quality and is comparatively immune to wilt.

In Madras and Burma, experiments with Egyptian and other varieties of cotton are in progress.

Tree Cottons.—Further trials with tree cottons have confirmed the opinion which I have previously expressed, viz., that they will never enter into regular cultivation in India. The experiments made by Messrs. Shaw, Wallace and Company with this class of cotton have generally failed. The chief centre of their operations was the Murbunj Farm. One hundred and seventy acres were planted out with perennial cottons in 1907. In the succeeding year this area was increased to about 300 acres. In August 1908 the plantations were inspected by me in company with the Director of Agriculture, Bengal, and a report was submitted to Government. The experiments had failed and therefore have been abandoned since March, 1909. Some success has been obtained with the Bourdon variety in the Bombay Presidency and favourable results have been obtained here and there in Assam and Burma, but the place of tree cottons as a field crop in Indian agriculture is very limited.

J. MOLLISON, M.R.A.C.,
Inspector General of Agriculture in India.

SIMLA;
The 5th August 1909.
REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEARS 1907-09.

(B. Coventry, Esq.)

1. Charge.—The Director returned from nine months' combined privilege leave and furlough on 27th November 1907, and for the remainder of the period under report, was in charge of his office.

2. Staff.—The European scientific staff of the Institute consisted as follows:—(1) The Imperial Agriculturist with one Supernumerary, (2) The Imperial Agricultural Chemist with one Supernumerary, (3) The Imperial Economic Botanist with one Supernumerary, (4) The Imperial Entomologist with one Supernumerary, (5) The Second Imperial Entomologist and (6) The Imperial Mycologist with one Supernumerary. Mr. C. J. Bergtheil, Imperial Bacteriologist, who for the last five years was on deputation with the Bengal Government carrying on investigations connected with indigo manufacture, joined his appointment at Pusa on the 1st April 1909, after the expiry of his deputation, but soon after (28th June) relinquished his post. Mr. F. M. Howlett, B.A., Second Imperial Entomologist, arrived from England on the 23rd November 1907 and commenced his investigation on diptera. Mr. G. P. Hector, M.A., B.Sc., arrived on the 14th January 1908 and took up the post of Supernumerary Economic Botanist in succession to Mr. R. J. D. Graham, M.A., B.Sc., transferred to the Central Provinces. Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, arrived on the 28th March 1908. Mr. W. Roberts, B.Sc., Supernumerary Agriculturist, was deputed to Bombay Presidency in April 1908 to assist the Deputy Director of Agriculture, Mr. A. G. Birt, B.Sc., Supernumerary Agriculturist, was in May 1908 transferred to the Agricultural Department, Eastern Bengal and Assam, as Acting Assistant
Director of Agriculture. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, arrived from England on the 7th October 1908 to undergo training under the Imperial Economic Botanist, and Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, arrived from England on the 19th November 1908. Drs. J. W. Leather and E. J. Butler proceeded on leave from the 15th and 1st April 1909 respectively, and Mr. H. E. Annett, B.Sc., Supernumerary Agricultural Chemist, and Mr. W. McRae, Supernumerary Mycologist, were appointed to officiate in the posts of Imperial Agricultural Chemist and Imperial Mycologist respectively.

3. Scientific Work.—The scientific work of the Institute during the period is indicated in the reports of the various sections.

4. College, Grounds, Roads, etc.—The College building has been taken over from the Public Works Department and has been fully occupied by the various sections. The spacious compound surrounding the College has been laid out; a general improvement in the condition of the roads and avenues has been introduced. Nearly 150 acres have been added to the cultivated area.

5. Students.—The College was opened for students in July 1908. The number of students admitted during the year was 19. Of these, 2 came for training in practical agriculture, 2 in economic botany (one for a special course in fruit pruning and weathering), 2 in chemistry, 7 in entomology, 3 in mycology and 3 came for a general course in agriculture. Seven students left after completion of training; one left on account of ill-health, and one was recalled to his province before completion. The student from the Central Provinces who came for a training in entomology died before completing his course. In addition to the training in the agricultural sciences above referred to, special classes have been opened to give a short industrial training in subjects such as lac cultivation and sericulture, and there are now 2 students
receiving a course of instruction in the latter subject. In the coming year it is intended to enlarge these special industrial trainings by the addition of more subjects such as fruit-growing, poultry-management, dairying, etc. It is hoped that these short courses will assist in reviving several old industries and promoting new ones which may profitably be worked as cottage industries.

6. Publications.—Much assistance has been given by the senior members of the staff in the preparation of publications. Special mention should be made of Dr. Leather who has had charge of the photographic department, of Mr. Maxwell-Lefroy who supervised the passing through the press of all the illustrations connected with publications, until he handed over the work to Mr. Howlett, and of the latter gentleman who, during the last year, has not only been responsible for the preparation and publication of illustrations, but has also assisted much in seeing the printed matter through the press.

7. Library.—The library contains over 6,000 volumes. The transfer of the books from the old building to the new, their arrangement and cataloguing have taken up a good deal of thought and time, and I am greatly indebted for the assistance that has been given in these matters by Dr. E. J. Butler, Mr. H. Maxwell-Lefroy and Mr. A. Howard. A new catalogue, revised and corrected up to 31st December 1908, is in the press.

8. General Health of the Station.—The general health of the station has been good. There was an outbreak of chicken-pox and acute ophthalmia amongst the menial establishment in April 1908. In March 1909, there were four cases of confluent small-pox among the subordinate staff; all recovered, and by prompt disinfection and isolation further spread of the disease was stopped. In the hospital, relief was given to 5,716 cases of whom 190 were indoor patients. The number of cases treated amongst European officials and their families was 226. The operations performed numbered 171 of which 14 were major.
1. Charge and Establishment.—The Imperial Agriculturist was absent on privilege leave from 10th September to 4th October 1907, and from 2nd July to 30th September 1908, when his duties were carried on by the Director; for the rest of the period under report he was in charge of his section. Mr. A. G. Birt, Supernumerary Agriculturist, worked in the section until 8th June 1908, when he was deputed to Eastern Bengal and Assam to officiate as Assistant Director of Agriculture. Mr. G. C. Sherrard joined the section as Supernumerary Agriculturist on 20th November 1908. There have been no important changes in the subordinate staff. Excellent work has been done by Mr. Judah Hyam, Veterinary Overseer, who has been in charge of the breeding herds, Mr. Gulabbhai Desai and Mr. M. Ikramuddin, Farm Overseers, and Mr. Ziauddin Hyder, fieldman in charge of the poultry.

2. Training.—Four men from Eastern Bengal and Assam have completed courses of two years, nine months, six months, and three months, respectively, in practical agriculture. Of these, two are now in charge of experimental farms, one is a fieldman and the other who is a graduate in agriculture of Cornell University, United States of America, is temporarily in charge of the Dacca experimental farm, but is intended for the post of Agricultural Supervisor in his province. Two students sent by the Punjab Agricultural Department for the general course in agriculture, remained under training. Mr. Gore, Manager of the Salvation Army’s farm in Gujarat, came for a short practical course last cold weather.

3. Cropping and Character of the Seasons.—The general cropping followed the same lines as in previous
years, being chiefly determined by the requirements of the breeding herds. Areas which promise to be suitable for future experimental work, have been treated uniformly with regard to cultivation and cropping, the produce of each acre weighed separately and the lands otherwise kept under close observation. Two blocks of 9 acres each were selected as suitable for the permanent manurial and rotation experiments referred to below.

The rainfall for the year 1907-08 was 32.35 inches (the normal being about 45 inches) and was badly distributed. There was a long break in the rains in July and August, and from the latter part of September till early January there was no rain. Cold weather sowings were made under very dry conditions, but the rains in the latter part of the cold weather were good. Notwithstanding the generally unfavourable conditions, the crops both kharif and rabi were excellent. The rainfall from the 1st of June 1908 to the 31st of March 1909 (which covers the kharif and rabi cropping seasons) was 18.23 inches. The monsoon arrived a full month later than usual and was very scanty, but kharif crops turned out to be little under the average. Rabi sowings, however, were made with very short moisture, and as practically no rain fell till the crops were in ear, the yields were reduced to less than ¼th of the normal. The experience of the last two years would seem to fix the minimum rainfall with which good kharif and rabi crops can be successively grown on the same land, as somewhere between 20 and 30 inches, if moderately well distributed. A considerable proportion of the rainfall is lost by surface drainage in heavy falls, so that the actual crop requirements are comparatively small. But it is only on very fine grained soils, such as the north Behar alluvium, where evaporation can be reduced to a minimum by suitable cultivation, that full advantage can be taken of the actual rain absorbed by the soil, and again suitable cultivation presupposes good cattle and efficient moisture-conserving implements which in this part of India are in the hands of few.
4. *Special Crops under Experiment.*—These included *(a)* sugarcane, *(b)* jute, *(c)* flax, and *(d)* tobacco.

*(a) Sugarcane.*—Experimental work on sugarcane is at present confined to determining the best varieties and the best conditions as regards cultivation, manuring, planting and irrigation. The results obtained will have only a local application, and it is recognised that the present work must either pave the way for larger investigations on this important crop, or, if local conditions are found to be unsuitable, work on the crop will be abandoned altogether. In the course of the last five years a large number of thick and of thin varieties of cane from all parts of India have been under trial. With regard to the thick varieties it has been found to be impossible, even with liberal manuring, to obtain the heavy crops grown in the best cane tracts, the maximum yield hitherto obtained being 35 tons of stripped canes per acre. The length and thickness of the individual canes are satisfactory, but the stools are deficient in tillering power, and the fact that many, from various causes, succumb altogether during the growing season, is further evidence of rather low vitality. The thin varieties, on the other hand, in most cases tiller extremely well, and with an application of oil cake or farm-yard manure equivalent to 100lb of nitrogen per acre, and with one or at most two waterings after planting, can, in a normal season, be depended on to give yields of 30 tons of stripped canes per acre. This, considering the comparatively low expenditure on the crop, is quite a satisfactory return. Various sugar factories have been established in Behar in the last few years, and these deal almost entirely with thin canes. Provided the difficulty is overcome of securing from a moderate distance a sufficient supply of canes to keep the mills going, there appears to be no reason why these should not prove a success.

*(b) Jute.*—Forty-four varieties of jute were grown on an area of 8 acres in 1907 and gave an average yield of 16$\frac{1}{4}$ maunds of fibre per acre, the season being no better than
the average with regard to moisture conditions. At one time there seemed to be a fair prospect of jute being grown in Behar on a large scale, but the difficulty of obtaining sufficient labour at the time of retting, the fall of the abnormally high prices of three years ago to their normal level, and the fact that in a very dry hot season like that of 1908 the crop may be a complete failure, has discouraged further cultivation. The Fibre Expert to the Government of Eastern Bengal and Assam has taken over the collection of varieties for classification and selection, but otherwise the crop is no longer grown at Pusa.

(c) Flax.—The results of the experiments with flax continue to be promising. In the rabi season of 1907-08 the yield and the quality of the flax straw were quite good, and there seems to be little reason to doubt that when the requirements of the crop are properly understood, flax will be capable of being successfully grown in Behar.

(d) Tobacco.—Zimmer’s Spanish tobacco was grown on an area of 5 acres in the cold weather of 1908-09 for experimental curing in the curing house, but at the critical moment the expert assistance promised could not be obtained. In any case, owing to the unfavourable seasonal conditions, the crop was considerably below the normal both in yield and in quality.

5. Manurial Experiments on Wheat.—In the cold weather of 1907-08, calcium cyanamidc and calcium nitrate were compared with sodium nitrate, Indian saltpetre, sulphate of ammonia, rape-cake and farm-yard manure as fertilizers for wheat. Owing to an attack of white-ants and the late application of the manures in a rather dry season, the results of the experiment were somewhat inconclusive, but calcium cyanamidc and calcium nitrate proved as effective as any of the other manures except rape-cake. The readiness with which the latter manure becomes available as plant food, even under fairly dry conditions, is remarkable.
6. Green Manuring.—Green manuring has been very successful, especially in the case of lands newly reclaimed from jungle. By green manuring such lands, they are immediately brought into a condition of high fertility, whereas under ordinary conditions moderate fertility is only obtained after two or three years' cultivation. Sann-hemp is a crop ordinarily employed for ploughing in. It grows rapidly and gives a large bulk for ploughing in about the middle of the monsoon, and becomes sufficiently decomposed before the sowing of the succeeding rabi crop to avoid danger of the land drying out from being too loose. The effects of green manuring are very marked in the two following crops and are discernible for two or three crops more.

7. Permanent Manurial and Rotation Experiments.—These were laid down last year according to the scheme described in the Proceedings of the Board of Agriculture, held in February 1908. It will be after some years only that the results obtained will have their full value. The kharif yields varied, on the whole, very consistently with the doses of manure applied, thus showing that the land selected was sufficiently uniform for the purpose. The rabi sown plots were so poor as in most cases to be incapable of being harvested.

8. Permanent Pasture Experiments.—Owing to the ever-increasing contraction of grazing areas in India, it is of importance to know the best conditions under which good pastures can be established and maintained. That good pastures can be grown in many parts of India there is little doubt. An area of 80 acres of unmanured pasture at Pusa was found sufficient to supply all the green food required by two hundred head of cows and young cattle for six months in the year while yielding quite a substantial amount in the remaining six months. Consequently, a series of permanent pasture experiments was laid down in the monsoon of 1907 according to the scheme described in the Proceedings of the Board of Agriculture, held in
February 1908, and it is anticipated that interesting and valuable information will be obtained. Already there is a decided change in the character of the herbage in some of the manured plots.

9. Breeding.—The Montgomery herd of cows continues to do well. The high milking qualities of this breed are year by year becoming more appreciated, and dealers from distant parts of India now carry off large numbers from the half-yearly fairs at Amritsar. Out of the Pusa herd of 39 cows, 16 have given over 4,000lb each of milk in their last lactation period (under a year in each case), and of these five have given over 5,000lb each, one has given 6,300lb and another just under 6,000lb. When it is remembered that the average yield of milk in some of the best dairying districts in England, is said to be under 5,000lb, and with a considerably lower percentage of butter fat than is found in the milk of the Montgomery breed, it is possible to realise what a valuable asset India has in the latter. At Pusa there is now the nucleus of what promises to be a very fine herd, and the work of raising its milking power by selection based on the milk records, is probably the most important at present in hand in this section.

The local herd of cattle is still maintained on behalf of the Bengal Government. How far it is likely to prove useful is still uncertain. This year there was considerable difficulty in disposing of all the young bulls even at comparatively low prices. This may have been due to the scarcity of fodder in the district. There can be little doubt, however, that if the herd is to be fully successful, it must be transferred to the Bengal Agricultural Department whose officers alone are in close touch with the districts which the herd is intended to benefit.

During last cold weather 80 Bikanir ewes were purchased. These are a white-fleeced breed with a high reputation for yield and quality of wool. The change from the arid conditions of the Bikanir desert to the moist climate and new food of Behar, induced a severe attack of
dysentery from which 30 died in a short time. The remainder, however, are now doing well. They are being crossed by a dumba ram by which means it is hoped to obtain greater hardiness, constitution and earlier maturity. Attention will also be paid to maintaining the quality of the wool by careful selection.

Poultry breeding is now conducted on a fairly large scale. During the last year there have been 19 pens of fowls representing 10 pure breeds and 3 crosses. It is too soon yet to say how the imported fowls will do. The difficulties of disease and pests incident to the introduction of Western live stock of any sort into India, have had to be faced, and they have been formidable. In the light of the experience already gained, arrangements have been made which will obviate some of the difficulties encountered. Again, many of the more recently produced breeds of fowl are partly of Eastern origin, and for this reason and because of the greater vitality which has resulted from their mixed origin, adapt themselves with greater readiness to Indian conditions. The great fecundity of fowls, as compared with larger animals, is another factor in their favour. But, while there will always be a demand on the part of fanciers for pure breeds, there is little doubt that the breed of fowl fully suited to India will have to be built up in India, and with this end in view various crosses are being tried at Pusa.

10. General Improvement of the Estate.—Fully 100 acres have been added to the cultivated area. Much still remains to be done in the way of reclamation, but the back of the work has been broken, and as soon as sufficient work-cattle are obtained, this kind of work will soon be brought to a conclusion.

11. Programme for 1909-10.—The permanent manorial and rotation and the permanent pasture experiments will be continued. Experimental work on flax will be continued. Work on sugarcane will be continued. Barley, maize, sorghum, cow-pea, rice and castor varieties will be tested.
Breeding work will be further extended. Selection in the Montgomery herd on the basis of milk records will be continued. It is anticipated that the Bengal Agricultural Department will take over the herd of local cattle. Sheep breeding will be continued on the lines indicated in the report. The breeding and distribution of fowls will be continued.

The training of students will be continued. Attention will be paid to the general improvement of the estate.
REPORT OF THE IMPERIAL ECONOMIC
BOTANIST FOR THE YEARS 1907-09.

(A. Howard, M.A., A.R.C.S., F.L.S.)

Charge of Office.—The Imperial Economic Botanist held charge of this section during the period under review, with the exception of six months from August 8th, 1907, to February 8th, 1908, when he took combined leave on account of illness, and Mr. R. J. D. Graham, M.A., B.Sc., Supernumerary Botanist, was placed in charge of current duties. While on leave he visited the various botanical gardens and experiment stations in Ceylon and spent some time at Peradenia, the head-quarters of the Ceylon Agricultural Department. He is indebted to Dr. Willis, the Director, for special facilities in studying the work and organisation of his department. Some new ideas were obtained which he hopes to make use of in India. Visits were also paid to some of the leading cacao, rubber, and tea estates in the island. Some work on geographical distribution was done at Newara Eliya, a paper on which it is hoped to publish shortly in England.

2. Teaching and Training.—The teaching work of the section commenced on October 1st, 1908, with two students from the Central Provinces. One of these was sent for a special course on the principles of fruit growing, the other for a general course of training in economic botany to fit him for the duties of first assistant to the Professor of Botany at the Nagpur Agricultural College. Both these students did excellent work and profited very considerably by their stay at Pusa. Two students from the mycological section attended the course of lectures and practical work on physiology in this section. During the present session two students from the Punjab have joined the section for a general course, and at least two more students
are expected in October next for the special course on the principles of fruit growing.

In addition to the external students, three supernumerary botanists have received training in the period under report. Of these Mr. R. J. D. Graham, M.A., B.Sc., left in February 1908, to take up the post of Economic Botanist in the Central Provinces. Mr. G. P. Hector, M.A., B.Sc., Economic Botanist-designate of Eastern Bengal and Assam, arrived at Pusa on January, 22nd, 1908, and remained under training. Mr. E. Holmes-Smith, B.Sc., Economic Botanist-designate of Burma, joined the section on October 12th, 1908, for six months' training in economic botany. This period has since been extended.

Mr. Abdul Rahman Khan, formerly Manager of the Lyallpur Farm, joined the section as an assistant on October 11th, 1908, and has undergone a special course of training since. He has worked well, has made a good deal of progress and has shown considerable aptitude for the work of plant breeding.

3. Wheat Investigations.—Considerable progress has been made with the investigations on Indian wheat. The quality of the wheat produced in India is a question of the greatest importance, both from the point of view of local consumption, and also of the export trade. Little attention, however, seems hitherto to have been paid to this matter. It appeared likely, both from the appearance of the grain and also of the nitrogen percentage, that some of the pure culture wheats at Pusa and Lyallpur were markedly superior in quality to the ordinary soft whites like Muzaffernaggar largely grown for export. Accordingly the co-operation of Mr. A. E. Humphries, a past President of the Incorporated National Association of British and Irish Millers and the highest authority in the Empire on the milling and baking properties of wheats, was secured with regard to the wheats of India. An arrangement was at the same time made with Dr. Leather, Imperial Agricultural Chemist, for the necessary analytical work to be done at Pusa. The first set of samples for
milling and baking tests were sent to England after the wheat harvest of 1908, and Mr. Humphries' report more than bore out the expectation that India can grow high grade wheats. This report was submitted for publication in the form of a bulletin in September last. Although several of the Punjab samples were superior to Muzaffernaggar white, Mr. Humphries considered that one of the Pusa selections, No. 6, was distinctly the best wheat. The publication of the bulletin has attracted a considerable amount of attention, and it was submitted by the Director of the Punjab Agricultural Department for the opinion of the Incorporated National Association of British and Irish Millers. The council of this association unanimously supported Mr. Humphries and Imperial Economic Botanist, and a full account of the proceedings is to be found in the *Miller* of May 3rd last, and was reprinted in the *Indian Trade Journal* of June 3rd, 1909. A second set of 28 samples of wheats was sent to England for testing during the present year.

Intimately associated with the quality of wheat is the question of the influence of such conditions as soil, climate and moisture on the grain characters. It was found in 1908 that the same sample of Muzaffernaggar wheat sown at Lyallpur, Muzaffernaggar and Pusa, gave rise to grain markedly differing in appearance, analysis and milling and baking qualities. In order to investigate this subject further, and also to discover experimentally a scientific basis for a scheme for wheat distribution in the Indo-Gangetic plain, this work has been considerably extended during the past *rabi* season in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces. The co-operation of other officers of the agricultural departments was obtained, and experiments were successfully carried out at the following stations:—Pusa, Bankipore, Dumraon, Partabgarh, Cawnpore, Orai, Alighar, Meerut and Lyallpur. Mr. Evans has promised to assist next *rabi* at Hoshangabad. The results of this year's work will be
published as soon as Mr. Humphries' report has been received.

The botanical survey of the wheats of India was completed during the last year, and an account of this work forms the first section of the book, *Monograph on Indian Wheats*, now in the press. The report on the detailed agricultural survey of the wheats of the Punjab was completed during the year, and for this work the thanks of the Local Government were received through the Director of Agriculture, Punjab. A similar survey of the wheats of Bengal was completed during the year, and the results of this work will be published after the next *rabi* harvest. Bengal apparently possesses some wheats new to science.

Perhaps the most important section of the wheat investigations is that concerned with selection and hybridization at Pusa. Several promising wheats have been isolated by selection and are now being tested for yield, agricultural characters and grain qualities. The plant-breeding work is now being conducted on a large scale, and the separate cultures, many hundreds in number, extend over several acres. The main object of this hybridization work is to improve the grain, straw, and rust resistance of the Indian wheats. The results already obtained are of the very greatest promise.

During the progress of the wheat investigations at Lyallpur, a comparison was made between the wheats of the Punjab and those of the United Provinces. The superiority of the former in vigour and straw characters was most marked. Accordingly during the past year a set of the types of Punjab wheat was placed at the disposal of the Economic Botanist, United Provinces, for growth at Cawnpore. The result surpassed expectations. These wheats showed a marked superiority over the other wheats cultivated at this station, and Mr. Leake has arranged to continue the testing of these wheats in the United Provinces. Besides the report on the Punjab wheats and the
bulletin on the milling and baking tests, two publications on this crop have been completed during the year. A memoir on *The Varietal Characters of Indian Wheats* has been published. Three papers on wheat dealing with the results obtained in the harvest of 1909 are in preparation.

4. *Fruit.*—The fruit experiments at Pusa have already yielded results of considerable practical importance, but it was impossible to find time to write during the last year a second report giving an account of these results. It is hoped, however, to take up this work shortly. Good crops of oranges, limes, custard apples, peaches, plums, guavas, and loquats were grown, and the litchis and mangos are coming into bearing. Preliminary experiments on sun-drying, evaporating and refrigerating, were carried out, and a method was devised and successfully tested for sending peaches long distances by rail in India.

5. *Fibres.*—Selection experiments in the case of flax *patwa* (*Hibiscus cannabinus*) and sumn-hemp (*Crotalaria juncea*) have been continued, and some promising races isolated. Three varieties of sisal-hemp (*Agave rigida sisalana*) have been established on a large scale.

6. *Oil Seeds.*—During the year a considerable amount of preliminary work was accomplished on the cultivated oil seeds of the genus *brassica*, and the study of the oil seeds of India will be considerably developed during future years.

7. *Minor Investigations.*—The study of the cassava varieties has been completed, and Mr. Hector is engaged in the preparation of a final report on this subject. He has completed the botanical examination of the Pusa pasture experiments, and the final report has been submitted. The work on *ganja*, barley and opium has been continued.

8. *Tobacco.*—A good deal of attention has been paid during the year to tobacco. The races of both *Nicotiana rustica* and *Nicotiana tabacum* which have been isolated at Pusa, have been studied. A memoir summing up
the work on the yellow flowered tobaccos of India (*Nicotiana rustica*) has been submitted for publication, and a second memoir dealing with the classification, description and biology of the races of *Nicotiana tabacum*, is in preparation. The method of growing this crop by furrow irrigation, was further tested and improved during the year. Arrangements have been made with the Peninsular Tobacco Company of Monghyr, to conduct a series of experiments at Pusa to ascertain the best variety and the best means of growing tobacco suitable for the manufacture of cigarettes. This work will be conducted in collaboration with one of the experts of the company.

9. *Programme for 1909-10*:

(1) **Training.**—The teaching work of the section will be continued on the lines laid down in the prospectus of the Institute.

(2) **Plant-Breeding and Plant Improvement.**—The following crops will be studied:—Wheat, tobacco, barley, oil seeds and fibre plants.

(a) **Wheat.**—The botanical and agricultural survey of the wheats of Bengal will be completed on the lines adopted in the investigations on the Punjab wheats. The production of improved varieties by selection and hybridization, will be continued as well as the investigation of the factors influencing the quality of the grain.

(b) **Tobacco.**—The botanical survey of the Indian tobaccos will be completed.

(c) **Oil-Seeds.**—The study of the oil-seeds of India which has been carried on on a small scale during the past year, will be extended on lines similar to those adopted in the investigations on wheat.

(d) **Barley.**—The work on this crop will be continued.

(e) **Fibres.**—The collection and investigation of fibre yielding plants will be continued.
(3) **Fruit Experiments.**—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

(4) **Minor Investigations.**—The economic importance of the male plant in *ganja* cultivation and the problem of the inheritance of sex, will be determined. The study of cassava as a famine food will be continued in collaboration with Imperial Agricultural Chemist.
REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST FOR THE YEARS 1907-09.

(J. W. Leather, Ph.D., F.I.C., F.C.S., and H. E. Annett, B.Sc., M.S.E.A.C.)

1. The Imperial Agricultural Chemist held charge of this section till April 14th, 1909, when he proceeded on leave, and Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was appointed to officiate for him. Mr. Annett acted as Agricultural Chemist at the Poona Agricultural College from August 13th to November 22nd, 1908.

2. The several subjects which are under investigation may be conveniently referred to as follows:—

3. Meteorology.—The usual meteorological records are kept by this section and forwarded monthly to the Imperial Meteorological Department.

4. Rainfall.—A self-registering rain gauge was fitted up at Pusa and used during the monsoon of 1907 in order to obtain some information regarding the rainfall per unit of time. This is wanted in connection with the estimates of the amount of rain water which runs off the land during heavy rains. The instrument was one which was fitted up by the Imperial Agricultural Chemist locally, and yielded only approximate data, and a more exact instrument will be necessary; but such data as were obtained show the heaviest falls during the monsoon of 1907 to be under 2" per hour. The monsoon was, however, a very weak one and included only one really large fall.

5. Evaporation.—An evaporimeter has been experimented with in order to determine the amount of water which evaporates from free surfaces of water. The results so far have not been very satisfactory.
6. Drainage.—Records from all the four drain gauges were maintained. In the monsoon of 1907, these differed only markedly in the amount of surface drainage which was greater from No. 1 than from the others. Nevertheless the No. 1 gauge probably yields the most reliable data. Nos. 2 and 4 had grass on them and were expected on this account to behave differently from Nos. 1 and 3. The rainfall was sufficiently heavy on two occasions to cause an overflow from the pipe fixed at a nominal 2" above the ground level, and the amounts that ran off were 0·5" during a 4" rainfall and 3·5" during a 7" rainfall. The amount of water which percolated was 7·5". The rainfall was 40·3" during the year (October 1906 to September 1907), and the amount which evaporated during the twelve months was accordingly 28·8". These are the quantities measured from No. 1 gauge.

The data of the drain gauges at the Cawnpore farm and the samples of the drainage water from them, are provided for this section by the courtesy of the Director of Land Records and Agriculture, United Provinces. The four years' data obtained from these gauges, show that the evaporation there amounts to between 14" and 20" in extreme cases, and that the average is approximately 17" per annum. Hence the amount lost from the Pusa soil is considerably greater than at Cawnpore. This result is probably fully explained by the fact (referred to below) that the Cawnpore soil contains less maximum water per cubic foot than the Pusa soil.

Regarding the constituents which are dissolved in the drainage water, the total amount of nitrogen (as nitrate) in the drainage water was 20lb per acre from the bare fallow soil and 0·04lb from that growing grass. This year maize is being cultivated on gauges Nos. 2 and 4 in place of grass. The Cawnpore gauge soil which is maintained fallow, continues to yield large amounts of nitrate. This varies, however, a good deal with the rainfall and also with the depth of the gauge. Over a series of years these gauges are yielding approximately equal
amounts of nitrate, but it is not all washed out during the same season; up to the present the deep gauges yield large amounts in a very wet year, whilst the shallower ones, although yielding also more in a year of heavy rainfall than in one of small precipitation, fall short of the deep gauges in this respect, and then recover their position in a year of short rainfall. The data are, however, meagre, and in any case the subject is closely related to that of the period when nitrates are principally formed and their subsequent disposition in the soil, a subject which, though understood fairly well for European conditions, is far from being so for Indian soils.

The monsoon of 1908 was such a weak one that practically no drainage was recorded from any of the four gauges. The rainfall this year up to June 30th has been considerably above the average. Up till May 31st, 1909, 5.15" of rain fell. In June 28.96" fell. Percolation began in gauges Nos. 3 and 4 (the 3' gauges) on June 10th, after 12.31" of rain (reckoning only June rainfall) had fallen. In the 6' gauges, Nos. 1 and 2, percolation began on the 11th and 12th June respectively.

Much trouble is caused by the burrowings of various insects into the gauges, and probably largely from this cause gauge No. 2 (a 6' gauge) has leaked considerably, and part of the drainage water from this gauge has had to be ignored.

7. Loss of Water from Soil.—The data relating to the first year's records of the amount of water in the soil at Pusa during the dry season 1906-07, and the deductions made therefrom, have been published as a memoir, No. 6, chemical series. The views put forward in that memoir have been supported by further experiments in the field, the results of which are about to be published.

In order to gain experience of other soils, similar records have been kept at the Cawnpore Agricultural Station, and through the courtesy of Mr. C. Rudston Brown, at Bhatowlia Indigo Factory in Behar, in addition
to another series at Pusa, determinations of the amount of water present in the soil having been made monthly throughout the dry season 1907-08. The latter season was unusually dry at Pusa, so that the soil here was desiccated to a greater extent than generally happens. After reviewing the data of the two seasons, it was found that too much weight had been placed on the effect of atmospheric humidity in the first method of calculating the rate of loss, and that the latter can be accounted for by the effect of temperature in addition to the special characteristics of the soil. The calculated values agree very closely with those found. The data for the Cawnpore soil show it to possess a marked difference from the Pusa soil in the amount of water present at the conclusion of the monsoon, for this quantity is only about 16lb per cubic foot, whereas the Pusa soil contains about 25lb. Moreover, during the season it lost water only to a depth of three feet as against seven feet at Pusa.

The soil at Bhatowlia was selected, because it is a coarse sand for more than 10 feet. This soil only contained about 5lb water per cubic foot at the conclusion of the monsoon.

8. Water Required by Plants.—An investigation of the amount of water transpired by plants, was commenced in 1907 by the pot-culture method. In the following cold weather one field experiment was made in conjunction with the latter, and it was found to yield data in close correspondence with those obtained from the pot-cultures. During the last year the pot-culture investigation was extended so as to include (a) a larger variety of crops and (b) a number of essentially different soils, and in conjunction with this a series of field experiments with various crops was carried out. The data which have been obtained have been put together in a memoir which will shortly be published under the title of "The Water Requirements of Crops in India."

9. Available Plant Food in Soils.—This investigation continues to occupy a part of the time of the section, but
is much more complicated than some of the other works. The phosphates form the chief objective, because of the importance which the more perfect valuation of this group of constituents in soils would possess. The only area in which field experiments have been made up to the present in conjunction with the laboratory work, is in Behar. The soil of a large part of Behar is, so far as one can tell from laboratory tests, greatly deficient in readily assimilable phosphates, and field trials were made during the monsoon of 1907 and the following cold weather. The former yielded doubtful results, but the latter yielded, with one exception, considerable increases due to superphosphate.

10. Soil Gases.—Closely allied to the study of the assimilable plant food in soils, is probably a more perfect knowledge of the nature of the gases in soils and their quantity. Such information as we possess regarding this subject is but meagre, and since the Indo-Gangetic alluvium offers an exceptionally suitable material for the work, an investigation in this subject was commenced. The results obtained have been embodied in a memoir entitled "The System Water, Calcium Carbonate, Carbonic Acid."

11. Black Cotton Soil.—An investigation into the nature of constituent or constituents of this soil which occasion its peculiar colour, was undertaken by Mr. Annett, Supernumerary Chemist. The results obtained from this investigation are about to be published.

12. Other Investigations.—Chief among these is a determination of how the composition of the various crops grown on the permanent experiment plots at Pusa, varies with different systems of manuring.

In conjunction with the Imperial Entomologist, some work has been done with the object of freeing stored wheat grain from weevil.

13. General Analytical Work.—The number of samples of agricultural materials which are sent by the provincial departments for general analysis, is now practically nil. The chief calls on the laboratory for this purpose
are made by Native States, the Irrigation Department and private persons. The number of such specimens examined is about \( \frac{1}{6} \)th of what it formerly was. This section of the work is now nominal and does not seriously interfere with other work.

14. Students.—Three students, two from the Punjab and one from Eastern Bengal and Assam, attended for a course in general chemistry from October 1908 till March 1909. These were all students taking the general course in agriculture. In June 1909, one student came to be trained as Analytical Assistant to the Agricultural Chemist of Bengal.

15. Establishment.—Mr. J. N. Sen, M.A., senior laboratory assistant, was, on the opening of the College in July 1908, appointed teaching assistant. Mr. D. B. Darab Sett, B.Sc., resigned his appointment to take up the post of Senior Assistant to the Agricultural Chemist, Burma. Mr. S. C. Kar took his M.A. degree at Calcutta University. Mr. D. N. Chatterjee, B.A., B.Sc., and Mr. C. S. Rama Aiyer, B.A., were appointed Junior Assistants. All the establishment have worked well and given great satisfaction.

16. Programme for 1909-10.—The programme of work for the coming year is chiefly a continuation of that described in the foregoing report which may be briefly summarised as follows:

1. Maintenance of drainage records.
2. Determination of the rate at which water is lost by soils.
3. Ascertaining the water requirements of plants.
4. Investigation of the work on the availability of plant food in soils.
5. Investigation of the nature of the dark colour of black cotton soil.

The investigation of nitrification in Indian soils will be taken up if possible.
The effect of soil or manure on the composition of certain seeds is an investigation which has been in progress tentatively and will be extended if considered desirable.

The prevention of weevil attacks on wheat is an investigation which is being conducted in collaboration with the Imperial Entomologist.

Instruction will be given to students on the lines indicated in the Pusa syllabus.
Training.—Students from the agricultural departments of the Punjab, Baroda, Bombay and Eastern Bengal and Assam were fully trained during 1907-09. As this is the first year, the full course of training was given under proper conditions. A considerable proportion of time was given to it, and the lecturing from October 1908 to April 1909 done by the Imperial Entomologist. The organisation and carrying out of this course has been the most important work of the last two years, and it is to be regretted that so few students took advantage of it. A short training, as part of the course in general agriculture, was given to two students from the Punjab and to a fieldman of the Fibre Expert, Eastern Bengal and Assam. Students from the United Provinces, Madras and Bengal arrived in June 1909.

2. Establishment.—The assistant for sericulture, Mr. L. M. Dass, was recently appointed; there have been no important changes. The First Assistant, Mr. C. S. Misra, has had direct charge of students, of the field work on the Pusa farm and the work with lac. Apart from the courses of lecturing given personally by the Imperial Entomologist, Mr. Misra has had charge of the practical and field work of students, which he has done in an admirable manner. He also visited Sind in reference to the boll-worm on cotton. The Second Assistant, Mr. C. C. Ghosh, has had charge of the insectary and has had very heavy additional work in connection with *eri*-silk, of which he will now be relieved. His work has been of great value. The Third Assistant, Mr. G. R. Dutt, has been in charge of economic records and collections, and has done
original work on aculeate hymenoptera. The assistant in charge of the collections, Mr. D. Nowrojee, has done excellent work with the arrangement and upkeep of the general insect collections which are now permanently stored in a proper manner. The Bengal assistant worked in the laboratory, as there is no proper accommodation for him as yet at Sabour, and with the Second Assistant, Mr. C. C. Ghosh, prepared the revision in Bengali of *Indian Insect Pests*, in addition to his ordinary work. The staff of the Second Imperial Entomologist worked under the guidance of the Imperial Entomologist until the arrival of this officer, and the artist's staff of the Institute also worked under him till March 1908.

3. **Buildings.**—The section moved into the permanent laboratory during May 1908. The section is now established in permanent quarters in the laboratory; the insectary, silkworm house and a godown are also being occupied.

4. **Provincial Work.**—The number of assistants employed in entomological work in the provincial agricultural departments is now 13, for teaching, demonstrating and field work. This number is inadequate to bring the practical work of entomology effectively before the agricultural classes, but a beginning is being made with practical teaching of entomology at the provincial agricultural colleges and also with demonstrations at shows. In March last, a meeting of the assistants was held at Pusa to discuss progress, to demonstrate improvements, to show the work in silk and lac, to teach how to put up show-cases for exhibitions and to arrange how best effective assistance could be given from Pusa, especially with regard to shows and demonstrations. The work of provincial assistants is under general direction from Pusa, in the sense that their monthly reports and programmes are sent here for criticism; assistance is given in preparing their programmes in all technical matters such as identifications, supply of apparatus, books, etc., and in the teaching given
at the college. There is no uniform system for all provinces, and the relations are closer in some cases than others, but all assistants can obtain the effective assistance of this section, where it can be given. Progress has been made in the general study of injurious insects in the provinces, notably in Madras, where a careful study has been made of the surul pest of groundnut, of paddy stem-borers and of the general pests of the province. In Bombay, an enquiry was made into the occurrence of the potato moth. In the Central Provinces, Bengal, Eastern Bengal and Assam and the Punjab, the general investigation of injurious insects has been continued, and in the last named province the progress of cotton boll-worm and its parasites has been closely watched. A general strengthening of the staff is required in most provinces.

5. Correspondence.—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries directly connected with insects injurious to crops, have been in part diverted to provincial departments, but a large mass of miscellaneous enquiries has been received and dealt with. Excluding correspondence with provincial agricultural departments, these are received from commercial firms, planters and planters' associations, zemindars, fruit-growers, superintendents of experimental farms and botanical gardens; specimens sent for report by the members of the Bombay Natural History Society, are, in some cases, forwarded and dealt with here, and there is a certain number of enquiries from persons interested in entomology for the identification of specimens. The increasing interest in silk, lac and bee-keeping also produced a large number of enquiries. Over one thousand of such enquiries were dealt with by the Imperial Entomologist personally during the last two years, and this work is, by no means, the least useful part of this section's activities.

6. Research.—Progress is steadily made with enquiry into the life-histories and habits of injurious insects. The
more important have been the cotton boll-worm, the potato moth, two cockchafer beetles, the mango leaf hopper, the mohwa beetle, the singhara beetle, the bristle beetle, the surface grass-hoppers, the big cricket, the rice and cane hispas, the sweet potato weevil, the til hawk moth, the Behar hairy caterpillar, the tur pod bug, the cane leaf hopper, the armyworm of rice, the rice stem-borer, the melon weevil, the rice and cane mealy bugs, the rice leaf hopper and the pests of castor, rice and indigo. The influence of climatic changes upon insect life and the problem of utilizing beneficial insects, have also been investigated. The search for an insecticide less poisonous than arsenic was continued and brought to a conclusion, the field trials showing that the new insecticide is extremely effective. An enquiry into the best method of checking thrips on tea in Darjeeling was taken up by arrangement with the Scientific Officer of the Indian Tea Association and spraying trials made; the method tried was found satisfactory and is in use at present. In connection with potato moth, the trial of methods of seed potato storage was made, and this work is being carried on in collaboration with the Central Provinces Agricultural Department. Trials are being made in the Central Provinces and also in Bengal. The relation of the wheat weevil to the percentage humidity of wheat is being investigated in collaboration with the Imperial Agricultural Chemist, for the Department of Commerce and Industry. Cantharides or blister beetles are a pest in India, and an endeavour is being made to ascertain if they are of commercial value, so that those who suffer from them, may derive profit from collecting them. The enquiry into the food of birds was continued by Mr. Mason, as also investigation of methods of fumigating plants, grain, etc. The question of taking steps to check the promiscuous introduction of noxious insects from other countries, was under consideration, and recommendations were made for dealing with plant imports. Mr. Mason visited the centres at which the army stores are baled and stored to investigate the occurrence in clothing, etc., of the
destructive insect *Anthrenus vorax*; this enquiry was completed and recommendations made for better baling. The question of apiculture was taken up to determine how far bees will thrive in the plains, and whether apiculture can be carried on sufficiently well here to enable it to be a subject for demonstration and teaching; this work is in progress.

7. *Sericulture.*—The cultivation of *eri*-silk was continued, and the process of spinning, dyeing and weaving taken up. This is carried on as a demonstration to students of the value of this silk as a home industry in India, and to enable any one who wishes to start it, to be taught the work practically. A practical spinning machine of a simple kind was devised by Mr. Ghosh which is now in use; it is being improved, and its value is being thoroughly tested. During the meeting of the assistants in March last, the work was taught to them, so that, they could, if opportunity arose, give advice. The Superintendent of Sericulture of the Baroda Government also came, as this silk has been introduced in Gujarat. The publication of an article in the *Agricultural Journal of India*, the exhibition at the Muzafferpur show and the work of the Baroda Agricultural Department, have drawn attention to the possibilities of this silk; it is being taken up in Tirhooit, Gujarat and elsewhere, and enquiries about it have been received from every province; eggs have been supplied free, or at a small price, to all who have asked for them, and the work has been shown to many enquirers. It is probable that this silk will be taken up in many parts of India, and that an industry will spring up, similar to that existing in Assam, which will give light remunerative work to women and children. Arrangements were made to supply cocoons for spinning as a famine relief work for *purdah* women in one district, and the work is being organised in some Tirhooit indigo concerns. It may be noted that the staff for this work consists of one assistant newly appointed, a fieldman and the coolies actually doing the work in
the silkworm house; to properly develop this industry would require a staff available for temporary service in tracts where conditions are favourable; the only men available for demonstrating in outside places are trained coolies, and there is room here for an increase of staff; so far as possible, requests for assistance are met from the available staff. As the purely experimental work on eri-silk is almost completed, the cultivation of mulberry silk has been taken up; the main object is to determine how far it is possible to grow mulberry silk profitably, to supply the raw material which is imported at present and to supplement the supply of raw silk produced at present in Lower Bengal, to see whether improvements can be effected and to provide instruction in rearing and reeling if the prospects are favourable.

The question of tussar silk is also being investigated, because in this, as in other silks, advice is asked on points which can be determined only by entomological, as apart from purely sericultural, enquiry.

8. Lac.—The cultivation of lac insect on ber (Zizyphus jujuba) has been continued, and progress made in extending the cultivation in Tirhoot. Seed has been supplied, and men trained for twelve indigo concerns in Tirhoot, and advice given about the cultivation of lac to many enquirer. Lac inoculation was done for the Public Works Department of Bengal in connection with canals, and assistance given to the Bikanir State in regard to the possibilities of lac culture there. The cultivation of lac as an adjunct to ordinary cultivation has been explained in an article for the Agricultural Journal of India, volume IV, part 3, and it is solely from that aspect that it is being done. The work of assisting the cultivation of lac will probably expand. Training in lac cultivation is given at Pusa at the present time, and advice given to enquirers.

9. Insect Survey.—The general collection of insects of India, apart from the purely economic one, has been transferred to its permanent quarters and is completely
arranged and catalogued. Mr. C. W. Mason has arranged the Lepidoptera, the Assistant to the Second Imperial Entomologist the Coleoptera. A large part has been sent to England for the use of authors of prospective volumes of the fauna of India; the Orthoptera, Neuroptera, Braconidae and Ichneumonidae, Cetonidae Chrysomelidae, Curculionidae, Microlepidoptera and Rhynchota Homoptera are the larger collections being worked at in this way. A large part has been returned, and the whole collection is yearly becoming more complete and useful. The greatest help was given by the late Colonel Bingham, and by his death we have lost an able collaborator who gave invaluable assistance to all who are interested in Indian entomology. We have now a good reference collection as well as a separate collection for students, of the insects of Pusa, both of which are necessities in daily work. In conjunction with the Indian Museum, the results of the past work are being worked up and utilised in determining the zones of insect life in India. Specimens were exchanged with the Indian Museum; a collection of Coleoptera was identified for the Bombay Natural History Society and completed from our duplicates. Similar collections were identified and made up for provincial agricultural colleges, and their collections are sent here for identification and arrangement. A good collection is the basis of accurate work and teaching, so that this work is of importance and can be done from Pusa only. The formation of the collection will be continued, but less time will be devoted to it.

10. Demonstration.—A series of excellent coloured plates with short printed explanations, has been issued, which are used for teaching in colleges, are exhibited at demonstration farms and are made up into show-cases for exhibitions and shows. This series will be continued and is being expanded also to cover silk, lac, bees and beneficial insects. As the work of the provincial departments expands, this work will also expand; and, since only simple methods of checking pests can be used, the teaching of the people and the demonstration of simple facts and remedies
will become an important part of the work. In all provinces, teaching at colleges, enquiry into local pests and demonstrations both of facts about insect life and remedies for pests, are now going on.

In February last an exhibit of injurious insects, lae and eri-silk was sent to the Muzafferpur agri-horticultural show. Increasing attention is being paid to this in provincial departments and the best methods of preparing such exhibits are being tested here; a complete exhibit in show-cases has been prepared as a model, and it is proposed to send exhibits to shows or to assist in this work to gain experience as to the class of exhibits that most appeal to the public. Show-cases of injurious insects, silk, lae, etc., with specimens, plates and explanations in the necessary languages, have been prepared for some provinces and will be prepared by the entomological assistants in others; and, as an aid to these, series of lantern slides in colour are being prepared in order that lantern lectures may be given at such shows. This work will be an additional tax on the time both of this section and of the provincial assistants, but it falls chiefly at one season and is an extremely important work.

11. Publications.—The marked influence of Indian Insect Pests is noticeable, and its publication in 1906 has been abundantly justified. A simplified revision in Bengali has been prepared and proposals submitted for its publication. Other vernacular revisions will follow as provincial work expands sufficiently to make them possible.

A text book on "Indian Insect Life" has been issued in July last. The issue of this volume of over 800 pages with over 500 half-tone illustrations and 85 coloured plates has entailed very heavy work which has fallen entirely upon the Imperial Entomologist. The publication of the volume completes the preparations for proper teaching and marks the close of the period of preparation of the past six years. The series of memoirs on injurious insects were continued, and popular articles on those of great importance
written for the *Agricultural Journal of India*. The influence of the latter is shown by the immediate increase in correspondence from the public in India after the publication of an article on a particular subject.

12. *Conclusion.*—As this is the only entomological centre in India, the section is so fully occupied in the immediately practical work of answering enquiries, assisting provincial departments, facilitating the teaching of agricultural entomology and assisting in the establishment of insect industries, that there is no time to apply research to subjects not of immediate necessity and this must be so until the staffs of the provincial departments expand. Research, as ordinarily understood, is done here only so far as will enable a practical answer to be given in each definite practical case. The progress that has been made in all branches of the subject and its great practical importance justify an expansion of the staff both at Pusa and in the provinces. To practically apply the results gained and to continue the progress which has been made possible from the research and enquiry of the past, require a constant expansion especially in provincial departments setting Pusa free to continue the work of enquiry.

13. *Programme for 1909-10.*—The work of the past in studying and advising on crop pests will be continued. Assistance will be given, when desired, in directing the work of provincial assistants, in coping with outbreaks of crop pests and in organising exhibitions for agricultural and other shows. The issue of coloured plates will be continued. Enquiries in progress on potato moth, fumigation of plant imports and grain and on wheat weevil will be continued. Advanced teaching in entomology will be continued. The question of publishing vernacular translations of the revised text of *Indian Insect Pests* will be considered. The possibilities of apiculture in the plains will be tested at Pusa. A short practical course of instruction in *eri*-silk and in lac culture will be given if required. Mulberry silk culture will be continued with a view to
offering instruction in rearing and simple methods of reeling. If possible, the question of producing better races will be taken up experimentally, but this may not be possible if the practical courses of teaching occupy much time.
REPORT OF THE SECOND IMPERIAL ENTOMOLOGIST FOR THE YEARS 1907-09.

(F. M. Howlett, B.A., F.E.S.)

1. Charge and Establishment.—Mr. Howlett arrived at Pusa in December 1907 and has been in charge of the section since. The staff consists of Mr. D. Nowrojee, First Assistant, with Messrs. P. G. Patel and H. N. Sharma, special Fly Assistants. Of these, Mr. Nowrojee carries on his previous work on Coleoptera, and Mr. Muhabat Singh has been detailed in his stead for work on the flies affecting crops and fruit. Mr. P. G. Patel has made a number of original observations on ticks, sand flies and muscidæ, and has had charge of the general collection; Mr. H. N. Sharma has been occupied with the life-histories of mosquitoes and investigation of their natural enemies. All have done good work in their particular branches.

2. Training.—Since diptera constitute a special group of insects requiring special methods and careful manipulation, a considerable amount of attention has been given to the instruction of the staff in these methods. Mr. P. G. Patel was sent to Belgachia, at the request of the Civil Veterinary Department, Bengal, to give a course of instruction relating to biting flies injurious to cattle. Messrs. P. N. Das and Syed Mohamed Raza Husain, of the civil veterinary departments of Bengal and the United Provinces, respectively, came to Pusa for a course of training in methods of observing and collecting pests and parasites of cattle and other stock. As a part of the course given to agricultural students in entomology, lectures were given on diptera and on blood-sucking insects, special attention being paid to fruit flies and cattle parasites. A short series of lectures on more purely economic lines was given to the provincial entomological assistants.
on the occasion of their last visit to Pusa. Mr. Chimaswami Pillai, sent by the Madras Government for instruction in methods of illustrating, finished his course and returned to Madras.

3. Work on Publications.—That portion of the book, "Indian Insect Life," which relates to diptera and the sections on mallophaga, anoplura and cimicidae, was completed, and the necessary illustrations prepared by the Second Imperial Entomologist or under his supervision, as were also a large number of the illustrations for the body of the work and other illustrations and maps required for memoirs and for the Agricultural Journal of India.

The business of seeing the Agricultural Journal of India through the press, and all work connected with the reproduction, etc., of the illustrations in zinco, half-tone, lithography and the three colour process, was also undertaken.

In February last the Second Imperial Entomologist acted as Secretary to the Board of Agriculture at the Nagpur meeting and prepared for publication the proceedings of the meeting.

The supervision and direction of the artists' staff of the Institute have been undertaken, and besides the work done for the various sections at Pusa, assistance has been given to the civil veterinary departments and to the Bombay Natural History Society in preparation of special illustrations of blood-sucking flies and of living snakes.

4. Entomological Work.—Work was done on the rice, tur pod and pea-stem flies. The first named was found to be doing serious damage to wheat (planted after rice) in Sibi, Baluchistan, and Mr. Muhabat Singh was sent to investigate and report on the outbreak. Work was done in fruit flies, and an attempt to check the annual attack of these pests on the peaches grown at Pusa, was this year so far successful that the period of severity was postponed until the Imperial Economic Botanist was enabled to complete the experiments in progress. It is unlikely that
any method short of netting, will have any radical effect on the flies under the conditions at Pusa. Methods for destroying the mango fly (the most destructive species in Behar) have been tested with success. Mr. Froggatt, Entomologist to the Government of New South Wales, visited Pusa in June 1908 for the purpose of obtaining information on the subject of fruit flies, as the Australian fruit flies are related to those found in India and constitute a very serious obstacle to the successful cultivation of fruit there. Since his return he has been supplied with fruit flies specimens for the purpose of assisting his investigation on the Australian species. Arrangements have been made with Professor Silvestri to supply parasites of some of the south Indian species in the hope that they may be utilised against the olive fruit fly, a species which inflicts great damage in Italy.

Among blood-sucking flies attention has been directed chiefly to the life-histories of sand flies, tabanidæ and muscidæ, and the Pusa species are now fairly well-known. A number of specimens have been received from various parts of India, from the officers of the civil veterinary departments and from medical men. A report on 800 specimens received from Bengal was communicated to Mr. D. Quinlan, Superintendent, Civil Veterinary Department, Bengal, and data as to the distribution of the various species are thus being obtained.

A number of specimens have been identified for medical men and for private individuals, and various enquiries regarding blood-suckers, parasites, infective and predaceous insects, have been received and answered. A report on the value of certain insecticides advertised as being efficacious against various parasites, has been supplied to the Inspector-General of Agriculture in India. Arrangements are in progress for supplying Indian blood-suckers to the Sleeping Sickness Commission in Uganda for the purpose of testing the possibility of sleeping sickness being transmitted by any Indian species as well as by the tsetse fly.
The life-histories of nearly all the mosquitos which occur in Pusa have now been ascertained, and a special study has been made to discover any efficient natural checks on their increase. Two species of fish have been found to be capable of destroying large numbers of anopheles larvae, while a small water insect seems not unlikely to prove a useful check on culex; experiments on a large scale have not yet been tried.

Observations on the life-history and habits of ticks have been made, and experiments on the best means of destroying them.

Some attempts have been made to discover the effect of various physical conditions on mosquitos and other blood-sucking insects, but, though some minor results of interest have been obtained, this very important line of research demands more time than the Second Imperial Entomologist has been able to give.

A considerable number of specimens have been lent to the Indian Museum in order to assist in the revision of the nomenclature of various groups of Indian diptera, and a large representative collection of tabanidæ has been lent to the British Museum to assist in like manner the revision of the family now in progress.

In January last a number of specimens, drawings and photographs of various blood-sucking species, were contributed to an exhibition of disease-carrying insects organised by Dr. Annandale at the Indian Museum.

In February last an exhibition of all kinds of blood-sucking and parasitic insects was arranged for the pathological section of the Bombay Medical Congress; a few slides and specimens were lent for incorporation with other exhibits; a simplified key to the different kinds of blood-sucking insects, was written for the use of visitors to the exhibition; a paper on the habit of sand flies was read before the pathological section; and a public lecture on blood-sucking insects delivered. The Second Imperial Entomologist derived much pleasure and benefit from the
opportunity of meeting and conversing with medical men from all parts of India.

5. **Correspondence.**—A considerable amount of correspondence has been involved in the investigation on biting flies. Sets of apparatus and copies of the bulletin on biting flies have been issued to the Directors of Agriculture, Punjab and Bengal, the Assistant to the Chief Commissioner, Baluchistan, the Assistant Political Agent, Khelat, the Honourable the Agent to the Governor-General, Quetta, His Britannic Majesty's Consul, Seistan, the Honourable the Secretary, Baluchistan Natural History Society, the superintendents, civil veterinary departments, Bengal and Eastern Bengal and Assam, the officer investigating camel diseases, the officers of the Indian Medical Service and Royal Army Medical Corps, and private individuals in all parts of India, and it is anticipated that the material thus obtained will greatly assist the enquiry.

Correspondence on matters connected with the working out and identification of the collections, has been carried on with experts in Europe and America and on various scientific subjects with the bacteriological laboratory at Parel, the Indian Museum, the Bombay Natural History Society, etc., and with various private individuals.

6. **Conclusion.**—The necessity of devoting a considerable amount of time to the illustrating and publication work of the Institute naturally restricts, to some degree, the work connected with pure entomology. During the past year the illustrating work had at times been particularly heavy. A further restriction is due to the fact that no laboratory accommodation was originally provided for this section, with the result that all work has to be carried on in a single room which perforce serves the purposes of office, laboratory, store-room, collecting room and insectary. The very important work on life-histories of insects in particular has suffered for lack of a suitable place for carrying on breeding operations, and there is no accommodation whatever for students.
The number of enquiries received is considerable and is expanding, but without further accommodation it will be impossible to cope with the expansion.

7. Programme for 1909-10.—Work on blood-sucking insects and parasites injurious to cattle and poultry will continue, and arrangements have been made for an investigation, in collaboration with Mr. Leese, Veterinary Officer investigating camel diseases, Lahore, on insects capable of transmitting surra.

Trials will be made of the relative value as checks of the various natural enemies of mosquitos discovered at Pusa, and to ascertain whether the introduction of Indian fish is likely to prove of practical value in eradicating anopheles in places where other measures are impracticable or difficult.

A short course of lectures on pests of live-stock and poultry for agricultural students, is being drawn up in collaboration with the Imperial Agriculturist, and all necessary assistance will be given in carrying out the ordinary course for students at Pusa.

Attention will chiefly be directed to the dipterous pests of crops and fruit and to the study of the tachinid parasites of insects found at Pusa. The collection of diptera will be as far as possible worked out from the systematic point of view.

The publication work and the control and supervision of the artist's staff will continue as hitherto, unless other arrangements are made for the allotment of the duties in connection with this branch.
1. Charge and Establishment.—The Imperial Mycologist held charge of his section till the 31st March 1909, when he proceeded on combined leave, and Mr. W. McRae, who had joined his appointment as Supernumerary Mycologist in March 1908, after a period of six months on deputation in the laboratory of Professor von Tubeuf at Munich, was appointed to officiate in his absence. The first assistant, Mr. S. K. Basu, resigned his appointment with effect from 16th December 1908. The post is not yet filled up. The appointment on probation of Mr. T. S. Lakshman Rao as assistant to the Supernumerary Mycologist, terminated on 31st March 1909, when Mr. A. Hafiz Khan, second fieldman, was promoted to the post. L. S. Subramanium, clerk on probation, was appointed third fieldman.

2. Laboratory.—The section moved into the new laboratories of the Phipps’ Institute in June 1908. In the temporary quarters previously occupied, the work was much interfered with by dirt and insects, and the move has given much needed relief from these. When some minor improvements are carried out, the section will be well-housed in its new quarters.

3. Training.—A mycological assistant for the United Provinces was under training until September 1907. Another for Bombay joined in June 1908, and the Assistant Professor of Botany, Poona Agricultural College, received a short course in April and May 1908. A mycological assistant for Madras joined in November 1908, and the Mycological Collector for Eastern Bengal and Assam joined in September 1908. A student from the Central Provinces received a course in cryptogamic
botany from July to September of last year, and again in plant anatomy from November to February. Two students from the Punjab undergoing a general course in agriculture, joined on the 1st June, 1909. The Assistant Mycologist, Bengal, who returned to Pusa in March, 1908, has remained in this laboratory pending the provision of accommodation for him at Bhagalpore. The prospects of assistants in the agricultural departments appear to have been hitherto insufficient to attract good men.

4. Organisation.—Much time has still to be given to organising the work particularly to meet the requirements of provincial departments. Collections have to be accumulated and worked out with what voluntary assistance can be got outside India. Duplicate collections will be, as far as possible, supplied to provincial departments which already have mycological assistants. Annotated specimens of Mildews and of Ascomycetes have been sent to Mr. Salmon of Wye College and to Messrs. H. and P. Sydow of Berlin, respectively, to be worked out for extension of the general survey of Indian parasitic fungi. Collections of diseased plants received from the Central Provinces, Bengal, Bombay, Burma and Madras, have been worked out and returned, and these will be gradually extended, as further material becomes available.

In the provinces, the question of the best means of expanding mycological work was considered by the Board of Agriculture which sat at Pusa in February, 1908. A small special staff of Indian assistants to be formed in each provincial department was recommended, their duties being defined as assisting the research work of the Pusa staff and conducting the training at the colleges. The ordinary staff of agricultural assistants should undertake such practical field work in preventing diseases as is necessary. In each province there will probably be appointed one assistant professor of mycology at the college and one assistant for work outside the central station. This will form a beginning which can be extended ultimately.
Arrangements have been made for unifying the proposed mycological course in the provincial colleges, and a memorandum on a course of lectures and practical work together with the most important diseases, has been compiled as a basis for this unification of mycological teaching.

5. Research Work.—A small number of diseases have been selected for detailed study which, in some cases, has continued over several years. The life-history and general biology of the parasites have been studied, and information obtained of their effects on the attacked plants. The following are the chief diseases specially investigated:

6. Sugarcane Diseases.—Red rot is the chief of these. The work of the period under report has been directed to elucidating the methods of infection. It has given some new results, and it is hoped to publish a further contribution to the study of this disease during the year. In the Samalkota farm red rot is now quite rare in the crop, and this may be considered due to the methods of set selection advocated by this section. Work is in progress on the life-history of two other sugarcane parasites, but so far has not reached the publication stage. A few inoculations to ascertain the mode of infection of smut proved successful and these experiments are being continued this season.

7. Palm Diseases.—The campaign against the palm disease of the Godaveri delta is still being prosecuted, and the entertainment of the special staff employed has been recommended for a third year. The Imperial Mycologist inspected the work in September and December 1907 and in January 1909. There has been no general recrudescence of the disease in the early months of this year, such as occurred last year, and the Imperial Mycologist was struck by the very small number of newly diseased trees seen in his tour in January last. Under the new system inaugurated in October 1908, it is hoped that cutting work will go on continuously and simultaneously over the whole of
the affected area. Successful inoculations with the parasite have been secured, and a further study of its life-history made.

A serious disease of coconut palms was reported from Travancore early in 1907, and the Imperial Mycologist visited the State in September and October of that year to investigate its cause. A report on the disease has since been published.

8. Diseases of Citrus Fruits.—The chief of these investigated were "white rust" which has appeared at Poona, and a disease which is ravaging the valuable orange orchards of Sylhet and Lower Burma. The former is identical with a disease which has recently appeared in Southern Europe. Suggestions for experimental treatment have been made. The other disease does not appear to have been previously recorded. The Imperial Mycologist visited Burma in January 1908 to investigate it, and experiments are in progress to ascertain its cause. It appears certain that it can be avoided by grafting on stalks of other citrus plants.

9. Wilt Diseases.—These diseases have engaged more attention during the period under report than any others. Out of the considerable number, all similar in their course, which affect economic plants in India, those of cotton, indigo, pigeon-pea and gram were selected for study. In all, the fungus to which the cotton wilt of the United States is attributed was present, and the assumption was that this fungus, which is said to be a virulent parasite in America, was the responsible agent in each case. Detailed experimental work has, however, thrown the gravest doubt on the parasitism of this species, and another organism was isolated from pigeon-pea which has been shown to be the cause of the disease in this crop. This organism has been called Fusarium udum, Butler. A memoir on the work is now in the press. The cause of the gram wilt disease has also been definitely determined, and successful infections obtained. The investigation has been lengthy and troublesome, but the diseases
referred to are amongst the most destructive in India and will well repay study. The experiments at Poona farm to raise a resistant strain of pigeon-pea, have been in progress four years and are promising well.

10. *Mulberry Disease of Kashmir.*—In a visit to Kashmir during the months of July, August and September, 1908, the Imperial Mycologist enquired into the diseases of mulberry and also those of apple, pear, peach, quince, cherry, apricot and grapevine. The results of part of this work have been published, and recommendations made for dealing with mulberry diseases. The study of the other diseases is in progress. A large collection of fungi was also made for the herbarium and these are being gradually worked out in the laboratory.

11. *Ginger Disease.*—This disease causing considerable damage in Eastern Bengal was investigated, and the probable cause of the disease determined. Experiments are still being carried out with the disease.

12. *Other Diseases of Plants.*—A new anthracnose of *val* (*Dolichos lablab*), some species of the rare genus, Choanephora, and the two maize smuts of India, have been studied, and a successful attempt has been made to work out the life-history of the very obscure paddy smut. As usual a large number of other diseases of crops were examined, and this work has formed a large portion of the routine work of the staff.

13. *Silkworm Disease.*—At the instance of the Imperial Entomologist an attempt was made to ascertain the cause of the heavy mortality amongst *erí*-silkworms during the hot weather of 1908 at Pusa. The mortality appears to be due to a specific disease allied to, but not identical with, that known as “flacherie” in ordinary silkworm.

14. *Programme for 1909-10.*—It is proposed to continue the work with sugarcane diseases and to publish a further contribution to our knowledge of red rot. If sanctioned by the Government of Madras, the palm disease campaign in the Godaveri delta will be continued. An account of
the parasite and a review of the work undertaken to prevent its spread will be published shortly.

It is hoped to complete during the year an illustrated account of the chief diseases of citrus fruit trees in India with suggestions for treatment.

It is proposed to continue the work on the wilt disease of leguminous crops, specially cow-pea, to determine the exact cause of the disease in each case.

The collection and identification of parasitic fungi will be continued. It is hoped to secure the publication of a complete list of the species of Ascomycetes in the Pusa herbarium.

It is hoped to complete the text of the book on Indian plant diseases during the year.

Students will be received for training, the regular course of instruction commencing on June 1st.
REPORT OF THE IMPERIAL COTTON SPECIALIST FOR THE YEARS 1907-09.

(G. A. Gammie, F.L.S.)

1. Charge.—Mr. Gammie joined the Imperial Department of Agriculture as Imperial Cotton Specialist on the 14th December, 1907, and has continued in charge of his office since. Until 10th October, 1908, when he was relieved by Mr. W. Burns, he held charge of the office of Economic Botanist, Bombay, in addition to his own duties, and from 6th August to 30th September, 1908, he held charge of the office of the Principal, College of Agriculture, Poona, owing to the illness of the Principal and the Professor of Agriculture.

2. Tours.—During the cold weather of 1907-08, the Imperial Cotton Specialist examined the cottons on all the farms of the Bombay Presidency and gave advice. In March 1908, he visited some farms in the Madras Presidency and discussed the experiments in progress with the Deputy Director of the northern division. During April and May an extensive enquiry was made regarding the varieties of cotton and the conditions under which the cotton crop is grown in Gujarat and Kathiawar. In Surat and Broach districts the quality of the cotton is best in the south and gradually gets worse as one proceeds northwards. Navasari has the finest and longest staple, then comes Surat and then Broach. This may be due to the heavier rainfall and greater atmospheric humidity at Navasari (owing to its proximity to the sea), for there is little apparent difference in the soil. Cultivators of the neighbouring districts have used Navasari seed, but, although the produce was ginned and despatched to Bombay separatedly, it failed to realise the same price as that obtained for cotton grown at Navasari. This may, however, have been due in part to the marks on the bales.
showing that the cotton came from Broach and Surat. The two cotton varieties *Broach deshi* and *ghoghari* grown in the latter two districts are quite suitable to the tract, but it is absolutely necessary for the cultivators to maintain the purity of the seed. The growing practice of separating seed from the fibre in ginning factories, instead of as formerly by hand gins, has tended to injure the quality by mixing the seed. The average farmer gets his seed haphazard from the general supply at the ginning factory, good, bad, early, late, medium, tall, bushy and ordinary varieties all mixed. There can be no improvement, unless the seed is at least equal to the average of the previous crop. The improvement by selection of seed continued from year to year, is most important. If careful selection of seed is practised, and if the cultivator takes the trouble to handgin his seed at home, there is hope that the lint will be improved in quality and that the outturn per acre will also increase. In selecting the seed, cotton should be picked from the best sound bolls of large, healthy plants of branching habit of growth, each plant having a large number of bolls. Of the two varieties now growing in these districts the *Broach deshi* variety is the *standard*, and at present its price in the Bombay market rules that of all other cottons of India.

Kathiawar accounts for more than one-third of the total area under cotton in the Bombay Presidency (excluding Sind). Formerly *wagad* and *lalio*, two varieties of nearly the same quality as *Broach* (though picked less carefully, and, on that account, fetching a lower price), were the only ones found in Kathiawar, but on account of the succession of years of irregular rainfall, beginning with the famine year of 1900, they have been largely replaced by two inferior coarse varieties *mathio* and *navesari* (not Navasari) from Central India which give good yields, mature early and can be grown without much risk in years of scanty rainfall.

During the month of October, 1908, the Cotton Specialist visited the Punjab, Sind, Rajputana, Central
India and Gujarat. Throughout the four first named, the prevailing cottons are of *neglectum* type mixed with a plant resembling *bani*. If these two cross freely very close observation would be needed to establish the fact; that they remain, on the whole, true to type is easily demonstrated. The produce of these plants is probably the most inferior cotton in India which, however, fetches a price in advance of its intrinsic merits on account of its white colour and suitability for adulteration with wool. Throughout the area is found intermixed a superior style of cotton which has been already distinguished by the Cotton Specialist as *malvensis*. Officers of the provincial departments who are serving in coarse cotton tracts are already testing the feasibility of establishing this as a pure race, and Mr. Clouston of the Central Provinces is sanguine of ultimate success.

In the Punjab alone there is an annual variety of *arboreum* which the Cotton Specialist has already named *sanguineum*. It occurs chiefly as a mixture in the fields, and from a trade point of view there is no particular reason why it should be isolated, as its cotton is in no way different from that of the more common varieties. At the Lyallpur farm the Economic Botanist was engaged in studying a set of Punjab cottons, so that he could draw out a scheme for future work in selection. The experiments with upland Georgian and Egyptian cottons were of prime importance. The former is not of the New Orleans type, naturalised in the southern parts of Bombay and Madras, and which is intolerant of cold, but the true Upland which requires a distinct autumn for its development. Sales of this cotton have proved that a good price can be readily obtained for it, and since the officers of the Punjab Department have found in this a product far in advance of anything they can hope to attain from the selection of their indigenous varieties, it was gratifying to see that they were attending specially to the establishment of first class varieties of upland Georgian. They ought in this connection to carefully study the methods
employed in the United States. Of the chance of success for Egyptian cotton in the Punjab there is more doubt. The Bombay merchants consider that the Egyptian cotton grown in Sind is distinctly inferior to that directly imported from Egypt, and that from the Punjab would probably be no better.

In Sind the Cotton Specialist discussed the subject of cotton cultivation with Mr. Henderson, Deputy Director of Agriculture. The latter is of opinion that the very sanguine estimates formed on the results of trial sowings of Egyptian cotton, must be considerably modified in the light of recent results. He states that no further extension of the area suitable for growing Egyptian cotton can be counted on outside the Jamrao canal district until a further system of perennial canals is constructed, and that on the Jamrao canal a maximum of not more than 10,000—20,000 acres could be sown under favourable circumstances. Further, owing to scarcity of labour, occasional scarcity of water and the often alkali condition of the soil, the Jamrao cultivators prefer a surer, if less profitable, return in the cultivation of millets and short stapled indigenous cotton to giving the requisite care to the cultivation of Egyptian cotton. Despite the unsatisfactory results hitherto obtained, Mr. Henderson believes that good results can be got with Egyptian cotton when Egyptian methods of cultivation are closely followed. He lays special stress on very careful cultivation and rotation of the cotton crop with berseem (Trifolium alexandrium).

The American cottons, Texas Big Boll and Boyd's Prolific and also the acclimatised Dharwar-American, have been tested during the last year in Sind and have given promising results. They have a shorter growing period than Egyptian cotton, enabling them to be sown on inundation canals.

At the sewage farm in Karachi Spence cotton, Egyptian cotton and Sea Island cotton were tried with disappointing results. This was to be expected, as cotton is in no way a suitable crop for a sewage farm.
The Central Indian cottons consist only of bani, jari and varadi, with the usual preponderance of inferior types, and the remarks made on the Central Provinces cottons below will also apply to these.

In November, 1908, the Cotton Specialist visited Bassein in the Konkan to study the results of Bourbon cotton cultivation there, and then proceeded to Pusa to discuss various subjects with the Inspector-General of Agriculture in India and other officers of the Imperial Department. Afterwards a visit was paid to Bhagalpur, and cotton matters were discussed there with Mr. Woodhouse, Bengal Economic Botanist. Cotton is not, of course, an important crop in this Presidency, but the attention of the officers of the department might be drawn to the fact that Gossypium intermedium (according to the classification of the Cotton Specialist) is perhaps common as a garden crop in some parts. At least three separate plots were seen between Muzafferpur and Pusa, adjoining the railway. Sir George Watt, in his recent great work, states that the famous Dacca muslins were manufactured from one of the coarsest cottons in India, and he reproduces Roxburgh's coloured figure to support his point. From internal evidence it may be gathered that Sir George Watt was ignorant of the existence of Gossypium intermedium, because the picture he gives shows clearly a distinct form of this race. Some varieties in favoured localities may produce fine staple which is far more likely to be used in the manufacture of a superfine cloth than one which closely approaches the coarse Bengal or Assam type. There is no record of Gossypium intermedium being found anywhere in Eastern Bengal, but local officers may not have suspected its existence as a garden crop grown in villages near houses and not in the fields. The real source of the Dacca muslin cotton is a matter sufficiently important for close investigation.

The cultivation of burhi cotton in Chota Nagpur is probably capable of extension. Hand gins have been supplied by the Deputy Director of Agriculture, Bengal,
for the use of villagers. The cultivation of the cotton crop generally in Chota Nagpur is on the decline, owing to the restriction of the *daha* system of cultivation. This system consists in burning thick layers of jungle on the land selected for the cotton crop. The land is thus fertilised with the ashes, and weeds are killed. If there is not enough jungle on the selected site, jungle including often valuable trees, is cut down at some distance and carried there. The system is a wasteful one, and its restriction cannot, therefore, be deprecated. Tree cottons are grown in the district to a limited extent. The plants give a fair return for three or four years after which their yields diminish.

During the same month a visit was paid to the Central Provinces and Berar Exhibition, and full advantage taken of such a favourable opportunity of studying samples of cottons from all parts of the province. Side by side with the experiments which are being conducted for the improvement of the local *jari* and *varadi* by the selecting out of a superior race known as *malvensis*, work of great importance has been done in the introduction of *burhi* cotton. The staple has been favourably reported on, but something further is required in the way of strength, and it is hoped the provincial department will attain this quality by selection. In the course of a conversation with an enterprising gentleman who cultivates about 1,000 acres of land near Yeotmal, it was learnt that *burhi* cotton is thoroughly at home in low lying ground where *jari* was killed by excessive rain in the last season. There is thus a chance for the introduction of *burhi* into areas of heavier rainfall, and Mr. Clouston has arranged to work out this point. It should not be grown, however, on the higher and drier lands which are exactly suitable for *jari*. Mr. Hemingway, Director of Agriculture, stated that a good deal of cotton wilt had been reported from the Satpuras, but he himself thinks that it is not really wilt, but damage caused by the heavy rainfall. He also stated that *bani* requires a heavier rainfall than *jari*, that the
cultivation of the former has declined owing to a long succession of abnormally dry seasons, and that with more favourable climatic conditions, bani will probably again come into favour. He also says that the ryots are quite alive to the necessity of selecting good seed and hand gin what is required for their own use.

In the adjoining tracts of the Nizam's territory, a particularly fine cotton known as karkeli is grown from its centre of trade. A quantity of the best karkeli seed cotton was obtained, and after ginning, was submitted to Messrs. Tata for opinion. They valued it as equal to fine Broach and further stated that the chief characteristic of the karkeli variety of cotton is its tension which is greater than that of any other variety of Indian cotton, and that it is greatly valued by the mills on that account. The Cotton Specialist has supplied seed to all parts where the coarser cottons are grown, and when samples of the produce are received, he will, if the results are promising, be able to arrange for its introduction on a larger scale. This cotton consists of jari of a very superior type with an admixture of bani and upland Georgian. It is even in staple and general characteristics. However the fact that inferior cotton is brought down from Central India for mixing purposes, is to be deplored.

At Barsi also a good type of cotton, mostly bani, used to be brought in from the Nizam's territory, but now, owing to the substitution of inferior varieties, its reputation has sadly diminished. It, may be mentioned here that there is little direct proof of deterioration of the cotton plant anywhere in India, and that falling off in quality is greatly due to substitution of inferior varieties, or to mixture of good and bad varieties at the ginning factories. During January, 1909, the Cotton Specialist toured in Gujarat to study the factors of environment which influence the characteristics of the distinct varieties of cotton which exist there. Such a study may make it possible to formulate general laws for the production of different varieties of cotton.
Many of the Kathiawar States this year have gladly undertaken to carry out experiments with superior cotton, and there is hope that the former good varieties will again find a footing there.

The experiments with *Bourbon* cotton at Nadiad farm are very promising. Years ago partial success was obtained in its cultivation in the Kaira district, and the ultimate failure was perhaps due to the ignorance of the requirements of a perennial cotton which needs careful pruning among other details. Some of the samples of cotton were valued very highly. Mr. Spence might have obtained success further north at Deesa if he had tackled the problem in the right way. Some samples of *Bourbon* cotton from the Coimbatore district have been favourably reported on by a Bombay merchant.

*Bourbon* is probably the only foreign tree cotton worth experimenting with in India, and an attempt is at present being made to obtain sufficient information to enable definite schemes to be formulated for its cultivation on a larger scale. Its chief virtue at present seems to be that it is not suitable for ordinary cotton soil tracts where it would immediately suffer by admixture, but it would thrive on red and sandy soils where cotton is not a usual crop. In the Madras Presidency it is almost the sole memorial of the long defunct cotton department, and it has there suffered from long and unmerited neglect.

In February, 1909, the Cotton Specialist attended the Board of Agriculture meeting at Nagpur, and there discussed cotton matters with the officers interested. In March he toured through the southern Mahratta country, Madras Presidency and Bangalore where he advised the recently appointed Economic Botanist as to the experiments he should undertake.

In the previous year three Bombay cottons were reported as having given satisfactory results at Bellary. Broach, however, shows a steady decline. The peculiar yellow coloured cotton of the Madras Presidency is objected to
in the Bombay market where a white colour is one of the chief desiderata. A constant introduction of fresh seed would only partially remove the difficulty, as even in the case of cotton at Dharwar from imported seed, it was pointed out to Mr. Gammie that it was darker in colour. In the southern part of the Madras Presidency it has been proved that the karangani is superior to uppaam, and steps are being taken to distribute quantities of the former. The introduction of the seed drill is considered the most important part of the work done.

From Burma intimation was received that the department had resolved to begin experiments; so, as a preliminary, sets of seeds of standard varieties were supplied in order that their behaviour might assist in arriving at some idea on what lines the trials should ultimately run.

3. Collection of Varieties.—A large collection of annual and perennial cottons, both indigenous and American, has been kept under observation at Kirkee and Ganeshkhind. The only tree cottons which gave any promise of success, were Bourbon and Spence cotton which is ordinarily indistinguishable from Bourbon.

4. Distribution of Seed.—Considerable quantities of cotton seed have been supplied, in all, to 47 persons in various parts of India.

5. Identification and Valuation.—A good many samples have been sent in for identification and valuation. All samples received for valuation were submitted to Bombay merchants, and the verdicts transmitted to the senders. An assistant recently appointed with a previous knowledge of cotton valuation, has studied the subject in Bombay and ought to prove of great help in the future in this line.

It is hoped to keep in close touch with cotton merchants. The Cotton Specialist has met and talked with a good many, and he feels that the trader and not the farmer is the chief obstacle in the way of improvement.
6. Programme for 1909-10.—It is proposed to tour in Eastern Bengal and Chittagong Hill Tracts in the autumn to advise on the possibilities of improvement of cultivation and introduction of suitable superior varieties. A visit may be paid to Burma later on. A scheme will be formulated for extended trials of Bourbon cotton, at least in the Madras and Bombay Presidencies. A tour will again be made in Gujarat to continue the investigation into the conditions which affect the production of cotton. This enquiry is also carried on wherever touring is done. The introduction of superior cotton into Kathiawar and of karkeli cotton into jari districts, will depend on the results achieved. Finally the Cotton Specialist is at the disposal of any one who may require his advice or assistance.
REPORT
OF THE
Agricultural Research Institute and College, Pusa.
(Including Report of the Imperial Cotton Specialist)
1909-10

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1910
### TABLE OF CONTENTS.

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introductory</td>
<td></td>
</tr>
<tr>
<td>1. Agriculture</td>
<td>1</td>
</tr>
<tr>
<td>2. Botany</td>
<td>2</td>
</tr>
<tr>
<td>3. Chemistry</td>
<td>2</td>
</tr>
<tr>
<td>4. Entomology</td>
<td>3</td>
</tr>
<tr>
<td>5. Mycology</td>
<td>4</td>
</tr>
<tr>
<td>6. Bacteriology</td>
<td>4</td>
</tr>
<tr>
<td>7. Cotton</td>
<td>4</td>
</tr>
<tr>
<td>8. Publications</td>
<td>6</td>
</tr>
<tr>
<td>9. Students</td>
<td>6</td>
</tr>
<tr>
<td>II. Report of the Director, Agricultural Research Institute, Pusa</td>
<td></td>
</tr>
<tr>
<td>1. Charge of Office</td>
<td>7</td>
</tr>
<tr>
<td>2. Staff</td>
<td>7</td>
</tr>
<tr>
<td>3. Scientific Work</td>
<td>9</td>
</tr>
<tr>
<td>4. Buildings, Grounds, etc.</td>
<td>9</td>
</tr>
<tr>
<td>5. Students</td>
<td>9</td>
</tr>
<tr>
<td>6. Publications</td>
<td>10</td>
</tr>
<tr>
<td>7. Library</td>
<td>10</td>
</tr>
<tr>
<td>8. General Health of the Station</td>
<td>10</td>
</tr>
<tr>
<td>9. Accounts</td>
<td>11</td>
</tr>
<tr>
<td>III. Report of the Imperial Agriculturist</td>
<td>12</td>
</tr>
<tr>
<td>1. Charge and Establishment</td>
<td>12</td>
</tr>
<tr>
<td>2. Training</td>
<td>12</td>
</tr>
<tr>
<td>3. Character of the Season</td>
<td>13</td>
</tr>
<tr>
<td>4. Cropping</td>
<td>13</td>
</tr>
<tr>
<td>5. Permanent Manural and Rotation Experiments</td>
<td>14</td>
</tr>
<tr>
<td>6. Permanent Pasture Experiments</td>
<td>14</td>
</tr>
<tr>
<td>7. Fodder</td>
<td>15</td>
</tr>
<tr>
<td>8. Breeding—</td>
<td></td>
</tr>
<tr>
<td>(a) Cattle and Sheep</td>
<td>15</td>
</tr>
<tr>
<td>(b) Poultry</td>
<td>16</td>
</tr>
<tr>
<td>9. Programme of Work for 1910-11</td>
<td>16</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>IV. Report of the Imperial Economic Botanist—</td>
<td></td>
</tr>
<tr>
<td>Part I.—Teaching, Training and Staff</td>
<td>18</td>
</tr>
<tr>
<td>Part II.—Investigations</td>
<td>18</td>
</tr>
<tr>
<td>1. Wheat</td>
<td>18</td>
</tr>
<tr>
<td>2. Fruit</td>
<td>20</td>
</tr>
<tr>
<td>3. Tobacco</td>
<td>20</td>
</tr>
<tr>
<td>4. Fibres</td>
<td>20</td>
</tr>
<tr>
<td>5. General</td>
<td>20</td>
</tr>
<tr>
<td>6. Programme of Work for 1910-11</td>
<td>21</td>
</tr>
<tr>
<td>7. Publications</td>
<td>22</td>
</tr>
<tr>
<td>V. Report of the Imperial Agricultural Chemist</td>
<td>23</td>
</tr>
<tr>
<td>1. Charge of Section</td>
<td>23</td>
</tr>
<tr>
<td>2. Meteorology</td>
<td>23</td>
</tr>
<tr>
<td>3. Drainage Data</td>
<td>23</td>
</tr>
<tr>
<td>4. Water Requirements of Crops</td>
<td>23</td>
</tr>
<tr>
<td>5. Soil Gases</td>
<td>24</td>
</tr>
<tr>
<td>6. Usar Land</td>
<td>24</td>
</tr>
<tr>
<td>7. General Analytical Work</td>
<td>26</td>
</tr>
<tr>
<td>8. Education</td>
<td>27</td>
</tr>
<tr>
<td>9. Establishment</td>
<td>27</td>
</tr>
<tr>
<td>10. Programme of Work for 1910-11</td>
<td>27</td>
</tr>
<tr>
<td>11. Publications</td>
<td>28</td>
</tr>
<tr>
<td>VI. Report of the Imperial Entomologist</td>
<td>29</td>
</tr>
<tr>
<td>1. Charge and Establishment</td>
<td>29</td>
</tr>
<tr>
<td>2. Training</td>
<td>30</td>
</tr>
<tr>
<td>3. Provincial Work</td>
<td>30</td>
</tr>
<tr>
<td>4. Correspondence</td>
<td>32</td>
</tr>
<tr>
<td>5. Research</td>
<td>33</td>
</tr>
<tr>
<td>6. Sericulture</td>
<td>33</td>
</tr>
<tr>
<td>7. Lac</td>
<td>36</td>
</tr>
<tr>
<td>8. Demonstration</td>
<td>36</td>
</tr>
<tr>
<td>9. Insect Survey</td>
<td>37</td>
</tr>
<tr>
<td>10. Miscellaneous</td>
<td>38</td>
</tr>
<tr>
<td>11. Programme of Work for 1910-11</td>
<td>38</td>
</tr>
<tr>
<td>12. Publications</td>
<td>39</td>
</tr>
<tr>
<td>VII. Report of the Imperial Mycologist</td>
<td>40</td>
</tr>
<tr>
<td>1. Charge and Establishment</td>
<td>40</td>
</tr>
<tr>
<td>2. Training</td>
<td>41</td>
</tr>
<tr>
<td>3. Accommodation</td>
<td>41</td>
</tr>
<tr>
<td>4. Aid to Provincial Departments</td>
<td>41</td>
</tr>
</tbody>
</table>
### 5. Research Work

- **(a)** Blister Blight of Tea
- **(b)** Other Tea Diseases
- **(c)** Palm Disease
- **(d)** Sugarcane Diseases
- **(e)** Wilt Diseases
- **(f)** Ginger Rot
- **(g)** Fruit Diseases
- **(h)** Forest Tree Diseases
- **(i)** Other Plant Diseases

42

### 6. Systematic Work

46

### 7. Miscellaneous

46

### 8. Programme of Work for 1910-11

46

### 9. Publications

47

### VIII. Report of the Imperial Agricultural Bacteriologist

- 1. Examination of Bacteria in the Soils of Pusa
- 2. Work on Nitrogen Fixation in Soils
- 3. Disease of Eri-Silk Worm
- 4. Trials with Trope-Ratine
- 5. Charge of Section and Establishment
- 6. Programme of Work for 1910-11

48

### IX. Report of the Imperial Cotton Specialist

- 1. Charge and Tours
- 2. Notes on Cultivation of Cotton in Provinces
  - **(a)** Eastern Bengal and Assam
  - **(b)** Bengal
  - **(c)** Central Provinces
  - **(d)** Berar
  - **(e)** Bombay
- 3. Valuing of Samples
- 4. Programme of Work for 1910-11

54

55

58

60

63

69

69

69
Report of the Agricultural Research Institute and College, Pusa.

( Including Report of the Imperial Cotton Specialist. )

1909-10.

INTRODUCTORY.

In presenting the report of the past year of the Agricultural Research Institute and College at Pusa, and that of the Imperial Cotton Specialist, I shall confine myself to a brief mention of the more important work undertaken in each section.

Agriculture.—The Permanent Manurial and Rotation experiments and the Permanent Pasture experiments have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from their results. Perhaps amongst the most useful work carried out is that of the preservation of fodder. In a country like India where cattle-food supplies are subject to the vicissitudes of an uncertain climate, this subject is of the highest interest. The production of ensilage on the American principle has been found the most satisfactory method of preservation. Maize was found to give the most nutritious food when thus prepared, but in point of yield per acre sorghum has given more weight and is therefore more economical. An objection to the American system of making ensilage in this country is the expense of constructing the silo. Experiments, however, are in progress
with a view of devising a cheap indigenous pattern which, if successful, will not only enable the better class of cultivator to adopt siloing, but will be of use perhaps to Government Departments in the preservation of fodder against famine years. As regards future work, that coming under the head of "Extension of Botanical Work" will doubtless prove the most important. The growth of selected varieties of wheats in extension of the work now being done by the Imperial Economic Botanist will be carried out on a practical scale with a view to still further extension in the future.

**Botany.**—No part of a scheme for the improvement of agriculture gives greater promise of success than that which deals with improvements emanating from the treatment of the plant. This is especially the case in India where not only are the plants of most crops degenerated specimens, but where the poverty of the cultivator makes improvement entailing the use of capital well-nigh impossible. By the introduction of a better plant, it is easily possible to increase yield and improve quality without adding to the cost of cultivation. The work which Mr. A. Howard, the Imperial Economic Botanist, is carrying out on wheat requires special recognition. The wheats which were sent home last year for testing have been found to rank in the same class as American and Canadian Spring wheats which command the highest price in the English market. It is almost needless to point out that these facts should have a most profound effect upon the export wheat trade of India. I desire here to record the appreciation felt for the invaluable assistance given by Mrs. Howard, who equally with her husband has accounted for the work of this Section.

**Chemistry.**—The principal work undertaken by this department during the past year has been the study of Soil Gases in relation to other constituents in the soil, the examination into the nature of Usar land and the investigations into the Water Requirements of Crops. The work of the first two is not in a sufficiently advanced stage to
need reference at this moment, but attention may be invited
to Dr. Leather’s work on the *Water Requirements of Crops.*
In India where water is the prime factor underlying the
successful growth of crops, its conservation and its eco-
nomic use are of first rate importance. These remarks
apply equally whether the water is derived from the
monsoon rainfall or the irrigation canal. How much water
is transpired by various crops, and during what period of
growth does the crop require the principal portion of this
water, are questions of as great importance to the agricul-
turist as to the irrigation engineer. In Chapter XI of the
Report of the Indian Irrigation Commission, 1901-1903, the
Commissioners remarked, “In the course of our investiga-
tions, we have been struck with the small amount of atten-
tion which appears to have been given by the Departments
of Agriculture and Public Works to matters connected
with the application of water to cultivated crops. At
present, most of the information which can be had on these
points has to be taken from papers published by the Agri-
cultural Bureau in America. . . . . . . . . . .
. . . . . . We consider it extremely desirable that
expert enquiry should be directed to these important
matters, which are so intimately connected with the
development of irrigation.”

This enquiry Dr. Leather has undertaken and in
Memoir No. 8, Chemical Series, he has published the results
of his work on the first section of the investigation, namely,
that which deals with the total amount of water transpired
by the crop and the period of growth during which the
greater part is assimilated. The ratio between the amount
of water transpired and the ultimate weight of dry crop is
worked out for most of the principal Indian crops.

*Entomology.*—One of the principal features of the work
of this section is the attention which is being paid to
industries that depend upon the products of insects. Thus
Eri, Mulberry and Tussar silk and the cultivation of Lac
are taking up much of the time of Mr. Maxwell-Lefroy, the
Imperial Entomologist, and his staff. The Eri silk industry
has spread considerably in Tirhoo, Bhagalpur and Patna, where owing to their proximity, these places are under the direct influence of this Institute. It is also to be found in Malabar, Dharwar, the West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkund, Betul, Chanda and Murshidabad. Progress is at present somewhat retarded by the want of middlemen for collecting the cocoons from the rearers and conveying them to the mills, but it is expected that enterprise will eventually overcome this difficulty.

Mycology.—The investigation into the Blister Blight of Tea carried out by Mr. W. McRae while he officiated as Imperial Mycologist, has been the most important new work undertaken during the year. The disease which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909, it extended, and this led to the Darjeeling Planters' Association asking the assistance of this Institute. It has spread still further this year into the Dooars and the Terai and its progress will be watched with anxiety by all interested in tea.

The Palm Disease in the Godavery Delta has not ceased to engage the attention of this Department, and recommendations have been made for continuing the work of repression, especially in the Kistna District where, in spite of the repeated warnings of the Imperial Mycologist, it was being neglected. A full account of the disease and measures taken to check it is in the press and will appear shortly.

Bacteriology.—It is only necessary to mention that with the appointment of Mr. C. M. Hutchinson as Imperial Agricultural Bacteriologist, this section has been opened during the year. The importance of the study of the biological aspect of soils in this country cannot be overestimated, and much useful information is anticipated from investigations in this quarter.

Cotton.—The importance of the cotton plant not only to India but to the British Empire has led the Government
to appoint a whole-time officer for this particular crop. Mention may here be made of the more important recommendations of the Imperial Cotton Specialist which will be found embodied in his report in greater detail. In *Eastern Bengal and Assam*, the prevalent type is that known as *Gossypium neglectum* var. *Assamica* of Watt and is commonly called the Garo Hill Cotton. It is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price. The Imperial Cotton Specialist recommends that in any experiments carried out by the Department, this type of cotton should be adhered to, lest the experience of generations which has taught the use of a kind of cotton capable of growing under excessive rainfall and the primitive agriculture of the Hill tracts, be lost and the present variety substituted by an unsuitable one. He, therefore, advises that trials should be confined to improving in this one type, the length of staple and the percentage of cotton to seed but that no attempt should be made to alter the special characteristics of the product.

In *Bengal* the cottons appear altogether to be of an inferior type. Trials should be confined in this Province to the possibilities of *G. intermedium* and *G. hirsutum*, the latter preferably in its two forms of *Buri* and Cambodia.

In the *Central Provinces*, it is pleasant to find that Mr. Clouston, Deputy Director of Agriculture, has selected a plant of the *Buri* variety which is promising well and that most valuable work is being done in these provinces by the introduction of *Buri*. The recommendations of the Imperial Cotton Specialist in regard to these provinces may be summarised as under:

1. The introduction of *Buri* to accompany *Bani* but not to oust *Jari*.
2. The improvement of *Bani* in its percentage of cotton.
3. The isolation of the different types of *Jari*. 
The report of the Imperial Cotton Specialist so far as other Provinces are concerned does not call for any comment.

Publications.—In addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets, two publications of importance have issued from the Institute during the past year, namely, Indian Insect Life by Mr. Maxwell-Lefroy assisted by Mr. F. M. Howlett and Wheat in India by Mr. and Mrs. Howard. Indian Insect Life containing 786 pages of printed matter and 619 illustrations has been well received both in India and abroad and is without doubt the most advanced and comprehensive manual of Indian insects yet published. Wheat in India containing 288 pages and 18 illustrations, deals in a complete manner with the production, varieties and improvement of Indian wheat. In order to be useful to all interested in the various aspects of wheat production, the scope of the book has been made as wide as possible.

Students.—Out of the students admitted in the previous year, nine continued their course and of these seven left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, viz., one each in Chemistry, Mycology, Entomology and Agriculture. In the short practical courses in Agriculture, Fruit-growing, Silk-culture, Lac cultivation, Cattle Breeding and Management and the like, 39 students were admitted, some of whom took up more than one subject.

BERNARD COVENTRY,
Offg. Inspector General
of Agriculture in India.

Simla;
The 1st October 1910.

(E. J. BUTLER, M.B., F.L.S.)

1. Charge of Office.—Mr. B. Coventry held charge of the office of Director up to the 9th May 1910, with the exception of one month in September-October 1909, when he was on privilege leave and Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist, acted for him during his absence in addition to his own duties. In consequence of his appointment as Officiating Inspector General of Agriculture in India, Mr. Coventry relinquished charge of the office of Director on the 9th May 1910, and I was appointed to officiate for him in addition to my own duties.

2. Staff.—Dr. J. Walter Leather, Ph.D., F.I.C., F.C.S., Imperial Agricultural Chemist, returned from leave on the 27th October 1909 and took over charge of the chemical section from Mr. H. E. Annett. The latter has been deputed to act as Agricultural Chemist, United Provinces, from the 3rd November 1909. The charge of the mycological section was taken over by me from Mr. W. McRae, M.A., B.Sc., on the 27th December 1909, when I returned from leave, and immediately after Mr. McRae proceeded to Madras to join his new appointment as Mycologist to the Government of Madras. His successor, Mr. F. J. F. Shaw, B. Sc., A.R.C.S., joined his appointment as Supernumerary Mycologist on the 28th January 1910. Mr. C. W. Mason, Supernumerary Entomologist, left the Department on the 19th December 1909, and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined this Institute as Supernumerary Entomologist on the 8th April 1910. The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., F.E.S., has been on leave since the 9th September 1909 and
is expected to return in January next. Mr. C. M. Hutchinson, B.A., joined the Department on the 24th December 1909, as Imperial Agricultural Bacteriologist. The charge of the Farm was relinquished by Mr. E. Shearer, Imperial Agriculturist, on the 17th July 1909, in consequence of his promotion to the post of Assistant Inspector General of Agriculture in India and the Director was placed in charge of the duties of the Imperial Agriculturist in addition to his own duties. Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, was appointed to be Assistant Agriculturist with effect from 17th July 1909. He was on privilege leave from 2nd to 20th November 1909, and from 6th June 1910 to 6th July 1910. Mr. A. McKerral, M.A., B.Sc., who has been appointed Assistant Inspector General of Agriculture in India, vice Mr. E. Shearer, resigned, has been lent to the Pusa staff to undertake the work of Imperial Agriculturist under the Director as a provisional measure. He joined his duties at this Institute on the 19th June 1910. The botanical section was in charge of Mr. A. Howard, M.A., A.R.C.S., F.L.S., up to 30th April 1910, when he proceeded on leave to England. Mr. G. P. Hector, M.A., B.Sc., Supernumerary Botanist, was transferred to Eastern Bengal and Assam on the 14th July 1909, and the services of Mr. E. Holmes-Smith, B.Sc., Economic Botanist designate of Burma, were transferred to this Department with effect from the 15th July 1909, for appointment as Supernumerary Botanist. The latter has been on deputation in the Bombay Presidency since the 6th March 1910, to acquire experience of work in a province.

The European Scientific Staff of the Institute consisted of the following:—

(1) The Imperial Agricultural Chemist with one Supernumerary, (2) the Imperial Mycologist with one Supernumerary, (3) the Imperial Entomologist with one Supernumerary, (4) the Imperial Economic Botanist with one Supernumerary, (5) the Second Imperial Entomologist, (6)
the Imperial Agricultural Bacteriologist, (7) the Assistant Inspector General of Agriculture in India (temporarily in charge of the agricultural section) with the Assistant Agriculturist.

During the year under report, the pay and position of several of the senior Indian assistants of the institute were improved and the first assistants in each section as well as other assistants engaged in teaching and research work have been admitted to gazetted rank.

3. Scientific Work.—The scientific work of the Institute during the year is indicated in the reports of the various Sections.

4. Buildings, Grounds, etc.—In consequence of the transfer of the head-quarters of the Inspector General of Agriculture in India to Pusa, two blocks of new quarters have been departmentally constructed for the use of his staff and in addition some old buildings have been placed at his disposal. The grounds surrounding the College building have been fully laid out and arrangements made for irrigating the lawns.

5. Students.—Out of the students admitted in the previous year, 9 continued their course and of these 7 left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, viz., one in Chemistry (an Assistant of the Agricultural Chemist, United Provinces) for a three months' course, one in Mycology (a private student from Bombay), one in Entomology, from the Central Provinces Department of Agriculture, and one for a general course in Agriculture from the Punjab Department of Agriculture. The private student in Mycology has, however, abandoned the course and left the Institute. There were at the end of the year four students under training, viz., one in Chemistry, two in Entomology and one for a general course.

The short courses in practical agriculture and in other allied practical subjects inaugurated last year at Pusa
were continued. The number of students admitted to the various sections for these courses was as follows:—Six in fruit-growing, eighteen in silk-culture, ten in lac cultivation, nine in cattle breeding and management, three in poultry management and three in tillage implements and agricultural machinery. The students for these courses came from different parts of India and some of them took up more than one subject.

6. Publications.—This work has been continued. During the year under report two new books, one "Indian Insect Life" by Mr. H. Maxwell-Lefroy, Imperial Entomologist, assisted by Mr. F. M. Howlett, Second Imperial Entomologist, and the other "Wheat in India" by Mr. A. Howard, Imperial Economic Botanist, and Mrs. Howard, were published in addition to the Agricultural Journal of India, the Mémories of the Department of Agriculture in India, Bulletins and Leaflets.

7. Library.—The revised catalogue of the library is still in the press. Over a thousand volumes have been added to the library during the year.

8. General Health of the Station.—The general health of the station during the year under report was good, excepting in the monsoon period. Relief was afforded in the hospital to 6,231 new cases, of which 6,015 were treated in the outdoor department and 216 admitted as indoor patients. These figures show an increase of 2,918 and 112 respectively over last year's totals. The increase in attendance was due to the greater prevalence of malarial and allied fevers during the months of July, August and September, 1909. 99 cases amongst European officers and their families were attended to.

The daily average number of patients treated was 6·96 indoor and 48·97 out-door as against 4·68 and 25·05 respectively during the previous 12 months.

Five deaths occurred in hospital—two cases from pneumonia in aged and debilitated subjects, one from malarial cachexia and two from Kala-Azar.
Eighty-eight surgical operations were performed, of which 4 were major and the remainder minor.

The prevailing diseases were malarial fevers, bowel complaints and rheumatic and skin affections. Malarial fever cases were diagnosed microscopically before treatment.

There were no cases of infectious diseases, except a case of chicken-pox (imported). Eight primary and three revaccinations were performed in the early part of the year.

9. Accounts.—The total expenditure incurred during the year was Rs. 3,12,427 as against Rs. 3,23,900 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,78,680, travelling allowance of officers and establishment Rs. 14,699, publications Rs. 30,000 and farm expenditure, scientific apparatus, books, contingencies, etc., Rs. 89,048.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles amounted to Rs. 5,573 as against Rs. 9,680 of the preceding year. The decrease is due to the abnormal rainfall (amounting to 72 inches) which damaged the crops.
REPORT OF THE IMPERIAL AGRICULTURIST
FOR THE YEAR 1909-10.
(A. McKerral, M.A., B.Sc.)

1. Charge and Establishment.—Mr. Ernest Shearer, Imperial Agriculturist, relinquished charge of the farm on 16th July 1909 on his promotion to the post of Assistant Inspector General of Agriculture in India, and his duties were taken up by Mr. Bernard Coventry, the Director, Agricultural Research Institute, in addition to his own work. Mr. G. Sherrard, who had previously acted as Supernumerary Agriculturist, was appointed Assistant Agriculturist. Amongst the subordinate staff, Mr. G. N. Desai, First Farm Overseer, was transferred in March 1910, to the Agricultural Department of the Bombay Presidency, and Mr. Ikramuddin, the Second Farm Overseer, was promoted to First Farm Overseer in his place. Mr. Ziauddin Hyder, fieldman, was in charge of the Poultry until promoted in April 1910 to the post of Second Farm Overseer, Mr. Nizamuddin Hyder being appointed in his place. Mr. Judah Hyam, the Veterinary Overseer, remained in charge of the breeding herds as before. During the year, the Government of India were pleased to raise him to Gazetted rank along with certain other Indian Assistants of the Institute.

2. Training.—The two students Bhai Sunder Singh and Bhai Kharak Singh, sent by the Punjab Agricultural Department for a general course of agriculture, completed their training and returned to their province to take up respectively the posts of Assistant Director of Agriculture and Assistant Professor of Agriculture. A third student, Chowdhuri Fateh-ud-din, sent by the same department, was admitted to a general course in agriculture from 18th August 1909.

Short courses in cattle breeding and management, poultry management, tillage implements, and agricultural machinery were given to some 15 students.
3. **Character of the Season.**—The rainfall for the season amounted to 72 inches, which is some 30 inches above normal. It was very badly distributed and was precipitated at times in such large quantities that the crops became injured. The result of the monsoon harvest was consequently a disappointment and the yields in no way approximated to expectation. The rain, too, was unusually heavy in the month of October, which not only retarded the preparation of the land for the *rabi* season, but caused unprecedented sickness amongst the labourers.

4. **Cropping.**—The trials with many varieties of sugar-cane were continued as in previous years. In spite, however, of the care and control with which the cultivation and selection of this crop was carried out, the results were disappointing. It has been realised that the locality is unsuited to the growth of thick canes such as were being cultivated and with the exception of a small area reserved for the Mycologist and Entomologist the cultivation of this crop has been abandoned. Jute and flax have been grown for experiments for the Fibre Expert to the Government of Eastern Bengal and Assam with varying degrees of success. With regard to jute, the experiments were mostly for the purpose of determining the botanical characters in a collection of specimens. While this crop grows well in these districts, it is generally recognised that it does not do so well as in Eastern Bengal and its cultivation amongst the cultivators of Behar is not extending. With regard to flax, prospects appear promising provided the crop is grown in the best possible way, that is to say in strong land with an abundance of moisture. The work in this crop is being extended, and the experiments now in progress should solve most of the doubts and difficulties which prevent its being more generally adopted. In addition to the usual cultivation of rice carried out on the farm, the use of bone meal and saltpetre was tried in a series of $\frac{1}{4}$ acre plots. Two alternate plots were unmanured and the other two manured with 30 seers
of saltpetre and 3 maunds of bone meal per acre. The results were as under:

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<th>Mds</th>
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<td>(1) Manured</td>
<td>30</td>
<td>17</td>
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<td>(2) Not manured</td>
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<td>(3) Manured</td>
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<td>(4) Not manured</td>
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The result is slightly in favour of the manured plots, but the difference is not sufficient to warrant the expenditure. The remainder of the crops on the farm were grown mainly for the purpose of fodder for the increasing numbers of cattle. These crops consist chiefly of maize, sorghum, arhar (*Cajanus indicus*), and oats. A large number of varieties of crops in small plots were grown for the use of the Entomologist and Mycologist. The brick-field area, brought under cultivation for the first time, was sown with a mixed crop of rice, sorghum, and *moong* (*Phaseolus mungo*), and gave quite satisfactory results.

5. **Permanent Manurial and Rotation Experiments.**—These have been continued according to the scheme described in the Proceedings of the Board of Agriculture, 1908. Sufficient time has not elapsed for making deductions from these experiments.

6. **Permanent Pasture Experiments.**—The series of permanent pasture experiments laid down in the monsoon of 1907, according to the scheme described in the Proceedings of the Board of Agriculture held at Pusa in February 1908, has been maintained. The experiments aim at determining the effect of different manurial dressings (1) on the total yield of the herbage and (2) on its quality and botanical composition. So far as yield is concerned, it is much too early as yet to make any deductions, especially as the first two seasons during which the experiments took place were not normal with respect to rainfall. With regard to the quality of the herbage also, sufficient time has not elapsed for radical changes to have taken place. In fact, as the total number of species of grasses and legumes which were originally present was small, it is
scarcely to be expected that such complete alteration of the flora as has characterised similar experiments in Europe may be looked for in the case of Pusa. The condition of the plots at present may be summarised as follows:—

In the cold weather, they consist mostly of *A pang* (*Andropogon annulatus*) with a certain amount of *dubh* (*Cynodon dactylon*) and in the rains, of *Digitaria* and *Rottboelia*. At the end of the rains, the whole area is overgrown by *rari* (*Saccharum spontaneum*) and *dabhi* (*Im-perata arundinacea*) which disappear entirely during the cold weather. The only legumes worthy of notice are *Medicago lupilina*, Linn., and *Indigofera linifolia*, Retz., both of which are "bottom" plants, useless for hay purposes. Weeds are practically a negligible quantity. On the whole, the composition of all the plots is as yet practically the same.

7. **Fodder.**—The supply of fodder for the cattle is one of the chief objects of the farm, and consequently by far the larger portion of the arable area is devoted to this purpose. Maize, sorghum, *arhar* (*Cajanus indicus*), and oats are the crops found most suitable. Ensilage is much resorted to, and if the process is properly carried out in silos of the American type, it is invariably a success. Maize probably gives the most nutritious food when thus prepared, but in point of yield per acre sorghum is more satisfactory and therefore more economical. The amount of silage made last year on the farm was 13,329 maunds.

8. **Breeding. (a) Cattle and Sheep.**—The Montgomery herd of cows continues to do well and its numbers have been increased. There are 62 cows, 3 bulls, and 108 young stock. The local herd of cattle which was maintained for the Bengal Government have been removed to Bettiah where they are being looked after by the Bengal Agricultural Department. This has given us more room for the extension of the Montgomery herd. The flock of 80 Bikanir sheep which were purchased two years ago have not done well. The change from an excessively arid to a humid tract caused a breakdown in their constitution and the
majority have died. The remainder will be got rid of, and in their place is being substituted a flock of Gorakhpur ewes which are good specimens of the local breed. These are at present doing well. It is intended to cross them with Dumbha rams with a view to improvement for mutton purposes.

(b) Poultry Breeding.—This work is now being conducted on a fairly large scale. The stock consists of 18 pens of fowls nearly all of pure breeds, one pen of Mammoth Bronze Turkeys, and one flock each of Embden Geese and Aylesbury ducks. The object is to supply at reasonable prices fresh blood of imported strains to Provincial Agricultural Farms and private individuals who are unable to afford the expense and risk of direct importation. This is effected either by egg distribution or by sale of birds. The price of eggs is Rs. 6 a dozen and birds are Rs. 30 for an adult trio and Rs. 16 for half grown birds. The eggs are sent by post or by rail in boxes specially made for the purpose, but it has to be acknowledged that this mode of distribution has not, by any means, been successful. The percentage of successful incubation from eggs transmitted by post or rail was extremely low, indeed so low that this method had to be discontinued. The failure is due doubtless to the fact that distances are so great in India, and the Postal and Railway authorities so unaccustomed to handling delicate articles like eggs, that the jolting and rough treatment in transit must have destroyed their fertility. The distribution of birds may be taken to have been altogether a success even in the case of long distances. The varieties of fowls which at present have done best are the Partridge Wyandotte, White Wyandotte, White Orpington, and Barred Plymouth Rocks. The Mammoth Bronze Turkeys have also done very well.

9. Programme of work for 1910-11:—1. Permanent Experiments.—The permanent manurial and rotation experiments and the pasture experiments will be continued.

2. Extension of Botanical work.—The growth of selected varieties of wheat will be taken up in extension of the
work now being done by the Imperial Economic Botanist. This work will be carried on in consultation with, and under the botanical surveillance of, the Imperial Economic Botanist.

3. Cattle Breeding.—The local herd has been transferred to the Bengal Agricultural Department and the Montgomery herd will now be considerably increased. Improvement of this breed by selection based principally on milk tests will be the chief object in view.

4. Sheep.—The crossing of Gorakhpur ewes with Dumbha rams will be undertaken.

5. Poultry.—Poultry breeding and distribution will be continued.

6. Training.—Courses in cattle breeding and the management of poultry will be given as heretofore.
Teaching, Training and Staff.—Two Supernumerary Botanists were in training during the year under review. Mr. G. P. Hector, M.A., B.Sc., the Economic Botanist-designate of Eastern Bengal and Assam, proceeded to that province on July 14th, 1909. Mr. E. Holmes-Smith, B.Sc., Supernumerary Botanist, worked at Pusa till February last when he proceeded to Bombay.

Five students attended the course on fruit growing and in addition, there were four students who attended special courses. One further short-course student was sent for a few weeks by the Economic Botanist to the Government of Bengal.

Mr. Ijaz Husain, Manager of the Lyallpur Farm, gave up his post in the Punjab Agricultural Department so as to become trained in this section as third assistant. My second assistant, Mr. Abdur Rahman Khan, has continued his training in Economic Botany in the section. I have pleasure in reporting the continued progress made by this assistant who, I believe, possesses real aptitude for and a thorough interest in Economic Botany. He is the joint author of an important memoir on some aspects of plant breeding in India recently submitted for publication.

While all other members of the staff have improved in their work, the services of my clerk, Ram Neehawar Lal and of my second fieldman, Sarup Singh, deserve mention.

Part II.

Investigations.

Wheat.—I am able to report very considerable progress in the wheat investigations of this section along several lines.
The expectations foreshadowed in Pusa Bulletin No. 14 on the possibility of growing stronger wheats with better milling qualities than those now exported from India have been abundantly realised during the past year. A further set of Pusa selected wheats was sent to Mr. Humphries for milling tests. Several of these wheats were found to possess great strength and high milling qualities and to be of the same class as American and Canadian Spring wheats which command the highest prices on the English market. The results of this work are published in Pusa Bulletin No. 17.

The results obtained during the year on the influence of the environment on the quality of wheat have been submitted for publication as a memoir. This work, which is being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the Government of the United Provinces, has been greatly extended during the past year. While it has been proved that environment influences quality, the most practical outcome of this work is the discovery of the fact that the quality of any wheat depends largely on the proper and efficient preparation of the land and that canal irrigation does not necessarily injuriously affect the milling qualities of wheat. It is expected that great consequences will result from these investigations and that they will be the means of opening a new chapter in the production of wheat in India and in the agricultural practices of the Indo-Gangetic plain.

The Monograph on Indian Wheat has been published during the year. While going through the press, it was necessary to add a considerable amount of new matter so as to bring it up to date. The book represents the results of the preliminary work on wheat which has been done at Pusa during the last four years and will, I trust, be of use to students and some members of the Agricultural Department.

The investigations on the natural crossing of wheat in India have been written up and incorporated in a memoir.
It has been proved that under canal irrigation in the Punjab, crossing is exceedingly common, a fact which will render seed distribution and wheat breeding work at Lyallpur somewhat difficult.

Many of the new Pusa selections and also some of the new hybrid wheats were grown on quarter acre plots at Pusa this year. As no rain fell during the growing period and as no irrigation water was applied, the crop derived its moisture from the water stored up in the soil from the previous monsoon. The yields varied from 25 maunds in the case of early varieties to 35 maunds per acre in the case of the later sorts and some of the new hybrids. About 2.5 tons of straw to the acre were produced. These yields are unprecedented for India and were possible on account of the system of cultivation and dry-farming employed in the Botanical area at Pusa.

Fruit.—The results so far obtained in fruit-growing at Pusa have been published in Pusa Bulletin No. 16. A visit was paid to Quetta during the year and proposals have been put forward for developing the fruit investigations of the section.

Tobacco.—The results of the tobacco investigations have been published in two memoirs on the subject which form a basis for further work. Natural crossing is common in the crop but easily prevented by raising seed under bag which gives rise to uniform crops. Some preliminary curing experiments have been conducted in conjunction with the Peninsular Tobacco Company with both American and Indian varieties. The Pusa varieties have given the best results so far.

Fibres.—A good deal of work has been done on Hibiscus cannabinus, but I have been unable to find time to write up the results. A memoir on san (Crotalaria juncea) has been published in which the beneficial effect of this crop as a green manure for tobacco has been described.

General.—A large amount of work on the occurrence of natural cross-fertilization in India has been written up
as a memoir and submitted for publication. The significance of this work both from the point of view of plant breeding and from that of seed distribution has been emphasised.

Programme of work for 1910-11.—1. Training.—The training of advanced students in this section will be continued on the lines laid down in the prospectus of the Institute. The course on fruit-growing will be given as usual in the cold weather.

2. Plant breeding and plant improvement.—During 1910, the following crops will be studied:—wheat, tobacco, barley, oilseeds and fibre plants.

(a) Wheat.—The botanical survey of the wheats of Baluchistan will be completed. The production of improved varieties by selection and hybridization will be continued. The co-operative experiments on the effect of environment on the milling and baking qualities of Indian wheats, which are being conducted in collaboration with Mr. H. M. Leake, Economic Botanist to the United Provinces, and of which the earlier results are now in course of publication, are being continued on an extended basis. The above experiments include the effect of weathering on the quality of the wheat crop and the Imperial Bacteriologist has agreed to undertake the study of the bacteriological aspect of this subject.

(b) Tobacco.—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of environment on the stability of the type and on the quality will continued.

(c) Oil-seeds.—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(d) Fibres.—The isolation and testing of pure races of the fibre plants of India will be continued.

(e) Fruit.—The fruit experiments will be continued on the lines laid down in the First Fruit Report.
(f) Minor Investigations.—The study of the varieties of cassava will be completed and the investigation on the inheritance of sex in *Ganja* continued.

**Publications.**—The following books and papers have been published and written during the year:


The Milling and Baking Qualities of Indian Wheats, No. 2. Some new Pusa Selections tested in 1909 (with G. L. C. Howard). *Bulletin No. 17 of the Agricultural Research Institute, Pusa*.


Wheat in India, its varieties, production and improvement (with G. L. C. Howard). Published by Thacker, Spink and Company, Calcutta.
REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST, FOR THE YEAR 1909-10.

(J. Walter Leather, Ph.D.; F.I.C.; F.C.S.)

Charge of Section.—Mr. H. E. Annett, B.Sc., M.S.E.A.C., Supernumerary Agricultural Chemist, was in charge of this section until October 27th when I returned from leave.

Meteorology.—In addition to the usual temperature, humidity, etc., records, an evaporimeter has been constructed and the data will prove of service to both the Meteorological and Irrigation Departments. The first instrument employed, a self-recording one, proved to be defective, chiefly because the atmospheric dust of the hot weather accumulated in the working parts. A much simpler and quite reliable instrument was kindly supplied to me by the Chief Engineer, Punjab Irrigation Branch, and reliable data can now be obtained, though the record is not self-maintained.

Drainage data.—The records of drainage under conditions of both bare-fallow and cropped soil at Cawnpore and Pusa are now bearing fruit and the first few years' results will be put together for publication at the close of the present monsoon. In addition to the quantities of water which percolate, evaporate or run off the land respectively, information regarding the period of most active nitrification, as also the effect of crops on nitrification is being gleaned. This subject is not entirely novel, M. Dëherain having published information in respect of it some 15 years ago, but it has not generally been acknowledged as important. The crops, wheat and maize, which were grown on two of the Pusa gauges, depressed in some way or other the formation of nitrates last year very materially.

Water requirements of crops.—The first section of this investigation was published during the year as Memoir
No. 8, Chemical Series, and dealt with both the total amount transpired as also the period during which the greater part was assimilated. The effects of temperature and humidity, proportion of water in the soil, manure, the nature of the crop, etc., were dealt with. One of the most important of these is manure, which whilst increasing the weight of the crop and consequently the amount of water required, effects an economy of the latter since the increased requirement of water is proportionately less than the increase in crop. Good tillage probably has a similar property. The second section of the investigation has to do (i) with the effect of different soils and (ii) with the results of field tests; this will be published shortly.

Soil Gases.—The first section of work in connection with the subject of soil gases dealing with the relations of carbonic acid to calcium carbonate and water, has been published as Memoir No. 7, Chemical Series, and it is expected that a second section dealing with the similar relations to magnesium carbonate will be published in the course of the cold weather.

Usar land.—At the request of the Deputy Director of Agriculture, Central Circle, United Provinces, an investigation into the nature of some land which has been going out of cultivation in the Mainpuri District, has been commenced and has indeed absorbed so much time that no less than three or four of the assistants are at present utilised for it.

The soil is Usar, of the "black alkali" type, but the amount of alkali present was thought at first to be too small to account for the sterility. The sub-soil water level has risen seriously of late years and no doubt was felt that this was one of the primary causes of the trouble. But in addition to this, preliminary tests showed that the soil is so highly impervious to water that this feature alone might account for sterility. All, or at least nearly all, the water assimilated by plants must move through a certain amount of soil before it comes in contact with the root; such distances may only be a few inches or centimetres,
but this feature of the process must nevertheless be recognised; and if the amount of water moving to the root in a given time is too small for the nourishment of the plant, there may be abundance of water in the soil, and yet unable to reach the roots sufficiently quickly; the plant's energy would thus become reduced, and the crop might die off altogether.

There were thus three distinct questions involved, namely, (i) the high sub-soil water level, (ii) the alkali in the soil, and (iii) the impervious nature of the soil. The investigations which are being conducted at Pusa have to do with Nos. (ii) and (iii) of these questions.

In order to study the subject in the field as far as possible, Mr. S. C. Kar, M.A., the second assistant, was deputed to work under the instructions of Mr. B. C. Burt, Deputy Director of Agriculture, United Provinces, at Bhadan, where a temporary laboratory was fitted up. Here the amounts of alkali and water were determined in the soil at specific points, in every 6 inches depth down to 7 feet or 8 feet from the surface, until the middle of May, when this part of the work was transferred to Pusa. In addition to an estimate of the amount of salts in these soils, it was especially desired to ascertain the amount of their upward movement during dry weather or their downward movement during the rains. But since no two tests can be taken in exactly the same place and since further it is known that the amounts of such salts vary considerably within comparatively short distances in the lateral direction, it became necessary to determine this latter, as an adjunct to the former feature. Such an investigation involves more work than might appear necessary at first sight and the whole series of tests are not yet complete, but it has become abundantly evident that (i) the amount of variation laterally is, as was anticipated, comparatively large, and (ii) that in these soils the amount of upward movement of salts to the surface during the dry weather is only nominal. This latter feature is quite in accord with expectation; the amount of salts brought to the surface
will depend largely on the amount of water moving upward; if the soil is highly impervious to water, such movements will be very limited; and consequently the amount of salts brought to the surface must likewise be limited. There was hardly any upward movement of water, and accordingly there could be no material concentration of salts at the surface.

The soil being so highly impervious to water, it became of first importance to try to measure this characteristic. By an improvement of a method originally suggested by Mr. Milton Whitney of the United States Department of Agriculture, a mechanical test has been devised, by the aid of which very interesting information has been obtained regarding the rate at which water can move through the Mainpuri as also through other soils. Thus for example, the Usar land in the Mainpuri District which we have been examining, is highly impervious as far down at least as the samples were drawn; the Juhi Usar reserve near Cawnpore is similar to a depth of 5 feet after which it is quite pervious to water; other sterile spots of land have proved to be quite pervious to water, and their sterility must be due to other causes.

In addition to these lines of investigation an exhaustive series of pot-cultures has been commenced at Pusa in order to ascertain whether the defective physical state of the Bhadan (Mainpuri) Usar soil can be remedied or reduced; and if this change were effected, whether the amount of alkali is itself sufficient to cause sterility; also what plants will grow most readily under such adverse conditions.

Finally, in addition to work on the Bhadan soil, the Usar land which has been wholly or partly reclaimed near Aligarh, by the Department and by Mr. Keventer respectively, is being examined in order to ascertain what changes have taken place during the period of years that the work has been in progress.

General Analytical Work.—The number of samples sent for analysis has remained, as in the preceding year,
much smaller than it formerly was. Most of the Provincial Departments are now able to execute all such work for themselves, and assistance in this respect has only been asked for from three provinces. The major part of the remaining samples has been submitted by the officers in charge of the Military Farms, who require opinions on soils and on grasses and other feeding stuffs.

Education.—One student from the Punjab took a short elementary course of Chemistry. One of the assistants of the Agricultural Chemist, United Provinces, is taking a three months' course. In addition, two new assistants on the ordinary establishment have been entertained, and these, as in all such cases, have been largely in the position of students.

Establishment.—The changes involved have been due (i) to a junior assistant not being confirmed and another appointed in his place, and (ii) to the temporary appointment of a graduate of the Bombay University to act during the absence of other members of the regular establishment. The latter case is of interest, because although this assistant is an M.A. graduate with very good credentials, he was willing to come for a purely temporary acting appointment on Rs. 50 and thereby try to learn something. The other assistant who was appointed during the year, worked purely as a volunteer for about a year in Mr. Hooper's laboratory at the Indian Museum, and has proved an excellent assistant. It is this class of man that deserves most encouragement and likewise generally makes the best public servant; young men who are willing in the first instance to show that they are capable of doing useful work rather than to sit down and do nothing until a highly paid appointment turns up.

Programme of Work for 1910-11.—1. The work on the availability of plant food in soils will be continued, the immediate aim being the more correct ascertainment of the composition of the aqueous solution in the soil. Included in this section of investigation are naturally the amounts of nitrate in soils and soil temperatures.
2. The investigation on soil moisture and water requirements of plants is being continued on lines which have been sufficiently indicated in the memoirs.

3. A joint investigation with Mr. Burt, Deputy Director of Agriculture, United Provinces, is being conducted into the causes of infertility in a tract of land in the Mainpuri District.

4. The effect of soil and manure on the composition of crops is a branch of study which is engaging the attention of a number of investigators and is one on which I have already obtained some information. It will be developed, if possible, at Pusa during the coming year.

5. Two points in relation to the Indian saltpetre manufacture, in respect of which it seems possible that an improvement can be suggested, will be investigated.

6. Education.—This requires no special comment; it will be conducted according to the lines laid down.

Publications.—The following papers have been published:

Memoir No. 8, "The Water Requirements of Crops in India" by Dr. J. Walter Leather.
Memoir No. 9, "The Nature of the Colour of Black Cotton Soil" by Mr. H. E. Annett.
(H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.)

Charge and Establishment.—The Imperial Entomologist held charge of the section during the year. The Supernumerary Entomologist, Mr. C. W. Mason, left the Department on December 19th and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined the Department as Supernumerary Entomologist on the 8th April. The first assistant, Mr. C. S. Misra, who has been on privilege leave from the 4th May to the end of June, had charge of the students, of the field-work on the Pusa Farm and Botanical area, and of the work with lac culture. Apart from the courses of lecturing given by the Imperial Entomologist personally, Mr. Misra has carried out the field and practical instruction of students, which he has done admirably, and also one of the two short courses of instruction given in lac culture. The second assistant, Mr. C. C. Ghosh, has had charge of the insectary and carried out all inquiries conducted there. His work has been of the very greatest utility; he has also been able to prepare a Bengali revision of Indian Insect Pests which has been published. The third assistant, Mr. G. R. Dutt, who was absent on privilege leave from 1st November 1909 to 31st January 1910, has been in charge of economic records, correspondence and collections and has done original work on Aculeate Hymenoptera. In spite of his heavy routine work he has found time for both original enquiry and for the compiling for publication of a list of the vernacular names of insects, which is being published. Mr. D. Nowrojee has been in charge of the general collections and has done excellent work in their upkeep and arrangement. The post of Sericulture Assistant, which was filled up by Mr. L. M. Dass, is now held by Mr. R. R. Ghose. The Bengal Entomological Assistant worked in the laboratory for some
months, pending the provision of accommodation at Sabour; the artist staff of the Institute also worked under the direction of the Imperial Entomologist from September to January. The Baroda Entomological Assistant spent a fortnight in Pusa discussing his year's work and the programme for next year.

Training.—The full course of Entomology was given to students from Madras, Central Provinces, Bengal and the United Provinces. It is to be regretted that no students have been sent for the course commencing on June 1st, 1910. A short training, as part of the course in general agriculture was given to a student from the Punjab. The short courses in Eri Silk cultivation have been taken up by 15 students from different parts of India and by boys sent by the United Provinces Agricultural Department. Irregular training in rearing has been given to a number of rearers from Indigo factories, zemindars, etc., who were taking up the industry. The courses in lac have been taken up by 10 students from Lucknow, Hyderabad, Bettiah, Dacca, Cuttack, Jullundur, Rajkot, Jodhpur and Gaya and three *malis* were trained for employment in lac-work in Behar.

Provincial work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now 16: 5 for teaching, 11 for field work. This number is wholly insufficient to bring the practical work of Entomology before the agricultural classes, but in the absence of Entomologists in the Provincial Departments to direct their work, the number is not being increased. It is something that applied Entomology forms part of the course of training at five Agricultural Colleges, but it is too much to expect eleven field-assistants to make any progress with showing how crop pests can be checked. As in previous years, the assistance offered in directing and checking the work of these assistants has been utilised by some provinces and the more technical work has been referred to Pusa, leaving the assistants free to do field work entirely. In Madras, the study of the destructive insects
has been continued on the lines laid down in 1906, and very substantial progress has been made; the pests have been carefully studied in almost every district and the preliminary work of collecting information on the spot materially advanced. Good work has been done against the Hairy Caterpillar pest in South Arcot and against the Deccan Grass-hopper which appeared in the Northern Division. In Bombay, very successful work has been done against the Rice Grass-hopper; the Potato-moth and Deccan Grass-hopper are being worked at where they occur and the work should bear fruit this year. Proposals have been made for putting the Entomological work on a better footing and placing it under the general direction of the Imperial Entomologist as in other provinces. In the Central Provinces, the success of the methods tried against Potato-moth has led to their adoption on a larger scale and a careful trial has been made of the trap-crop method of checking boll-worm of cotton on the farms. The cultivation of Eri silk has been experimentally taken up at Multai and Chanda. An investigation into termites in Hoshangabad has been started with the Deputy Director of Agriculture, Northern Circle, and the general pests of the province are being investigated. In Bengal, and Eastern Bengal and Assam, the general investigation of injurious insects has been continued; in the latter, the work against Potato-moth is likely to give good results. In the United Provinces, the work against the Cane Grass-hopper has been the principal item and the general investigation of injurious insects has been continued. The cultivation of Eri silk has been experimentally taken up at Cawnpore. In the Punjab, sericulture and bee-keeping have been experimented with and the general crop pests of the province investigated. In Baroda, good work has been done in inducing cultivators to take an interest in and adopt measures against the Hairy Caterpillar, the boll-worm and the til stem-borer, in addition to the usual cases of insect pests reported from various crops.
In general, the provincial work is preliminary and directed to ascertaining what are the pests of the province and how far they are destructive. Only in Madras is the work so far advanced that an accurate statement of the crop-pests can be prepared and a reasonable estimate formed of the possibilities of developing the work. In almost all provinces, progress has been made in coping with crop-pests as they occur in serious outbreaks, but in almost all the work requires systematising on a permanent basis that will conduce to steady progress and eventual thoroughness. Much advance cannot be achieved while the present staff in the provinces is limited to eleven assistants and the direction of the work is in the hands of various officers in the Provincial Departments who have other work to do and who do not want additional staff to look after.

Correspondence.—As in previous years, there has been a large volume of enquiries on all matters connected with insects; the enquiries connected with insects attacking crops have been mainly diverted to the Provincial Departments, but a large mass of miscellaneous enquiries has been received and dealt with. A part of these are from official sources, exclusive of the correspondence with Provincial Agricultural Departments, but a large part also is from the general public; they deal with garden and fruit pests, household pests, insects in grain and timber, insects on domestic animals, insecticides, spraying machines and the identification of insects. The parcels of injurious insects sent in numbered 117. A total of 1,255 enquiries came from official and public sources and at least as many again from planters and others in close touch with the section were answered demi-officially without record. The enquiries with regard to silk numbered over 1,000 and there were many concerning bee-keeping and lac. So far as possible, these are answered by reference to publications, or by the despatch of a leaflet or reprint but they are of such wide range that a very large number must be answered fully and this occupies much time. I hold this work to be of very direct value and I believe every enquiry has been fully and promptly met to the best of our ability.
Research.—Progress has been made with enquiry into the life histories and habits of injurious insects. The more important have been the Palm-weevil, and Rhinoceros beetle, the Army worm, the Rice Swarming Caterpillar, the Deccan Grass-hopper, the Wheat Stem-borer, the Pink Boll-worm, the Indigo Leaf-webber, the Dusky Cotton Bug, Wheat weevil, Rice grain moth. A more careful enquiry into the white ant problem has been commenced partly at Pusa, partly at Hoshangabad in conjunction with the Deputy Director of Agriculture, Northern Circle, Central Provinces. In collaboration with the Imperial Agricultural Chemist, the enquiry was continued into the relation between weevil and the percentage moisture of wheat. The enquiry into the food of birds by Mr. C. W. Mason was brought to a conclusion and the results will be published. The new insecticide was thoroughly tested and is now on sale. An increasing number of patent insecticides have been referred here for trial and report; these have been tested and, with the check afforded by the analysis of the Imperial Agricultural Chemist, reported on as to their value for Indian conditions. Only one has proved to be of any value for this country and, with this exception, the insecticides introduced by this Department are those at present in use; arrangements are made for their sale and we maintain a register of the places where both insecticides and all patterns of spraying machines can be purchased, so that enquirers can be at once referred to the proper places. Until private enterprise finds this business worth taking up, the trial of insecticides and sprayers must be done here and arrangements made for their sale. The question of apiculture is still being considered and further attempts are being made to determine how far bees will thrive and be profitable in the plains.

Sericulture.—The cultivation of Eri silk was continued and all processes to the production of the finished cloth carried on. Three weavers, an average of twelve spinners and cleaners, and about fifteen rearers are constantly
employed and we endeavour to produce every variety of cloth that is likely to be made of this material. The course of training was given to 19 persons, mainly those who wish themselves to take it up as an industry or the employees of those who are commencing the industry. The Pusa Continuous Spinning Machine was perfected and arrangements made for its sale. Assistance was given to the inventor, Mr. R. W. Coryton, of a very ingenious machine for cleaning the cocoons prior to spinning and this machine is now being sold. Every process from rearing the worms to weaving the cloth is being conducted in the silk house, so that visitors can see and quickly understand the whole process. The demand for seed has been very large (in one month 2½ million eggs were sent out) and arrangements were made for an exchange of seed between rearers in different parts of India, this section being the medium for effecting the exchange. Seed was supplied from Pusa to as many persons as possible, but the demand was far in excess of what could be supplied. Many hundreds of persons have given a trial to the industry and while many have, for the present, stopped owing to the absence of any means of disposing of small quantities of cocoons, many are continuing successfully. No attempt was made by this section to popularise or to draw attention to this industry except in Tirhoot, with the sole exception of the publication of an article in the Agricultural Journal of India; yet hundreds of enquiries have come in, from every part of India except Assam, and it is evident that, if there was the organisation to help, advise and buy small lots of cocoons, the industry could be taken up on a very large scale, affording light remunerative work to women and children which they take to readily. In Tirhoot, an attempt was made to induce the Behar Indigo Concerns to serve as buying centres for the hundreds of small lots of cocoons that were being offered but this has failed. Many Tirhoot rearers are still carrying on the industry in order to make and sell cloth but at the commencement all small rearers want to sell cocoons. The industry is establishing
itself, as centres for buying cocoons develop naturally and as the rearers take to making cloth. It is evident that the larger land-owners must take it up first and that the small cultivators cannot do so without some organisation to dispose of their products. It is also necessary at first to be in touch with Pusa or some other centre that can advise and help. The industry is most extensive at present in Tirhoot, Bhagalpur and Patna, the three divisions nearest to Pusa but is being tried also in Malabar, Dharwar, West Coast, Gujarat, Kathiawar, Sind, Patiala, Rohilkhand, Betul, Chanda and Murshidabad. The Salvation Army has also taken it up at Bangalore and elsewhere. Enquiries were made from silk spinning firms in England, France, Switzerland and Japan as to the value of Eri silk cocoons for industrial use there; one Indian silk spinning mill is spinning Eri silk yarn of fine counts, which is being used for weaving in India; but until there is some organisation for collecting and selling large quantities of cocoons, the industrial uses of this material cannot be developed. In this question, we have had the assistance of Mr. Drieberg of the Ceylon Agricultural Society, who is interested in the same problem. Trials are being made at Pusa with hybrids between *Attacus ricini*, the Eri, and *Attacus cynthia*, the wild form; these are not encouraging but may yield a more robust race. The disease of Eri worms which is occasionally a serious and inexplicable factor, is being investigated in collaboration with the Imperial Agricultural Bacteriologist and trials are being made of the various varieties of castor for feeding the worms.

Mulberry silk cultivation was continued mainly to determine how far it can be profitably taken up either to provide raw silk, or to supply cocoons. All available varieties have been collected at Pusa for hybridising. The rearing of the best Italian and French varieties has been very successful; the rearing of the ordinary Bengal varieties has shown that they are not worth cultivating in Behar, and the cultivation of a hybrid between the European univoltine worms and the Bengal multivoltine is
giving good results. The problem of increasing the supply of good cocoons for reeling is of very great importance and there is good reason to believe that very much better cocoons could be produced on a large scale if the industry were developed on the right lines. The experiments of the Bengal Silk Committee and those carried out at Pusa show that success is probable, but that it will take time and organisation to develop the supply and keep rearers on the right lines; failure in inevitable if the present Bengal varieties are cultivated as the silk is almost unsaleable and not worth growing and reeling in new localities. The present experimental work is very satisfactory and the very depressed condition of the silk industry fully justifies the employment of a proper staff to complete and develop these lines of improvement.

Lac.—The cultivation of the lac-insect on *Ber (Zizyphus Jujuba)*, *Siris (Serissa alomeruta)*, etc., has been carried on as before and two short courses of training were given to ten students from Bengal, Hyderabad (Deccan), the Punjab, the United Provinces, Kathiawar and Jodhpur, as well as to *malis* from factories in Tirhoot. Lac for seed was supplied to the Bombay and Baroda Departments of Agriculture, to a Court of Ward's Estate in Orissa and arrangements have been completed for forwarding the same to Formosa through the Japanese Consul at Bombay. The most important work of the past year was an enquiry into the races of the lac insect in collaboration with the Forest Department which sent in samples from all parts of India and Burma. The samples are being collected, arranged and forwarded to Mr. E. E. Green, the Government Entomologist, Ceylon, for examination. The number of enquiries regarding lac cultivation in India increased considerably and every assistance was given to those wishing to start it on waste lands in agricultural areas.

Demonstration.—The series of coloured plates of pests has been added to and copies circulated to all Provincial Departments, to the Bombay Natural History Society, the Quetta Museum, the Madras Museum, the Bishop Cotton
School, Simla, the Indian Gardening Association, Calcutta, the Central Agricultural Committee of Madras, the Ceylon Agricultural Society, Colombo, Department of Agriculture, Baroda State, Mycologist and Entomologist, Mysore State and the Director, Educational Section, United Provinces Exhibition, Allahabad. These plates are being utilised in demonstration in all provinces and in vernacular and other publications in Bengal, Eastern Bengal and Assam, Bombay, the United Provinces and the Central Provinces. They are also used in preparing show cases of crop pests for exhibitions, shows, farms, etc. Sample show cases have been prepared and sent out; all Entomological Assistants have been trained in preparing them and it is now only necessary to complete the series of plates to cover: all crop-pests, beneficial insects and such useful insects as silk, lac and bees. Trials are being made of coloured lantern slides of these plates to enable lectures to be given at agricultural shows, etc. Assistance was given in preparing show-cases and exhibits for the agricultural section of the Lahore Exhibition and a working exhibit of Eri and mulberry silk was sent to the Muzafferpur Exhibition.

Insect Survey.—Less time has been given to the work with the general collection, only new accessions being placed and arranged. The students' working collection has been very much added to. Collections have been sent away for the use of authors of coming volumes of the Fauna of India. These include the Collembola, Orthoptera, Mallophaga, Braconidae and Ichneumonidae, Neuroptera, Odonata, Dynastidae, Rutelidae and Cetoniidae, Cantharidae, Curculionidae, Microlepidoptera, Thysanoptera, Rhynchota, Heteroptera and Homoptera. Further collections were identified and arranged for the Bombay Natural History Society, and specimens were identified for private collectors, for the Madras Museum and the Quetta Museum. Similar collections were made up and identified for Provincial Agricultural Colleges and a large mass of identified material is available for distribution.
Miscellaneous.—The Imperial Entomologist is President of the Entomological Section of the Bombay Natural History Society and lectured to the Society in September. All entomological enquiries sent to the Society are referred to him and insect specimens sent in for identification are referred to Pusa. The Imperial Entomologist also acted as Chairman of the Indian Sub-Committee of the International Congress of Entomology to be held at Brussels in 1910. An exhibit illustrating the work of the section was sent to the delegate for India, Mr. F. M. Howlett, Second Imperial Entomologist. Assistance has been given to the Government of Japan in regard to Eri silk and lac and the latter insect is being introduced into Formosa. The improvements made in the treatment of Eri silk have been communicated to the Ceylon Agricultural Society. Parasitised cotton boll-worms were sent to Ceylon and Egypt to introduce the parasite; live Eri cocoons were sent to Ceylon, China and Formosa, and live tussur cocoons to Egypt; Eri cocoons were also sent to England and France, the former in order to be crossed with A. cynthia, to improve the race. In exchange, cynthia cocoons were received at Pusa for the same purpose.

Programme of work for 1910-11.—The work of the past in studying and advising on crop-pests will be continued. Assistance will be given, when desired, in directing the work of provincial assistants, in coping with outbreaks of crop pests and in organising exhibitions for agricultural shows. Assistance is being given in the entomological exhibits at the Allahabad Exhibition. The issue of coloured plates is being continued and coloured lantern slides for lectures will be issued for trial. Further work on apiculture will be done and the short courses of instruction in Eri silk, mulberry silk and lac continued. The progress of the Eri silk industry will be assisted specially with a view to finding foreign markets and to the using of the material for products required in India. The question
of growing better races of mulberry silk for supply to the Bengal filatures will be further tested and the general question of improving the silk industry investigated.

Publications.—The edition of Indian Insect Pests is exhausted and the progress for the last four years makes a new edition necessary. A revision up to June 1909, has been translated into Bengali by the second assistant, Mr. C. C. Ghosh, and published in Calcutta. Applications for permission to publish other translations have been referred to the respective Provincial Departments as a revision of the text is required and the staff at Pusa cannot translate into all vernaculars. "Indian Insect Life" has been issued and is now available for all students and workers in Entomology. A list of other publications is attached. This is smaller than it might be, but the time has not been available for preparing more and the issue of these has entailed much work that should not fall on the staff of this section.

PUBLICATIONS.

Indian Insect Life. (Text-Book.) September, 1909.
Fasaler Poka. (Test-Book.) September, 1910.
Instructions for rearing Eri Silk. (Leaflet in English, Hindi, Bengali.) January, 1910.
Vernacular Names of Insects. (Bulletin in press.)
Tukra Disease of Mulberry. (Agri. Journ. Ind. and Bengal Agricultural Journal.) April, 1910.
Three Journal Reviews.
(E. J. Butler, M.B., F.L.S.)

Charge and Establishment.—Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, held charge of the Section until December 27th, 1909, when I returned from leave. Mr. McRae joined his new appointment as Mycologist to the Government of Madras immediately after; his loss was much felt, but he has taken charge of mycological work in a province which is second to none in India in the number and magnitude of its fungus diseases of plants. His successor, Mr. F. J. F. Shaw, B.Sc., A.R.C.S., joined his appointment on January 28th, 1910. The vacant post of first assistant was filled by Mr. J. F. Dastur, B.Sc., on May 14th, 1910. Mr. J. H. Mitter, second assistant, was appointed Assistant Professor of Mycology in the Punjab Agricultural College, Lyallpur, from June 1st, 1910. The remaining members of the laboratory staff have each received promotion as a consequence. All have done good work. Messrs. J. H. Mitter and S. N. Mitra have given material assistance in the training of students and in general laboratory work; the latter, Mr. A. Hafiz Khan and Munshi Inayat Khan in field work and on tour; while Mr. Hafiz Khan, by his keenness and capacity for independent research is proving a valuable assistant. In Munshi Inayat Khan we have one of the most useful types of native botanical assistants; without any English education, he has yet an almost phenomenal knowledge of indigenous plants gathered during long service under Mr. Duthie in the Saharanpur Herbarium and as a collector in all parts of Northern India. He is in charge of the herbarium and collections, which are well kept up. The Bengal Mycological Assistant worked in the laboratory pending the provision of accommodation for him at Bhagalpur, until April 14th, 1910.
2. **Training.**—Nine students in all received instruction during the year. Of these two were second year students undergoing the full course. Their training ended on March 31st, 1910. Three were members of the Punjab Agricultural Department and received elementary instruction as part of a general agricultural course. As the Provincial Colleges are now in a position to teach elementary mycology, it is not expected that any more students of this class will be received. The student under training as Mycological Collector for Eastern Bengal finished his course on March 2nd, 1910. A Forest Ranger was deputed from the Punjab for an elementary training in the diseases of fruit and forest trees, and a private student from Oudh received a short course in fruit and vegetable diseases. Only one student (private) joined for the full two years' course at the beginning of the new term, June 1st, 1910, and he has since abandoned it. The three senior students took up about half my time in January, February, March and June, chiefly in the preparation of the lectures.

3. **Accommodation.**—The capacity of the general laboratory for students and assistants has been taxed at times, especially when several have been simultaneously engaged in original work. For a time eleven were working in the one room, which is too many for the space available. A portion of the clerk's room has been fitted to relieve pressure in the laboratory. The chief requirement at present is a small outside room with enclosure attached for inoculation and pot-culture experiments. The herbarium has been largely added to (364 named sheets), and has ample space for subsequent expansion in a room on the 1st floor. Improvements were made in the sterilising and culture rooms.

4. **Aid to Provincial Departments.**—Collections of named fungi, chiefly parasitic, have been furnished to the Madras, Punjab, Bengal and Eastern Bengal and Assam Departments. Duplicate collections made in Bombay and Burma have been identified as far as possible and the determinations forwarded to these Departments. This work
will be continued so as to provide a nucleus for a mycological herbarium in every provincial college. The detailed syllabus for an elementary course of lectures and practical work in Indian Mycology, drawn up last year, is being utilised as a basis for the mycological instruction in several colleges. The recommendation of the Board of Agriculture of 1908, that each province should have at least an Assistant Professor of Mycology and one other assistant is being worked up to fairly well. Besides Madras, which has now its own Mycologist, Mr. McRae, with one scientific assistant, Bengal, Bombay and the Punjab have each an Assistant Professor of Mycology attached to its college, the two former having a Mycological Assistant as well. The Central Provinces College has a Mycological Assistant, and Eastern Bengal a Mycological Collector. All these, except the Bombay Assistant Professor, have been trained at Pusa.

5. Research Work. Blister Blight of Tea.—This was the most important new work taken up during the year. The disease, which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909 it extended, and the Darjeeling Planters' Association asked for the assistance of Pusa. Mr. McRae spent a considerable time in a local investigation of the blight. The life-history of the fungus (*Exobasidium vexans* Massee), before imperfectly known, was fully worked out and an extensive series of experiments on remedial measures undertaken. As a result of these, definite recommendations were made for the cold weather of 1909-10 and general measures for the control of the blight advocated. The results of the work were communicated in two reports to the Darjeeling Planters' Association, by which body they were printed for circulation to the planters concerned. In the present season, the blight is continuing to spread and already threatens the Dooars and Terai. Its progress will be watched with great anxiety by all interested in tea. It is feared that the climatic conditions prevalent in these districts will induce
greater virulence than anything known in Assam, but this will not be known with certainty until the close of the present or perhaps another season. A popular account of the disease is given in the Agricultural Journal of India for April, 1910, and a fuller report is in the press as a bulletin.

*Other Tea Diseases.*—Mr. Shaw is engaged in the study of the obscure canker of tea, which has long been known but the cause of which is still not ascertained. A disease of tea seed was investigated, but the cause was not definitely discovered.

*Palm Disease.*—The campaign having as its object to prevent the spread of the bud-rot of palms on the East Coast and to stamp it out within the affected area was prosecuted with energy by the executive officer in charge, Mr. W. K. Green, Special Deputy Collector, Godavari District. I accompanied Mr. McRae, to whom the scientific control has now passed, and Mr. Green on a short tour of inspection early in the present year. Recommendations for continuing the work have been made, especially for its energetic prosecution in Kistna District, where it has been neglected in spite of repeated warnings. Mr. Green was put in charge of work in Kistna as well as in Godavari from January last and this led to better work. A full account of the disease and measures taken to check it is in the press as a memoir. Mr. McRae enquired into a disease of palms at Bapatla in December but found it was not fungal. The coconut root disease in Travancore mentioned in last report is engaging the attention of the newly started Agricultural Department of that State, and measures have been taken on the lines suggested to prevent its spread. The cultivators of neighbouring districts have been warned through vernacular pamphlets of the danger of introducing certain coconut produce from Travancore.

*Sugarcane Diseases.*—The work in connection with these has not yet reached the stage of publication. Field experiments on the methods of infection of red rot having developed unexpected difficulties, it will probably be neces-
sary to continue in pot culture. Nothing has occurred to shake the opinion advocated by this section that it is primarily a disease conveyed in the sets and it is encouraging to report that scarcely a trace of it could be found at Samalkota Farm in the last crop. Similarly at Pusa there is ordinarily little, except near where the inoculation experiments are in progress. These results are believed to be due almost entirely to the methods of set selection recommended in 1906. There is, however, a good deal still to be elucidated. The life history of three undescribed sugar-cane parasites has been in great part worked out. One causes a root disease in certain varieties of cane at Samalkota; its study has been carried out chiefly by Mr. Hafiz Khan, who has also investigated a leaf disease at Pusa. The third is prevalent in Behar. Work on sugarcane smut was continued.

Wilt-Diseases.—The results of the work of several years on the wilt disease of pigeon pea were issued as a memoir early in 1910. No opportunity arose for the study of other field crop wilts still awaiting investigation. In November, Mr. McRae visited the Wynad at the request of the United Planters' Association of Southern India to investigate the pepper-vine wilt. He was accompanied by Mr. R. Anstead, Planting Expert to the Association, in conjunction with whom a scheme of experiments in the treatment of the disease was drawn up. As the cause, and indeed the whole history of this disease are still obscure, little advice of real value to pepper planters can be given as yet.

Ginger rot.—The investigation of this disease, caused by *Pythium gracile*, was continued by Mr. McRae, who visited Rangpur, Eastern Bengal, twice during the season. It is the principal trouble connected with ginger growing in this district and in Gujarat. It is hoped to publish an illustrated account shortly, with suggestions for treatment. Experiments so far appear to indicate that it is possible to check it by careful seed selection and rotation.

Fruit Diseases.—The survey of diseases of temperate fruit trees in India, was continued, chiefly from material
collected in Kashmir in 1908. Wither tip of citrus trees occurred at Pusa and experimental treatment was carried out. Other citrus diseases are under study at Pusa. A papaya disease which has killed a number of trees at Pusa was studied by one of the students and Mr. Mitra, but the work is not yet ready for publication.

Forest Tree Diseases.—As usual a number of these were investigated for the Forest Department and other persons. The chief of interest was Fomes lucidus, a probable parasite of several valuable trees including Shisham (Dalbergia sissoo) and Areca palm. An illustrated note on this was written for the “Indian Forester.” The well-known parasite of the Himalayan blue pine, Trametes Pini, was discovered for the first time attacking deodar near Simla. Mr. Hafiz has been occupied in an attempt to determine the manner of spread of this fungus from specimens forwarded by the Imperial Forest Botanist.

Other Plant Diseases.—Two diseases caused by species of Phytophthora were investigated by the senior students under supervision. The life history of Phytophthora Colocasiae was worked out. The other, which attacks seedling castor, appears to be undescribed previously. The work will be published after some further necessary study. Several cases of disease of important crops caused by the root-rot fungus, Rhizoctonia, were studied. Jute, potato, linseed, tomato, brinjal, castor and some pulses are amongst the plants attacked by this fungus, the existence of which in India has only recently been ascertained. An illustrated account of the leaf spot of turmeric, due to a new species of Taphrina, has been prepared for publication. Specimens of rice bunt, caused by Tilletia horrida, were received from Germany, on rice said to be of Indian origin. As this disease has only been reported from Japan and the Southern States an enquiry is being made as to its possible occurrence in India, especially Burma. The disease of
Para rubber trees due to *Corticium javanicum* was reported from estates in South India. Other rubber tree diseases were received from Burma. The examination of and reporting on these and many other diseases of crops and economic trees formed a large part of the routine work of the section.

*Systematic work.*—This was prosecuted as time allowed but the progress made was small owing to pressure of other work. As the demands from the Provincial Colleges for correct determination of their parasitic and other fungi are increasing, it is hoped to give more time to the subject than has been possible recently.

*Miscellaneous.*—Eight show-cases illustrating characteristic fungus diseases of plants were prepared for the Lahore Exhibition and six for the Bengal Department to exhibit at shows. Suggestions were made for regulations for the control of the importation into India of plants or parts of plants likely to introduce dangerous fungus diseases. Mr. Shaw assisted the Imperial Bacteriologist in the laboratory work in connection with Eri silk-worm disease.

*Programme of work for 1910-11.*—It is proposed to resume the work on soil fungi if time allows.

The work on the wilt diseases of crops, especially of indigo and cowpea and, if opportunity occurs, of cotton, gram and sesamum, will be continued.

The investigation of sugarcane diseases is being continued and the new results will be published.

It is hoped to obtain more information regarding the occurrence of *Rhizoctonia* on the crops mentioned above and to investigate its life history and treatment.

The study of the diseases of papaya, castor, colocasia and rice mentioned above, of tea canker and of heart-rot of blue pine will be continued.

The study of some anthracnoses of pulse crops will be continued.
It is hoped to work through another portion of the collections and to publish the determinations.

The training of students in Mycology will be continued. No student is taking the full course this session.

PUBLICATIONS.

Fomes lucidus (Leys) Fr., a suspected parasite. E. J. Butler. Indian Forester, September 1909.


The principal work of the Section for six months during which I have been in charge has been directed towards a general examination of the bacteria in the soils of Pusa. The scheme of work has resolved itself into:

(1) Observation of occurrence and activity of bacteria at varying depths in the soil—
   (a) with regard to varying species;
   (b) with regard to their relations to soil chemistry.

(a) Determination of the species occurring in soils naturally involves a large amount of culture work extending over a long period of time, and has only been undertaken in consideration of the absence of information on this point so far as Indian soils are concerned. It is hoped that further experience gained in this way will enable a distinction to be drawn between those species whose widespread occurrence and activity makes them of importance from an agricultural standpoint, and others whose restricted development renders it unnecessary to study their characters from this point of view.

In addition to cultures made from samples obtained by boring, observations have been carried on periodically as to the bacterial content of soils in the Botanical Section especially those under experimental treatment by "weathering"; it is hoped that some light may be thrown upon the causes underlying the differences resulting from this method of dealing with soils.

The ordinary cultural methods of differentiation have been somewhat restricted by the impossibility of using gelatine owing to the high temperatures at Pusa in the
months of March, April, May and June. It is hoped that it may be found possible in the future to establish a hill station laboratory, where this difficulty may be eliminated during the hot season.

(b) The distribution and activity of the nitrifying organisms has been studied closely in samples taken from various depths and localities. The value of the information acquired has been considerably discounted by the contamination of some of the cultures owing to the absence of a suitable room for carrying out inoculations and withdrawing samples. During the dry hot months the air is charged with dust particles carrying innumerable bacteria and the periodical withdrawal of samples from the culture flasks is attended with great risk of infection of the latter, when conducted in the open laboratory. A suitable room, capable of being isolated from the general laboratory and kept free from dust and currents of air, was selected early in February, and arrangements are being made to have it converted for this purpose.

Active nitrification has been observed in borings from the plots attached to the pot culture house down to a depth of 24 inches, the greatest amount taking place in the second six inches. The samples were taken in February, when the dryness of the surface soil would naturally depress the general level of bacterial activity.

It is of interest to observe that salts of magnesia have been found to inhibit nitrification entirely in Pusa soils when the latter are seeded into liquid media. This effect is being further investigated with a view to determining its underlying causes. Samples have been obtained from borings to a depth of nine feet and it has been of interest to discover the relatively enormous numbers of bacteria present in the Pusa soils and their occurrence in the samples taken from the lowest depth, it having been found necessary to use dilutions of one in one hundred thousand in order to obtain a workable number of colonies in plating.
Some work has been done on nitrogen fixation in certain soil samples, but only of a tentative nature, fuller consideration of the subject being postponed until such time as my assistants have acquired more knowledge of bacteriological methods. It is proposed to make exhaustive enquiries into the distribution and characters of nitrogen fixing organisms in Indian soils, as it seems probable that this source of nitrogen is of prime importance and may even afford possibilities of control in actual practice, either by actually supplying such organisms to soils in which they are deficient, or, as the more hopeful means, by adopting methods of agricultural practice which would allow of the fullest development of those already naturally present.

*Disease of Eri Silk Worms.*—At the request of the Imperial Entomologist, a lengthy enquiry into the causes producing a very high mortality amongst Eri Worms has been undertaken, and is still in progress. The disease, the symptoms of which resemble those appearing in Flacherie of the Mulberry Worm, is associated with the presence of a bacterium, pure cultures of which have been made from the gut of diseased worms; attempts to establish the pathogenicity of this bacterium for Eri Worms, by feeding with leaf sprinkled with water shaken up with the cultures have so far failed to give decisive results. From enquiries made in Assam in the course of a tour undertaken with the object of enquiring into this matter, it appears that the disease, although known to native sericulturists, is considered due to defective feeding and management and not to be of the nature of an epidemic. Further experiments will be carried out with a view to determining the effect of varying food materials and feeding methods. Numerous sections of the intestine of normal and diseased worms were made by Mr. Shaw of the Mycological Section, showing the defective digestion characteristic of the disease and the development of the bacteria in the gut. These illustrate clearly the differences in the digestive processes incident to the disease, but it is not certain whether the increased number of bacteria is a cause or an effect of the
abnormal condition, although it appears probable that they contribute largely to the final result.

In connection with this enquiry, cultures were made from eggs of the Eri moth, which in many cases were found infected with a bacterium, differing however in cultural and morphological characters from that found in the gut of the diseased worms. Eggs of the same brood hatched out successfully forming healthy worms, but the next generation became diseased and died off. Further enquiries will be made as to the transmission of disease by inheritance.

The efficacy of Trope-Ratine, a patent vermin killer specially prepared for use in India, was tested at the instance of the Director. Rats fed on this material appeared to benefit from its nourishing qualities but were otherwise unaffected. One mouse, however, succumbed and was subsequently eaten by the rats without ill effects to the latter. It appears probable that the material had been kept too long since its preparation to retain its original virulence, a period of nearly five months having elapsed since its despatch from England.

I took over charge of the Section on 27th December 1909. As no previous establishment had been formed a Third Assistant was appointed, Mr. C. S. Rama Aiyer, previously acting as an assistant in the Chemical Section here. Subsequently in May, Mr. N. V. Joshi, who then held the post of an assistant under the Agricultural Chemist to the Government of Bombay, at Poona, was appointed as first assistant. The post of a second assistant is still vacant. Owing to the impossibility of obtaining qualified bacteriologists at the small rate of pay provided for this Section, I have been obliged to appoint men without any bacteriological qualifications; this necessarily results in most of my time being spent in training my assistants in the necessary technique, and this will of course retard the progress of the various investigations which, I hope, to carry out. Owing to the very special
nature of bacteriological research, a lengthy course of training and wide experience of the methods in use is necessary before any student can hope to do research work of any value on this subject, and I wish to record my emphatic opinion that in view of the admitted fact that adequate knowledge of the bearing of the biological factor on soil fertility is of prime importance in agricultural practice, it is highly expedient that the work of this Section should be facilitated by the addition of a trained Supernumerary to my staff.

Programme of work for 1910-11.—In addition to the work indicated in the following programme already submitted to the Board in February, certain special subjects for investigation will be taken up as occasion arises and opportunity permits. Of these, the further work necessary on the disease of Eri Silk Worms, and any special work on bacterial diseases of plants, will be leading features.

The Biological aspects of tillage in Indian soils.—This will involve investigations extending over a prolonged period, the basis of which would include a general investigation of the bacterial content of Indian soils.

Concurrently with this general investigation special observations will be made with the intention of determining the biological factors underlying certain problems of agricultural interest such as those connected with the custom of embanking wheat lands. They will also include enquiries into:

(1) The biological aspects of the availability of plant food in soils.
(2) The biological factors concerned in the decomposition of organic matter in Indian cultivated soils.
(3) Biological aspects of:
   (a) Green manuring in India.
   (b) "Weathering" of soils.
   (c) Effect of ploughing land when too wet, before sowing.
No. (1) will be carried out in collaboration with the Imperial Agricultural Chemist, No. (2) in collaboration with the Imperial Mycologist, and No. (3) in collaboration with the Imperial Economic Botanist.
REPORT OF THE IMPERIAL COTTON SPECIALIST
FOR THE YEAR 1909-10.

(G. A. Gammie, F.L.S.)

I held charge of the appointment throughout the year. From the 6th to the 9th July 1909, I visited Bombay to discuss work in cotton with some of the principal merchants there. From the 26th to the 28th July I visited Jalgaon to advise regarding the cotton section of the Exhibition to be held in the following January; from the 13th October to the 11th November I visited the Garo Hills, Dacca and Chittagong in Eastern Bengal at the invitation of the Agricultural Department; from the 12th to the 27th November I visited various parts of Bengal in company with the Economic Botanist with whom I discussed the future line of work to be conducted in his province. From the 28th November to the 7th December I was in the Central Provinces arranging matters with the Deputy Director of the Southern Division, from the 14th to the 16th December I met the Deputy Director of the Northern Division at Harda and settled with him the details of future trials in his division, from the 18th January to the 23rd January I visited the Farms of the Southern Maratha Country with Mr. Clouston, Deputy Director of Agriculture, Southern Division, Central Provinces, and Mr. Main, Deputy Director of Agriculture, Bombay. From the 26th January to the 5th February I attended the Jalgaon Exhibition where I took charge of the Cotton Section and discussed matters of interest with merchants and cultivators of Khandesh and Berar. From the 17th to the 21st March I visited places on the hill tracts of Belgaum and Dharwar to ascertain the progress of experiments with buri cotton. From the 1st to the 5th May I visited Cawnpur at the invitation of the Economic Botanist to advise regarding his experiments. From the 21st June till the end of the month I
toured with the Deputy Director of Agriculture, Bombay, and discussed minutely with him the results of the trials achieved so far by him.

The following are the notes and reports drawn up by me and they embody the information and impressions gathered on the more important aspects of the cultivation of cotton in the provinces:

**Eastern Bengal and Assam.**—In company with Mr. Hector, I have completed an enquiry on the cultivation of cotton in the Garo Hills and Chittagong Hill tracts. In a note on the subject of cotton by Mr. Hart based on his visit to the Chittagong Ginning Mill, he states that "one of the important problems to tackle is to find out (1) whether that of the Garo Hills is a better jat than those grown in the Chittagong Hill tracts or (2) whether the difference is due simply to soil and climate."

Probably all the hill cottons belong to *Gossypium neglectum*, var. *Assamica* of Watt in his "Wild and Cultivated Cotton Plants of the World." The most perfect form found in the Garo Hills is a very large boled plant but a smaller boled variety is also found. This Garo Hill cotton is pronounced to be the finest grown in the Hill tracts of the Provinces and its staple often reaches from $\frac{3}{4}$ to 1 inch in length. It must be remembered, however, that it is not used in commerce as cotton but as a substitute or adulterant in wool manufacture and that any attempt to improve it from the point of view of the cotton merchant would result in a serious diminution of price as it would then at once come into competition with the inferior grades of cotton which are so largely produced in some parts of India more accessible to the markets.

In the Chittagong Hill tracts and probably in all the other tracts also, a small boled form is common. The cotton is shorter in staple than that of the Garo Hills and the percentage of cotton to seed is lower. We were informed by the American Missionaries at Tura who take special interest in cotton cultivation that they had been
unable to rear tree cottons. Taking into consideration the heavy rainfall of the Hill tracts, it is obvious that any experiment towards the introduction of ordinary commercial cottons, which seldom tolerate a rainfall of more than 40 inches, is doomed to failure. They have, however, promised to undertake trials with buri and Cambodia which are known to withstand heavy rainfall but even in the remote event of their success, it is difficult to imagine that they would thrive under the peculiar system of Jhum* cultivation which, from all accounts, gives the indigenous plant exactly the conditions it requires. Mr. Hutchinson, the Superintendent of the Chittagong Hill Tracts, informed me that he made a trial with buri cotton. The plants made a good growth and looked so well during the vegetative period that the cultivators were favourably impressed with its possibilities, but finally it refused to form bolls and thus was absolutely unproductive.

There is, of course, no doubt that the Garo Hill cotton is the best and the proprietor of the Ginning Factory at Chittagong classified the cottons according to value as follows:—

(1) Garo Hill or Chilmari; (2) Jala from Lamding, (3) Bong from Chittagong, (4) Cachari and Comilla. The difference in price to the cultivators between the best and the worst varieties may be only Re.1 per maund, while at the same time, it is understood that this may mean at least Rs. 4 or Rs. 5 to the merchant.

So far as I can gather, and I presume this to be correct, there are scarcely any appreciable differences of climate in these tracts and the rainfall is very heavy. The superiority of the Garo Hill cotton may be due to the great proportion of lime in the soil as calcareous rocks abound. I would suggest that samples of soils be procured from Jhums* in the Garo Hills and Chittagong Hill Tracts for the determination of this point by the Agricultural Chemist. At the same time, it would be interesting if he could dis-

* Temporary fields made in a forest by cutting down jungle and burning it over the land.
cover the reason why Jhums require such a long period of rest. The mixture of crops in a Jhum seems to be regulated in such a way that each comes to maturity successively. Cotton is the last to do so and when ripening, it covers the ground at about the correct density for the production of a full crop. I learn from Mr. Hutchinson that he has tried the cultivation of Garo Hill cotton on the initiative of Messrs. Ralli Brothers and, in his opinion, the resulting cotton was in no way different from that of the prevailing variety of his district. Mr. K. C. Dewan, Sub-Deputy Collector, says the average acre outturn in Chittagong is 400 to 480 lbs. of seed cotton, while the average of 9 cropping experiments in the Garo Hills gives 500 lbs. of seed cotton and 25½ lbs. of clean cotton. This is a percentage of cotton to seed of nearly 51. Taking the Chittagong cotton to have an average of 40 (and it is certainly not more) the acre outturn of clean cotton would only average 176 lbs., leaving an excess in favour of Garo Hill cotton of 78 lbs. per acre. From the bazar rates that I have been able to obtain, it appears that all the seed cotton is paid for at about the same rates while it is obvious that from its superior quality and higher ginning percentage, the buyer should give a higher price for Garo Hill cotton. At present, I understand that the cotton trade is in the hands of native merchants who make advances to the cultivators on the security of the crop and that the method of disposing of the produce finally to Europe is doubtful.

In conclusion, I would recommend (1) that no alteration should be made in the type of cotton grown as the experience of generations has taught it to be the only sort capable of growing under the excessive rainfall and the primitive agriculture of the Hill Tracts; (2) that any selection to be done should be undertaken with the view of increasing the length of the staple, and the percentage of cotton to seed, but not, however, with the idea of modifying the special characteristics of the product; (3) that the Garo Hill cotton should be experimentally introduced
into all the tracts so that it can pass under the judgment of local cultivators and the Chittagong cottons should also be tried on a small scale on the Garo Hills to find out whether the change of locality will affect it as regards size of bolls and quantity and quality of produce. All experiments should be placed under the supervision or control of some officer in the Agricultural Department, as work of this nature, when conducted by men with no training in agriculture, is either neglected or fails through lack of the necessary knowledge.

I have discussed cotton matters freely with Mr. Hector, the Economic Botanist, and he is in possession of my views.

Bengal.—There are three species of Gossypium cultivated in Bengal, viz., (1) the late variety, G. intermedium, Todaro (probably), said to be grown most largely as a mixture with rāhar and other crops in North Behar; (2) G. neglectum Todaro, vars. Bengalensis and Kokatia, comprised in the “early variety” of the agricultural returns and (3) an early maturing form of G. hirsutum, called Buri. In addition to these, two American tree cottons—Bourbon and Brazilian or chain-seeded are grown sporadically for their cotton which is used for spinning the sacred thread. Throughout Behar, cotton seems never to be grown as a pure field crop, but only as a mixture with rāhar (Cajanus indicus). Probably little of the produce finds its way to the mills as the bulk is used for stuffing quilts and cushions and for other domestic purposes.

As regards projected experiments with a view of popularising cotton cultivation in Bengal only two species appear to hold out any promise of ultimate success. These are the intermedium and hirsutum.

According to Mr. N. C. Chaudhary who has devoted considerable attention to the subject of cotton cultivation in Bengal, the advantages of G. intermedium accrue from its heavy production and fineness of staple and its drawbacks are comprised in its long period of growth and low percentage of cotton to seed. The crop often occupies the ground until June or July, thereby delaying the cultivators
in the preparation of land for the bhadoi crop. The percentage of cotton to seed is said to be only about 20 and the outturn of clean cotton per acre from 50 to 150 lbs. The market rate of the cotton varies from Rs. 12 to Rs. 14 per Imperial maund. Mr. Chaudhary says, however, that owing to the shortage of the crop due to excessive rains, the price is this season at least Rs. 5 higher than usual and that Bhuri cotton has lately been bought by the Calcutta mills @ Rs. 30 per maund.

_G. intermedium_ is said to be represented by two forms, one _Deshila_ with small bolls and low percentage, the other _Bhogila_, with larger bolls and higher percentage.

By means of the usual methods of selection, it may be possible to improve these varieties (which are eminently suitable for the soil and climate of Bengal) in the points of which they are at present not quite satisfactory. I shall be obliged if Mr. Woodhouse, the Economic Botanist would undertake a trial on the Bhagalpur College Farm and perhaps Mr. Smith, the Deputy Director of Agriculture, might duplicate the experiment in one or more of his farms. The doubt as to whether these cottons will grow or not need not actually exist, the only questions involved are the possibility of increasing the outturn and percentage. At the same time, if samples are supplied to the Calcutta mills, it would be possible to decide whether or not these cottons are really worth growing. Areas of at least half an acre of each should be grown so that the outturns and percentages could be calculated on a fairly large scale and ample material would also be furnished for purposes of selection.

_G. hirsutum_, _Buri_, appears to have adapted itself admirably to the natural conditions of the higher lands of Bengal. In Central Provinces, the experience so far gained shows that it withstands a considerably higher rainfall than the local varieties, its outturn and percentage are high and the cotton is valued at the same rate as fine Broach which is accepted as the best of the cottons produced in India. In Bengal, it possesses the valuable charac-
teristic of being a short season variety and being of a low habit of growth it would not compete with a crop such as rahar. Its behaviour at the Chaibassa Agricultural Station proves that it thrives even under very unfavourable conditions. I would recommend that careful trials be made with this cotton in the way I have suggested above for G. intermedium and in the same localities. It was growing well on the Bhagalpur Farm and I can see no particular objection to its being grown on the Bengal plain. There is another cotton of almost the same characteristics known as Cambodia or Cochin China cotton. This is giving good results both in the Madras and Bombay Presidencies and I have reason to believe that it is still more resistant to heavy rainfall than Buri. If early application be made, a supply of seed could probably be obtained from the Deputy Director of Agriculture, Bombay Presidency, Poona.

As regards the two varieties of G. neglectum, I consider that they are scarcely worth dealing with, as they are no better than the common low grade cottons which predominate throughout the areas producing the so-called commercial Bengal cottons.

Of the tree cottons, Bourbon may be induced to yield as an annual crop, but it would be advisable not to exploit such an unsatisfactory class of plant.

If the officers of the Bengal Agricultural Department consent to carry out the trials I have suggested, they will not have to undertake a complicated task. They need merely study the possibilities of G. intermedium and G. hirsutum, the latter preferably in its two forms of Buri and Cambodia.

Central Provinces.—At the Telinkheri Farm, which I visited in the company of Mr. Clouston, the Deputy Director of Agriculture, the field of selected Buri looked extremely well and promised to be highly productive. Mr. Clouston had, with rare judgment, selected a type of plant with short, lower branches and I consider it very fortunate that at such an early period of the cultivation of
this plant he should have had the forethought to pick out what is clearly the best type of plant. I was also pleased to see at Akola that this type had been selected for growth on the seed farms. In Chutia Nagpur, the original Indian home of this variety of cotton, Mr. Woodhouse, the Economic Botanist in Bengal, and myself after examination of the mixed type in the field arrived at the conclusion that this was the type to work on and it was particularly interesting to see at Nagpur and Akola the facility with which this type perpetuates its character of growth. I consider that valuable work is being done in the improvement of cotton in these provinces by the rapid introduction of Buri. There is of course the danger of its failure in a season of drought, but in India success can only be attained by incurring a certain amount of risk.

I think that Mr. Evans, the Second Deputy Director of Agriculture, should carefully test the possibilities of this cotton within his charge. From favourable indications afforded by other indigenous varieties already there, I think, his trials will yield him good results. There is, however, at present great variation in the period at which plants ripen their bolls, some plants have completed the process before others have even started, but as all the cotton ripens well within the cold season, this circumstance is perhaps not one of practical importance.

Within the jari area, the variety Malvensis shows most promise. Bani grown at Akola being out of its natural element was actually priced lower than Malvensis at Jalgaon. This point is of considerable importance in its way as it goes to prove that Bani is the finest cotton in the Central Provinces and Berar only when grown in localities which have been found to be absolutely suitable to it, and care should be taken not to introduce it into tracts where the variety Malvensis of Jari is indicated as the safer plant to grow. Owing to its requirement for a heavier
rainfall than that prevailing in Jari tracts, Buri in time may supplant Bani or at least it may check the spread of Jari; so far as we can see at present, the latter will have no competitor. The only problem in its connection is to ascertain how the outturn of the fine varieties, such as Malvensis compares with that of the coarser.

I do not think that any type differing from those we already know will be discovered in this Province. Assuming this to be so, work in cotton should proceed on only a few lines and these may be summarised as follows:—

(1) The introduction of Buri to accompany Bani but by no means to oust Jari.

(2) The improvement of Bani in its percentage and outturn.

(3) The isolation of the different types of Jari (which has already been done) and the comparative value of each from the grower's point of view.

I would like to mention here that in my opinion a cotton plot should be at least an acre in extent as the details of outturn are of such vital importance. I find that on small plots too much attention is paid to individual plants and niggling selections are made in trifling differences such as minute variations in the length and quality of lint, etc.

The farmer and trader want to know the outturn and ginning percentage of the crop. The latter will not materially enhance his terms for trifling differences in quality and the former will insist on growing the variety which puts most money in his pocket. The cultivator loses money, however, through his predilection for sending dirty cotton to market. The merchant is often keener on making a good bargain than on paying the farmer higher rates for superior quality.

In addition to what he can secure from Mr. Clouston's long list of selections, I am arranging to supply Mr. Evans
with seeds picked from the best commercial samples obtained from his own division, and I expect he will shortly be in a position to carry through his demonstrations rapidly and soon reach the cultivators. From what I can gather, some of the cottons of his division are already considered good so that his task is simplified to a certain extent.

In conclusion, I wish to record my appreciation of the work being done in cotton by Mr. Clouston and by the projected experiments formulated by Mr. Evans. If they are supported as they deserve, I venture to predict that the Central Provinces will be the first in India to demonstrate that it is possible to obtain a decided improvement in Indian cotton, provided the requisite degree of intelligence and energy are brought to bear on the question and I again repeat that it is futile to work out our problems on flower bed areas.

Berar.—The Province of Berar known in days of vore by the name Vaidarbha, has been famous for the cultivation of cotton. It grew some of the best varieties yielding a fine strong fibre. It was the home of the once celebrated Jari and Bani varieties that afforded a superior sort of material not only to the mill industry in India but also to that in England. At the time of the Civil War between America and England in 1863, when no cotton was received from America, this province supplied the deficiency to a considerable extent.

Area.—Cotton occupies the foremost rank among other agricultural crops, and in comparison to the total cropped area, it is grown much more extensively in this province than in Bombay Presidency. It occupies the second place in India so far as cotton cultivation is concerned, Bombay Presidency being first. Nearly two-thirds of the cultivable area is put under cotton, the average area ranging between 28 to 31 lakhs of acres per annum. The average outturn per acre is about 100 pounds clean cotton.
The following six talukas grow the bulk of cotton:

- Akola: 740,000 acres
- Amraoti: 700,000 acres
- Buldana: 360,000 acres
- Ellichpur: 420,000 acres
- Yeotmal: 350,000 acres
- Berar: 480,000 acres

Area under cotton in:

- the Central Provinces: 1,250,000 acres
- Berar: 3,000,000 acres

Total: 4,250,000 acres

The valley of the Payanghat has an area under cotton to the extent of about 40 per cent. and this valley, it is said, grows the best cotton.

The area under cotton has of late considerably increased in the districts of Basim and Yeotmal as it is found to be more paying than other crops.

The earliest varieties grown in the Province were Jari (Chanda Jari) and Bani. The former was a cold weather variety with fine silky staple about 1½ inches long; the latter was sown at the beginning of the rains and had a fine silky staple about an inch long. The best Bani was grown in the Wardha District and it was this variety mixed with a considerable proportion of Chanda Jari which was known to the trade as "Hinganghat." In Berar Bani (possibly with a mixture of Jari) was known as "Amraotis" or "Oomaras."

Now coarse Jari has come into existence which is sown at the beginning of the rains. This is hardier, coarse and prolific in outturn having a staple of about ½ to ¾ inch long.

The two varieties (cold weather Jari and Bani) yielded a long staple but the outturn of Bani was less and was more delicate. Both these varieties had a reputation in the Bombay market until within the last 45 years; but they have been ousted by a variety known as Kati Bilayat.
Vilayati, Houri or new Jari. The evil seems to have been recognised as early as 1867. Dr. Humes then remarked that:

"The subject of cotton in Berar is one that requires immediate supervision. It has been left in the hands of ignorant Koonbees, who have no thought for the morrow, but grow whatever pays best at the time. The Khandesh variety is being grown largely to the ousting of the other varieties, to the most certain ruin of the Berar cotton trade. At present they get from Vilayati Khandesh an early crop, also a large one, getting three or four pickings instead of two or three as they get from indigenous cotton. They get Rs. 4 or Rs. 5 a bale less in price than for the indigenous cotton, but the greater bulk compensates, and much more, for this small loss. But this apparent prosperity will be short-lived, for it is only by mixing this Vilayati Khandesh cotton with the indigenous cottons that merchants can get it accepted."

The new Jari in recent years has become very popular as its character is sturdy and can stand both excessive rain and partial drought.

Mr. Gaskin, former Director of Agriculture, Central Provinces, says Jari is popular for its hardiness and certainty of its heavy yield (1,000 lbs. of seed cotton) giving 330 lbs. lint per acre; the ease with which it is picked up and the fact that it ripens early and so can be placed in the market in October, November.

Bulk for bulk its yield is much larger than that of old Jari and Bani though the staple is much shorter and less glossy. The old varieties come in the market in January and February whereas the present variety ripens much earlier and enables the cultivator to line his coat with silver in the months of November, December. These circumstances have mostly thrust out the old indigenous varieties of cotton. The change, it is said, came about in this way.

With a view to improve the cultivation in the province, Government introduced the seed known as Vilayati or Houri, also called Jari in some provinces, different from the old Berar Jari. The seed was distributed gratis. The trial was so successful and it became so popular that the
old varieties were completely driven out. In connection with the introduction of this variety, Mr. Gaskin observes that by the irony of fate the very cotton which Government endeavoured to eradicate became known as one which they had introduced.

Mr. B. P. Standen, C.I.E., former Director of Agriculture, Central Provinces, states "These are hardy plants which can be cultivated with success in any part of the province when the soil overlies the trap and drains early and the temperature of the cold season is not so low as to kill the plant in December." According to him, Jari (the local Houri) has thrust out the old indigenous varieties, Bani and old Jari, because the former, even in the most unfavourable years, pays better than the latter. The same officer is of opinion that the cultivation of Bani on the Ghats south of Berar is due to a spirit of conservatism on the part of the cultivators rather than to any prudential consideration. Not only does Bani yield a smaller proportion of lint (25 per cent.) than Jari, but it gives also under the most favourable circumstances a small average crop and is more liable to damage from the vicissitudes of the seasons. For these reasons, the old famous varieties of Berar have dwindled and disappeared.

The Jari which is cultivated at present is a mixture of the following four varieties mixed to a small extent with Upland Georgian:—

(1) G. N. Rosea. (3) G. N. Vera.
(2) Do. Cutchica. (4) Do. Vera Malvensis,
and also Bani plants.

Broadly speaking the fibre produced by these varieties increases in value as we go down the list, Rosea producing the shortest staple and priced lowest in the market.

To ascertain the relative value of the outturn of these different types, they were separated out and the seeds obtained were experimented along with Berar Jari and Bani on the Akola Farm in the year 1907-1908 by Mr. Clouston, the Deputy Director of Agriculture, Central Provinces.
The results are summarised below:

<table>
<thead>
<tr>
<th>Name of Variety</th>
<th>Outturn of seed cotton per acre</th>
<th>Percentage of lint</th>
<th>Value of Outturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malvensis</td>
<td>240 lbs.</td>
<td>33</td>
<td>27 a. p. 0 0</td>
</tr>
<tr>
<td>Verum</td>
<td>182</td>
<td>33</td>
<td>17 8 10</td>
</tr>
<tr>
<td>Roseum</td>
<td>258</td>
<td>39</td>
<td>24 14 0</td>
</tr>
<tr>
<td>Roseum Cutchica</td>
<td>194</td>
<td>38</td>
<td>18 11 3</td>
</tr>
<tr>
<td>Berar Jari</td>
<td>255</td>
<td>38</td>
<td>24 9 6</td>
</tr>
<tr>
<td>Bani</td>
<td>151</td>
<td>26</td>
<td>16 15 9</td>
</tr>
</tbody>
</table>

From the above statement, it will be seen that Malvensis having good staple has fetched more but the yield and percentage of lint are less than Roseum and Berar Jari.

The following was the valuation of these types last year:

Roseum: $\text{R}54$ per candy of 560 lbs.
Cutchica: $\text{R}54$ do. do.
Vera: $\text{R}54$ do. do.
Malvensis: $\text{R}63$ do. do.
Bani: $\text{R}64$ do. do.

From the valuation, it is quite clear that Malvensis is a very promising variety and compares very favourably with the Bani.

During the current year at the Jalgaon Exhibition all these varieties were exhibited by the Agricultural Department of the Central Provinces. They were subjected to examination and the opinion given by the cotton merchants is as below:

*Buri.*—Staple long, fine, good cotton. Value per candy of 784 lbs. $\text{R}340$.

*Roseum.*—Staple coarse, short, free from foreign matter. $\text{R}268$ per candy.

*Verum.*—Softer than Roseum $\text{R}272$ per candy.
Berar Jari.—Much cleaner than Khandesh. Will fetch a rupee or two more than ordinary Khandesh. Value Rs. 270 per candy.

Malvensis.—Not strong, but longer and silkier; much cleaner than Varadi. Value Rs. 295 per candy.

Bani.—Percentage 26, less silky but longer and stronger than Malvensis. Rs. 285 per candy.

Note:—Rough cottons are always cleaner than soft cottons.

The basis for valuation was Broach at Rs. 320 per candy.

Selection of seed.—Seed selection is known by the name of Alkabalka. At one time, it was practised extensively. The mode adopted was to select the best opened bolls at the second picking and stack the cotton. This was separately ginned and the seed so obtained was reserved for sowing for the next season.

Now-a-days on account of the introduction of ginning factories any seed is used for sowing and no effort is made towards selection. At the commencement of the gin factories, the machine ginned seeds were looked upon as unsuitable for cultivation, but this prejudice has unfortunately fast died out and the seed for sowing is purchased from Banias who give such seeds as they have at their own price. It is absolutely necessary to revive the old and useful practice of selecting seed and getting it hand-ginned.

Picking.—This is done usually after Diwali, by women and children. Payment is made in kind. 1-20th part of the cotton picked is the labour charges for the first picking; for the subsequent pickings, a higher proportion has to be given. These rates depend upon the cheapness of labour. If the labour is scarce, the rates are higher and vice versa.

This practice is still in vogue in some places, but it has been replaced in recent years by cash payment as the cash payment is found to be cheaper. The usual rate of cash payment is annas three per maund of cotton picked. A
labourer is able to pick from a good field two to three maunds of cotton a day, thus earning from 10 to 12 annas a day. A good crop will give 3 pickings.

**Outturn.**—The average outturn of *Houri* is about 400 lbs. of seed cotton per acre and its average market price is Rs.50 per Khandi of 560 lbs. An acre of land under cotton would thus give about Rs.35 to a cultivator from which the cost of cultivation which is usually Rs.14 may be deducted; the net profit would therefore be about Rs.20.

**Bombay.**—During the year 1909-10 within a radius of 10 miles from Surat, the seed of a cross grown on the Surat Farm was distributed to the cultivators by the Agricultural Department. The produce of this cross, amounting to about 100 bhars 100,000 lbs. (960 lbs. make one bhar at Surat) has been purchased through the agency of the Bombay Agricultural Department by a gin-owner of Surat who gave Rs.7 more per bhar for this cotton than the Surat local cotton. The quantity so purchased will gin out about 30,000 lbs. of seed; in addition to this quantity, the Surat Farm also will produce about 5,000 lbs. seed of this cross, the total quantity of seed would, therefore, come to about 35,000 lbs. It is the intention of the Deputy Director of Agriculture, Bombay Presidency, to distribute this quantity to the cultivators of one village only so that this year one village will grow only the cross cotton which will throw sufficient light with regard to the improvement of cotton.

Cordial acknowledgment is due to Messrs. Tata, Sons and Company, Bombay, for their kindness and promptitude in giving valuations and opinions on cotton samples whenever they were submitted to them.

**Programme of work for 1910-11.**—The work for the next year will consist of a further enquiry into the cottons of Central Provinces, Central India, Gujarat, Kathiawar and Southern Maratha Country.
REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including Report of the Imperial Cotton Specialist)

1910-II

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1912
### TABLE OF CONTENTS.

I. Report of the Director, Agricultural Research Institute and College, Pusa—

1. Charge .................................................. 1  
2. Staff and work of the Institute .................. 1  
3. Agriculture ............................................ 2  
4. Chemistry .............................................. 3  
5. Botany .................................................. 5  
6. Mycology ............................................... 7  
7. Entomology ............................................ 9  
8. Second Entomological Section .................. 11  
9. Bacteriology .......................................... 12  
10. Training ............................................... 14  
11. Upkeep of the Estate .............................. 15  
12. Library ................................................ 16  
13. Publications ......................................... 17  
14. General Health of the Station ................. 17  
15. Accounts .............................................. 18  
16. Visitors .............................................. 19  

II. Report of the Imperial Agriculturist—

1. Charge .................................................. 20  
2. Tours ................................................... 20  
3. Training ............................................... 21  
4. Character of the Season .......................... 21  
5. Cropping .............................................. 22  
6. Permanent Manurial and Rotation Experiments. 22  
7. Permanent Pasture .................................. 23  
8. Thrashing .............................................. 23  
9. Clearing and Levelling ........................... 23  
10. Work Cattle .......................................... 23  
11. Breeding Herd ....................................... 23  
12. Sheep .................................................. 24  
13. Poultry ............................................... 24  
14. Programme of Work for 1911-12 ................ 24
III. Report of the Imperial Agricultural Chemist—

1. Charge of Section and Establishment .......................... 26
2. Meteorology .................................................... 27
3. Drainage Data .................................................. 27
4. The Amount of Nitrate in Soils ................................ 28
5. The Water Requirements of Crops ............................... 28
6. Usar Land ...................................................... 29
7. Date Palm Sugar ............................................... 31
8. Saltpetre ...................................................... 31
9. Education ...................................................... 32
10. Programme of Work for 1911-12 ................................ 33
11. Publications .................................................. 33

IV. Report of the Imperial Economic Botanist—

Part I.—Teaching, Training and Staff ............................... 34
Part II.—Special Work in England ................................. 34
Part III.—The Hop Industry in Kashmir ............................ 38
Part IV.—The Development of the Fruit Industry of Baluchistan .............................. 40
Part V.—Investigations .............................................. 42
(1) Wheat ............................................................ 42
(2) Tobacco .......................................................... 45
(3) Fibres ............................................................ 47
(4) Programme of Work for 1911-12 ............................... 47
(5) Publications ...................................................... 48

V. Report of the Imperial Mycologist—

1. Charge and Establishment ......................................... 50
2. Training ........................................................... 50
3. Aid to Provincial Departments .................................... 50
4. Plant Disease Investigations ...................................... 50
5. Systematic Work .................................................. 55
6. Miscellaneous ..................................................... 55
7. Programme of Work for 1911-12 ................................ 56
8. Publications ...................................................... 57

VI. Report of the Imperial Entomologist—

1. Charge and Establishment ......................................... 58
2. Visitors ............................................................ 59
3. Training ........................................................... 59

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Provincial Work</td>
<td>60</td>
</tr>
<tr>
<td>5. Correspondence</td>
<td>61</td>
</tr>
<tr>
<td>6. Research</td>
<td>62</td>
</tr>
<tr>
<td>7. Insecticides and Sprayers</td>
<td>62</td>
</tr>
<tr>
<td>8. Sericulture</td>
<td>62</td>
</tr>
<tr>
<td>9. Lac Culture</td>
<td>65</td>
</tr>
<tr>
<td>10. Apiculture</td>
<td>65</td>
</tr>
<tr>
<td>11. Demonstration</td>
<td>65</td>
</tr>
<tr>
<td>12. Insect Survey</td>
<td>66</td>
</tr>
<tr>
<td>13. Miscellaneous</td>
<td>67</td>
</tr>
<tr>
<td>14. Programme of Work for 1911-12</td>
<td>67</td>
</tr>
<tr>
<td>15. Publications</td>
<td>67</td>
</tr>
</tbody>
</table>

VII. Report of the Second Imperial Entomologist—

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Charge</td>
<td>69</td>
</tr>
<tr>
<td>2. Nature of Work</td>
<td>69</td>
</tr>
<tr>
<td>3. Investigations in Hand</td>
<td>70</td>
</tr>
<tr>
<td>4. Publications and Training</td>
<td>71</td>
</tr>
<tr>
<td>5. First International Congress of Entomology at Brussels</td>
<td>71</td>
</tr>
<tr>
<td>6. Work on House-flies</td>
<td>71</td>
</tr>
<tr>
<td>7. Work on Ticks and Rat-fleas</td>
<td>71</td>
</tr>
<tr>
<td>8. Programme of Work for 1911-12</td>
<td>72</td>
</tr>
</tbody>
</table>

VIII. Report of the Imperial Agricultural Bacteriologist—

<table>
<thead>
<tr>
<th></th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preliminary Work in Testing Methods</td>
<td>73</td>
</tr>
<tr>
<td>2. Bacteriological Analysis of Pusa Soils</td>
<td>74</td>
</tr>
<tr>
<td>3. Effect of Hot Weather ploughing upon the Bacteriological Content of the Soil</td>
<td>74</td>
</tr>
</tbody>
</table>
| 4. Special Problems dealt with—
  (1) A Bacterial Disease of Tobacco | 77 |
  (2) A Disease of the Eri Silk-worm | 77 |
  (3) The Efficacy of Ratin and Trope Ratin | 77 |
  (4) A Disease of Tussar Silk-worms | 78 |
  (5) A scheme for Bacteriological Work in connection with the proposed Dairy at Pusa | 78 |
| 5. Programme of Work for 1911-12 | 79 |
| 6. Publications | 79 |
### IX. Report of the Imperial Cotton Specialist—

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Charge</td>
<td>80</td>
</tr>
<tr>
<td>2. Tours</td>
<td>80</td>
</tr>
<tr>
<td>3. Central Provinces Cottons</td>
<td>81</td>
</tr>
<tr>
<td>4. Bombay Cottons</td>
<td>87</td>
</tr>
<tr>
<td>5. Madras Cottons</td>
<td>98</td>
</tr>
<tr>
<td>6. Bengal Cottons</td>
<td>99</td>
</tr>
<tr>
<td>7. Punjab Cottons</td>
<td>101</td>
</tr>
<tr>
<td>8. Valuations</td>
<td>101</td>
</tr>
<tr>
<td>9. Programme of Work for 1911-12</td>
<td>101</td>
</tr>
<tr>
<td>10. Publications</td>
<td>102</td>
</tr>
</tbody>
</table>

(E. J. Butler, M.B., F.L.S.)

1. Charge.—I held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, throughout the year, in addition to my duties of Imperial Mycologist.

2. Staff and work of the Institute.—The Institute is organised in seven scientific sections, Agricultural, Chemical, Botanical, Mycological, Entomological, Second Entomological, and Bacteriological, the detailed reports of which are given in the body of this report. For much of the period under review, the superior staff was below strength. Towards its close, three supernumerary officers were absent on deputation or filling leave vacancies in the provinces; the Imperial Entomologist was on long leave; the Assistant Agriculturist’s post was vacant; while I occupied the dual posts of Director and Imperial Mycologist. Thus, there were only eight European officers of the Pusa staff actually at work for the Imperial Department, and of these two (the Imperial Economic Botanist and his Personal Assistant) were engaged in Baluchistan, developing the
fruit industry of that province, in addition to their own duties.

The following summary gives very briefly the organisation of the staff, and the main lines of work of each section during the year.

3. Agriculture.—Mr. A. McKerral, Assistant Inspector General of Agriculture, was lent to take charge of the farm up to the 17th November, 1910, when Mr. G. Sherrard, Assistant Agriculturist, took over all except the work in connection with cattle and poultry breeding, which remained under Mr. McKerral until February, 1911. Mr. Sherrard held charge up to the 16th June, 1911, when he was appointed Professor of Agriculture, Bengal Agricultural College, Sabour, and Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, was lent to take charge, pending permanent arrangements. Mr. H. Southern joined the staff as Supernumerary Agriculturist on the 29th November, 1910, but left again on the 13th February, 1911, to officiate for Mr. Sampson, Deputy Director of Agriculture, Southern Circle, Madras, who was about to proceed on leave.

Notwithstanding these frequent changes, and in spite of the fact that since February the farm has been managed by only a single officer, steady progress continues to be recorded. The rabi sowings were completed at an earlier date than any previous year, and the harvest was exceptionally good. A yield of 33 maunds of oats per acre was obtained from one field, and a record was established in thrashing, 241 maunds of oats being thrashed in one day with the steam thrasher. The rains set in early in June, 1911, and most of the kharif crops were sown before the end of the month and give excellent promise. Against this, the kharif of 1910 was marked by extensive floods in Behar, and a large part of the crops on the lower lands was lost owing to a breach in the protective embankment.

The experimental work on the farm suffered from the floods in the monsoon of 1910, one block of the permanent manurial and rotation experiments having been completely
destroyed. The duplicate block on higher land, however, escaped. It is too early to expect results from these experiments. The permanent pasture experiments were abandoned during the year, after full consideration of the results to date. It is evident that the improvement of pasture land will have to be attempted on different lines, and a modified plan of experiment is under consideration. A comprehensive series of manurial experiments with flax was started by the Fibre Expert to the Government of Eastern Bengal and Assam, in collaboration with the Inspector General of Agriculture, but an outbreak of dodder necessitated the destruction by burning of the whole crop. Flax dodder is not indigenous to India, and there is no doubt that every effort should be made to keep it out in future, and to destroy what was introduced in the past. Experiments with jute and paddy were continued, the former according to plans drawn up by the Fibre Expert. As the area under arable cultivation is now more than sufficient to provide fodder and grain for the breeding herd and work cattle, it is hoped to extend experimental work in the near future. A considerable part of the farm is devoted to crops grown for the other sections for observation and experiment.

The farm stock have done well. The Montgomery herd has been increased by natural growth and purchase. Proposals for a dairy were submitted during the year, but sanction has been withheld for the present. There is an undoubted demand for instruction in dairying, and with the large herd of excellent milch cattle now being formed at Pusa, a dairy will ultimately prove an essential part of the equipment of the Institute. The management of the poultry has been in the hands of the Inspector General of Agriculture for the greater part of the year.

I wish to record my appreciation of Mr. Sherrard's work not only on the farm, but in assisting me in the general management of the Estate.

4. Chemistry.—Dr. Leather held charge throughout the year. Mr. Annett, on the termination of his acting ap-
pointment as Agricultural Chemist, United Provinces, and on expiry of his privilege leave, resumed charge of his duties as Supernumerary Agricultural Chemist at Pusa on the 11th November, 1910. He has been since appointed to act as Principal of the Agricultural College, Cawnpore, and left Pusa to join this appointment on the 24th June, 1911.

The important investigation on the water requirements of crops in India, to which allusion has been made in previous reports, has advanced a stage, and a second memoir on the subject has been published by Dr. Leather. The principal conclusions arrived at are, that the nature of the soil has no effect on the transpiration ratio, but profoundly influences the rate at which water can move through the soil, and hence the total weight of crop produced. Also, that practically the whole of the water used by a crop is obtained within the root range, some 6 to 7 feet in alluvial soil, the large stores of water below this depth being substantially of no service to the plant.

Drain gauges to test the quantity and composition of the subsoil drainage water from arable land were erected some years ago at Cawnpore and Pusa, and the results of several years' records are now in the press. They yield information of the greatest interest on some of the factors which must always fundamentally influence Indian agriculture, when compared with that of temperate climates. Thus it has been found that the loss of water from bare fallow soil is almost constant year by year in any one place, and is at Pusa nearly double that at Rothamsted in England. At Cawnpore, on the other hand, it is little more than at Rothamsted, and this difference between Pusa and Cawnpore requires to be explained but probably depends on the nature of the soil. The protective influence against evaporation due to the presence of a crop has been approximately determined for different periods of the year. The amount of nitrate present in the drainage water from fallow land is very much greater than at Rothamsted, twice or three times as much, and nitrification occurs with
great vigour after the first heavy rain of the monsoon, but is not active during the dry months.

Dr. Leather has continued his investigation of usar land, with special reference to its physical state. He has also, in consultation with the Director of Agriculture, and the Irrigation Department, United Provinces, carried out the first stage of a comprehensive experiment directed to determine once for all whether, as is frequently stated, irrigation leads in certain lands to an increase of alkali.

Mr. Annett is engaged on a general investigation of the Date Palm sugar industry, a very important Indian industry, about which little accurate information is available.

An improved method of refining crude saltpetre was devised by Dr. Leather, and has been described in a Bulletin recently published. More nitrate is obtained than by the ordinary methods in use, the product is of higher quality, less fuel is required, and the process is independent of the weather. Its financial possibilities, however, remain to be demonstrated, and arrangements have been made to test the method on a commercial scale this year.

5. Botany.—Mr. Howard resumed charge of this section, on the expiry of privilege leave and deputation in England, on the 29th July, 1910. He was deputed to advise the Kashmir Durbar on hop cultivation from the 1st August to the 27th September, 1910. During his absence Maulvi Abdur Rahman Khan, Second Assistant, held charge of the current duties of the section. Mrs. Howard, who has ably assisted her husband during the past five years, was appointed Personal Assistant for three years from the 1st October, 1910. Mr. E. Holmes Smith, Supernumerary Economic Botanist, was on deputation in the Bombay Presidency throughout the year. He leaves the Department on the expiry of his agreement in October, 1911. Mr. Howard has been placed in charge of a scheme to develop the fruit industry of Baluchistan, in addition to his own duties, for a period of three years from the 1st May, 1911. He will work in Baluchistan for five months, from May to September, each year.
During his absence in England, Mr. Howard carried out some experiments in the production of rust resistant wheats suitable for India, and studied the trade requirements for improved Indian wheat and tobacco. He also enquired into modern methods of hop cultivation and drying and fruit packing, with a view to utilising the information on his return to India.

The possibilities of hop growing in Kashmir are apparent, when it is learnt that with a production per acre of one-fifth of that of Kent, an annual average profit of over £7 per acre has been realised on the Government hop garden, for the last sixteen years. In Mr. Howard’s report to the Durbar, the directions are indicated in which improvements are possible, if it is decided to continue the industry on the present lines, and also the steps which are necessary if hop growing in Kashmir is to be placed on modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

Perhaps the most important work on which Pusa is engaged at present is the improvement of Indian wheat. The lines on which this is being carried out have been sufficiently indicated in previous reports of the Botanical Section. The best Pusa wheats produced in 1910 were shown at Mark Lane, and on the Liverpool Corn Exchange, while Mr. Howard was in England, and were acknowledged to be without any superiors on the market at the time. During the past year, the high grain-quality of some of the best of these types has been combined with the high yield of low-quality Indian wheats, as a result of hybridization. The demand, both in India and abroad, for some of the improved wheats produced at Pusa has been far in excess of the supply. It is estimated that over 1,000 acres of the new wheats will be sown in Behar this year. At Raipur and Cawnpore, some of these wheats have proved equally successful, and extended trials have been arranged for at a number of other stations in the wheat-growing tracts of India. Mr. Howard is careful to point out that the full benefit of improved varieties can only be realised if cultiva-
tion is good and moisture is adequate. Disappointment is bound to result, if the influence of these two all-important factors in crop production in India is disregarded.

The improvement of tobacco is being carried on on similar lines to that of wheat. Both in yield and quality of leaf very encouraging results have been obtained.

The botanical study of certain fibres was continued, the isolation of the varieties of *san* (*Crotalaria juncea*) and *patwa* (*Hibiscus cannabinus*), and their improvement by selection and crossing, being the principal work in progress in this direction.

Further work on pollination in important crops of India was carried out, and a Memoir published giving the data for a number of crops.

Towards the end of the year, the lines of work on the improvement of the fruit industry of Baluchistan were developed, and the site of a new Experimental Station for the purpose selected near Quetta.

6. *Mycology.*—I held charge of this section during the year, in addition to the office of Director. Mr. Shaw continued to hold the post of Supernumerary Mycologist.

Much time was given to systematic work, as it was found that progress in Indian economic mycology was greatly hampered by the difficulty in determining the identity of the fungi of the country. All the specimens of one of the larger groups, the Ascomycetes, were worked through and annotated lists were published after the close of the year under review.

The charge of the campaign against palm disease in Godavari and Kistna Districts was taken over by the Madras Mycologist in 1910. It is being continued on the same general lines as before. A full account of the disease, and of the campaign against it carried on since 1907, was written by me and published as a Memoir in September, 1910. The conclusions arrived at are that the operations have been entirely successful in limiting the disease in Godavari to the area previously infected; the work in Kistna was started later, but the progress is encouraging
in this district also. The effect of the work in reducing the severity of the disease within the infected tract was not easy to estimate when the report was written, but with the further records since available it appears that a distinct decrease in the mortality is noticeable at the present time. If the disease can be effectively confined to the existing limits, the outlay incurred will be amply justified, and there is every reason to hope that the continuation of the work will lead to its being gradually stamped out altogether.

The need for a mycologist to work specially on the diseases of the tea plant has become increasingly apparent, and the Indian Tea Association have decided to add an appointment of this nature to their Scientific Department. Meanwhile, Pusa gives such assistance as is possible. Mr. McRae's Bulletin on blister-blight in Darjeeling, published at the beginning of the year, indicates the lines on which the control of this dangerous blight should be attempted. Many planters are experimenting on these lines, but the disease is firmly established and still spreading; unless a cheap and effective method of lessening its ravages can be worked out, there is every reason to fear that the result will be a permanent and considerable reduction of the Darjeeling tea crop. The copper-blight of tea was described by Mr. Shaw, the parasite which causes it not having been previously known to occur in India. A disease of tea seed was investigated by me, and shown to be probably associated with an insect which punctures the seed, and so admits rotting fungi to the tissues of the interior. It is believed that this insect can be fairly easily destroyed.

Other diseases investigated by the section, of which accounts were published during the year, were soft rot of ginger (by Mr. McRae), turmeric leaf spot (by myself), and heart rot of the blue pine (by Mr. Hafiz). Forest diseases, of which the last named is an instance, cause great losses in India; Pusa gives such assistance as it can to the Forest Department, but there is room for a mycologist to work specially at these diseases.
Mr. Shaw is engaged in investigating the root rot of a number of cultivated plants, caused by a species of Rhizoctonia. The parasite appears to be the same in all cases and its complete study, in view of the large range of its victims, is most desirable.

The usual routine work of advising cultivators and the general public interested in agriculture on the diseases of plants and allied matters, which in this section, as in the Entomological, forms a very essential part of the work, was continued. Assistance was also given to Provincial Agricultural Departments in advising on the work of their Mycological assistants, and in providing material for reference collections in their colleges.

7. **Entomology.**—Mr. Lefroy held charge of this section up to the 31st January, 1911, when he proceeded on leave, and Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, took over charge.

As in previous years, several provinces have freely availed of the assistance offered by Pusa in co-ordinating and checking the work of their Entomological assistants. Of these latter there are now seventeen, some engaged in teaching at the six Provincial Agricultural Colleges, the others in field work. The advisory function of the Entomological Section at Pusa is of great importance in the present position of Economic Entomology in India. The section helps by determining crop pests reported by Provincial assistants, and advises regarding the methods of control likely to be effective in checking them. In several provinces these methods have been demonstrated on a large scale, as in the work against potato moth and surface caterpillars in Bengal, cane grasshopper and potato moth in the United Provinces and several pests in Madras. In Baroda State also, the Entomological Assistant keeps in close touch with Pusa, and has shown much practical energy. In the same connection, mention should be made of the arrangements made directly by the section for demonstrating the life histories and characters of injurious and beneficial insects. A considerable exhibit was
arranged for the Allahabad Exhibition; show cases, coloured plates with brief descriptive leaflets, and coloured lantern slides, were issued for demonstration and distribution to those interested.

Sericulture continues to form an important branch of the work. Eri silk production has been developed as a cottage industry in many parts of India, and received a great stimulus through the display arranged at the Allahabad Exhibition, and smaller exhibits shown at local shows in Bengal. The industry has been taken up by the Agricultural Departments of Bengal and the United Provinces. Difficulty is still experienced in disposing of small parcels of cocoons and thread, the mills being unwilling to buy except in large quantities. Experiments in mulberry silk production have been extended. Crosses were effected between European univoltine and indigenous multivoltine races, with a view to obtaining a robust multivoltine race, yielding silk of better quality than is produced by native forms. Broods of European mulberry silk-worms were successfully reared at Pusa, the resulting thread being well reported on by the trade. Experimental work forms only a part of the activities of the sericultural branch; a great volume of correspondence has arisen in connection with it, and arrangements for the supply of disease-free eggs, castor seed, samples of cloth and machines for spinning, doubling and twisting have required much organising. Twenty students from various parts of India attended the special courses of practical instruction in silk culture during the year.

Lac culture was continued, and a practical training given to students in this subject. A large amount of material was collected, with a view to working out the races of lac insects in collaboration with Mr. Green of Ceylon, a specialist in the group.

Bees of two specially selected Italian strains were imported, and an attempt is being made to acclimatise them at Pusa. Apiculture is still, however, in the experimental stage.
The study of the life histories of injurious insects has progressed, a number of important pests having been reared in the insectary and their habits studied. Mr. Ghosh has prepared a memoir on palm beetles, and Mr. Dutt on some Aculeate Hymenoptera. Other memoirs on life histories are in preparation.

The insect survey of India has been continued as time permits. Large collections have been sent for study by specialists, and to the authors of volumes of the "Fauna of India" series. Mr. Nowrojee has prepared a memoir on some aquatic insects.

The investigation of the damage caused by termites (white-ants), started by Mr. Lefroy in collaboration with Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, was continued by Mr. Fletcher. The latter officer was also invited to tour with the Railway Sleeper Commission, to advise on the best methods of reducing the enormous losses caused on Indian railways by these insects, and is carrying out experiments on the preservation of wood from their attacks.

8. Second Entomological Section.—This section is engaged in the study of Dipterous insects, and in particular those which suck blood and which may transmit disease. Mr. Howlett, who is in charge of it, only rejoined after absence on sick leave for a year and five months, towards the end of March, 1911. The work of the section was therefore practically in abeyance until the last quarter of the year.

Since his return, Mr. Howlett has had to devote much time to disposing of collections of material accumulated in his absence. The identification of these has progressed with assistance from the Indian and British Museums.

As special work, Mr. Howlett has been engaged in a study of parasites of Tabanidæ ("horse-flies"); the temperature reactions of mosquitoes, temperature apparently being one of the main factors controlling mosquito bite; the relative efficiency of the fish known as "Millions" and other enemies of mosquito-larvae; and peach flies. In the
latter investigation a method of destroying the male fly, which is simple, cheap and effective, has been discovered, and though it seems improbable that anything short of netting the trees will completely prevent the female reaching them, the destruction of the males should very much reduce the damage done.

While on leave, Mr. Howlett attended as Indian delegate the First International Congress of Entomology at Brussels, and read two papers by Mr. Lefroy and himself. He also carried out, in collaboration with two other gentlemen, a successful series of experiments on the range and rate of flight of house-flies under natural conditions, points of importance in view of their behaviour as carriers of disease. The results were published by the Local Government Board in England.

Since his return, Mr. Howlett has again given invaluable assistance in supervising much of the work of the artist staff, and in advising the other sections in the preparation of illustrations for publication.

In certain respects the work of this section differs widely from that of the other sections at Pusa. It was founded to study Diptera, not only those (comparatively few in number) which are serious crop pests, but also those which convey disease to man and animals. Mr. Howlett's work is, therefore, closely related to the work of the Medical and Veterinary Departments, and it is probable, taking into account the great developments towards a realization of the importance of biting flies as disease carriers, that the activities of the Second Entomological Section will expand in this direction rather than on more purely agricultural lines.

9. Bacteriology.—Mr. Hutchinson held charge of this section throughout the year.

Much of his work has been of preliminary nature, confined largely to trial and selection of the bacteriological methods best adapted for dealing with the special conditions of soil and climate in India. The main lines have been aimed at determining under what conditions various
soils will best serve as culture media for those bacteria, naturally present in them, on which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

A special study has been made of the effect of hot weather ploughing on the bacteriological content of the soil, and the possibility of a bacteriological explanation of the undoubted increase in fertility resulting therefrom. It was found that the net result is an extremely rapid formation of ammonia, part of which becomes available to plants and part of which is lost. Depletion of the soil nitrogen is a necessary consequence and the maintenance of fertility must depend on the restoration of this by green manuring or otherwise.

A bacterial disease of tobacco occurring in Rangpur was investigated by Mr. Hutchinson. It was found to be caused by a strain of Bacillus solanacearum, an organism known to cause disease in several cultivated crops, such as potato, brinjal and tomato. The Rangpur strain differs from those described in America and Japan in some of its pathogenic features.

A disease of the Eri silk-worm, which causes havoc in the broods at certain times of the year, was also studied. It was found to be associated with the presence of bacteria in the intestine.

Certain preparations known as Ratin and Trope Ratin, prepared in Copenhagen, have been widely recommended as rat exterminators, and have been suggested for use in India, both with a view to checking plague and to protect crops against the ravages of field rats. Mr. Hutchinson carried out tests of these preparations. Ratin was found to have lost its virulence, but it is suggested that this might be recovered by preparation in India. Trope Ratin was found effective within a limited time after its preparation, but its cost precludes any possibility of its use on a large scale by cultivators. Neither can be recommended for employment at present.
Agricultural Bacteriology in the wider sense, including the bacteriology of industries dependent on agriculture, has made great strides in recent years, and developments in the practical application of this branch of agricultural science in the tropics now appear probable, which were scarcely anticipated when this section was founded at Pusa. Proposals are being made for strengthening the section, which is understaffed.

10. Training.—Two different classes of instruction are provided at Pusa. Students are admitted for a post-graduate training in the scientific sections, being ordinarily required to take up a single subject only. Exceptionally, to meet definite requirements of Provincial Departments, which are not in a position to train their own men for such positions as Assistant Director, Farm Manager and the like, post-graduate students have been admitted to a general course, including a period of study in each of the chief sections as well as practical work on the farm. Ordinarily, however, it has been held by the Board of Agriculture that students requiring a practical agricultural training are best provided for by the six Provincial Colleges, and now that these are all in working order, it is not anticipated that there will be much further demand for the post-graduate general course. The second class of instruction given at Pusa consists of short courses of an essentially practical nature in special subjects such as silk and lac culture, cattle and poultry breeding and management, and fruit growing. To these it is hoped to add dairying, for which there is a decided demand which we are not yet in a position to meet, while the course in tillage implements and agricultural machinery was discontinued during the year, as it was not fulfilling any useful purpose. Instruction is imparted in English or in the vernacular, and no educational qualifications whatever are required.

Of the post-graduate students, one continued his course in general agriculture, and one in entomology left after having finished his course during the year. Six students were admitted, two in general agriculture, two in chemistry
and two in entomology. The two students in general agriculture were recalled to their province after completing one year's training, as their services were required by the Provincial Department.

The short courses continue to be popular, students from all parts of India having been admitted. Four took up fruit growing; eight, cattle breeding and management; nine, poultry breeding and management; three, tillage implements and agricultural machinery; twenty, sericulture; and fifteen, lac culture. A certain amount of instruction in bee-keeping was given to some students interested in the subject, but as apiculture at Pusa is still in the experimental stage, regular courses have not yet been established. As far as possible, only those have been admitted to the short courses who propose to take up the subjects taught as a subsidiary means of livelihood to agriculture. In some cases, it was found that non-agriculturists sought admission in order to obtain certificates which would get them employment under Government, especially in Native States. Usually such students were not admitted, or if admitted, certificates were not given to them.

11. **Upkeep of the Estate.**—As a result of the floods, to which the low-lying portions of the farm are subject, and which resulted in a loss of over 100 acres of crops in July, 1910, the Public Works Department was requested to revise the arrangements for draining this part of the Estate, and in particular to repair and strengthen the protective embankments were defective. The flood referred to was probably the highest on record, and gave us a very anxious time, but the bulk of the protective works stood very well, and amply justified the outlay which was incurred on them. The repairs have been deferred pending allotment of funds; fortunately there has been no flood up to date this year.

Two additional blocks of quarters have been constructed departmentally for the use of the staff of the Inspector General of Agriculture, in continuation of those built last year. A new workshop and weigh-bridge for coal were
constructed in connection with the power-house, and plans have been prepared for a coal bunker. The ice plant has been fitted up and is now under trial. It is capable of turning out half a ton of ice in the day. An ice store is being built departmentally. The laboratories consume a good deal of ice which has formerly been obtained from Calcutta, and it is hoped that the new plant will not only prove a convenience but will effect an economy. Much trouble was experienced with the gas supply, owing to the retorts burning out. This culminated in a complete stoppage of gas for some weeks in the hot weather. The Oriental Gas Company of Calcutta kindly spared the services of their Chief Distributing Engineer, Mr. E. P. Reilly, to overhaul the installation. The laying of the retorts was found to be defective, and other minor alterations were carried out under Mr. Reilly's supervision, with the result that no further trouble has been experienced. We are under an obligation to the Company for their courtesy in sending up one of their best engineers to help us.

Provisional estimates for providing a Middle English School for the use of the staff of the Institute and the residents in the neighbourhood were sanctioned, the cost to be borne jointly by the Governments of India and Bengal. The estimates did not provide for residential quarters for the teachers; plans for the school and quarters were prepared with assistance from Mr. Preston, Inspector of Schools, Patna Division, and submitted with revised estimates for consideration by the Bengal Government. Some minor improvements were carried out in the students' hostel.

12. Library.—The revised catalogue of the library, corrected up to the end of 1908, was issued. The correction of the proofs and seeing it through the press entailed a great deal of work. The card catalogue was revised, and a register of new additions is now maintained in such a form that further editions of the printed catalogue can be brought out without much trouble. The loan arrangements are working admirably, and I am glad to note that
advantage is being more freely taken of the facilities for borrowing books given to officers of the Provincial Departments. The library is still wanting in many of the more expensive sets of periodicals; the sectional grants for purchase of books usually do not exceed 500 rupees; this is not more than sufficient for current literature, and there is no general grant from which expensive periodicals can be paid for. The new additions amounted to about 1,500 volumes. The library is rapidly becoming overcrowded and proposals for its extension are under consideration. The Director is in general charge of library arrangements and I wish to express my satisfaction with the work of Babu Anukul Chandra Chatterjee, the Librarian.

13. Publications.—The Journal, Memoirs and Bulletins were continued. As the Department expands, more work is submitted for publication, the Provincial Departments supplying an increasing volume of contributions. The grant for publications was reduced during the year, and transferred to the budget of the Inspector General of Agriculture. Much of the publication work is now done by the Inspector General, who is Editor-in-Chief, the Pusa staff supervising the illustration work and also acting as an advisory committee. The free distribution list was considerably curtailed during the year, consequent on the reduction of the grant.

14. General Health of the Station.—The general health of the station during the year under report was good. Relief was afforded to 7,657 new cases, of which 7,477 were treated in the outdoor department, and 180 admitted as indoor patients. This is an increase of 1,426 cases over last year’s total. The increase in attendance was due to the great prevalence of malarial fevers, and cholera, in the surrounding villages. One hundred and forty-six cases amongst European officials and families were attended to, an increase of 47 over last year’s total. The daily average number of patients treated was 7·87 indoor and 49·05 outdoor, as against 6·96 and 48·97 respectively during the previous 12 months.
Four deaths occurred in Hospital,—two from malarial cachexia, one from Bright’s disease and one from neglected hernia.

Two cases of cholera occurred amongst the families of the Indian staff in August, 1910, with one death. Immediate and successful measures were taken to prevent the disease spreading on the Estate.

One hundred and one surgical operations were performed: of which eight were major and the remainder minor.

The prevailing diseases were malarial fevers, kala azar, bowel complaints, rheumatic complaints and skin diseases. Blood diseases were diagnosed microscopically.

Quinine was issued prophylactically on the Estate towards the close of the monsoon.

Fourteen primary and ten re-vaccinations were performed in the early part of the year.

All drains in the building area of the Estate were made pucca during the year. A small cemetery was constructed departmentally. The number of residents within the Estate was over 700 on the date of the recent census.

15. Accounts.—The total expenditure incurred during the current year was Rs. 2,99,587, as against Rs. 3,12,427 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,87,383, travelling allowance of officers and establishment Rs. 22,315 and farm expenditure, scientific apparatus, books, fuel, stores for electric and gas installation, contingencies, etc., Rs. 89,889. The grant for the "Agricultural Periodicals and Journal " has been transferred from this office budget to that of the Inspector General of Agriculture in India from 1st April, 1910.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles, and Mr. Lefroy’s book "Indian Insect Life," amounted to Rs. 13,462, as against Rs. 5,573 in the preceding year. Of this amount the sale proceeds of “Indian Insect Life” accounted for Rs. 5,490.
16. Visitors.—During the year under report the Hon'ble Mr. E. D. Maclagan, C.S.I., I.C.S., Secretary to the Government of India, Revenue and Agriculture Department, the Hon'ble Mr. F. C. Gates, C.S.I., I.C.S., Financial Commissioner to the Government of Burma, Mr. R. Inouye, Assistant Professor, Agricultural College of Tokio Imperial University, Mons. H. Brenier of the Commerce and Industry Department of French Indo-China, and Dr. Vermoesen, Mycologist Elect to the Belgian Congo, visited the Institute. Dr. Vermoesen worked in the Mycological laboratory for over two months at the end of the year.

(A. C. Dobbs, B.A.)

Charge of the Pusa Farm during the greater part of the period under report was held by Mr. G. Sherrard, Assistant Agriculturist. The services of the Assistant Inspector General of Agriculture were also placed at the disposal of the Director for farm purposes, and in fact Mr. A. McKerral wrote the Annual Report for 1909-10.

In June 1911 Mr. Sherrard left Pusa to take up the appointment of Professor of Agriculture at the Bengal Agricultural College, Sabour.

Mr. H. Southern was at Pusa as Supernumerary Agriculturist from November 1910 to February 1911, when he left to go to Madras, where he is officiating as a Deputy Director of that Province.

Mr. Ikramuddin held the appointment of First Overseer and Mr. Ziauddin Hyder that of Second Overseer throughout the year.

Mr. Judah Hyam continued in charge of the breeding herd and Mr. Nizamuddin Hyder of the poultry. Mr. L. S. Joseph was appointed Veterinary Assistant in May 1911, and has taken charge of the current duties of the Overseer during Mr. Judah Hyam’s absence on privilege leave.

Mahomed Yakub Mukadam of the Lyallpur Farm was appointed as Surveyor in May 1911.

The farm staff is to be congratulated on the thorough and timely preparation of the land for both the rabi and monsoon crops which is noted below, and the veterinary staff on the condition, and continued freedom from disease, of the breeding cattle.

Tours.—Mr. Sherrard visited the provincial farms at Dacca and Sabour in December.
Many members of the staff attended the Allahabad Exhibition in connection with the Pusa exhibits.

Training.—Mr. Fatehuddin, B.A., Assistant Director of Agriculture for the Punjab, continued his course in general agriculture during the whole period under report.

Babu B. L. Mukerji, B.Ag., and Babu B. B. Das, B.Ag., stipendiaries of Eastern Bengal and Assam, attended the course of general agriculture from July 1910 till March 1911, when they left to take up their duties at Dacca.

Mr. A. B. Hay-Webb worked on the farm as a visitor from 2nd to 27th March 1911.

The numbers of students attending the short courses have been:

- Cattle-breeding: 8
- Poultry Management: 9
- Tillage Implements and Agricultural Machinery: 3

Character of the Season.—The monsoon of 1910 was early. The rainfall was somewhat small (about 33"), but very well distributed and, in spite of the loss of the crops on large areas of low-lying ground owing to the river rising to a level higher than any previously recorded and owing to the breach of a bund that had previously protected the farm, the crops provided an amount of silage very much greater than the requirements of the cattle for one year. Over 4 inches of rain fell in October, thus ensuring an ample supply of moisture for the greater part of the rabi season, and as the sowings were completed at an earlier date than in any previous year since the establishment of the farm, these crops obtained an exceptionally favourable start, which enabled them to give a very good yield in spite of the fact that no further appreciable quantity of rain fell before harvest.

Rain also fell early in June 1911, and, owing again to the land having been thoroughly prepared beforehand, practically all the crops were sown before the end of the month and give excellent promise.

*This course has since been abolished as it has been found to serve no useful purpose.
Cropping.—The greater part of the farm was, as usual, devoted to growing fodder and grain for the working bullocks and the breeding herd. Maize, sorghum, oats, peas, khesari (*Lathyrus*), gram (*Cicer*) and *arhar* (*Cajanus*) were the principal crops grown for these purposes.

The maize provided a large quantity of excellent silage; that from the sorghum was not so good, much of it being decayed, and the right stage at which to cut this crop for siloing under the conditions obtaining here has yet to be ascertained. The oats provided a large amount of excellent feed both of grain and straw. The area of pulses grown was not, however, sufficient to make purchases of this class of food unnecessary.

Much of the *arhar* was spoilt by the floods.

A considerable area was, as usual, sown with Sann hemp for green manure.

Guinea grass, growing on nearly 3 acres within the influence of the bamboo avenues, gave over 300 maunds per acre of green fodder, with only two irrigations in the dry season; lucerne, with constant irrigation, gave over 200 maunds per acre.

Other crops grown on a small scale were flax (which had to be destroyed because of the appearance of dodder) and paddy. Experiments with paddy were inconclusive, the difference between the yields of the plots not exceeding the margin attributable to error.

The projected growth of varieties of wheat in extension of the work done by the Imperial Economic Botanist was abandoned. A large number of crops were grown, on small plots, under observation and for experiments carried on by the scientific officers.

Soybeans, obtained from Nagpur, yielded nearly 7 maunds per acre, which is not sufficient to pay for the cultivation and for the occupation of the land for two seasons.

*Permanent Manurial and Rotation Experiments.*—These were continued in accordance with the original scheme and the result recorded for future reference.
Permanent Pasture.—The manurial experiments were abandoned this year. There seems to be no doubt whatever that the direction which the experiments on pasture here should take is that of ascertaining the extent to which systematic grazing and extensive surface cultivation, combined possibly with the sowing of quick-growing catch crops, will enable land that cannot be economically used except as pasture to be maintained in a reasonably productive and profitable condition. The upland pasture is now ploughed up every three years and replanted with doob, but the doob does not look well on close examination even in the first year after planting, and disappears rapidly during the second year. A small part of the ploughed land has been sown with Sann-hemp this year for ploughing in before planting the doob.

Thrashing.—A record was established in thrashing the oats this year, 241 maunds being thrashed in one day. The heavy yield of grain, amounting on one field to 33 maunds per acre, no doubt contributed to this result.

Clearing and Levelling.—A large kiln was cleared from the former brick-field and a road across this area laid out and part constructed.

Work-cattle.—The number of cattle in use has been increased by the breaking-in of young cattle, purchased, and supplied from the Montgomery herd. The Montgomery cattle are rather slow, but can pull heavy loads. Foot-and-mouth disease broke out among the working bullocks towards the end of the monsoon of 1910, but was checked and suppressed by prompt measures.

Breeding Herd.—The Montgomery herd has been maintained in excellent condition, and the numbers of cows and heifers increased during the year. Fifty-four cattle were sold and four transferred to the working cattle during the year.

Only three animals died—less than 2 per cent., which is a very small percentage considering that the greater number of the cattle are cows and young calves.
Sheep.—The Gorakhpur sheep have done well, and the cross between them and the Dumbha ram appears to be successful.

Poultry-breeding.—One or two of the varieties of poultry originally imported have proved failures, and others have been substituted for them. Indigenous varieties have been obtained and appear in some cases to be worth keeping. But the work cannot yet be said to be beyond the experimental stage. The distribution of eggs by post and rail has been discontinued, but a considerable number of fowls have been distributed to the provincial farms and sold to private persons.

Programme of work for 1911-12.—1. Cropping.—An endeavour will be made to bring the different areas of the farm under systematic rotations suited to each and to the requirements of the cattle. It is proposed to increase the proportion of leguminous crops, and, in view of the excess of fodder provided by the present cropping, to reintroduce revenue-producing crops such as wheat, oil-seeds and possibly tobacco, on a small scale.

2. Pasture.—It is proposed to try simple experiments on the effect of surface cultivation and the sowing of leguminous catch crops on pastures.

3. Laying out.—The clearing of the former brick-field will be continued when time can be spared. The systematic grading of the fields all over the estate towards the roads or drains, so as to prevent the accumulation of water in patches in the centre of the fields, will be kept particularly in view.

Steps will be taken to prevent erosion and "washing" during heavy rain in a few places where it now takes place.

4. Breeding-herd.—The improvement of the milking capacity of the Montgomery herd will continue to be the principal object in view.

5. Sheep.—The production of cross-bred sheep with a view to ascertaining the suitability of the Gorakhpur Dumbha cross for mutton production will be continued.
6. Poultry.—Further trial will be given to some of the breeds already imported, the requirements of the provincial farms will be kept in view, and indigenous breeds will be further studied. The number of different breeds will probably be considerably reduced.

(J. Walter Leather, Ph.D., F.I.C.)

Charge of Section and Establishment.—The section was in charge of myself during the entire year.

Mr. H. E. Annett, Supernumerary Agricultural Chemist, acted as Agricultural Chemist, United Provinces, until 10th November 1910. He again went to Cawnpore on 24th June 1911 to act as Principal, Agricultural College.

The changes involved during the year have been as follows:—Babu Subodh Chandra Kar, M.A., the second assistant, died on 19th July 1910. Subodh Babu joined the establishment at Dehra Dun in 1902 as a volunteer assistant and gradually rose to the position of second assistant. He had shown unusual ability and would no doubt have risen to still higher office. His death was a very severe loss. Babu Jatindra Nath Mukerjee, B.A., B.Sc., the third assistant, has been appointed second assistant. Mr. Bhailal Motibhai Amin, B.A., who was promoted third assistant, has, during the year, been appointed on deputation as assistant in the laboratory of the Behar Indigo Planters' Association. Mr. K. S. Vishwanatham, B.A., was selected by the Imperial Bacteriologist as his second assistant. Babu Adhar Krishna Bose was selected by the Scientific Officer, Indian Tea Association, as his assistant. The latter changes, although occasioning loss to the establishment, must be considered in the light of a compliment to the section and fulfil one of its important functions. Other changes have been as follows:—Mr. G. K. Lele, L.Ag., Nagpur, was appointed a junior assistant in August 1910; Mr. D. K. Ambekar, M.A., had to resign his appointment in April on account of family reasons; Mr. R. C. Sohoni left at the end of his probationary period.
Meteorology.—In addition to the ordinary meteorological records, the record of evaporation, which was mentioned in the last annual report, is being maintained. A record of soil temperatures has also been commenced during the year and will yield information as to diurnal and seasonal variations of temperature. Self-recording hygrometer and barometer will also be set up. Most of the information provided by these records will become immediately useful in connection with one or other investigations at the Institute.

Drainage Data.—These are being continued, and the first several years' records together with those of the Cawnpore gauges have been written up for publication. Among the deductions which have been possible are the following:—(a) The amount of water draining away annually varies with the rainfall, it being large in wet years; but the amount which evaporates from bare fallow soil is almost constant for any one place. At Cawnpore about 18" of water thus evaporates per annum, at Pusa about 28"; the corresponding figure at Rothamsted is about 15". The explanation for the larger amount evaporating at Pusa than at Cawnpore probably lies chiefly in the nature of the soil, but this is a matter which remains to be demonstrated. (b) Drainage from cropped land is naturally affected by the extra factor—the crop—and the drainage data have yielded some very interesting information in regard to it. On the one hand a crop transpires large amounts of water; on the other its presence acts as a "shield" to the moisture of the surface soil preventing it, in a measure, from evaporating. Thus the crop introduces into the question two factors, which are mutually opposed to one another, and the amount of drainage occurring from cropped land will be greater or less according to the magnitude of their respective influences. The effect of good crops growing on the Pusa and Cawnpore gauges has been to reduce direct evaporation to two-thirds or one-half of what the soil would have suffered had no crop been present. How much this "protective" effect is, when converted into inches of water, naturally de-
pends on the season of the year. During the dry season the general loss from this cause is much less than during the monsoon; hence the "protection" provided by a "rabi" crop will be generally much less than that of a "rains" crop; the former may be 2" or 3", the latter 7" or 8" of water. (c) The amount of water which runs off the land during heavy rain is known to vary within wide limits, and although the gauges have yielded some information on the subject, it relates to only one soil maintained perfectly level. No very explicit deductions are therefore possible, but the general conclusion has been drawn that perhaps popular ideas have exaggerated its amount.

*The Amount of Nitrate in Soils.*—This subject is one which has long been considered of great importance, and the drainage water from the gauges, as also some field records, have added much to our knowledge of the subject in so far as India is concerned. The total amount annually formed in fallow land is very much greater—twice or three times—than at Rothamsted. Then another feature has appeared, namely, that nitrification is not active throughout the dry weather, that is in fallow land—not irrigated; absence of moisture in the surface soil during a part of this period might be a controlling factor, but it is not a complete explanation, because the sub-soil is always moist, and here nitrification is similarly restricted to the monsoon. Nor does the variation of temperature offer any better explanation. With the advent of the monsoon, however, nitrates form with astonishing rapidity, the occurrence being most marked immediately after the first heavy rain. This investigation promises to prove of great interest.

*The Water Requirements of Crops.*—Allusion has been made in previous reports to this subject, and a second memoir, No. 10, Chemical Series, has been published. In continuation of what was published in Memoir No. 8, it has been found that the nature of the soil has no effect on the Transpiration Ratio; at the same time this factor has a great influence on the rate of water movement, and hence indirectly on the weight of crop produced. Field experi-
ments over several years have shown that practically the whole of the water assimilated by a crop is obtained within the root range, some 6 to 7 ft. in alluvial soil, and that although the stores of water present below this depth are very great, they are substantially of no service to the plant. The field experiments were at the same time utilised to check the values of the Transpiration Ratios which had been found by pot-culture methods. The two methods yielded very similar values for this factor.

The investigation into the availability of plant food in soils is being continued, but many difficulties have been met with, and its progress is slow.

Usar Land.—Reference was made to this subject in the last report, and the work has been extended. The first investigation had to do with a certain stretch of land in the Mainpuri District, and a very exhaustive series of tests showed that this class of usar land not only contains sodium carbonate, but is also highly impervious to water. The amount of movement of water, whether in the downward direction during wet weather, or towards the surface during the dry period, is thus necessarily only small; consequently also there cannot be any large amount of movement of salts.

Experiments made at Pusa on this soil have shown that by the application of common salt its physical state can be altered and the salts washed out. Rice was grown on some of it last year and is now growing again, but the method is, I fear, not financially feasible. In other experiments also made by pot-culture at Pusa, the physical defect (imperviousness) was separated from the chemical defect (alkali salts) and then plants sown. It was then found that of the two the alkali was the more pernicious.

During the past cold weather the investigation has been continued in another direction in collaboration with the Irrigation Department. One of the features of this alkali land is frequently the occurrence of “alkali spots” in the middle of fields otherwise quite fertile. It has been frequently argued that these result from the presence of
canals and excessive irrigation. The fact that the introduction of a canal is accompanied by a rise of the sub-soil water level has lent support to the argument. The two features are, however, distinct, and it certainly does not necessarily follow that they are related. We have some soil, taken from fertile land in the immediate neighbourhood of alkali spots under observation; it is maintained fallow with an artificial sub-soil water-supply at 2 ft. from the surface, and the experiment should show whether it will thereby become "alkali."

But the work of the past cold weather dealt with another aspect of this question. It is not only in canal-irrigated areas that "alkali spots" occur in cultivated fields; they are to be found in well-irrigated tracts also. It was decided, in consultation with the Director of Agriculture and the Superintending Engineer, to take samples from a series of such "alkali spots" situated (a) within a canal-irrigated tract, and (b) within a neighbouring well-irrigated tract, and to compare them by means of such methods as we at present possess. A suitable tract of country was found in the Muttra and Etah Districts. In the Sadabad (Muttra) and western part of Jalesar (Etah) parganas is a tract of country under well-irrigation, and alkali spots occur in many of the fields; thirty such alkali spots were sampled to a depth of 9 ft., excepting in cases where the kankar was too hard to drill through. In the eastern half of pargana Jalesar the irrigation is principally from the Etawah branch, Ganges canal, and in this tract twenty-nine alkali spots were similarly sampled to a depth of 9 ft. In each case a separate sample of every succeeding 6" was taken, and the whole of the specimens are now under examination. The first tract named is particularly suitable because although it has always depended on well-irrigation, the new Hathras branch of the Ganges canal is under construction, and the tract will hence shortly come under the influence of canal irrigation. All the fifty-nine alkali spots have been registered, mapped to show the approximate area, and the exact position of the boring, from which
the sample was taken in February, registered by means of distance and direction from a stone bench-mark especially put down on the field border. We shall thus not only have the results of the comparative tests of the present year, but it will be possible to form a very exact opinion at a future time, say ten or fifteen years hence, as to whether the introduction of canal irrigation has caused either an increase of the area of these "alkali spots" or any increase in the percentage of "alkali" in the soil. The tests of the soil of experimental plots near Aligarh which were referred to in last year's report showed that the only really effective means which had been tried was gypsum, and in that case the cost had been prohibitive. The land which Mr. Keven-ter has reclaimed was especially interesting. By the application of very large amounts of manure and liberal irrigation, crops have been grown for a number of years on some very bad alkali land. But the samples taken to a depth of 9 ft. showed that the result of the treatment had been to reclaim only the top foot of soil, and that below this layer, the soil is as bad as it was originally. The crops subsist in fact on the liberal manure supply of the top soil and can even then only succeed by the aid of frequent irrigation.

Date Palm.—Immediately after his return from Cawnpore, Mr. H. E. Annett took up, at my suggestion, the general investigation of the Date Palm Sugar industry. Hitherto nothing had been done in relation to the chemistry involved in this industry, and it is obviously desirable that this omission should be rectified. Mr. Annett toured twice in the Jessore District, which is one of the principal centres, and carried out a series of analyses of the juice on the spot and later on of raw sugar at Pusa, besides collecting much valuable information in regard to the methods which are employed. The work will be continued on Mr. Annett's return from Cawnpore.

Saltpetre.—During the year an attempt has been made to work out the practical details of an improved method of refining crude saltpetre which had occurred to me some
years ago as possibly feasible. The chief defects of the present methods are (i) the considerable time required in order to obtain the refined product, (ii) the amount of fuel used is greater than it should be, (iii) a serious loss of nitrate occurs, (iv) much of the refined saltpetre is of low quality, (v) the colour of the refined saltpetre is often brown instead of white, (vi) refining is often interrupted during the rains period.

After working on a laboratory scale, an apparatus was constructed which would deal with a maund of crude saltpetre per charge, and this was worked daily at the Allahabad Exhibition. It was in charge of Babu Jatindra Nath Mukerjee, who has carried out the whole of the experimental work connected with the process. The process is successful in largely eliminating the defects enumerated; nearly nine-tenths of the potassium nitrate in the crude saltpetre is obtained during the day as a white refined saltpetre of over 90 per cent. purity; no water has to be evaporated, and the process is independent of the weather. The other fraction of the potassium nitrate, which is not obtained by this process, remains in the muds and can be extracted by present methods.

The process created a great deal of interest among the refiners who visited the Exhibition, but there is naturally a considerable difference between entertaining an interest and actually replacing the present methods by a somewhat costly machine, and no definite opinion can be formed as to whether the new process will be adopted until it has been tried on a reasonably large scale, so as to form an accurate idea of the actual cost of working it. A proposal is at present under consideration to erect the plant at a refinery in Behar. A Bulletin has also been written on the subject.

Education.—There are two students from the United Provinces and Bengal, respectively, at present undergoing training, and another is to come from Travancore State. There are also two probationary assistants who have recently joined this section, who are in the position of students.
Programme of work for 1911-12.—1. The work on the availability of plant food in soils will be continued.

2. In relation to moisture requirements of crops, the current work has to do with the moisture conditions necessary to a green manure crop.

3. The investigation on Usar will be continued on the lines indicated in the body of this report.

4. The chemistry and manufacture of Date Palm Sugar will be investigated by the Supernumerary Agricultural Chemist.

5. Improvements in the refining of saltpetre will continue to be studied.

6. Education.—This requires no special comment and will be conducted according to the lines laid down.

Publications.—The following papers have been published:


"Chapter on Industrial and Agricultural Chemistry" for the Report of Board of Scientific Advice, by Mr. D. Hooper and Dr. J. Walter Leather, 1909-10.


(A. Howard, M.A., A.R.C.S., F.L.S.)

Part I.

Teaching, Training and Staff.

Charge.—I held charge of the section during the year under review except for the first 28 days of July when I was on privilege leave and on special duty in England.

Up to the end of July Maulvi Abdur Rahman Khan, Second Assistant, was in charge of the section. During my deputation to the Kashmir State in August and September 1910, he was also in charge of the current work at Pusa. In consequence of the satisfactory manner in which this assistant carried out his duties during five months in my absence in 1910, his services were rewarded by the grant of a special charge allowance for the whole period in question.

Students.—Four short course students attended the section during the year. Three of these worked well, especially the two sent from the Lushai Hills by Major Cole.

Staff.—In addition to the work done by my second assistant, Maulvi Abdur Rahman Khan, during my absence from Pusa in 1910, which has already been referred to, I have pleasure in recording the promising work of this assistant in Economic Botany. The third assistant, Munshi Ijaz Husain, who was in charge of current duties at Pusa on two occasions for short periods, has also improved in his work and made himself useful in connection with the tobacco-curing experiments. The work of the rest of the staff was satisfactory.

Part II.

Special Work in England.

To enable me to complete the work referred to in this section my privilege leave was extended by 17 days to a
period of three months. During this time the work done was the following:

Wheat.—One of the directions in which the improvement of Indian wheat has been attempted at Pusa has been the increase in rust-resisting power of the kinds at present in cultivation in the plains. This is a subject which has on several previous occasions occupied the attention of the Government of India, but little or no results of practical value have been obtained in the past. It was found at Pusa and at Lyallpur that although the types at present in cultivation differ considerably in rust-resisting power, and that in consequence a considerable improvement in this character is possible by simple isolation methods, nevertheless India does not possess any wheats with the same power of withstanding rust as is shown by many of the wheats of Northern Europe, and especially by American Club. The quality of resistance of the best Indian wheats is of quite a lower order than that possessed by the wheats grown under the more adverse climatic conditions of the North Temperate Zone. This is seen not only when the two classes are grown side by side in India, but also when they are cultivated together in England. One of the directions, therefore, in which improvement might be attempted was, in the light of the work already done at Cambridge on the inheritance of rust resistance in wheat, the production of new kinds by hybridization between Indian wheats and some rust-resistant forms from Northern Europe or America. Attempts to carry this out in practice at Pusa failed on account of the impossibility of getting the rust-resisting parents to flower in time for crossing to be done and for the resulting grain to ripen before the hot weather set in. This difficulty was overcome by sending the Indian parents to Cambridge for spring sowing in 1910 and by carrying out the actual hybridization work in England. Thanks to the facilities given by Professor Biffen at Cambridge, crosses were made by us between various Indian types and American Club and other rust-resistant wheats at Cambridge, and the first generation of the hybrids was
grown at Pusa during the past wheat season. A duplicate set of these seeds was also successfully grown for us at the Cawnpore Experiment Station by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Now that the difficulty of growing the first generation in India has been overcome, it is expected that among the progeny of these crosses wheats will be isolated of much greater rust-resistance than any of the types now grown in India. The work will be pushed on as rapidly as possible, and it is hoped before very long to have the results on a field scale.

Advantage was taken of my visit to England to consult with Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, on many matters connected with the milling and baking qualities of Indian wheat and to go over in detail the samples sent to England for testing in 1910. I obtained a large amount of valuable technical information on the quality of wheat and also took full opportunity of discussing in detail the lines of future work on the improvement of Indian wheat. I consider Pusa has been exceedingly fortunate in securing for the milling and baking tests not only the invaluable assistance of an authority of the standing of Mr. Humphries in the wheat trade, but also his active interest in the work of improving the crop in India. I consider it will be far better in every way to continue to have the final tests of Indian wheats done in England than to attempt to carry out the work at Pusa under laboratory conditions. Results obtained under such circumstances in India will never carry the same weight as the opinion of the best available expert in the milling and baking trade.

In order to compare the appearance of the new Pusa wheats with those now on the market from various parts of the world, I visited Mark Lane with Mr. Humphries and the Liverpool Corn Exchange with Mr. Broomhall, the proprietor of the Corn-Trade News and Milling. It was acknowledged that there were no wheats on the market superior in combined appearance, quality and condition to
the best Pusa wheats. As far as quality only is concerned, Indian wheats are somewhat inferior to Manitobas, but in their greater dryness and in the greater thinness of the skin our best Pusa wheats at least make up for their slight lack of quality. As wheats are sold entirely on the appearance of the samples taken from the ships, it is of the greatest importance to the Indian wheat trade to keep the various grades of Indian wheats separate and not to mix red and white, hard and soft wheats in the same sample. This lowers the price that would otherwise be obtained, while adulteration with earth and other seeds does still greater harm. I saw several good samples of Indian hard white wheat at Mark Lane entirely spoiled by admixture with soft white and red wheat and with dirt and other seeds. A great work remains to be done in teaching the Indian cultivator the great importance of quality, uniformity and appearance in the wheat grown for sale in Europe. In Liverpool, the Pusa wheats were greatly admired and were shown to a meeting of Liverpool millers by Mr. Broomhall, who, in returning the samples to me in London, wrote: "I have just sent you back the samples you left with me. I have shown them to several of our millers who have greatly admired them. The wheat appears equal in value to the best Manitoba." (Letter dated July 8th, 1910.)

While at Liverpool the opportunity was taken of visiting the large new Grain Elevator recently erected by the Liverpool Grain Storage and Transit Company, which embodies all the latest American and Canadian improvements in construction.

Tobacco.—In connection with the work in progress at Pusa on the improvement of Indian tobacco, arrangements were made with one of the Directors of the Imperial Tobacco Company in London to visit two of the best factories in London to see the types of leaf made use of in England. These visits were of the greatest use, and some of the information obtained was applied in the tobacco-curing experiments at Pusa during the past year.
Hops.—In anticipation of my deputation to Kashmir to advise the Durbar on the improvement of the hop industry in that State, three visits were paid to Kent to see the latest forms of hop-drying oasts and the developments which have taken place in hop growing during the last five years. The information obtained was made use of in my subsequent visit to Kashmir.

Fruit packing.—In connection with the proposals for developing the fruit industry of Baluchistan then under the consideration of the Secretary of State, some time was devoted to studying the methods of packing and transporting fresh fruit both in use in England and also employed by the various countries which export fruit to London. Very valuable information was obtained which will be of considerable use in working out the best methods of sending fresh fruit from Baluchistan to India. By a fortunate circumstance I got in touch with one of the Directors of the largest company in Great Britain engaged in the manufacture of fruit packages on the American system, and in consequence have had no difficulty in importing into Baluchistan a large selection of model packages and packing materials for use in the experiments of the present year.

A study of the methods of packing used for transporting fruit from France, the Channel Islands and South Africa to London shows how backward India is in this respect and what great improvements are necessary in this country.

Part III.

The Hop Industry in Kashmir.

In accordance with the orders of the Government of India the months of August and September 1910 were spent on deputation in Kashmir for the purpose of advising the Durbar as to the best means of extending and improving the hop industry. A detailed report on this subject was submitted, which was afterwards printed by the State.
At present hop growing in Kashmir is in a very primitive condition, the average yield of sun-dried hops being less than \(2\frac{1}{2}\) cwt. to the acre, or one-fifth the average yield of Kent. In spite of this, however, the net profits are very great, and for the last sixteen years have averaged about 130 per cent. or over £7 an acre.

The natural advantages possessed by Kashmir as a possible competitor in the world's hop production are considerable. Labour is cheap, plentiful, easily trained and easily managed. The soil of considerable areas of the valley is suitable for hops, while irrigation water is abundant, should it be found necessary to supplement the rainfall. Insect and fungoid pests are almost entirely absent, while the cost of transport to India is likely to be much cheaper as soon as the rope railway to Jammu is completed. These advantages, however, are not likely to be utilised to the full unless the Durbar decides to take the necessary steps to place the industry on modern lines.

In the details of cultivation, irrigation, training, picking and drying there is great room for improvement, and it was a great surprise to me to find that even a crop of \(2\frac{1}{2}\) cwt. of saleable hops could be produced under present conditions. The cultivation of the crop is exceedingly defective, and a large amount of moisture is lost by the dense growth of grass and weeds and the absence of a surface mulch. This necessitates surface irrigation and the consequent hardening of the land and loss of tilth. Beyond the provision of single poles there are no attempts at training, so that there is insufficient space for the free development of bine and hops. The drying is done on sheets in the sun, and during this process the hops are a good deal broken, and a large amount of lupulin is lost.

In my report an attempt was made not only to present the scientific principles which underlie modern hop production, but also to indicate the improvements which are possible if it is decided to continue the industry on the present lines. In addition the steps were indicated that would be necessary if hop growing in Kashmir is to be placed on
modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

In addition to the work on hops two other matters were dealt with in Kashmir at the request of the Revenue Minister. The first was an investigation into the wine industry, which is carried on by the State near Srinagar, and the second related to a general scheme for the improvement of the agricultural and horticultural industries of the State. In the case of wine industry, I recommended that this should be given up and the past expenditure in this direction regarded as a bad debt. As regards the development of the agricultural industries of the State, I drew up a detailed scheme in which many directions of improvement were indicated, and in which I recommended the amalgamation of the present agricultural and allied efforts of the State into one strong department under a competent European officer with the necessary experience. Time did not permit me to make all the necessary enquiries into a fourth subject on which my advice was asked for by the Revenue Minister and by the Minister for Education. This related to the introduction of Agricultural Education into the State, on which no useful suggestions could be made without first of all going into the present educational system as a whole.

**Part IV.**

*The Development of the Fruit Industry of Baluchistan.*

The proposals put forward by this section in 1909 for the development of the fruit industry of Baluchistan were, during the year under review, finally sanctioned by the Secretary of State, and work was commenced at Quetta in May of the present year. This extension of the work of the section has necessarily involved not only some re-organisation of the work at Pusa, but also an extension of the staff. The Pusa work both in training and investigation is now in great measure limited to *rabi* crops, thereby allowing the months May to September to be devoted to
fruit work in Baluchistan. The staff has been strengthened by the addition of a new appointment, that of Personal Assistant, which was given to a candidate who had worked in this section for nearly five years previously as a volunteer.

During the months May and June of the present year the lines of future work on the fruit industry of the Province have been worked out in detail, and a scheme has been put forward which has been accepted by the Local Government.

This falls into three parts. In the first place, a modern fruit experiment station will be started for the purpose both of demonstrating improved methods of producing and transporting fruit and also of affording facilities for further experiments likely to be of practical value to the country. One of the features of the new experiment station will be a nursery in which the best varieties will be propagated in large number for distribution to the zemin-dars. In the second place, a neglected fruit garden will be taken in hand, and methods of renovation will be commenced this year. Thirdly, steps are being taken to work out the most suitable methods of grading, packing and transporting fruit so as to make the most use of the present facilities for railway transport to India.

The country round Quetta has been explored, and a suitable site for the new experiment station has been selected, and steps have been taken by the local Government to acquire the land. The Honourable Colonel Ramsay, C.I.E., Agent to the Governor General in Baluchistan, who has strongly supported the scheme from the beginning, has placed a large fruit garden at my disposal for the renovation experiment. It is hoped that a beginning will be made with the packing experiments during the present year, and the necessary buildings for the fruit experiment station will be erected by September next.

In the preliminary work involved in the scheme I have been greatly assisted by the Political Officers stationed at Quetta. Mr. H. R. C. Dobbs, I.C.S., C.I.E., Officiating
Revenue and Judicial Commissioner in Baluchistan, has furthered the scheme in every way possible, while I am greatly indebted to Colonel McConaghey, Political Agent, Quetta-Pishin, and to Captain Keyes, Assistant Political Agent, Quetta, for the ready manner in which they have placed their wide knowledge of the country and of the people at my disposal.

Part V.

Investigations.

Wheat.—During the past year the Pusa wheat experiments have been extended in several directions, and results of great value have been obtained.

Seed Distribution.—A beginning was made during the year at several centres in the growth of Pusa wheats for seed distribution purposes. In Behar two planters volunteered to take up the work in 1910, and in both cases the yields obtained were far in excess of those obtained by the people with the local wheats. The seed thus obtained has been widely distributed to other planters, with the result that over 1,000 acres of the new wheats will be sown next October in Behar at a large number of centres. Over 100 maunds of surplus seed grown in the botanical area at Pusa was distributed last April in Behar alone, the demand greatly exceeding the supply. In the Central Provinces some of the early Pusa varieties were grown by Mr. Clouston, Deputy Director of Agriculture, at the Raipur Farm on a fairly large scale. Both in yield and quality these wheats proved superior to the large collection of other Indian wheats grown there. A further supply of other rapidly maturing wheats was accordingly sent to Raipur last April, and the best of these will be grown on a large scale by Mr. Clouston for distribution, mainly in the Chattisgarh Division. Incidentally the wheat experiments at Raipur during the past season indicate that organic matter in the right condition is the limiting factor in wheat production in this tract. This matter is being taken up by
Mr. Clouston, and when the best method of enriching the soil by green manuring has been worked out I feel confident that wheat growing in this and similar tracts will at once be placed on a higher plane. In consequence of the satisfactory results obtained at Raipur, arrangements have been made with Mr. Evans at Hoshangabad for the trial of one of the earliest of Pusa wheats at that station. In the United Provinces the methods of cultivation of wheats which have proved successful at Pusa were tried on a large scale in the botanical area at Cawnpore by Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces. Both in yield and appearance of the grain the results obtained were very much better than those realised in the district. The Cawnpore results are particularly valuable, as they indicate the possibility of growing large yields of wheat of high quality under canal irrigation. At the Aligarh experiment station Dr. Parr, Deputy Director of Agriculture, United Provinces, obtained very high yields with one of the Pusa selections and has arranged for extended trials of this wheat in his circle during the next year. Arrangements for the trials of Pusa wheats next year have been made at Mirpurkhas in Sind and in the Punjab at Lyallpur and Gurdaspur.

A considerable demand for the new wheats has arisen from Australia in consequence of the satisfactory behaviour of the Indian samples grown there in 1909. In the same year a small sample of Pusa 6 was tried in Hungary with the result that 16 maunds of this variety were asked for by and supplied to the Minister of Agriculture of Austria-Hungary in April last.

One result of the wheat investigations, which is of considerable importance to India and to the future policy of the Agricultural Department, deserves special notice. This is the value of the variety of a crop when it stands alone. It is sometimes thought that in the case of crops improved varieties can be produced of such excellence that when distributed to cultivators greatly improved yields will result, no matter what the methods of cultivation adopted by the
people may be. A little consideration will show that these expectations are bound to result in disappointment as they entirely disregard the fact that two of the limiting factors in crop production in India are the methods of cultivation and moisture conservation adopted. Inadequate preparation for any crop and insufficient moisture cut across the real yielding power of varieties and tend to bring them to the same level. Optimum yields of the varieties and therefore true comparisons in yielding power are only possible if the limiting factors of bad cultivation and poor moisture conservation are removed. The full benefit of improved varieties, and especially those of high quality, can only be realised if cultivation is good and moisture is adequate. It is suggested that in all seed distribution schemes in India due attention should be paid to the prime importance of cultivation and moisture conservation as well as to the value of improved varieties. That it is possible to obtain greatly increased yields using only the means now possessed by the cultivators has been abundantly proved by the results obtained in the botanical area at Pusa during the last three years.

Trade Aspects.—Advantage was taken during the year of several opportunities of bringing the results of the wheat experiments to the notice both of the trade and of those interested in the cultivation of the crop. Everywhere the greatest surprise was expressed that wheats like those shown could be grown in India. In Karachi and Calcutta I ascertained from the leading wheat merchants that no difficulties are likely to be experienced by the growers in disposing (with considerable advantage to themselves) of uniform parcels of wheat of high quality. It is essential, however, that the quantities should be large and that the grades should be maintained from year to year. In Bombay a paper was read on the Pusa wheat experiments in the rooms of the Bombay Natural History Society, at which most of the wheat merchants attended, and at which an exhibit of the new wheats was shown. At the Allahabad Agricultural Conference I opened the discussion on wheat,
and as a result an extended trial of improved wheats and of improved methods of cultivation was arranged on some of the Court of Wards Estates. At the meeting of the Behar Planters’ Association in February 1911 an account was given of the improved methods of wheat growing at Pusa which will be tried at a good many centres in Behar next year. Unfortunately, however, the demand for seed which arose after the meeting was far greater than the supply.

**Milling and Baking Tests.**—The most interesting point with regard to the milling and baking tests of Indian wheats during the past year is concerned with the quality of the new wheats raised at Pusa by hybridizing high yielding Indian wheats of poor quality (Muzaffernagar white and Punjab Type 9) with types of high grain quality but of lower yield. The results obtained show that the problem of combining high yield and high quality has been solved, the new wheats behaving in the mill and bakehouse like the high quality parent. A bulletin summing up the present position of this aspect of the subject and giving the results of 1910 in detail has been published. In response to numerous requests a full account of the actual methods adopted at Pusa in growing the crop has also been included. Translations in Urdu and Hindi of this paper have been prepared during the year by members of the staff.

**Influence of the Environment on Quality.**—The experiments on this subject which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, were greatly extended during the year, and a large number of samples have been forwarded to England for complete milling and baking tests. It is expected that the results will confirm the opinion previously expressed that high quality and high yield both depend on proper cultivation and on proper soil management previous to sowing time.

**Tobacco.**—A considerable amount of progress has been obtained during the year in the tobacco experiments.
Manuring.—It has been found at Pusa that the success of this crop in Behar depends on the rapidity of growth during October and November, and that this rapid growth is only possible provided a large supply of organic manure in the right condition is added to the soil. It is usual to use indigo *seeth*, oilcake and cattle manure for this purpose, but the application of these substances in sufficient quantity is a costly process. In 1909 it was found that green manuring with *san*, if carried out in good time so as to allow of a thorough incorporation with the soil, was not only as effective as the organic manures usually employed but also far cheaper. During the present year the results were repeated, and trials of the same varieties with *seeth*, *san*, cattle manure and oilcake were made. Both in yield and quality of cured leaf the results with *san* were entirely satisfactory, and accordingly the Pusa results have been brought to the notice of planters interested in tobacco growing in Behar, and extensive trials with *san* are now being made in the district. As in wheat growing it has been found at Pusa that attention to the details of cultivation and moisture conservation are of the greatest importance in tobacco cultivation. About 34 maunds of cured leaf (omitting the lower portions of the stalk usually included in Behar) were obtained to the acre at Pusa last year—a yield greatly in excess of the crops in the neighbourhood.

Curing.—Results of considerable promise have been obtained in the curing experiments which are being conducted in collaboration with the Peninsular Tobacco Company at Monghyr. The varieties used were both American, and also the most promising of the Pusa selections, and the method adopted was a modification of that usually employed by the people. Under the conditions of the experiment the Indian tobacco gave better results than the American, and one of the Pusa selections gave leaf of considerable promise. The experiments are being continued on a large scale.

Breeding.—Both in *Nicotiana tabacum* and in *Nicotiana rustica* considerable progress has been made by the
Personal Assistant in the investigation of the inheritance of characters in this crop which, as was expected, has turned out to be a somewhat complex subject. The object of this work is to discover the mode of inheritance of the various leaf characters in particular so that new and improved varieties can be made by hybridization. Practically nothing is known on this subject, and the scientific breeding of tobacco is still in its infancy.

Fibres.—San (Crotalaria juncea, L.).—Several new varieties of this crop have been isolated during the year, and interesting results have been obtained with this crop as a green manure. These are being repeated during the next cold weather at Pusa.

Patwa (Hibiscus Cannabinus, L.).—A paper on this crop in India is now about to appear in which the work done during the past four years at Pusa is summed up. Natural cross-fertilization takes place in this crop to a considerable extent, but it has been found possible to eliminate to a great extent the effects of this by removing the hybrids during the seedling and vegetative stages. Possibly these methods can be extended to other Indian crops in which crossing takes place and can be made use of on seed farms.

Pollination.—The importance of a close study of the methods of pollination in the crops of India and the bearing of these matters on the growth of seed for distribution to the cultivators in India were dealt with in a memoir published during the year. This matter was referred to in the previous annual report. The paper in question has attracted a good deal of attention, and the subject has been developed still further during the year. Natural cross-fertilization has been found to occur in til (Sesamum indicum), rahar (Cajanun indicus), niger (Guizotia Abyssinica) and in Jute (Corchorus capsularis). Some progress was made during the year in working out the pollination details in the various oil-seed crops grown in India.

Programme of work for 1911-12.—1. Training.—The training of advanced students in this section will be continued.
2. Plant Breeding and Plant Improvement.—During 1911-12 the following crops will be studied:—wheat, tobacco, oil-seeds and fibre plants.

(a) Wheat.—The botanical survey of the wheats of Baluchistan and the agricultural survey of the wheats of Bengal will be completed. The production of improved and rust-resistant varieties by selection and hybridization will be continued. The co-operative experiments on the influence of the environment on the milling and baking qualities of Indian wheats which are being conducted in collaboration with Mr. H. Martin Leake, Economic Botanist to the Government of the United Provinces, will be continued on an extended basis.

(b) Tobacco.—The production of new varieties by selection and hybridization will be continued as well as the testing and curing of the varieties already isolated. The investigations on the influence of the environment on the stability of the type and quality will be continued.

(c) Oil-seeds.—The study of the oil-seeds of India will be continued on similar lines to those adopted in the investigations on wheat.

(d) Fibres.—The isolation and testing of pure races of the fibre plants of India will be continued.

(e) Fruit.—The fruit experiments at Pusa will be continued on the lines laid down in the First Fruit Report. During the months May to September, the work connected with the development of the fruit industry of Baluchistan will be commenced.

Publications.—The large amount of work that had to be got through during the past year has delayed the publication of results, but it is hoped this will be disposed of during the next year.
A fifth volume of *Die Züchtung der landwirtschaftlichen Kultur-Pflanzen* dealing with the breeding of tropical plants is now being published by Messrs. Paul Parey of Berlin under the editorship of Professor Dr. C. Fruwirth of Vienna. I accepted the invitation to contribute the articles on the following crops:—

Jute (*Corchorus capsularis* and *Corchorus olitorius*), *til* (*Sesamum indicum*), *patwa* (*Hibiscus cannabinus*), *rozelle* (*Hibiscus Sabdariffa*) and *san* (*Crotalaria juncea*), and papers on these have been forwarded to Vienna.

In addition the following papers have been published during the year:—

1. Suggestions for the Development of the Hop Industry of Kashmir. (Printed by the Kashmir State for official use.)
REPORT OF THE IMPERIAL MYCOLOGIST
FOR THE YEAR 1910-11.

(E. J. Butler, M.B., F.L.S.)

1. Charge and Establishment.—I remained in charge of the section throughout the year. Mr. F. J. F. Shaw held the post of Supernumerary Mycologist. Mr. J. F. Dastur was confirmed in his appointment as first assistant. Babu P. C. Kar was appointed to the vacant post of second clerk. All the staff have worked well.

2. Training.—Mr. F. Fateh-ud-din, Assistant Director of Agriculture, Punjab, attended for a mycological course once a week up to April 3rd. A forest ranger from the same province received a course of training in fruit diseases up to August 13th. A private student from Bombay abandoned the course early in the year. Amongst visitors Dr. Vermoesen, Mycologist elect to the Belgian Congo, worked in the Laboratory for over two months at the end of the year.

3. Aid to Provincial Departments.—Collections of named fungi, chiefly parasitic, have been supplied to the Madras and Mysore mycologists. A considerable number of specimens have been named for nearly all the provinces, the largest number being for Bombay and Eastern Bengal and Assam. Advice regarding the work of Provincial assistants has been given on several occasions.

4. Plant disease investigations. (a) Palm diseases.—A memoir giving a full account of the bud-rot of palmyra, coco and areca palms in Madras was published in September. An organised campaign, having as its object to prevent the spread of the disease and to stamp it out within the affected area in Godavari and Kistna Districts, has been in progress since 1907. The parasite (Pythium palmivorum) attacks the crown of the palm only, killing the tree by destroying the growing point. Spores capable of
spreading infection from tree to tree are liberated at an advanced stage of the disease. No other method of checking this infection was found practicable than burning the diseased tops before spores had time to form. This was carried out by gangs of toddy drawers recruited by a staff of subordinate officers of the Revenue Department under the control of a special Deputy Collector. Up to the end of the financial year 1910 about half a million palms had been cut out in Godavari at a cost of some Rs. 50,000. The operations were extended to Kistna in January, 1910. The conclusions given in the memoir are as follows:—"The operations have been entirely successful in limiting the disease in Godavari District to the area previously infected. Now that they have been extended into Kistna, it is fully trusted that they will be equally successful in checking the alarming spread to the south which has been going on for some time in that direction. This alone should fully justify the cost of the operations and their continuation. It is unfortunately impossible to estimate the number of trees saved from attack within the infected area. Still the number of trees saved in those parts where the work has been longest in progress must be many thousands, and apart from preventing any extension in the Godavari District, it is not unlikely that the value of the palms actually saved within the district already exceeds the cost of the operations." Since 1910 the control of the work has passed into the hands of the recently appointed Madras Mycologist, Mr. W. McRae.

(b) Tea diseases.—A bulletin by Mr. W. McRae, on the outbreak of blister blight of tea in Darjeeling District, was published in July. This contained a more complete account of the disease than the publications on the same subject mentioned in last year's report. It is unfortunately probable that the blight has come to stay in Darjeeling as it does not seem to have appreciably diminished since its first appearance. Many planters are experimenting on the lines suggested by Mr. McRae for its control, but it is evident that effective measures will be most difficult to carry
out. A tea parasite, *Laestadia Theae*, found in Java some 12 years ago but not previously recorded in India, was reported from the Dooars in July. It causes a leaf disease, known as copper-blight, which spreads with great rapidity, but appears to be closely dependent on weather conditions. A note describing its characters was written by Mr. F. J. F. Shaw for the January number of the Agricultural Journal of India. A disease of tea seed known for many years in Assam was investigated by the Imperial Mycologist in collaboration with the officers of the Scientific Department of the Indian Tea Association. It has been shown to be probably associated with the tea seed bug, *Poecilocoris latus*, which punctures the seed and sucks the juice. Through the opening thus made fungi are able to enter, and the subsequent injury to the seed is due to the growth of one or other of several species of rot-producing fungi at the expense of the seed tissues. The Tea Association is issuing a pamphlet pointing out that this insect is probably much more injurious in seed gardens than was previously suspected and recommending measures for its destruction. Several other tea diseases were investigated during the year, in particular the stem canker, the cause of which is still obscure.

(e) *Soft rot of ginger.*—Mr. W. McRae published an account of this disease in the Agricultural Journal of India, April, 1911. It is prevalent in Eastern Bengal, Gujrat, and probably elsewhere. In Rangpur the loss in damp soils is 10 to 15 per cent. of the crop; in bad years almost the whole may be lost. The cause appears to be the attack of a fungus (*Pythium gracile*) on the rhizomes and base of the plant. As a result of experiments carried out at Rangpur in 1908-09, Mr. McRae was in a position to recommend effective measures for checking the disease.

(d) *Turmeric leaf-spot.*—This is a disease found all over Northern India, but not usually very destructive. It was found by the Imperial Mycologist to be caused by an undescribed species of *Taphrina*, and an account of it was published in the Annales Mycologici in February, 1911.
It is probably responsible for a reduction of the yield which may be much greater than the cultivators themselves suspect, but no treatment can be recommended as yet.

(e) Wilt diseases.—Experiments carried out at Pusa and independently by the Mycological Assistant of the Bombay Department at Poona, have demonstrated that the fungus which causes rahar (pigeon pea) wilt produces virulent spores on the stem of diseased plants. Hence it is advisable to pull out attacked plants early. Mr. Shaw has found that the cause of the death of cotton seedlings at Cawnpore is Rhizoctonia and not a Fusarium wilt. It is probable, however, that the cotton disease in the Central Provinces, Berars and other parts of India is a true wilt, and it is hoped to investigate this shortly. A gram disease resembling wilt, sent from the neighbourhood of Peshawar, was found to be caused by Ascochyta Pisi and not Fusarium. A supposed outbreak of indigo wilt which caused a good deal of alarm in September, was shown to be due to leaf-sucking insects.

(f) Sugarcane diseases.—The field experiments with red rot and Cephalosporium disease were abandoned as the plots became infected throughout, and were also attacked by white-ants. Successful inoculations were obtained with a fungus which causes a root disease in Madras and has not previously been described. The Bombay Department is following the recommendations of this section in introducing healthy sets into some districts where red-rot is severe.

(g) Forest tree diseases.—These continue to occupy a certain amount of time as there is no Mycologist attached to the Forest Department. The chief work of the year was the study by A. Hafiz Khan of the passage from root to root below ground of Trametes Pini, the fungus which causes heart rot of the blue pine. He published an account of his investigation in the Indian Forester, October, 1910. A serious disease of the Nahor (Mesua ferrea) has appeared in Sibsagar and Tista Divisions. It is undoubtedly caused by a fungus at the base of the tree, but we have
failed to isolate the species. A leaf disease of Piauhyensis rubber reported from Assam was identified as *Cercospora Cearae*, which has not previously been recorded on this tree. Diseases of sal, Casuarina, babul pods and deodar were also examined for the Forest Department.

(h) *Root-rot caused by Rhizoctonia.*—In September of last year a number of crops on the Farm were attacked by a species of *Rhizoctonia*. The crops damaged were principally groundnut, cowpea and jute, at the same time specimens of cotton seedlings from Cawnpore showed similar symptoms of disease. The fungus was isolated from each host and cross inoculations performed with a view to ascertaining whether special races of the fungus are restricted to particular hosts and the extent to which crops are liable to infection in the field. Owing to the subsequent discovery of *Rhizoctonia* on the mulberry and papaw, the scope of the work has since become extended; at present, except in the case of the *Rhizoctonia* on jute, the evidence is against the existence of special physiological races on particular hosts. A fruiting stage of the fungus was discovered on the groundnut and coincides with one which has been previously described as occurring on potatoes in America.

(i) *Other plant diseases.*—A disease of wheat which does not appear to resemble any hitherto described, was reported from Dharwar and Hoshangabad. It is hoped to investigate it more fully next season. The anthracnose of chillies caused by *Colletotrichum nigrum* was widespread last year, and we had several enquiries about it. Other anthracnoses examined were those of beans, sida, mango and plantain. An attack of a species of *Phytophthora* on rhea was reported from Dacca. The study of the *Phytophthora* on castor was continued. The downy mildew of *Cucurbitaceae*, *Plasmopara cubensis*, was found at Pusa during the year. This disease, which has been spreading gradually throughout the temperate portions of the world during the past fifteen years from centres in the United States and Japan, was not previously known in India.
The conidial stage of the *Sclerospora* on jowar was found in Bombay and supports the conclusion previously arrived at that the disease is identical with that of bajra due to *Sclerospora graminicola*. The number of parcels of specimens sent in for examination was 97, and, as usual, a large part of the routine work of the section was the identification of these; recommendations for the check of diseases caused by them were given when possible.

5. *Systematic work.*—Much time was given to this branch of the work during the year. It has been pointed out in previous reports that the accumulation of a good classified collection of Indian fungi is as necessary a part of the equipment of the section as the microscopes or other tools of the laboratory. In India, unlike more advanced countries, we have nowhere to turn to to get this work done for us. It is true that we have received generous help from specialists in other countries, but to secure this we have to undertake our share of the work. Within the past few years a large body of the *Phycomycetes*, rusts and smuts of India have been determined. The *Ascomycetes* were taken up last year, and some hundreds of specimens worked through and sent to Berlin, where the determinations will be published in collaboration with Messrs. H. and P. Sydow. Two large groups, the *Basidiomycetes* and *Deuteromycetes*, remain to be worked out, but it will not be possible to undertake their study for some years. Considerable additions to our knowledge of Indian *Phycomycetes* and rusts were also made during the year. Over 600 sheets were added to the herbarium.

6. *Miscellaneous.*—Mr. Shaw assisted the Imperial Bacteriologist in investigations of eri silkworm diseases and tobacco wilt. Eight show-cases of typical fungus diseases of plants were exhibited at the Allahabad Exhibition. A teaching collection of fungi with notes was prepared for the Elphinstone College, Bombay. A report was written on the invasion of *lantana*, a noxious weed of Mysore and Coorg, and measures for its check recommended. The
proposals made in collaboration with the Imperial Entomologist, for the legislative control of plant imports likely to introduce injurious insects and fungi into India, were printed and circulated for the consideration of Local Governments and public bodies interested, and have met with, on the whole, a favourable reception. To carry these proposals into effect will be one of the most important duties of the section in the near future. A note on the organisation of the service for the control of insect pests and fungus diseases was drawn up, also in collaboration with the Imperial Entomologist, for the International Institute of Agriculture, Rome. An outbreak of flax dodder at Pusa was dealt with, the crop being burnt. Recommendations were made to the Scientific Department of the Indian Tea Association of the best means to adopt for disinfecting tea seed intended for export, as this was insisted on in the country for which the seed was intended.

7. **Programme of work for 1911-12.**—(1) **Research and Experimental work.**—The work on the wilt diseases of crops will be continued on the lines indicated in the memoir on Pigeon-pea wilt published last year.

The investigation of the fungus diseases of sugarcane will be continued. The chief points of the present enquiry are the spread of red-rot through the soil, the relative immunity of thin canes to this disease, and the study of two undescribed cane diseases.

The study of some fruit diseases commenced last year will be continued, particularly with reference to their control by spraying.

The Supernumerary Mycologist is engaged on an investigation of the root-rot of a number of crops caused by the fungus *Rhizoctonia solani*. This will be continued.

(2) **Training.**—This will be continued on the lines indicated in the prospectus. Short courses will also be given to students taking the fruit growing and general courses and to private students, as during the past year.

(3) **Advice regarding the fungus diseases of plants** will continue to be given to other departments, particularly the
Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will also be continued.

(4) The collection and identification of Indian parasitic fungi will be continued.

**PUBLICATIONS.**


REPORT OF THE IMPERIAL ENTOMOLOGIST
FOR THE YEAR 1910-11.

(T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S.)

Charge and Establishment.—Mr. Maxwell Lefroy, the Imperial Entomologist, held charge of the section until 30th January, when he proceeded on privilege leave and furlough out of India, the work of the section being then continued by me until the close of the period under review. There have been no changes in the permanent establishment during the year. Mr. C. S. Misra, the First Assistant, who was on privilege leave from the commencement of the year to 9th July 1910, had charge of the field-work on the Pusa Farm and Botanical Area and of the lac work, and has given two courses of instruction to students who attended for the short course in lac culture. Besides this, and apart from the personal instruction given by the Imperial Entomologist, Mr. Misra has had charge of the Laboratory and field training of the students in General Entomology; in this, as in his other work, he has done admirably. Mr. C. C. Ghosh, the Second Assistant, has been in charge of the insectary and has carried out extremely useful work in rearing and observation of insect pests. The Third Assistant, Mr. G. R. Dutt, has been in charge of the economic collections and records and has carried out the issue of coloured plates and lantern slides; in addition to his own heavy routine work, he has found time to study the Aculeate Hymenoptera and has prepared a Memoir on the life-history and habits of some of these insects. Mr. D. Nowrojee has been in charge of the general collections of insects and has done very good work in their upkeep and arrangement; this is work which naturally expands automatically every year, but Mr. Nowrojee has been able to do original work as well, and has written a Memoir on aquatic insects which is in the press at the date of this report.
He was away on privilege leave from 16th December 1910 to 6th January 1911. Mr. R. R. Ghose, who held the post of Sericulture Assistant, resigned on 25th October 1910, since when the position has been filled by Mr. M. N. De, who has worked hard and satisfactorily.

Visitors.—The Assistant Professor of Biology in the Punjab Government College, Lahore, and the Lecturer in Entomology at the Cawnpore Agricultural College, both worked in the Laboratory during their vacation periods, the former from December to January and the latter from March to June. The Entomological Assistant to the Baroda State spent a fortnight in Pusa discussing his work and his programme for the ensuing year and in collecting information likely to be of use. The Entomological Assistant, Burma, also spent about three months at Pusa, learning the practical side of Sericulture and obtaining information about crop-pests.

Training.—One student from the United Provinces remained from last year and continued his course in General Entomology until October. During the year, the newly-appointed Lecturer in Entomology at the Lyallpur Agricultural College and the Entomological Assistant in the North-West Frontier Province were received for the full course of training in Advanced Entomology, and will complete their course in December next. It is to be regretted that no students have been sent for the course commencing on 1st June 1911. The short courses in Sericulture were attended by many applicants from all parts of India, and of these thirteen have completed their course during the year; seven other students were received in June 1911, of whom six remain under instruction. The semi-annual short courses in Lac-culture have been taken up by fifteen students, of whom six were Forest Rangers specially deputed for this purpose. A certain amount of instruction in Bee-keeping has also been given to interested applicants, but as Apiculture in the Plains of India is still in an experimental stage, no regular course of instruction can be given before its success is assured.
Provincial Work.—The number of assistants employed in Entomological work in the Provincial Agricultural Departments is now seventeen, of whom six are engaged in teaching in the Agricultural Colleges and eleven in field-work, and of the above numbers two (one in each class) are still under training at Pusa. In view of the enormous areas to be dealt with and the general ignorance of the cultivating classes regarding insect pests and their control, this number appears very inadequate to place the practical side of Economic Entomology in its proper position as a normal part of agricultural practice, but the number of assistants is not being increased in the absence of Provincial Entomologists to direct their work. The fact that Economic Entomology forms part of the regular course in Agriculture at six of the Provincial Colleges must count for something in the spread of a knowledge of crop-pests amongst the agricultural classes. As in previous years, the assistance offered from Pusa in co-ordinating and checking the work of these assistants has been utilised by some provinces, who have referred the more technical work to Pusa, leaving the field-assistants free to undertake practical work and demonstrations.

In Madras, steady progress has been made in investigating the insect-pests of crops and in devising and demonstrating means of control applicable against each, and very good work has been done; this is the more important because the insect-pests of Madras are to a large extent different from those which occur in the plains of Northern India. In the Central Provinces, the experiments against Termites (white-ants) have been continued at Hoshangabad in collaboration with the Deputy Director of Agriculture, Northern Circle, and work against Potato Moth has also been continued. In the United Provinces, good work has been done in demonstration of methods against Cane Grasshopper and Potato Moth. In Bengal, very good work has been done in experiments and demonstration of methods of storing potatoes to keep them from Potato Moth, which is steadily spreading throughout the province. In Eastern
Bengal and Assam, the principal pests dealt with have been the Rice Grasshopper, Semiaquatic Rice Caterpillar and the Behar Hairy Caterpillar. In Baroda State, the Entomological Assistant has done good work in promoting an interest amongst cultivators in such pests as the Hairy Caterpillar, the Bollworm and the Til stem-borer and in inducing the adoption of measures against these and other pests.

Generally speaking, the Entomological work in the Provinces is at present preliminary and is necessarily confined to little more than inspection of the experimental farms, noting the local pests and the destruction caused by them and demonstrating methods to cultivators in the event of any special outbreak. Much more than this cannot be done whilst the Provincial Entomological staff is so limited.

Correspondence.—This is a subject which increases automatically every year as the work of this Department becomes more widely known. In addition to local inquiries as to insects attacking crops received and answered by the Provincial Agricultural Departments, a very large volume of correspondence is received and dealt with at Pusa; this includes a large amount of correspondence received from official sources, but a very large proportion is in reply to questions and requests for information and advice by the general public, and these include queries on almost every conceivable phase of Entomological work— insects damaging crops, gardens, orchards, timber, ornamental trees and shrubs, books and papers, stored cereals and produce of all kinds, insects on domestic animals, silk, lac, bee-keeping, insecticides and sprayers, and the identification of insects—and even on subjects not strictly concerned with insects, such as the destruction of rats. The parcels of injurious insects sent in numbered 166. A total of 2,384 inquiries came in from official and public sources, and the whole of these were dealt with as fully as possible. This is work which occupies a very large and constantly increasing proportion of time, but we consider that this work has a very direct value and that it is our duty to satisfy
every inquirer to the best of our ability. The large increase of clerical work during the year has thrown a great deal of additional work on the Clerk (S. C. Mukerji) and Typist (T. V. V. Subramani), both of whom have worked very satisfactorily and their work deserves special mention.

Research.—Progress has been made with inquiry into the life-histories and habits of injurious insects. Amongst the more important of these have been the Rhinoceros Beetle, the Surface and Painted Grasshoppers, Potato Bug, Lucerne Hypera, Small Cabbage Caterpillar, Termites, Rice Weevil, Green Bug, Potato Mealy Bug, Fish Insect and Red Pumpkin Beetle. Experiments have been made on the preservation of wood from attack by Termites (white-ants). Assistance has been afforded to the Imperial Agricultural Bacteriologist in furtherance of his work on the diseases of Eri Silkworms.

Insecticides and Sprayers.—A number of patent insecticides received for trial have been tested and reported on as to their suitability for Indian conditions; as a rule, they are not superior in efficacy to simple mixtures procurable locally, whilst their prices are prohibitive. Information on insecticides for Indian use has been collected in Bulletin No. 23. An increasing number of spraying machines is sold in India every year, and this Department keeps a register of the places where insecticides and spraying machines are obtainable, so that inquirers can be at once referred to the vendor supplying the kind suited to their needs.

Sericulture.—Experiments have been made on the crossing of Italian and French Univoltine Mulberry Silkworms with all the available indigenous multivoltine races, the object being to secure a robust and vigorous multivoltine race yielding a better silk than is produced by the native forms at present cultivated. Up to the present the mongrel races produced by crossing the European univoltine with Nistari and Burmese stock give the best promise as regards yield and quality of silk. Some of the
crosses between multivoltine indigenous races have also produced individuals more vigorous, more productive and less liable to disease than either parent stock. It will, however, require some time to establish a race which can be recommended.

Mulberry Silkworms from European seed were successfully reared at Pusa on bush mulberry in November 1910 and March 1911, the resulting thread having been valued by the trade in Calcutta at prices which compare extremely favourably with that obtainable from any multivoltine race. If it is possible to rear one (or, in many localities, two) broods of European worms on bush mulberry in Bengal and Eastern Bengal—and the Pusa experiments indicate no reason why this should not be done—the fact may have an important bearing on the silk trade.

The cultivation of Eri Silkworms has been continued at Pusa and is at present carried on in almost every district in India. The interest displayed in the cultivation of the Eri worm received a great stimulus through the display of Eri products at the Allahabad Exhibition, where a large building was entirely devoted to sericultural methods and manufactures collected and exhibited by this section. Here every process, from the egg to the finished cloth, was shown actually at work under practical conditions, and all kinds of silk cocoons, threads, cloths, etc., were also exhibited, a gold medal being awarded for these exhibits at the close of the Exhibition. An assistant from Pusa was in charge of the exhibits, and his time was fully occupied in explaining the processes and attending to innumerable inquiries from interested visitors, and particularly in bringing to their notice the advantages of Eri Silk and its cultivation in the provinces in localities where the climatic conditions and other factors are favourable to the adoption and extension of the industry. Batches of visitors—especially of the cultivating classes—were taken round and carefully shown the details of the work. A discussion was also held at the Agricultural Conference at Allahabad regarding the steps to be taken to extend the industry in the
United Provinces. Illustrated pamphlets, in English, Urdu and Hindi, describing the methods of rearing Eri and Mulberry worms, had been prepared at Pusa beforehand, and the real interest evoked by the exhibits could be gauged fairly accurately by the demand for these pamphlets and the large volume of further inquiries which has since come in to Pusa. Besides Allahabad, Mulberry and Eri worms, cocoons, thread, cloth, etc., and spinning and twisting machines in working order were shown at the local Agricultural Exhibitions at Muzafierpur, Bankipur, Malda, Banjetia, Singeswar and Calcutta.

Disease-free Eri and Mulberry silkworms' eggs, cocoons, thread, samples of Eri cloth, castor seed, mulberry cuttings and seed have been distributed to inquirers in all parts of India as far as possible. Trained rearers have also been sent to many places to teach Eri-culture to cultivators and others desirous of trying this product. Arrangements for sale of spinning machines have been continued, and at the request of the Imperial Entomologist, who pointed out what was required, a combined doubling and twisting machine, for doubling and twisting mulberry silk in one operation, was designed and produced by Mr. E. F. Watson and is now on sale. In extension of the work done here Eri silk-work was taken up by the Bengal Agricultural Department at Sabour from 1st April 1911, and it is hoped that the exhibition of this industry, within reach of the silk trade at Bhagalpur, will lead to the extension of the popularity and production of Eri Silk. Eri Silk has also been taken up by the Agricultural Department in the United Provinces, where Mr. Akhtar Mohammad Khan, Deputy Collector, has been deputed to conduct experiments at Shahjahanpur, and at Coimbatore by the Madras Agricultural Department. Successful attempts have been made to twist and dye Tussar Silk, but rearing of this has not been done at Pusa. In March 1911, at the request of the Director of Agriculture, I made a short tour in Eastern Bengal to investigate into the decline of the Mulberry silk trade and advise remedial measures; the result, which has
been reported already, cannot be summarized here. Eri thread of fine count has been produced on a commercial scale by the Chhoi Silk Mill Co. at Bombay, and the use of this fine thread should have an important influence on the development of the industry. There is still some difficulty in the disposal of small parcels of cocoons and thread by rearers on a small scale, the mills being unwilling to buy except in large quantities; a good deal of help in this direction has, however, been afforded by Calcutta firms who have been taking small parcels for shipment of the silk to Europe for experimental purposes.

*Lac-culture.*—Experimental work in lac-culture was continued, and brood-lac was supplied to applicants in Bengal, Central India, Madras and Bombay. Fifteen students were given a thorough practical training in lac-culture and numerous inquiries on this subject were also dealt with by correspondence. A continuation was made of the collection of material in collaboration with the Forest Department, with a view to the working out of the races of Lac Insects by Mr. E. Ernest Green, Ceylon Government Entomologist, 67 parcels containing 325 lots of specimens from a large number of food-plants having been received during the year. The material, as it accumulates, is sorted out with a view to facilitate the working out of the various races when the collection is completed.

*Apiculture.*—Two strains of specially selected Italian honey-bees were imported from England in November 1910, with a view to ascertaining their suitability to the conditions prevalent in the plains of India. The experiment has so far proved a success, but it is too early as yet to pronounce definitely on this.

*Demonstration.*—The most important item under this heading is probably the Allahabad Exhibition. Apart from the exhibits in the Silk House, 15 show-cases of insects injurious to crops and 24 cases showing the food of as many common Indian birds were prepared and exhibited in the Agricultural Court, 19 show-cases of Indian insects
were prepared for the Forestry Court, where this exhibit was awarded a gold medal, and, in the absence of the Second Imperial Entomologist, an exhibit of four show-cases was prepared for the Medical Court by the Supernumerary Entomologist to show the relations between insects and such diseases as Malaria, Enteric Fever, Plague, Myiasis, Cholera, Sandfly Fever, Yellow Fever, etc. I attended the Agricultural Conference held in January at the Allahabad Exhibition, and read a paper discussing practical remedies against two of the most destructive insects of the United Provinces.

Steady progress has been made in the preparation and issue of coloured plates illustrative of insect-pests of crops, and these have been distributed to all Provincial Agricultural Departments, to Museums, Agricultural Societies and numerous Educational Establishments. These plates are available for demonstration and for use in illustration of popular articles in vernacular and other Provincial journals. Show-cases were prepared and sent to the Dashehra Exhibition in Mysore. Coloured lantern slides of subjects selected from the coloured plates of crop-pests have been prepared and a large series of these is now available, besides series on Silk and Lac.

Insect Survey.—Comparatively very little time has been devoted to the general collections, but steady progress has been made, a large number of accessions having been added and arranged. Considerable additions have been made to the Students' Working Collections. Collections have been made up and sent out for identification by specialists and to authors of volumes in preparation for the Fauna of India Series; these include Collembola, Orthoptera, Tettigidae, Termitidae, Neuroptera, Odonata, Braconidae, and Ichneumonidae Hymenoptera Aculeata, Dynastidae, Rutelidae and Cetoniidae, Curculionidae, Cleridae, Microlepidoptera, Thysanoptera and Rhynchota. Collections have been identified for Provincial Assistants, the Indian Museum, the Bombay Natural History Society's Museum, the Quetta Museum and for many private collectors.
Miscellaneous.—Exhibits illustrating the work of the section were sent to the International Congress of Entomology held at Brussels in August 1910. Entomological inquiries and notes sent in to the Bombay Natural History Society have been dealt with and the Imperial Entomologist lectured to the Society on the eve of his departure from India. Requests from officials and private persons outside of India for information, specimens, etc., have been complied with as far as possible. Live Eri cocoons have been sent to England, France and Morocco.

Programme of work for 1911-12.—The work of the past in advising on insects will be continued, and concurrently the study of the insect-pests of crops will be carried out in the Insectary at Pusa and by the Provincial Assistants. Assistance will be given, when desired, in co-ordinating and directing the Entomological work in the Provinces, and special help will be given in the event of any serious outbreak. The issue of coloured plates and lantern slides will be continued. The experimental work with bees will be continued and extended if possible. Instruction in Eri and Mulberry silk-culture and in the cultivation of Lac will be given to students attending short courses in these subjects. Further collections will be made of lac insects in all stages for the purpose of ascertaining the relationships of the various races. New insecticides and apparatus submitted for trial will be tested with a view to their utility under Indian conditions. Rearing of Eri Silk-worms will be continued and all possible help given to those commencing this industry. Further experimental work will be done on the mongrelisation of the races of the Mulberry Silk-worm, and it is anticipated that the provision of cold-storage at Pusa will much facilitate this. Special attention will be devoted to acquiring a knowledge of Indian Termites (white-ants), the damage they do, and the best methods of preserving crops and constructional material from their ravages.

Publications.—A list of the more important of these is attached, but less and less time is available for work of this
nature as the energies of the staff become more fully occupied in other directions; and this is the more regrettable because a large amount of information relative to the life-histories of many economically important insects has been gathered during the last few years. Amongst the publications now in hand or proposed to be written, and for which a large amount of material is now ready, are practical manuals on lac culture and bee-keeping, Memoirs on life histories of Orthoptera, Hymenoptera, Coleoptera, Lepidoptera and Rhynchota, a Memoir on Termites, a revision of Indian Insect Pests, a revision of Insects injurious to Indian Agriculture, and separate manuals on insects injurious to Fruit-trees, Garden-crops and Grains, etc.

Eri Silk as a Cottage Industry. (Pamphlet in English, Urdu and Hindi.) December, 1910.
Mulberry Silk in the United Provinces. (Pamphlet in English, Urdu and Hindi.) December, 1910.
List of Injurious Indian Insects. April, 1911.
List of Insects in Pusa Collection. December, 1910.
Life-histories of Aquatic Insects. D. Nowrojee. (Memoir in the press.)
Food of Birds in India. C. W. Mason. (Memoir in the press.)
Palm Beetles. C. C. Ghosh. (Memoir in the press.)
Two Insect Pests of United Provinces. T. Bainbrigge Fletcher. (Agri. Journal, April, 1911.)
Four Reviews in Agricultural Journal and one in Bombay Natural History Society's Journal.
Insecticides. H. Maxwell-Lefroy. (Bulletin No. 23.) August, 1911.
Eri Silk. H. Maxwell-Lefroy and C. C. Ghosh. (Memoir in the press.)
The Moth-Borer (Chilo simplex) by T. Bainbrigge Fletcher. (Pamphlet in English.)

(F. M. Howlett, B.A.)

In 1909, after a year and nine months' service, I was absent on sick leave for a year and five months, returning to Pusa on March 22nd last. I have, therefore, now just completed two years of active service, and the present is a convenient opportunity for putting forward one or two conclusions regarding the work of my section.

I was appointed to study Diptera, and in particular those insects which suck blood and which may transmit disease.

Roughly speaking the study of any group of insects usually takes one or two distinct but complementary lines:

(1) Taxonomies.—The study of the structure of dead specimens as a means of obtaining an accurate nomenclature and scheme of classification, thereby facilitating the correlation of results obtained by work in other branches.

(2) Bionomics.—The study of the life-history, from egg to adult, and the habits of living insects, their relations with other organisms and the factors which determine their various activities as a means of obtaining knowledge which will enable us to control these activities.

Of these, (1) can be undertaken in any country to which specimens can be sent, and at any place affording sufficient facilities in the way of necessary literature. In this country the Indian Museum is the only institution at present possessing a library with any pretensions to adequacy in respect of Dipterous taxonomies; (2) can be undertaken only on the spot. The elucidation of the life-history and reactions of insects is the only way whereby we can attain to more than an empirical knowledge of how to control them. To follow this line in the case of a group such as Diptera, about which so little is yet known, demands moreover a
somewhat broader scientific outlook than is necessary to the pure systematist.

It would of course be possible to pursue taxonomic studies and occupy ourselves with the description and naming of new species of Diptera, useful work which might well be extended over several years, but this would, in my view, constitute under the circumstances a misdirection of energy, since such work can be better and more easily done elsewhere.

On these and other grounds I have regarded (2) as the direction in which our work should proceed, and I have now a foundation in a knowledge of the main features in the life-history and habits of all groups of blood-sucking insects in India, as also of the few Diptera which are of any considerable direct agricultural importance. I make use advisedly of the phrase "main features," since the present arrangements regarding laboratory accommodation do not admit of insects being kept alive except under conditions so unsuitable as often to make it difficult or impossible to obtain reliable results from observation of individuals in captivity. Our disabilities in this direction are serious, but I am glad to say that steps are now being taken towards the provision of more suitable accommodation.

I returned from England in March, arriving at Bombay on the 10th and at Pusa on the 22nd. No touring has been undertaken since that date. I found that since my departure an amount of material has accumulated which has occupied a good deal of my attention and which will take time to arrange and work out. A portion of our Nemocera has been named by Mr. Brunetti at the Indian Museum, and the identifications of a number of the Tabanidæ sent to the British Museum in 1908 have now been published, which will facilitate work in this group.

I do not here attempt to submit a detailed report of the past four months. In addition to work on the collection and on blood-insects in general, attention has been directed in particular to (1) parasites of Tabanidæ, mainly observations
on an egg-parasite of our common hot weather Tabanus
\(T. \text{albimedius}\); (2) temperature reactions of Mosquitoes; I believe I have found that temperature constitutes at least one of the main factors controlling mosquito-bite; more observations are required, and the work is still in progress; (3) the relative efficiency of "millions" and other enemies of mosquito-larvae, in progress; (4) Peach-flies; with regard to these last it seems improbable that their attacks can be completely prevented by anything short of netting the trees, but we have now a cheap and simple method (depending on the "chemico-sexual" reactions of the male flies) whereby the damage they do may be very much reduced.

A number of publications are in hand. Four students have been received, though it was impossible to allot them any window-space in which to work.

While absent on sick leave, I attended the First International Congress of Entomology at Brussels, and though unable to enjoy the lavish hospitality which was displayed by the Congress Officials towards all visiting delegates, I was present at all the meetings and read two papers, by Mr. Lefroy and myself. These will be published in the Proceedings of the Congress. From the scientific point of view, the Congress was most successful, the great majority of the papers read being of a high standard of excellence, and I cannot overestimate the value of this opportunity of getting into touch with recent work, and of meeting and exchanging views with Entomologists of other countries.

In connection with a plague of house-flies near Norwich I carried out (in collaboration with Dr. Copeman, F.R.S., Medical Inspector to the Local Government Board, and Mr. Merriman) what I believe to be the first successful series of experiments on the range and rate of flight of these insects under natural conditions, a point of considerable importance with regard to disease-transmission. The results are published in "New Series No. 53 of the Local Government Board Reports on Public Health and Medical Subjects."

Prior to sailing for India I spent five weeks in Cambridge, working in Professor Nuttall's laboratory on the
respiratory mechanism of Ticks and the influence of temperature on rat-fleas; I may remark that the temperature which was fatal to adult fleas was found to be unexpectedly low. I also prepared several illustrations for Professor Nuttall, made an experimental study of the effects of various degrees of magnification and reduction in reproducing drawings and wrote two articles [on (1) Mosquitos and Temperature, (2) Methods of preserving Insects] which were published in "Parasitology."

Programme of work for 1911-12.—Work on blood-sucking insects, ticks, and other similar parasites directly or indirectly injurious to man will be continued, and attention will also be given to Dipterous pests of crops and fruit. Instruction will be given to agricultural students in these subjects.

A large amount of time will have to be given to working through and arranging the material which has accumulated during my absence, sent in by Medical and Veterinary Officers.

Special investigations proposed are:—

(1) Life-history and habits of Simulium (hill cattle-fly), the dung-infesting Cattle-flies, Sand-flies, and such house-flies as are likely to be found acting as carriers of intestinal diseases.

(2) Bionomics of Mosquitos, with special reference to the influence of temperature.

(3) Influence of external conditions on the life-history of Fleas.

(4) Reaction of Diptera to chemical stimuli.
REPORT OF THE IMPERIAL BACTERIOLOGIST
FOR THE YEAR 1910-11.

(C. M. Hutchinson, B.A.)

The work of the Bacteriological Section during the past year, the first during which it has been in operation, has necessarily been largely confined to trial and selection of the methods best adapted for dealing with the special conditions of soil and climate obtaining in India. The biological analysis of a soil not only involves a determination of the number and kinds of bacteria contained in it and their relation to the production of plant food, but must also include investigations having for their aim the discovery of how such bacterial functions as make for fertility may be encouraged and used to the best advantage in the ordinary operations of agricultural practice. Hence the main lines of work of this section have been aimed at determining under what conditions various soils will best serve as culture media for those bacteria, naturally present in them, upon which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

Much preliminary work has been done in testing methods already in use, and modifying them in accordance with the requirements of local conditions.

Special attention has been paid to methods of plating soils in such a way as to obtain information as to the number, kinds, and functions of the bacteria in them; this has involved a study of media suitable for the purpose, and of methods of inoculation, and this study is still in progress, as it appears probable that each soil requires variation in the composition of the medium in which it is to be plated, in accordance with its chemical and physical character, and with special regard to its previous agricultural history. In soil plates made for the purpose of counting the numbers of bacteria present per unit volume or unit weight,
special attention must be paid to the variations in soil climate previous to the time of sampling, as otherwise erroneous conclusions may be drawn as to the number of bacteria normally present. For instance, a rainfall of one-tenth of an inch in December has been found to raise the number of bacteria to 100 millions per gram in the course of 36 hours, whereas the same soil contained only 5 millions per gram two weeks later. Similarly the rate of decomposition and nitrification of organic matter in Indian soils appears to be very different from that which has been observed in Europe, and is no doubt to be correlated with the special conditions of soil and climate of this country. These cases have been referred to as illustrations of the necessity for proceeding with great caution in working out special problems by the application of generally accepted methods.

A complete series of experiments has been carried out to determine the best means of sterilizing soils, as the majority of experiments on soil bacteriology depend upon work with sterile soil as a medium. Great difficulty has been experienced in obtaining completely sterile soil; intermittent steaming in many cases has failed to ensure sterility, possibly owing to the rapid formation and germination of spores by some of the numerous spore formers present, and the use of the autoclave for pots of soil, of which only one can be inserted at a time, makes an experiment involving the use of some 50 pots almost impracticable, owing to the differences in time involved. A sterilizing plant for dealing with a large number of pots simultaneously is very much needed.

Samples of Pusa soils have been analysed bacteriologically, pure cultures of the bacteria found have been made, and their physiological functions examined. Special attention has been paid to their relative ammonifying power, and the knowledge thus obtained is now being utilized in dealing with special problems.

A special study has been made of the effect of hot weather ploughing upon the bacterial content of the soil and
its possible relation to the undoubted increase in fertility resulting therefrom. It has been found that this operation increases the rate of ammonification of the soil humus, probably by the selective action of combined desiccation and abnormal temperature; similar results can be obtained by heating the soil to 60° C., the soil plates shewing a survival of the more active ammonifiers such as B. Mycoides and B. Subtilis, whilst the highly aerated condition of the soil inhibits the activity of surviving anaerobic spore formers. The net result is an extremely rapid formation of ammonia, part of which is retained by the soil and nitrified or taken up directly by plants, and part is lost by diffusion; in this way rapid depletion of the soil nitrogen must take place, and subsequent fertility will depend upon the judicious use of green manures; the economic value of the method depends upon the power which it places in the hands of the agriculturist of rapidly converting green manure or other organic nitrogen into plant food, although this may be counterbalanced to some extent by loss of nitrogen as ammonia.

Study of Pusa soil taken from depths down to nine feet shows large numbers of bacteria even at this low level; nitrification has been found actively proceeding in the third foot from the surface, the greatest amount of this taking place in the second six inches. Owing to the open texture of this soil it is improbable that denitrification occurs to any appreciable extent, but the rapid rate of ammonification and the vigorous growth of soil bacteria no doubt interfere with the production of nitrates.

A method of quantitative estimation of the changes in soil due to bacterial action, by periodical analysis of the soil gases, has given much information as to the conditions favourable for nitrification in soils; it is hoped that this method will be invaluable in the future for dealing with such problems as arise out of soil irrigation and drainage, and the use of green manures.

In connection with the experiments upon soil sterilization as a laboratory method, investigations have been car-
ried out to determine the effect of various methods of partial or complete sterilization upon fertility; these investigations are still in progress and have yielded some results of great interest, such as the fact that the addition of Toluene to a soil already sterilized by heat increases its suitability as a medium for the growth of ammonifying bacteria and consequently its fertility; this renders it unnecessary to assume that such action is due to the suppression of phagocytes, although there is of course no reason why such removal should not contribute to the general effect in soils partially sterilized by addition of Toluene.

So far but little work has been done upon any but local soils, as these have afforded ample opportunity for research, but samples of Usar soil have been examined in connection with the use of gypsum, cattle manure, and straw as means of modifying their infertile condition. Dr. Leather kindly supplied samples of these soils, and also some black cotton, Shillong, Bangalore, and Akola soils, which have been used for purposes of comparison with Pusa soils.

A circular letter was addressed to Directors of Agriculture and Principals of Agricultural Colleges in the Provinces with a view to eliciting their opinions as to the scope for bacteriological work on soils, and the existence of special problems of local interest suitable for investigation by this section. The replies were of great interest as shewing the very general realization of the value of such work, and many useful suggestions as to lines of enquiry were received. The opinion was expressed in several quarters that the training of assistants as soil bacteriologists who would be capable of dealing with local problems in the Provinces, should be an important item in the work of this section at Pusa. This is a point of view with which I am in complete agreement and I wish to express my opinion that the work done during the past year has shown the necessity for training in the use of the special laboratory methods which are necessary in India, and that such assistants as may be selected for work on soil bacteriology in the provinces
should undergo a preliminary training at Pusa. It is important that these men should have a previous training in analytical chemistry of a high order, as my experience has been that it is possible to teach bacteriology to a chemist, but that the converse alternative is a waste of time. This was my own experience at Pusa with a medically-trained bacteriologist who acted for a time as my assistant, and whose qualifications as a biologist did not fit him for work as a soil bacteriologist, this being due to the very different nature of the work involved in medical and soil bacteriology. On the other hand my present three assistants who are all chemists, have shown great aptitude for bacteriological work, and their previous training as analysts has been invaluable in dealing with soil problems, which depend largely for their solution upon quantitative estimation of chemical changes in soil constituents.

Certain special problems have been dealt with during the year; these include investigations of the cause of:

1. A bacterial disease of Tobacco occurring in Rangpur, due to the presence of a strain of Bacillus Solanacearum, differing from those described in America and Japan in its pathogenicity both for Tobacco and other Solanaceous plants, such as Tomato and Brinjal (Solanum Melongena).

2. A disease of the Eri silkworm associated with the presence of bacteria in the intestine; Memoirs on these two subjects are in hand. Invaluable assistance in the preparation of sections for microscopic examination in connection with these diseases was afforded by Mr. Shaw of the Mycological Section, who was kindly permitted by the Imperial Mycologist to devote a considerable amount of time to this work.

3. The efficacy of Ratin and Trope Ratin as rat exterminators in India. Experiments were made with fresh samples received from England, and a report on the results was furnished to the Inspector General of Agriculture in India.
Ratin is a bacterial culture prepared in Copenhagen, which is intended to produce an infectious disease in rats which have fed on baits treated with it, and which then spread the contagion amongst others. Although the cultures when received at Pusa were alive, as was proved by transfers, no pathogenic effects followed when given with food to captive rats. In corresponding with the Director of the Ratin Laboratory at Copenhagen I suggested that the virulence of the cultures might be regained by cultural methods in India.

*Trope Ratin* is not a bacterial culture but a vegetable poison, the principal feature of which is its toxicity for rats and mice and harmlessness for other animals. Experiments proved that its efficacy in India depends upon its use within a limited period of time after its preparation, as rapid deterioration takes place with loss of toxicity. Its cost precludes any possibility of use on a large scale by cultivators, but might allow of employment in special cases, such as in granaries or warehouses.

4. A disease of *Tussar* silkworms at Chaibassa was investigated and a report submitted to the Director of Agriculture in Bengal. The general conclusion arrived at was that death was due to bacterial invasion of the alimentary canal, but that as the extent to which this developed was dependent on unsuitable diet consequent principally on climatic causes, it would be impracticable to apply preventive or remedial measures.

5. A scheme for bacteriological work in connection with the proposed dairy at Pusa was elaborated, including the idea of a course of training for students in Bacteriology as applied to dairy work.
Programme of work for 1911-12.—1. The systematic investigation of the distribution, physiological character, and functions of soil bacteria in India will be continued.

2. A special line of enquiry will be taken up as to the relations existing between the practice of green manuring in India and the activities of soil bacteria.

3. Special problems, such as plant diseases of bacterial origin, will be dealt with as occasion may arise and opportunity permit.

4. The training of the assistants in the section will be continued.

Publication.—An article on the influence of Bacteria upon soil fertility was published in the Agricultural Journal of India, Vol. VI, Part II, April 1911.

(G. A. Gammie, F.L.S.)

I held charge of the appointment from the 1st July to the 5th August 1910, when I proceeded on privilege leave. During my absence, Mr. S. V. Shevade, B.Sc., held current charge of my office. I resumed my duties on my return on the 6th November and continued in charge until the end of the year under report.

In July, Londa, Dharwar Experimental Station, Gokak Experimental Station and Vadgaon (all in the Bombay Presidency) were visited. In the months of August and September, Mr. Shevade visited Vadgaon, Dharwar, Gadag, Kilgiri and Kumbarganvi. After my return from leave, I visited Vadgaon and made a tour in the Central Provinces in the company of the respective Deputy Directors. Khandwa, Raipur, Nagpur and Akola were visited. In November, I also visited Dhulia and Ahmednagar. In December, I again went to Vadgaon in connection with a scheme to introduce cotton into this tract, and in January I visited Khanapur. Londa, Belgaum and Desur with the same object. In the same month I saw the cotton-experiments at Sholapur. In February, I completed my observations on cotton growing in the Deccan, at Takari and Islamapur and joined the Deputy Director on tour in Gujarat, visiting Navsari, Surat and Nadiad. In March, I met the Deputy Director of Agriculture, Bengal, to advise him regarding the prospects of cotton cultivation at Chinsurah. I again visited the Experimental Stations in the Southern Mahratta Country. For the remainder of the period I was engaged in laying down a series of trials in my experimental station at Kirkee.
Central Provinces Cottons.

I visited the Experimental Station at Khandwa, where I met Mr. Evans, the Deputy Director of the Northern Division. This station is 13 acres in extent and is divided into $\frac{1}{2}$ acre plots, seven of which are devoted to cotton and five to Jowar and Bajri varieties. The experiments on cotton will be continued this year, taking in, however, only four varieties, malvensis, roseum, Saugor Jari, Bhuri and, perhaps, Cambodia. The following are the notes I drew out on the ground during my inspection:

Karkeli.—This being Hinganghāt (Bani) is not suited to this tract, and the fact is sufficiently proved by the appearance of the plot this season.

*Malvensis* is strong and vigorous and the outturn promises to be satisfactory. The staple, almost as harsh as, is longer than that of *roseum*. Which of the two will ultimately prove to be the most profitable is a point only to be determined by a test of outturn per acre. Local opinion strongly inclines to the belief that *roseum* is the more remunerative crop. This year *roseum*, being on a high-lying plot with shallow soil, cannot safely be compared for outturn with *malvensis*, which is on a lower level with deeper and richer soil.

*Saugor Jari* had borne its ripe bolls intact for about a month, and the White Flowered Varhadi or *roseum* also retained its ripe cotton uncommonly well. Practically none had yet fallen to the ground. The retention of the ripe cotton in the open bolls is a characteristic general to our indigenous Indian cottons.

Of *Bhuri* and *Cambodia* it can be safely said that the former is almost certain to succeed in the better classes of soil in this district. The group of cultivators, who accompanied us in the fields, concurred in my view after inspecting the crop as it stood on the ground.

*Cambodia* does not promise so well in the northern as in the southern cotton districts. However, to make the mat-
ter certain, it would be quite worth while to give it another year's chance.

Saugor Jari is a dwarf variety, coming so quickly to maturity that the first picking is ready this year in the middle of October. The seed was originally brought from the Rehli Taluka of the Saugor District. It is an extremely prolific cropper and appears to be suitable more especially for the poorer classes of soils, which are apt to lose moisture rapidly when the late monsoon fails as it often does in this district.

The seed obtained locally in Burhanpur has produced a crop so mixed (the mixture consisting of Jari with a smaller proportion of Bani and Upland Georgian) that the fact strengthens our conviction that, if pure varieties are established by the Department, which will then distribute them for general cultivation, methods must decidedly be devised, by home or village ginning or otherwise, to ensure that these varieties are maintained in their purity. As regards the establishment of this particular Experimental Station I foresee with satisfaction, that, being by its very nature a demonstration on an actual cultivator's land with the implements and labour supplied from his stock, the results will be readily visible to him and his neighbours.

In Berar and the Central Provinces, where cotton is usually grown associated with Tur (Cajanus indicus) more attention could be profitably paid to the cleanliness of the fields, which are infested with coarse grasses, Celosia argentea and other weeds.

I visited the Experimental Stations at Raipur, Nagpur and Akola in the company of Mr. Clouston, the Deputy Director, and Mr. Graham, the Economic Botanist.

At Raipur, which is beyond the cotton tracts, two plots were devoted to Bhuri and Cambodia cottons. The former gave a good crop last year and promised well for this. The Rajnandgaon Mill bought the produce at a fair price and the Manager is anxious to see the increased cultivation of this variety. It suffers from boll-worm, however, and the
general conditions of the district do not seem to be altogether favourable.

Cambodia looks unthrifty and chances are decidedly in its disfavour, but I advised Mr. Clouston to give it another trial as the rains have been abnormally heavy. Attempts to introduce the cultivation of *Deshi* cotton and *Jowar* have resulted in failure.

At Rajnandgaon we visited two fields of *Bhuri* in the company of Mr. Fredericson, the Manager of the local mill. These had done very well and the local cultivators were impressed with the result. Mr. Fredericson, however, says that *Bhuri* will not altogether serve as a substitute for American Upland, which is superior in quality. It will compete on favourable terms with the longer stapled indigenous varieties such as *Broach*, and this, after all, is a desideratum in the Central Provinces.

At Nagpur, Mr. Clouston still retains his plots sown from seeds locally obtained from many parts of the province and these have enabled him to gauge the nature and extent of the mixtures as they normally exist in the fields. Various high-class Uplands from American seed do not hold out promise of success. The utility of protecting cotton fields against insect attacks with girdles of *Bhendi* still seems to be a moot point, but, from my own experience, I cannot help considering that there is much to be said in its favour. Insects certainly prefer it to cotton, and if care be exercised in its destruction when its purpose is effected, much latent and active insect life must be destroyed at the same time.

The varieties of cotton actually under serious trial consist of *Bhuri, malvensis, vera, cutchica* and *rosea*.

In order of their value in length of staple they would stand thus:—(excluding *Bhuri*), *malvensis, vera, rosea* and *cutchica*. The last two are white-flowered forms of the two preceding them. *Malvensis* and *vera* (yellow-flowered forms) are decidedly superior in the matter of staple, but they are surpassed in percentage and total yield by *rosea* and *cutchica* (white-flowered forms). The valuations given
by the trade are practically equal for all, so, from a cultivator's point of view, the two last can safely be taken as the best to grow. Mr. Clouston estimates that he has gained from 2 to 3 per cent. in quantity by selection, and I seized the opportunity to point out to him that this is really a long step in advance, especially when it becomes established over the enormous cotton tracts of the Central Provinces and Berar.

The popular belief is that, by scientific methods, an increase in length of staple and proportion of cotton to seed can be easily attained, but the public generally and members of the Agricultural Department also should hold steadily in their view the fact that to evolve an addition of even one or two per cent. in length of staple and percentage of cotton to seed in a few years is in itself a notable feat, and that it is chimerical perhaps to hope to reach anything better. Anyhow, it would at least serve as an excellent foundation for a fresh start in advance.

Forms of all varieties with narrow-lobed leaves are more easily fixed than those with broad lobes. Undue importance should not, however, be attached to the degree of division in the leaves. At the Telinkheri farm there are plots of Bhuri, Cambodia and the indigenous varieties. All have suffered, although slightly so, from water-logging during the recent heavy rains. Cotton is a crop with a decided predilection for a well-drained soil.

The Department of these provinces is quite alive to the danger of the possibility of the reputation of their selected seed being ruined by the addition of local bazar seed by unscrupulous dealers for the sake of a temporary profit. It is difficult to conceive how such a contingency can be met in the case of indigenous varieties in which the seeds do not differ materially.

Cambodia, in all cases, seems to be inferior in strength and quality of produce to Bhuri in the Central Provinces and Berar, and it is also about three weeks longer in arriving at maturity, an objection of vital importance in these short season tracts.
At Akola, where a large area of the Experimental Station is devoted to the raising of selected seed, the cottons comprise *Bhuri, malvensis, vera, rosea, cutchica* and *Bani*. *Bani* has fallen into disrepute and one seed farm at Risod, especially devoted to producing its seed, has great difficulty in disposing of it. *Bhuri* seed is in rapidly increasing demand as are also *malvensis* and *rosea*, but the last-named, from its productiveness and hardiness, appeals most strongly to the cultivator. The manurial experiments appear so far to prove that farmyard manure has a distinct effect, but, that on account of their cost and trifling action there is little or practically no advantage gained from the use of artificial fertilizers. Farmyard manure and urine earth mixed give a better result than either applied alone.

All the varieties of cotton are pure now, and the chief difficulty ahead lies in the maintenance of this purity in the cultivator's fields. An accidental admixture of varieties on this station arose from the fact that whole seed was fed to the cattle and this often germinated in the manure when spread on the fields. Crushing the seed, of course, has removed this defect.

Experiments with English and indigenous ploughs and with the *Bhakar* go to prove that ploughing tends to assist water-logging in a wet season when the *Bhakar* is most effectual, but the latter method fails in a season of drought. As the cultivator can only guess what the season is going to be this conclusion is not obviously helpful. It appears to be advantageous to follow the local practice of sowing cotton in anticipation of the setting-in of the rains, and the converse applies to *Jowar*, which suffers badly if dry weather supervenes after germination.

In 1910, there were 3,000 acres of *Bhuri* under cultivation in Berar. Unfortunately the epidemic of plague greatly retarded its preparation for the market. The area actually under seed farm of all varieties is 600 acres. Three varieties of seed are supplied on purchase from this farm, namely, *malvensis, rosea* and *Bhuri*. At Risod in the
Hinganghat tract *Bani* is grown for distribution, but there is no call for the seed as the people are introducing the coarser, hardier and more productive *Jari* (vera) and *Varhadi* (rosea). An efficient hand gin of moderate cost and simple construction which would clean an appreciable amount of cotton per working day is an urgent necessity in the cotton tracts.

I wish here to emphasize my opinion that a real advance in the improvement of some of the staple cottons of the Central Provinces and Berar has already been effected. The cultivators show a practical appreciation of the fact by cheerfully paying enhanced rates for the selected seed supplied by the experimental stations. The chief difficulty in the future will be to maintain the varieties sufficiently pure. For some years to come the difficulty must either be met by large extensions of seed farms or by special arrangements with reliable cultivators either of villages collectively or as individual persons. At the same time steps should be taken to ensure that the cultivators receive fair rates for their improved produce.

It seems, however, too hopeful to look forward to the time when the people will realize the advantages of clean cultivation and cleanly methods of harvesting and marketing.

The British Cotton Growing Association sent the following gratifying account of the season's cottons grown at Akola:

*Value of Middling American 8·07d.*

No. 1. *Bhuri.—"Fully good middling" in grade. Staple about 1 inch. Strong. Value 7·90d. to 8·00d.*

No. 2. *Bani. —"Fully good middling" in grade. Staple about 1½ inch. Fine, but little soft. Value 8·40d.*

No. 3. *Malvensis. —"Fully good middling" in grade, little stained. Staple 1 to 1½ inch, irregular and rather soft. Value 8·20d.*

It is mentioned that "with the exception of the fourth sample, *Roseum,* all the samples sent are useful cottons which could be readily sold in this market at considerably higher prices than are obtained from East Indian cotton, and we hope that there may be some possibility of these cottons being produced in quantity in your district."

*Bombay Cottons.*

*Trial with Bhuri cotton at Kumbarganvi (12 miles from Dharwar).*—In March 1909, while discussing cotton matters with the Deputy Director of Agriculture at Dharwar, I suggested the possibility of a successful introduction of *Bhuri* into the tract lying in the heavy rainfall zone where land was largely left uncultivated. Accordingly a plot of about 3 acres was taken up at Kumbarganvi. The soil is shaly, and is known in local Kanarese as *Masari,* *Bhurkati* or *Reviti* in Marathi and *Gorat* in Gujarati.

The average annual rainfall is 50 to 60 inches, falling heavily from June to the end of September and more lightly till the beginning of November.

Two ploughings and three harrowings were given but no manure. The seed (obtained in 1908 from Bengal) was sown by drill at the rate of 20 lbs. per acre on the 18th August 1909. Germination was excellent and the plants were thinned out to a foot apart in the rows, which were at 2 feet intervals. The plants were soon attacked by stem borers and caterpillars. The latter were removed by hand, a difficult operation as the creatures concealed themselves during the day. This attack lasted for four weeks. It was estimated that 50 per cent. of the crop was attacked but the sequel proved that the plants received no material injury. The first picking was started on the 15th January; this gave 14 lbs. 7 oz. of seed cotton; the second was on the 25th February and gave 72 lbs. of seed cotton, the third and
the fourth on the 18th March and 1st April respectively and gave 130 lbs. (per acre 216 lbs. 7 oz.). The percentage of lint 1st picking—33·25; 2nd—34·12; and the 3rd—34·37.

The valuations showed that the resulting clean cotton was of very poor quality, the report being that it was no better than Bengals. The first, second and third pickings were valued at Rs. 280, Rs. 275 and Rs. 260 per candy of 784 lbs. Broach cotton in the same day's market being Rs. 330, Surat Rs. 345, and Navasari Rs. 360. Under normal circumstances Bhuri in Bengal stands at least as high as Broach. The unfavourable result was, however, instructive in that it suggested experiments with this cotton in various soils to determine the actual influence of soil on the final product.

Kulthi is probably the best rotation for cotton in this soil as it is already the custom to grow it here, and the heavy rainfall forbids the idea of growing Jowar. Kumpta was tried on a small plot, but, as was naturally to be expected, it was a failure.

The Cambodia cotton plants suffered so badly from the attacks of caterpillars that only a very few plants survived. They remained stunted in growth and the situation was manifestly unsuitable to them.

These two varieties were also sown on black soil at Aravadgi, about 2 miles distant from Kumbarganvi. The crops on the whole were superior to those at Kumbarganvi, but they suffered from the same insect attacks and in addition became so badly infested with Aphides that they had to be treated with spraying of kerosine oil emulsion.

Cambodia and Bhuri produced at Vadgaon from the same seed in 1910 were reported on by Messrs. Tata Brothers as being equal to Superfine Wardha Good at Rs. 340 and Fine Hinganghat Good at Rs. 340 respectively. This further exemplifies the effect of the soil on the quality of cotton, and trials, suggested by these valuations, are being undertaken during the present year at additional centres in order that we may ascertain the precise effects on the cotton
plant and its ultimate product induced by diverse climates and soils.

Another report from Khanapur gives a valuation of *Bhuri* at Rs. 370 and Cambodia at Rs. 340.

The 1910 crop of *Bhuri* at Kumbarganvi was valued at Rs. 380, Fine Surats of the same day being Rs. 380.

In the light of the second year's valuation it is difficult to understand why the first year's crop at Kumbarganvi should have been so inferior.

The Professor of Agriculture, Poona, kindly allowed me the use of a plot of land at Lonavla, (where the average rainfall is 186.56 inches) to test the behaviour of *Bhuri*, Cambodia and *Kil* under a very heavy rainfall. The last-named, in its own home in the Garo Hills, luxuriates in almost quite as heavy a rainfall. Seeds of the three varieties were sown on the 19th June, Cambodia germinated well, but *Kil* and *Bhuri* only indifferently. The heavy rains and cold winds prevented further growth in the two latter and they died. Cambodia held out till about the end of July and finally succumbed in the heavy rain of August. It was a foregone conclusion perhaps that no cotton will withstand such heavy and continuous rainfall, but still it is satisfactory to obtain tangible proof of the fact.

*Bourbon Cotton Cultivation on the Western Coast.*—In former years it was demonstrated to their own satisfaction by a few enthusiasts (who probably owed their success to watchful care), that Bourbon cotton could be profitably grown in the Konkan, and sporadic plants are certainly persistent and quite common in villages. To arouse fresh interest in the subject I persuaded some Mamlatdars to induce land-owning friends to make experiments and I supplied the necessary seed. The final reports, however, proved disappointing as, owing to heavy rains, not one trial resulted in success. Now that a Divisional Inspector has been appointed for the Konkan I hope that, under his supervision, further trials with Comilla cotton, a plant from a heavy rainfall area, may show some measure of success.
Cotton Crop Experiments conducted on the Dry Farm Experimental Station of Ahmednagar.—Here we have adverse conditions under another aspect, namely, of drought and not excessive rainfall. The season on the whole was reported to be good, but the rainfall was above the average and towards the end of the season was also untimely. The germination of the seeds was therefore affected by the packing of the soil which occurs during heavy falls of rain. The subsequent resowing of the numerous gaps and more than usually rapid growth of weeds threw an excessive addition to the normal cost of cultivation. The first picking when approaching maturity was destroyed by the heavy downpour in the Swati rains. The plants, however, recovered, but the occurrence of a sudden frost finally destroyed the crop. Karkeli on the whole proved most resistant, yielding at the rate of 144 lbs. of seed cotton per acre, while 5 types of Khandesh cotton gave 94, 100, 104, 112, 114 lbs. respectively. Although due attention was paid to all the details of treatment and cultivation, no workable precautions could possibly be employed to insure the crops against the vicissitudes of such an abnormal season.

The following are valuations by Messrs. Tata Sons on samples from Ahmednagar:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of cotton</th>
<th>Remark</th>
<th>Valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Karkeli</td>
<td>Equal to P. Barri Gd., which class is very rare or non-existent. Soft in feel and of good staple.</td>
<td>Rs. 330</td>
</tr>
<tr>
<td>2</td>
<td>N. V. M. type</td>
<td>Same as above, but slightly better in staple.</td>
<td>335</td>
</tr>
<tr>
<td>3</td>
<td>N. V. K. type</td>
<td>Same as No. 1, but slightly inferior in staple.</td>
<td>325</td>
</tr>
<tr>
<td>4</td>
<td>N. V. type</td>
<td>Same as N. V. K.</td>
<td>325</td>
</tr>
<tr>
<td>5</td>
<td>N. R. C. type</td>
<td>Rather rough and very short in staple; more like Khandesh.</td>
<td>305</td>
</tr>
<tr>
<td>6</td>
<td>Khandesh</td>
<td>This is a superior quality of Khandesh cotton, superfine in colour. The district rarely, if ever, produces such cotton.</td>
<td>315</td>
</tr>
</tbody>
</table>

Basis.—Khandesh Gd. Rs. 310 per candy of 784 lbs.
Cotton Crop Experiments on the Dhulia Experimental Station.—I visited this station on the 29th November.

The first plot of cotton inspected was labelled N. R., a selection of *Neglectum roseum* out of the types ordinarily grown in the fields. The plants were robust, the stand even and the production excellent. The staple is that of Varhadi. Last year the produce of this was above 900 lbs. of seed cotton per acre with a percentage of 37.5. The seed cotton is bought by the merchants at the rate of Rs. 21-8-0 per maund (144 lbs.) against the rate of Rs. 20-8-0 per local cotton.

The second plot was of N. R. C. (*Neglectum roseum cutchicum*). This is also a selection from the local cotton. The crop produced last year was 850 lbs., percentage 35. The staple is a little longer and finer than that of N. R. and the cotton was valued at Rs. 10 more per candy (784 lbs.).

The third plot was that of *malvensis*, N. V. M.; differs from *vera* proper or *Jari* in the superiority of its staple. It has been grown on a large scale only this year.

Comilla Cotton.—Fresh seed was imported this year from Hill Tipperah as the acclimatized plant had deteriorated. The lobes of the leaves are broad as well as narrow and the flowers are usually white, but some are yellow. The crop is very poor and very late.

Bhuri.—This plot looks good and productive. One cultivator at Amalner is said to have 20 acres of good Bhuri under cultivation. There is a rising demand for its seed and the prospects of success in Khandesh as in Berar are decidedly hopeful at present.

Cambodia looks more sturdy than Bhuri but it is a later crop. The prospects of both are of course uncertain until they have been subjected to the experience of a dry season. The cultivator at Amalner, already mentioned, has obtained from the merchants Rs. 10 per maund (144 lbs.) of seed cotton over the price of local cotton.

Of the crosses, that of Comilla with Bani is most promising as regards both quantity and quality. The selected
plants yield a staple over $\frac{3}{4}$ inch and ginning percentage of about 33.

*Karkeli* is not very promising, but still it yields a profit quite equal to that of the local crop.

*Bani* from Akola looks well, but it will never be a favourite crop in a tract where the cultivators prize the qualities of hardiness and high percentage of cotton.

*Neglectum var. kathiawarenisis.*—The growth is very vigorous and prolific. Last year it yielded 741 lbs. of seed cotton per acre, with a percentage of 27·10.

The following are some of the results obtained on the station:

<table>
<thead>
<tr>
<th>Name</th>
<th>Seed cotton per acre</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Neglectum var. malvensis</em></td>
<td>686</td>
<td>26·10</td>
</tr>
<tr>
<td>&quot; vera</td>
<td>729</td>
<td>30·00</td>
</tr>
<tr>
<td>&quot; catchica</td>
<td>780</td>
<td>35·50</td>
</tr>
<tr>
<td>&quot; rosca</td>
<td>870</td>
<td>37·50</td>
</tr>
</tbody>
</table>

*Inter se* crossing in Bhuri and Cambodia has produced enormously strong plants.

As in the Central Provinces and Berar so also in Khandesh the same difficulty in the distribution and maintenance of the pure varieties has to be surmounted. So far there is only one demonstration plot, *viz.*, at Amalner, where the different types are grown. There is also a demonstration held at the Experimental Station every October and this had the desired effect of introducing the improved varieties to the attention of the cultivators who send in orders for seeds. In the local practice, seeds are sown through two tubes placed behind and dragged after the *bhakar*. This requires the attention of three people while the Gujarat drill (which is being introduced) only requires two. The Gujarat bullock hoe is also said to be more effective, as it brings the earth better round the plants.
The Manager of Messrs. Volkart’s Spinning and Pressing Factory informed me that he was buying extensively pure supplies of the very coarse *Varadi (roseum)* cotton which he considers does really possess a staple. He says that this cotton is mostly used in Germany, Austria and Hungary and that *Bengals* are used in Italy. Fraudulent practices are obviously carried on by cultivators. Wet and damaged cotton is packed into the centre of finer stuff and much leaf and dirt is present. The dry, brown leaf is not so objectionable because it can be blown away, but it is difficult to free the cotton from the black leaf caused by damp.

Khandesh cotton seed bears a good reputation in the European market, its refraction being only 6 per cent. while that from Berar is 6\(\frac{1}{2}\) to 7.

The cultivators, as a rule, do not take away the seed during the ginning season, but just before sowing time, when they have made up their minds as to what they are to grow, they take whatever they can get in the shape of seed from the mounds in the compounds of the ginning factories. A few of the more careful cultivators, however, especially those who farm on a large scale, bring their seed cotton to the ginning factory, see it ginned in their presence, and often sell it during the process to the highest bidder. They take away there and then what they require for the next season’s sowing.

*Cotton Experiments at Sholapur.*—I visited these in January in company with Mr. Patil, the Divisional Inspector of Agriculture. The first plots seen were at Mohanmala on land owned by the late Rao Bahadur Warad. These experiments were started last year with the object of ascertaining the mixture existing in the cotton fields of the Sholapur District and also the value of the component parts of such mixtures.
The seeds were collected from all the talukas of the district. Mr. Patil has separated out these types and furnished the following analysis:

*A statement showing the Analysis of Cottons in the Sholapur District, 1910-11.*

### NEGLECTUMS

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Name of village from which the seed was obtained</th>
<th>Name of Taluka</th>
<th>Total No. of plants in each plot</th>
<th>White flowered broad lobed</th>
<th>White flowered narrow lobed</th>
<th>Yellow flowered broad lobed</th>
<th>Yellow flowered narrow lobed</th>
<th>Branch</th>
<th>Upland Georgian</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Peha</td>
<td>Pandharpur</td>
<td>166</td>
<td>6</td>
<td>63:25</td>
<td>1:8</td>
<td>17:46</td>
<td>6</td>
<td>10:26</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Jeur</td>
<td>Karmala</td>
<td>123</td>
<td>0</td>
<td>23:57</td>
<td>1:81</td>
<td>10:56</td>
<td>63:4</td>
<td>10:06</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tadola</td>
<td>Barsi</td>
<td>93</td>
<td>0</td>
<td>69:9</td>
<td>6:45</td>
<td>13:9</td>
<td>4:36</td>
<td>5:37</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pomalwadi</td>
<td>Karmala</td>
<td>74</td>
<td>0</td>
<td>49:5</td>
<td>1:3</td>
<td>10:8</td>
<td>40:5</td>
<td>6:7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Tembhrurii</td>
<td>Ditto</td>
<td>49</td>
<td>0</td>
<td>59:18</td>
<td>2:03</td>
<td>14:3</td>
<td>18:3</td>
<td>6:1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Malshiras</td>
<td>Malshiras</td>
<td>75</td>
<td>0</td>
<td>76:0</td>
<td>4:0</td>
<td>14:6</td>
<td>4:0</td>
<td>1:3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Akluj</td>
<td>Ditto</td>
<td>88</td>
<td>0</td>
<td>58:0</td>
<td>3:4</td>
<td>6:8</td>
<td>25:0</td>
<td>6:8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Vairag</td>
<td>Barsi</td>
<td>51</td>
<td>0</td>
<td>80:4</td>
<td>0</td>
<td>9:8</td>
<td>5:88</td>
<td>3:92</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Sangola</td>
<td>Sangola</td>
<td>36</td>
<td>0</td>
<td>55:5</td>
<td>0</td>
<td>19:41</td>
<td>2:8</td>
<td>2:2</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Bhalani</td>
<td>Pandharpur</td>
<td>83</td>
<td>1:2</td>
<td>56:6</td>
<td>0</td>
<td>20:4</td>
<td>1:14</td>
<td>7:2</td>
<td></td>
</tr>
</tbody>
</table>
I understand from Mr. Patil that the experiments are to be transferred to Karmala, about 12 miles from Jeur Station. The villagers there have lost their crops through the use of unsuitable seed obtained locally from ginning mills. The cotton usually grown by them is a mixture of neglectum with a little Jowari Hatti and Upland. The people prefer the narrow-lobed neglectum and say that they are willing to buy up any quantity of seed. The rainfall is said to be precarious and the methods of cultivation poor so that the locality seems altogether unsuitable for high class cottons. I have recommended that pure varieties of neglectum be obtained either from Dhulia or from Akola. We have since sent 1,300 lbs. of Varhadi seed to Mr. Patil, also 150 lbs. of Sangor-Jari seed, an early ripening dwarf, prolific variety, which ripens its crop at least three weeks in advance of Jari and Varhadi: I also visited Pasare’s Estate on which the Department is working with manurai experiments.

The following are valuations by Messrs. Tata Sons on samples sent from each of the treated plots:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plot manured with F. Y. manure.</td>
<td>Strong in fibre and of good staple and has the appearance of the usual cotton of the Sholapur District, weaker in staple than No. 1.</td>
<td>Rs. 335</td>
<td>Western style.</td>
</tr>
<tr>
<td>2</td>
<td>Plot manured with pot-sulphate and superphosphate.</td>
<td>Staple and strength of fibres between Nos. 1 and 2.</td>
<td>325</td>
<td>Ditto.</td>
</tr>
<tr>
<td>3</td>
<td>Plot manured with ammonia sulphate and superphosphate.</td>
<td>Equal to No. 1.</td>
<td>330</td>
<td>Ditto.</td>
</tr>
<tr>
<td>4</td>
<td>Manured with superphosphate.</td>
<td>Equal to No. 3.</td>
<td>330</td>
<td>Ditto.</td>
</tr>
<tr>
<td>5</td>
<td>Manured with ammonia sulphate only.</td>
<td>Equal to No. 1.</td>
<td>335</td>
<td>Ditto.</td>
</tr>
<tr>
<td>6</td>
<td>Check plot: no manure.</td>
<td>Equal to No. 1. This is the best of the whole group in colour, length of staple and strength of fibre.</td>
<td>310</td>
<td>Ditto.</td>
</tr>
<tr>
<td>7</td>
<td>Manured with pot-sulphate only.</td>
<td>Equal to No. 1.</td>
<td>335</td>
<td>Ditto.</td>
</tr>
<tr>
<td>8</td>
<td>No manure; check plot.</td>
<td>Equal to No. 1.</td>
<td>325</td>
<td>Ditto.</td>
</tr>
<tr>
<td>9</td>
<td>Manured with ammonia sulphate, superphosphate and pot-sulphate.</td>
<td>Equal to No. 1.</td>
<td>335</td>
<td>Ditto.</td>
</tr>
</tbody>
</table>

Basis.—Good Western Gd., Rs. 1335.

*Fine Brench Gd.*, Rs. 360.
Again, in company with Mr. Patil, I visited the experiments with Broach cotton (seeds imported from Navasari last year) near Islampur in the Krishna Valley. This is a highly cultivated and fertile tract and agricultural operations have been very carefully attended to.

In the first field local Jowari Hatti and the imported Broach are growing side by side. The former was ripening, while the latter bore only flowers and unripe bolls.

In another field of imported Broach, sown in June, the bolls were ripening. From the conditions of these two trials one sown in the end of July and the other in June, it is plainly obvious that no delay should occur in the sowing of Broach cotton in this district. I also suggested the trial of Bhuri and Cambodia in this tract.

The following are valuations of local Jowari Hatti and Broach cotton grown in adjacent plots on these trials:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>If the seed is Bengal, it has certainly improved in Islampur soil and looks more like Miraj cotton.</td>
<td>Rs. 335</td>
<td>Western style.</td>
</tr>
<tr>
<td>2</td>
<td>Same remark as above; it is better in colour than No. 1</td>
<td>340</td>
<td>Ditto.</td>
</tr>
<tr>
<td>3</td>
<td>Shows deterioration in colour only</td>
<td>390</td>
<td>Surat style.</td>
</tr>
<tr>
<td>4</td>
<td>Better than No. 3 in colour, but slightly shorter in staple</td>
<td>385</td>
<td>Ditto.</td>
</tr>
</tbody>
</table>

N.B.—Nos. 1 and 2 are Jowari Hatti; Nos. 3 and 4 are from seed imported from Navasari.

Basis of valuation per candy:
- Fine Surat Gd., Rs. 380.
- Breach Gd., Rs. 390.
- Good Western Gd., Rs. 335.
(Candy of 784 lbs.)

Some experiments are being conducted at Nadiad in the Kaira District to solve the very difficult problem of finding a better cotton than the local Rosi.

Three varieties are at present under trial; Bourbon, Bhuri and Cambodia:

Bourbon.—This was the second year of its growth. During the first year it yielded 400 lbs. of seed cotton per acre, second year, 1,000 lbs. of seed
cotton per acre. The second year’s growth was extremely satisfactory, so much so that the branches had intermixed and it was impossible to go into the field. It remained to be seen whether after pruning (third year) the outturn is maintained.

*Bhuri.*—This was sown in May under irrigation only until the rains broke; outturn 1,100 lbs. of seed cotton per acre.

*Cambodia.*—Sown in May under irrigation like Bhuri; outturn 800 lbs. of seed cotton per acre.

It seems that both *Bhuri* and Cambodia should be established before the rains to reap a good harvest. It was gathered that cultivators from the neighbourhood occasionally visited the farm and were satisfied with the growth, outturn, etc., and as a consequence of this the Superintendent has received many requisitions for the supply of seed of all the three varieties mentioned above.

Samples were valued by Messrs. Tata, Sons & Co. as follows:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Value (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Surat</td>
<td>380</td>
</tr>
<tr>
<td>Navasari</td>
<td>400</td>
</tr>
<tr>
<td>Fine Broach</td>
<td>360</td>
</tr>
</tbody>
</table>

**Valuation of Nadiad Samples**

*Bourbon*—Equal to F. Navasari Gd., good in colour and staple, Rs. 400.

*Cambodia*—Equal to F. Broach Gd., but better in staple, Rs. 365.

*Bhuri.*—Equal to F. Broach Gd., Rs. 360.

From these valuations it will be seen that there is a strong possibility of at least three high class cottons being introduced profitably into Northern Gujerat.

Full reports of the cotton operations on the Bombay Experimental Stations will be found in the Progress Reports. Mr. Keatinge, the Director of Agriculture, in a recent note has clearly shown the present condition and prospects of cotton cultivation in the Bombay Presidency. This is entitled "Note on Improved and Exotic Cottons in the Bombay Presidency." It should be carefully studied by all who are interested in the improvement of Indian cottons.
Good work is being done in the Southern Districts of the Presidency judging from the samples of selected cottons which were sent to me for valuation.

These were adjudged by the Directors of the Bombay Cotton Association, Limited, who remarked that all the samples showed nice clean cotton and the differences in price is all practically due to staple. That the Karunganni samples are more suitable for weaving mills than the Uppam samples, but both styles should suit buyers for export and local consumption.

The following is their detailed report:—

Samples of cotton from Madras submitted by the Imperial Cotton Specialist:—

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Description</th>
<th>Approximate market value in Rs. per candy of 784 lbs. less 5½ per cent. discount</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uppam Variety.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 U</td>
<td>Ordinary field crop</td>
<td>335</td>
<td>Rather harsh instaple; very clean.</td>
</tr>
<tr>
<td>2 U</td>
<td>Pedigree Uppam</td>
<td>340</td>
<td>Staple rather better than No. 1.</td>
</tr>
<tr>
<td>3 U</td>
<td>Ditto</td>
<td>340</td>
<td>Ditto.</td>
</tr>
<tr>
<td>4 U</td>
<td>Ditto</td>
<td>335</td>
<td>Ditto.</td>
</tr>
<tr>
<td>5 U</td>
<td>Ditto</td>
<td>335</td>
<td>Ditto.</td>
</tr>
<tr>
<td>6 U</td>
<td>Ditto</td>
<td>345</td>
<td>Ditto.</td>
</tr>
<tr>
<td>7 U</td>
<td>Ditto</td>
<td>340</td>
<td>Ditto.</td>
</tr>
<tr>
<td>Serial No.</td>
<td>Description</td>
<td>Approximate market value in Rs. per cwt of 784 lbs less 5½ per cent. discount</td>
<td>REMARKS</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>1 K</td>
<td>Karunganni ordinary field crop</td>
<td>345</td>
<td>Silky staple.</td>
</tr>
<tr>
<td>2 K</td>
<td>Pedigree Karunganni</td>
<td>345</td>
<td>Ditto.</td>
</tr>
<tr>
<td>3 K</td>
<td>Ditto</td>
<td>345</td>
<td>Ditto.</td>
</tr>
<tr>
<td>4 K</td>
<td>Selected Karunganni</td>
<td>345</td>
<td>Ditto.</td>
</tr>
<tr>
<td>5 K</td>
<td>Ditto</td>
<td>343</td>
<td>Ditto.</td>
</tr>
<tr>
<td>6 K</td>
<td>Pedigree Karunganni</td>
<td>350</td>
<td>Irregular in staple.</td>
</tr>
<tr>
<td>7 K</td>
<td>Ditto</td>
<td>345</td>
<td>Staple rather irregular.</td>
</tr>
<tr>
<td>8 K</td>
<td>Ditto</td>
<td>345</td>
<td>Staple good and silky.</td>
</tr>
<tr>
<td>9 K</td>
<td>Ditto</td>
<td>350</td>
<td>Ditto.</td>
</tr>
<tr>
<td>10 K</td>
<td>Ditto</td>
<td>345</td>
<td>Ditto.</td>
</tr>
<tr>
<td>11 K</td>
<td>Ditto</td>
<td>370</td>
<td>Long silky staple, excellent,</td>
</tr>
<tr>
<td>12 K</td>
<td>Ditto</td>
<td></td>
<td>spinning cotton.</td>
</tr>
<tr>
<td>13 K</td>
<td>Ditto</td>
<td>370</td>
<td>Ditto.</td>
</tr>
<tr>
<td>14 K</td>
<td>Ditto</td>
<td>375</td>
<td>Ditto.</td>
</tr>
<tr>
<td>15 K</td>
<td>Ditto</td>
<td>380</td>
<td>Ditto.</td>
</tr>
</tbody>
</table>

It will be seen from the above that the selections have been valued almost in their correct order by Mr. Sampson.

**Bengal Cottons.**

I visited the Experimental Station at Chinsurah and furnished the following report, which was based on an inspection and discussion with Mr. Smith, Deputy Director of Agriculture.

The first plots seen were of Cambodia and Bhuri cottons, one-fifth of an acre each. These were on well-drained raised land and their condition was very satisfactory indeed. As explained to me, I gathered that this class of land is very rare in the province, its height above the general level being due to an accumulation of silt and weeds thrown up while excavating tanks. It is the most suitable of soils for plantains, etc., and we can scarcely expect a cotton crop to compete with these in value. The second series of plots visited were of the same cottons on paddy land, lying at the general level. The plants were unthrifty and showed distinct signs of damage by water-logging earlier in the sea-
son. Practically no crop had been produced and the immature bolls were shrivelling. The plots of indigenous varieties were only just coming into flower. This means that bolls could only be ripened during the hot weather, and as their produce at the best would only be equal to the most inferior Berar or Khandesh cotton, they are scarcely worth troubling with in a tract which grows more highly remunerative crops, such as rice and jute. Deshila and Bhogila are still later and the length of time they occupy the ground is a serious objection to their cultivation. It is to be regretted that the primitive people of Chutia Nagpur cannot be induced to extend the cultivation of Bhuri cotton in their country, but, so far as they are concerned, there is probably no material incentive for them to so exert themselves.

All the Indian varieties of cotton have now been tried in the deltic area of Bengal, and the inevitable conclusion to be drawn from the experience thus earned is that the conditions of soil and climate are not in any way suitable for cotton cultivation, and I cannot recommend that experiments with a view to introduce their culture should be persevered with.

The following samples from Chinsurah, Bengal, were kindly reported on for me by Messrs. Tata, Sons & Co. of Bombay:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Report</th>
<th>Price per candy</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cambodla</td>
<td>The cotton has preserved its silkiness and staple, but has deteriorated in class. It is F. G. in class.</td>
<td>Rs. 300</td>
<td>Bengal style.</td>
</tr>
<tr>
<td>2</td>
<td>Bhuri</td>
<td>Better than No. 1</td>
<td>310</td>
<td>Ditto.</td>
</tr>
<tr>
<td>3</td>
<td>Deshila</td>
<td>Very much deteriorated, and is like G. Bengal.</td>
<td>275</td>
<td>Ditto.</td>
</tr>
<tr>
<td>4</td>
<td>Bhogila</td>
<td>Deteriorated and can be likened to F. G. Bengal.</td>
<td>285</td>
<td>Ditto.</td>
</tr>
</tbody>
</table>

*Basis per candy of 784 lbs.*

F. Bengal, Rs. 315.
It will thus be seen that no very remunerative cotton has as yet been established in Bengal.

Punjab Cottons.

Excellent results are being attained by Mr. Milne, the Economic Botanist, as will be seen from the account published in his progress report and by the British Cotton Growing Association, Manchester. It was considered that 161 A. F. was the best, while Pride of Georgia coming second is nearly equal by 199 F., 220 F., and King's Cotton is slightly lower than the last three. The reports on the indigenous cottons are not so favourable. It is to be hoped that the extension in the cultivation of the higher class cottons in the Punjab will be persevered with.

Valuations.—All samples received were submitted to Messrs. Tata, Sons & Co., Bombay, for valuation. Cordial acknowledgment is due to these gentlemen for their kindness and promptitude in giving opinions on cottons whenever submitted to them.

Some samples were also submitted to the Bombay Chamber of Commerce, to whom thanks are also due.

Programme of work for 1911-12.—1. To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

2. By special invitation of the Department of Agriculture, Punjab, to report on the work done in the way of cotton improvement in that province. The question of the distribution of seeds of improved varieties will be further discussed with the proper authorities in the Central Provinces and Bombay Presidency.

3. The study of the behaviour of Bourbon, Bhuri, and such other cottons in non-cotton producing tracts as detailed in my last year's programme will be continued.

4. The conditions of cotton cultivation in Kathiawar and adjacent parts would be investigated.

5. An enquiry will be commenced on the manurial requirements of cotton.
PUBLICATIONS.

The present position and prospects of Cotton Cultivation in India. For the International Congress of Tropical Agriculture, Brussels, May, 1910.