ANNUAL REPORT

OF THE

IMPERIAL DEPARTMENT OF AGRICULTURE

FOR THE YEAR

1904-05.

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TABLE OF CONTENTS.

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

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 resumé 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.

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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

* Proceedings of the Board of Agriculture, Government Printing Press, Calcutta.

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 R16½ 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, sessamum, 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 hoped 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 R100 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 manurial 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 diarrhœa 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 potasium 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 phoshate 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.

Constituent.	Percentage of different constituents in the samples.		
	Apatite, Hazaribagh mica mines (*a*).	Trichinopoly phosphate (*a*).	Christmas Island phosphate (*b*).
Moisture	0·37	1·62	0·74
Organic matter	...	2·71	2·80
Lime	36·42	37·22	...
Iron and alumina	1·89	11·90	2·01
Alkalis, etc.	3·00	7·76	...
Phosphoric acid	28·39	22·83	38·89
Carbonic acid	0·03	5·56	1·95
Silica	29·90	10·40	0·10
Calcium phosphate	61·98	49·84	84·90
Calcium carbonate	...	12·62	4·43

(*a*) Analyses 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 leguminosæ. 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 outturns 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 Rusts.**—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 teleutospores 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 versâ*. 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 hypogœa*) 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 fieldmen 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 (*Acrididæ*) 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 R5,000. 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

* Report on Sheep and Cattle Feeding Experiments, by Mr. W. Bruce, B.Sc., F.H.A S. Bulletin No. IV of 1904 of the Edinburgh and East of Scotland College of Agriculture.

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 (*Cephaleuros 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 theivora*). 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 oxidization 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 indigotin 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 Baled 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 R18 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 'Wlingi' 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** (*Ipomæa 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 waterlifts, 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

* Report on an Inquiry into the State of the Tasar Silk Industry in Bengal and the Central Provinces of India by Mr. N. G. Mukerjee, M.A., M.R.A.C., F.H.A.S., Assistant Director of Agriculture, Bengal. Price R2.

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:—

Section of Department.	1901-02.	1902-03.	1903-04.	1904-05.
	₹	₹	₹	₹
Inspector General	21,849	43,623	56,956	1,15,753
Pusa	...	...	50,550	1,27,833
Agricultural Chemist . . .	11,060	26,000	21,164	23,517
Cryptogamic Botanist . . .	...	18,972	18,009	21,080
Government Entomologist . .	...	...	16,246	27,230
TOTAL .	32,909	88,595	1,62,064	3,15,413

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
Fodder 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 Agricutural 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 R20 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.

Part II.

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. he 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 R60,350. 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 indigenous 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. Regarding annual cottons the case is different, and although the results are by no means conclusive, we are able to forecast the probabilities of success and the lines on which the experiments should in future be conducted. 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 ₹1,26,575, the principal items being ₹15,750 for pay of gazetted officers, ₹15,000 for irrigation scheme, ₹30,000 for clearing and arable cultivation, and ₹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 Mozafferpore 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 :—

Soils	88
Atmospheric dust	60
Waters	97
Manures	92
Salt earths and salts	74
Feeding stuffs	297
Sugars	65
Insecticides	1
Cassava starch	4
Jute	9
Crude rubbers	15
Timber	1
Paper	14
Coffee	1
Butter	3
	821

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 *nitrogenous* 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

these, the only method which can be considered at all suitable 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 ·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 ·1 or ·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 :—

	Rainfall.	Nitrogen—lbs., per acre.		Total.
	Inches.	As ammonia	As nitrate.	
Dehra Dun . . .	87·45	2·178	1·391	3·596
Cawnpore . . .	49·36	2·482	·768	3·250

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 ·055 lb. of "ammonia," nitrogen and ·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 ·61 lb., and would not contain more than ·1 per cent. or ·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.

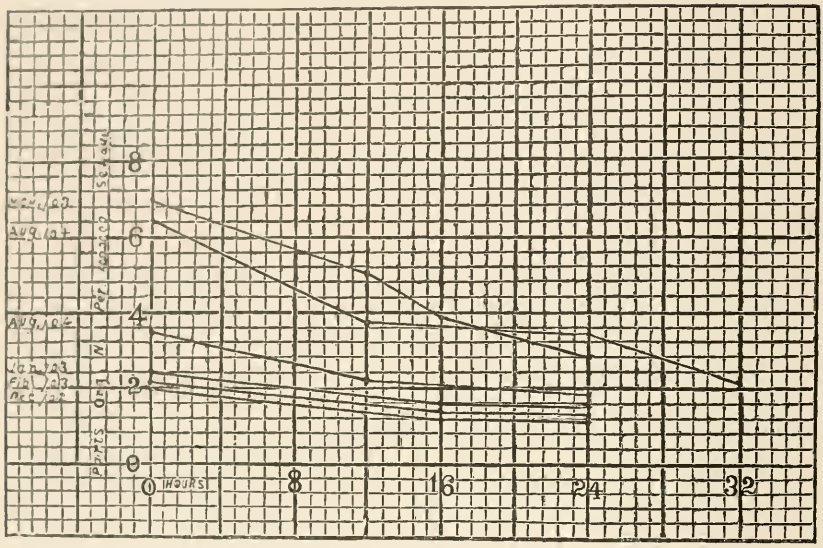
Experiments with manures have not so far been made independently by me; no experimental farm is attached to this office at Dehra Dun, and my province has been restricted to that of adviser at other farms. Sewage has been a subject of special investigation, and is dealt with in the succeeding paragraph.

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 Jamna 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 "lixiviated" 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 :—

		Percentage of oil varied— from	to
52 samples of	Sesamum indicum	45	56
91 „	Brassica (several varieties)	27	49
20 „	Eruca sativa	25	36
31 „	Guizotia abyssynica	36	43
54 „	Linum usitatissium	35	44
30 „	Carthamus tinctorius	22	33
(i) 58 „	Arachis hypogœa	39	50
100 „	Ricinius communis (kernel)	55	71
10 „	Poppy	44	48
(ii) 80 „	Cotton seed	15	21
10 „	Mohwa seed	46	49

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 cyanogenetic 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 cyanogenetic 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 ·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 ·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, 1·0 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 :—

	Fyzabad *gur.*	Balaghat *gur.*
Sucrose	63·14	85·81
Glucose	9·91	6·49
Ash	3·65	...
Water	8·26	...

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 o fSyed 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 Muhammad 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 ·5 per cent. of glucose. It is in this direction, 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 transport. 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. Numerous 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 examining 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 1903; 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.

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Agricultural Chemist to the Govt. of India.

Dated the 22nd July, 1905.

Part IV.

ANNUAL REPORT OF THE CRYPTOGAMIC BOTANIST TO THE GOVERNMENT OF INDIA FOR THE YEAR ENDING THE 30TH JUNE, 1905, WITH A BRIEF ACCOUNT OF THE WORK OF THE OFFICE OF CRYPTOGAMIC BOTANY OF THE DEPARTMENT OF AGRICULTURE SINCE ITS CREATION.

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 Behar 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 (groundnut, 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 Nilgiris. 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 æcidial 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 *Æcidium* 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 *Uredineæ* 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. Penniseti*), linseed rust (*Melampsora Lini*), rusts on indigo, lentil, lucerne, etc. (species of *Uromyces*), several members of the genus *Peridermium* on conifers, teak rust (*Uredo Tectonæ*), castor oil rust (*Melampsorella Ricini*), etc. The *juar* and *bajra* rusts were considered identical by Barclay and described as *Puccinia Penniseti*. 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, *Sphæronæma adiposum*, 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 *Colletotrichum falcatum* and

Sphæronæma 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 *Sphæronæma* 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 Neliampatties. 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 (*Glœosporium*) 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 *Septoglœum 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 ½ 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 ⅓ 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 Tritici*), 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. *Colletotrichum Lineola* 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 *Phythophthora*. 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. **Mycorhiza.**—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 mycorhiza 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 *Leguminosæ* and the evident fact that the plant does not suffer from the association suggests that such mycorhizas 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 Leguminosæ.**—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 *Eryiphaceæ* 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 R50,000 per annum for a period of three years was made on the condition that the planters found a sum of R75,000 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 R50,000 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 ₹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, datd 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 Sirsiah 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 Sirsiah 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 Sirsiah 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 insured 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 Rungpore 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.,

Dated the 11th September, 1905. *Jute Specialist to the Government of Bengal.*

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 30 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 $\frac{1}{4}$ 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. Eve n 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.

Serial No.	Title.	Author.	Where published.
		General Agriculture.	
1	Text Book on Indian Agriculture, 3 volumes.	J. Mollison, M.R.A.C., Inspector General of Agriculture in India.	Government Central Book Depôt, Bombay, 1901. Price R7-8-0.
2	Note on Improvement of Indian Cotton, 1901-02.	Ditto ditto	Office of the Inspector General of Agriculture in India, Nagpur, Central Provinces.
3	Note on Improvement of Indian Cotton, 1902-03.	Ditto ditto	Ditto ditto
4	Note on Cotton in Burma . . .	I. H. Burkill, M.A., Officiating Reporter on Economic Products to the Government of India.	Government Printing Press, Calcutta, 1904.
5	Note on Cotton in Bhainsi, Nizam's Dominions.	Ditto ditto . .	Ditto , 1905.
6	Note on the question of the possibility of extending cotton cultivation in Burma.	J. Mollison, M.R.A.C., Inspector General of Agriculture in India.	Ditto , 1904.
7	Note on Tree Cotton Experiments of Messrs. Shaw, Wallace & Co. of Calcutta.	F. G. Sly, I.C.S., Officiating Inspector General of Agriculture in India.	Government of India, Revenue and Agricultural Department Government Printing, India, Calcutta, 1905.

8	Cultivation of Longer stapled-cottons at the Cawnpur Experiment Station.	P. Subbiah, Principal, Cawnpur Agricultural School.	Bulletin No. 15 of 1901. United Provinces Department of Agriculture. Allahabad Government Press. Price 6 annas.
9	Experimental cultivation of Egyptian cotton at the Nagpur Experimental Farm.	R. S. Joshi, L. Ag., Assistant Director of Agriculture, Central Provinces.	Bulletin No. 3 of 1901. Nagpur Secretariat Press. Price 2 annas.
10	The Cotton seed oil Industry . .	F. G. Sly, I.C.S., Commissioner of Settlements and Agriculture, Central Provinces.	Bulletin No. 9 of 1902. Department of Agriculture, Nagpur Secretariat Press. Price 3 annas.
11	Note on the cotton-seed oil Industry and the Establishment of cotton seed oil Mills in India.	J. Mollison, M.R.A.C., Inspector General of Agriculture in India.	Agricultural Ledger No. 9 of 1903. Government Printing, India, Calcutta. Price 2 annas.
12	Cultivation of sugarcane in the Bombay Presidency.	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India and J. Mollison, Esq., M.R.A.C., Deputy Director of Agriculture, Bombay Presidency.	Agricultural Ledger No. 8 of 1898. Government Printing, India, Calcutta.
14	The Sugar Industry of the United Provinces of Agra and Oudh.	Sayid Muhammed Hadi, M.R.A.C., Assistant Director of Agriculture, United Provinces.	Government Press, Allahabad, 1902. Price R3.
15	Improvement in native methods of sugar manufacture.	S. M. Hadi, M.R.A.C , M.R.A.S., Assistant Director of Land Records and Agriculture, United Provinces.	Bulletin No. 19 of 1905. Allahabad Government Printing Press. Price 2 annas.
16	Sugarcane in the Godavari and Ganjam Districts.	C. A. Barber, M.A., F.L.S., Botanist to the Government of Madras. Dr. J. W. Leather, Ph.D., F.C.S., Agricultural Chemist to the Government of India. C. K. Subba Rao, B.A., Sub-Assistant Director of Agriculture, Madras.	Bulletin No. 43 of 1901. Department of Agriculture, Madras. Price 2 annas.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		General Agriculture—continued.	
17	Sugarcanes of Madras . . .	C. Benson, M.R.A.C., Deputy Director of Agriculture, Madras.	Bulletin No. 46 of 1902. Department of Agriculture, Madras. Government Press, Madras. Price 2 annas.
18	Sugarcane cultivation in the Deccan Districts of Madras Presidency.	C. K. Subba Rao, B.A., Sub-Assistant Director of Agriculture, Madras.	Bulletin No. 50 of 1904. Department of Agriculture, Madras. Government Press, Madras. Price 1 anna.
19	Sugar manufacture. The deterioration of cut sugarcane.	J. Weinberg, Officiating Curator, Indian Museum, Industrial Section, Calcutta.	Agricultural Ledger No. 6 of 1903. Government Printing, India, Calcutta. Price 2 annas.
20	*Saccharum officinarum.* (Sugar manufacture.) The Diffusion Process of extracting sugar from sugarcane.	I. H. Burkill, M.A., Officiating Reporter on Economic Products to the Government of India.	Agricultural Ledger No. 8 of 1903. Government Printing, India, Calcutta. Price 3 annas.
21	*Saccharum officinarum.* The Central Factory system with reference especially to countries growing sugarcane.	I. H. Burkill, M.A., Officiating Reporter on Economic Products to the Government of India, and J. Weinberg, Esq., Officiating Curator, Indian Museum, Calcutta, Industrial Section.	Agricultural Ledger No. 12 of 1903. Government Printing, India, Calcutta. Price 2 annas.
22	*Camellia thea* (The Tea plant.) The Principles of Tea Pruning.	Sir George Watt, Kt., M.B., C.M., F.L.S., C.I.E., Reporter on Economic Products to the Government of India, and Harold H. Mann, M.Sc., F.I.C., F.L.S., Scientific Officer to the Indian Tea Association.	Agricultural Ledger No. 1 of 1903. Government Printing, India, Calcutta. Price 3 annas.

23	The Pests and blights of the Tea Plant	Sir George Watt, Kt., M.B., C.M., F.L.S., C.I.E., Reporter on Economic Products to the Government of India and Dr. H. H. Mann, D. Sc., F.I.C., F.L.S., Scientific Officer to the Indian Tea Association.	Government Printing, India, Calcutta, 1903. Price R3.
24	Report on the cultivation and manufacture of Indigo.	Christopher Rawson, F.I.C. . . .	Behar Indigo Planters' Association, Ld., Muzafferpore.
25	An account of the Research work in Indigo carried out at Dalsingserai station.	W. Popplewell Bloxam, B.Sc. (London), F.C.S., F.I.C.	Bengal Secretariat Book Depôt, Calcutta, Price R5.
26	Papers on Jute, 1902-03 . . .	Department of Agriculture, Bengal . .	Bengal Secretariat Press, Calcutta.
27	Selected Papers on enquiry into Deterioration of Jute, 1903-04.	Ditto . .	Ditto
28	Report on Deterioration of Jute . .	Sub Committee B. of Board of Scientific Advice.	Government Printing Press, Calcutta.
29	*Hibiscus cannabinus* (Bimlipatam Jute) Reports upon Bimlipatam Jute.	Professor Wyndham R. Dunstan, F.R.S., Director, Imperial Institute, London.	Agricultural Ledger No. 11 of 1903. Government Printing, India, Calcutta. Price 2 annas.
30	Sisal Hemp culture	Dr. H. H. Mann, M.S.C., F.I.C., F.L.S., Scientific Officer to the Indian Tea Association, Limited, and James Hunter.	Indian Tea Association, Ld., Calcutta, 1904.
31	*Agave.* The Alœ plant and its fibre .	Department of Agriculture, Central Provinces.	Bulletin No. 4 of 1901. Nagpur Secretariat Press. Price 2 annas.
32	*Marsdenia tenacissima.* (Rajmahal Hemp.) Papers relating to fibre of Marsdenia tenacissima.	Professor Wyndham R. Dunstan, F.R.S., Director, Imperial Institute, London. I. H. Burkill, Esq., M.A., Officiating Reporter on Economic Products to the Government of India.	Agricultural Ledger No. 8 of 1904. Government Printing, India, Calcutta. Price 1 anna.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		General Agriculture—continued.	
33	Simple machines for extracting plantain fibre.	R. L. Proudlock, Curator, Government Botanic Gardens, the Nilgiris, Madras.	Bulletin No. 47 of 1902. Department of Agriculture, Madras. Government Press, Madras. Price 2 annas.
34	*Triticum vulgare* (Wheat). Australian methods of testing and improving wheat. Their applicability to India with special reference to the prevention of rust.	W. H. Moreland, B.A., LL.B., C.I.E., I.C.S., Director of Land Records and Agriculture, North-Western Provinces and Oudh.	Agricultural Ledger No. 2 of 1901. Government Printing, India, Calcutta. Price 3 annas.
35	*Piper nigram* (Pepper). Cultivation of pepper in the Bombay Presidency. A further account of manures used in spice gardens.	J. Mollison, M.R.A.C., Inspector General of Agriculture in India.	Agricultural Ledger No. 3 of 1901. Government Printing, India, Calcutta. Price 2 annas.
36	*Manihot utilissima* (*Cassava, Tapioca, Manioc.*) The Tapioca Plant : Its history, cultivation, and uses. A review of existing information.	I. H. Burkill, M.A., Officiating Reporter on Economic Products to the Government of India.	Agricultural Ledger No. 10 of 1904. Government Printing, India, Calcutta. Price 3 annas.
37	*Carthamus tinctorius* (Safflower) . .	Reginald Abbey-Yates	Agricultural Ledger No. 11 of 1904. Government Printing, India, Calcutta. Price 3 annas.
38	Maize at the Cawnpur Experiment Station.	P. Subbiah, Principal, Cawnpore Agricultural School.	Bulletin No. 16 of 1901. United Provinces Department of Agriculture. Allahabad Government Press. Price 6 annas.

39	*Paspalum Dilatatum.* A new fodder grass for India.	Reporter on Economic Products to the Government of India.	Agricultural Ledger No. 1 of 1901. Government Printing, India, Calcutta. Price 2 annas.
40	*Paspalum dilatatum.* A new fodder grass for India.	Department of Agriculture, Central Provinces.	Bulletin No. 7 of 1902. Department of Agriculture, Nagpur Secretariat Press. Price 1 anna.
41	Prickly pear and aloe as fodder for cattle during scarcity.	R. R. Mehta, M.R.A.C., Acting Deputy Director of Agriculture, Bombay Presidency.	Bulletin No. 22 of 1904. Department of Agriculture, Bombay. Bombay Government Central Press.
42	India-Rubber. Papers relating to Rubber from *Willughbeia edulis* and *Urceola esculenta* in Burma.	Professor Wyndham R. Dunstan, F.R.S., Director of Imperial Institute, London. S. Carr, Deputy Conservator of Forests, Rangoon Division. Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India.	Agricultural Ledger No. 10 of 1903. Government Printing, India, Calcutta. Price 2 annas.
43	Rhubarb	Department of Land Records and Agriculture, Assam.	Bulletin No. 11 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.
44	The Spanish chestnut	Ditto ditto . .	Bulletin No. 12 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.
45	Award on the competition for prizes for silos in the Khasi Hills, 1904-05.	Ditto ditto .	Bulletin No. 13 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.
46	Shillong Government Farm . . .	Ditto ditto . .	Bulletin No. 10 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		General Agriculture—continued.	
47	Asparagus	B. C. Basu, M.R.A.C., Assistant Director of Agriculture, Assam.	Bulletin No. 14 of 1904. Department of Agriculture, Assam. Assam Secretariat Press, Shillong.
48	The cultivation of pulse crops in the Assam Valley.	B. C. Basu, M.R.A.C., Assistant Director of Agriculture, Assam.	Bulletin No. 9 of 1902. Department of Agriculture, Assam. Assam Secretariat Printing Office, Shillong, Price 2 annas.
49	Pulses of India. (Assam Valley Pulses.) The cultivation of pulse crops in the Assam Valley.	B. C. Basu, M.R.A.C., Assistant to the Director, Department of Agriculture, Assam.	Agricultural Ledger No. 5 of 1903. Government Printing, India, Calcutta. Price 2 annas.
50	Classified list of cultivated crops in the Bombay Presidency.	W. P. Symonds, I.C.S	Bulletin No. 23 of 1904. Department of Agriculture, Bombay. Bombay Government Central Press.
51	Dates of Sowing and Harvesting important crops in the Bombay Presidency.	H. S. Lawrence, I.C.S., Director of Agriculture, Bombay Presidency.	Bulletin No. 24 of 1904. Department of Agriculture, Bombay. Bombay Government Central Press.
52	Water of the soil	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India.	Government Printing Press, Calcutta.
53	A Note on Agricultural Improvements suitable to North-West Provinces and Oudh.	W. H. Moreland, B.A., LL.B., I.C.S., Director of Agriculture, United Provinces.	Bulletin No. 17 of 1901. United Provinces, Department of Agriculture. Allahabad Government Press. Price 2 annas.

54	Different systems of Housing Cattle and conserving manure in the United Provinces.	P. V. Subbiah, Principal, Cawnpur Agricultural School.	Bulletin No. 14 of 1901 of the United Provinces Department of Agriculture. Allahabad Government Press. Price 2 annas.
55	The utilization of night-soil as manure .	R. S. Joshi, L. Ag., Assistant Director of Agriculture, Central Provinces.	Bulletin No. 5 of 1901. Nagpur Secretariat Press. Price 2 annas.
56	Proceedings of the Board of Agriculture	.....	Government Printing Press, Calcutta.
57	Annual Report of the Board of Scientific Advice.	.....	Government Printing Press, Calcutta. Price 6 annas.
58	Report of the Indian Famine Commission of 1901.	.....	Government Printing Press, Calcutta. Price 14 annas.
59	Report of the Indian Irrigation Commission, 1901 to 1903.	.....	Government Printing Press, Calcutta. Price R1-8.
60	Agricultural Statistics of British India, 1902-03. Agricultural Statistics of Native States .	Director-General of Statistics . .	Government Printing Press, Calcutta. Price R3.
61	Area and yield of certain principal crops in India.	Department of Commerce and Industry .	Government Printing Press, Calcutta. Price 5 annas.
62	The Agriculture of the United Provinces	W. H. Moreland, B.A., LL.B., C.I.E., I.C.S., Director of Land Records and Agriculture, United Provinces.	Pioneer Press, Allahabad, 1904.
63	Annual Report of the Department of Agriculture, Bengal.	Department of Agriculture . . .	Bengal Secretariat Press, Calcutta. Price 8 annas.
64	Annual Report of the Department of Agriculture, United Provinces.	Ditto . . .	Government Printing Press, Allahabad Price 4 annas.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		General Agriculture—continued.	
65	Annual Report of the Department of Agriculture, Punjab.	Department of Agriculture . . .	Civil and Military Press, Lahore. Price 4 annas.
66	Annual Report of the Department of Agriculture, Bombay.	Ditto . . .	Bombay Government Central Press. Price 10 annas.
67	Annual Report of the Department of Agriculture, Central Provinces.	Ditto . . .	Nagpur Secretariat Press. Price 8 annas.
68	Annual Report of the Department of Agriculture, Madras.	Ditto . . .	Government Press, Madras. Price 4 annas.
69	Annual Report of the Department of Agriculture, Assam.	Ditto . . .	Shillong Secretariat Press. Price R1.
70	Annual Report of the Department of Agriculture, Burma.	Ditto . . .	Rangoon Secretariat Press. Price 7 annas.
71	Annual Report of the Experiment Farms in Bengal.	Ditto . . .	Bengal Secretariat Press, Calcutta.
72	Annual Report of the Experiment Farms in the United Provinces.	Ditto . . .	United Provinces Government Press, Allahabad. Price 8 annas.
73	Annual Report of the Lyallpur Farm in the Punjab.	Ditto . . .	The Civil and Military Gazette Press, Lahore. Price 12 annas.

74	Annual Report of the Experiment Farms in Bombay.	Department of Agriculture . . .	Government Central Press, Bombay. Price 12 annas.
75	Annual Report of the Experiment Farms in the Central Provinces.	Ditto . . .	Secretariat Press, Nagpur.
76	Annual Report of the Experiment Farms in Madras.	Ditto . . .	Government Press, Madras.
		Agricultural Chemistry.	
1	The Composition of Indian soils . .	Dr. J. W. Leather, F.I.C., F C.S., Agricultural Chemist to the Government of India.	Agricultural Ledger No. 2 of 1898. Government Printing, India, Calcutta.
2	Reclamation of Reh or Usar-land . .	Ditto ditto .	Agricultural Ledger No. 7 of 1897. Government Printing, India, Calcutta.
3	Ditto ditto . .	Ditto ditto .	Agricultural Ledger No. 13 of 1897. Government Printing, India, Calcutta.
4	The sampling of soils. Transactions of the Chemical Society, 1902, Volume 81.	Ditto ditto .	Chemical Society, London.
5	Manure Farm Yard	Ditto ditto .	Agricultural Ledger No. 3 of 1894. Government Printing, India, Calcutta.
6	Indian Manures: Their composition, conservation and application.	Ditto ditto .	Agricultural Ledger No. 8 of 1897. Government Printing, India, Calcutta.
7	The disposal of night-soil . . .	Ditto ditto .	Agricultural Ledger No. 16 of 1895. Government Printing, India, Calcutta.
8	The value of silt as manure . . .	Ditto ditto .	Agricultural Ledger No. 5 of 1897. Government Printing, India, Calcutta.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		Agricultural Chemistry—continued.	
9	Experiments on the growth of wheat and maize at the Cawnpore Experimental Farm.	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India.	Bulletin No. 9 of 1900 of North Western Provinces. Allahabad Government Printing Press.
10	Experiments at the Cawnpore Farm on the growth of wheat (*a*) with green manuring, and (*b*) in rotation with leguminous crops.	Ditto ditto	Bulletin No. 10 of 1900. Government Printing Press, Allahabad.
11	Well waters and soils	Ditto ditto	Agricultural Ledger No. 14 of 1895. Government Printing, India, Calcutta.
12	Some excessively saline Indian well waters. Transactions of the Chemical Society, 1902, Volume 81.	Ditto ditto	Chemical Society, London.
13	Indian Food Grains and Fodders. Their Chemical composition.	Ditto ditto	Agricultural Ledger No. 10 of 1901. Government Printing, India, Calcutta. Price 3 annas.
14	Chemical composition of sugar and sugarcane juice or the raw sugar.	Ditto ditto	Agricultural Ledger No. 13 of 1895. Government Printing, India, Calcutta.
15	Chemical composition of sugarcane and raw sugar.	Ditto ditto	Agricultural Ledger No. 3 of 1897. Government Printing, India, Calcutta.
16	Ditto.	Ditto ditto	Agricultural Ledger No. 19 of 1896.

17	The groundnut crop	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India, and C. Benson, M.R.A.C., Deputy Director of Agriculture, Madras.	Madras Department of Agriculture, Bulletin No. 41 of 1900. Madras Government Printing Press. Price 9 pies.
18	The composition of Indian Cows' and Buffaloes' milk.	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India.	The Analyst, 1901.
19	Procedure to be adopted in the systematic examination of varieties of crops.	Ditto ditto	Bulletin No. 8 of 1900.
20	Some recent investigations in the Chemistry of Agriculture.	Ditto ditto	.....
21	Indian Food Grains and Fodders. Their Chemical composition.	Ditto ditto	Agricultural Ledger No. 7 of 1903. Government Printing, India, Calcutta. Price 6 annas.
22	Agricultural value of City sewage in India.	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India, and J. Mollison, Esq., M.R.A.C., Inspector General of Agriculture in India.	Agricultural Ledger No. 2 of 1903. Government Printing, India, Calcutta. Price 2 annas.
23	The determination of small quantities of Iron.	Dr. J. W. Leather, F.I.C., F.C.S., Agricultural Chemist to the Government of India.	Journal, Society Chemistry Industry, XXIV, page 385.
24	The Tea soils of Cachar and Sylhet .	Dr. H. H. Mann, M.Sc., F.I.C., F.L.S., Scientific Officer to the Indian Tea Association, Ld., Calcutta.	Indian Tea Association, Ld., Calcutta.
25	The Tea soils of Assam . . .	Ditto ditto	Ditto ditto
26	Ferment of the Tea Leaf, Parts I-III .	Ditto ditto	Ditto ditto

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		Agricultural Chemistry—concluded.	
27	Annual Report of the Agricultural Chemist to the Government of Mysore, 1903.	Dr. A. Lehmann, B.S.A., Agricultural Chemist to the Government of Mysore.	Government Central Press, Mysore, Bangalore.
		Botany.	
1	Note on Provisional Classification of Indian wheats cultivated during 1901-03 at the Poona and Manjri Farms, Bombay.	Professor G. A. Gammie, F.L.S., College of Science, Poona.	Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.
2	Note on the Classification of Indian Cottons (tentative) and cross-breeding experiments at the Poona Farm, 1901-03.	Ditto ditto	Ditto ditto
3	The Indian Cottons	Ditto ditto	Ditto ditto
4	Potato Diseases in India . . .	Dr. E. J. Butler, M.B., F.L.S., Cryptogamic Botanist to the Government of India.	Agricultural Ledger No. 4 of 1903. Government Printing, India, Calcutta. Price 4 annas.
5	The Indian Wheat Rust Problem, Part I.	Ditto ditto	Imperial Department of Agriculture, Bulletin No. 1 of 1903. Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.

6	Stump Rot on Tea and Coffee. Proceedings of Annual General Meeting of the South Mysore Planters' Association, March 1903.	Ditto	ditto	South Mysore Planters' Association, March 1903, Bangalore.
7	Report on spike disease among Sandal wood trees.	Ditto	ditto	Indian Forester, Appendix Series, April 1904.
8	A Deodar Disease in Juansar . .	Ditto	ditto	Indian Forester, Appendix Series, November 1903.
9	Pilzkrankheiten in Indien im Jahre 1903	Ditto	ditto	Zeitschrift fur Polanzenkrankheiten. Bd. XV, 1 Heft, 1905.
10	Pepper Vine Disease. Proceedings of Wynaad Planters' Association, October 1904.	Ditto	ditto	Wynaad Planters' Association, Wynaad.
11	Views on Rai Bahadur M. Muthannah's Report on spike disease in Sandal wood.	Ditto	ditto	Indian Forester, Appendix Series, October 1904.
12	Red Rust. A serious blight of the Tea Plant.	Dr. H. H. Mann, D.Sc., F.I.C., F.L.S., Scientific officer to the Indian Tea Association, and C. M. Hutchinson, Assistant Scientific officer to the Indian Tea Association.		Indian Tea Association, Calcutta, 1904.
13	Diseases of *Andropogon sorghum* in the Madras Presidency.	C. A. Barber, M.A., F.L.S., Government Botanist, Madras.		Bulletin No. 49 of 1904, Department of Agriculture, Madras. Government Press, Madras.
14	The Localization of the indigo-producing substance in the indigo-yielding plants.	H. M. Leake, M.A., F.L.S., Economic Botanist to the Government of the United Provinces.		Annals of Botany, volume XIX, 1905.

List of recent Agricultural Publications in India—continued.

Serial No.	Title.	Author.	Where published.
		Botany—concluded.	
15	The occurrence of 'Hard Seed' in *Indigofera arrecta Hochst.*	H. M. Leake, M.A., F.L.S., Economic Botanist to the Government of the United Provinces.	Journal, Royal Horticultural Society, volume XXIX, 1905.
16	Variation in *Indigofera sumatrana Gaert*, as induced by climatic conditions.	Ditto ditto	Ditto ditto
17	A Note on Plants used for food during famines and periods of scarcity.	Professor G. A. Gammie, F.L.S., College of Science, Poona.	Records of the Botanical Survey of India, volume II, No. 2, 1902.
		Entomology.	
1	Note on the Danger of introducing insect pests.	H. M. Lefroy, M.A., F.E.S., F.Z.S., Entomologist to the Government of India.	Leaflet. Office of Inspector General of Agriculture in India.
2	Instructions for destroying Hoppers .	Ditto ditto	Ditto ditto
3	The six spotted Lady Bird Beetle . .	Ditto ditto . .	Leaflet. Office of Inspector General of Agriculture in India.
4	The Red Cotton Bug	Ditto ditto . .	Ditto ditto
5	The Cotton Leaf Hopper . . .	Ditto ditto . .	Ditto ditto
6	The Dusky Cotton Bug . . .	Ditto ditto . .	Ditto ditto

7	The Success Knapsack Sprayer . .	Ditto	ditto . .	Ditto ditto
8	Insects attacking Cotton . . .	Ditto	ditto . .	Ditto ditto
9	Kerosine Emulsion	Ditto	ditto . .	Ditto ditto
10	Rosin washes as Insecticides . . .	Ditto	ditto . .	Ditto ditto
11	Lead Arseniate	Ditto	ditto . .	Ditto ditto
12	Crude Oil Emulsion	Ditto	ditto . .	Ditto ditto
13	How to rear caterpillars that attack crops	Ditto	ditto . .	Ditto ditto
14	Note on Cotton in Behar . . .	Ditto	ditto . .	Occasional Bulletin, No. 1, Pusa.
15	Insect Pests of Coffee	Ditto	ditto . .	Imperial Department of Agriculture Bulletin No. 2 of 1903. Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.
16	Classification of Insects	Ditto	ditto	Leaflet. Office of Inspector General of Agriculture in India, Nagpur, Central Provinces.
17	Simple spraying apparatus . . .	Ditto	ditto . .	Ditto ditto
18	Fumigation of seeds	Ditto	ditto . .	Ditto ditto
19	Insects injuring sugarcane . . .	Ditto	ditto	Ditto ditto
20	Notes on the work of Assistants . .	Ditto	ditto	Ditto ditto
21	Report on an enquiry into the state of Tasar Silk Industry in Bengal and the Central Provinces.	N. G. Mukerjea, M.A., M.R.A.C., & P.H.A.S., Assistant Director of Agriculture, Bengal.		The Bengal Secretariat Book Depôt. Price R2.

List of recent Agricultural Publications in India—concluded.

Serial No.	Title.	Author.	Where published.
		Entomology—concluded.	
22	The Mosquito Blight of Tea . .	Dr. H. H. Mann, D.Sc., F.I.C., F.L.S., Scientific Officer, Indian Tea Association.	Indian Tea Association, Calcutta.
23	*Acridiidiæ* A plague of Grasshoppers in the Central Provinces.	Stewart Stockman, M.R.C.V.S., Assistant Bacteriologist, Civil Veterinary Department.	Agricultural Ledger No. 3 of 1903. Government Printing, India, Calcutta. Price 3 annas.
33	*Termes taprobanes*. White ants as a pest of trees.	Department of Agriculture, Central Provinces.	Bulletin No. 6 of 1902. Department of Agriculture, Central Provinces, Nagpur, Secretariat Press, Nagpur. Price 2 annas.

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