Selected Articles.

Agricultural and Veterinary Research in the Colonies, Protectorates, and Mandated Territories.

THE following memorandum on "Agricultural and Veterinary Research in the Colonies, Protectorates, and Mandated Territories" by the Parliamentary Under-Secretary of State for the Colonies is taken from the Appendices to the Summary of Proceedings of the Colonial Office Conference, 1927 :—

In the absence of an Agricultural Adviser at the Colonial Office I have endeavoured to compile a memorandum on the work of the Agricultural and Veterinary Departments of the principal Colonial Governments represented at this Conference.

I must mention at the outset the important Report* recently published, of a Committee which has been sitting under the Chairmanship of Lord Lovat. This Committee was appointed to consider the recruitment and training of officers and to make suggestions for improving the supply of candidates and in regard to the efficiency of agricultural research and administration, and, apart from its practical recommendations, it provides an excellent review of the general situation. It also presents a considered scheme for dealing with the problems before us, and it should be most carefully studied. (Copies are being circulated separately to members of the Conference.) I am only concerned to point out in this memorandum what seem to me to be the main issues.

I am fully conscious, that any lay memorandum must leave a great deal to be desired from the scientific point of view, but my main object in drawing it up has been to provide Governors and senior administrative officers, who are, for the most part, in the same position as I am as regards technical knowledge, with such data as I have been able to collect, in order that they may have a more comprehensive view of the subject than can be obtained in any single Colony. The problems will receive more expert consideration at the forthcoming Empire-wide Agricultural Research Conference to be held in London in October next, with their own delegates.

I do not pretend that the memorandum is exhaustive, and indeed I have had to omit reference to much excellent work already in progress. I have merely attempted to give a general view.

The welfare and progress of agriculture is now-a-days the most vital concern of every Colonial Administration. The prosperity of the people, the trade, and, not least, the revenue, of each dependency is mainly dependent upon its agricultural production. Apart from mineral and timber resources, rich though they may be, agriculture may be said to be *the*

* Cmd. 2825.

main industry of our Colonial Empire. On the efficiency of agriculture depends therefore not only the food supply of the population but indeed all economic and social progress.

In England itself we have been slow in realising to what degree it is in the highest interests of the State to encourage and find money for the prosecution of agricultural research and the application of the results of that research to increased production. Until recent years such efforts, as far as Great Britain was concerned, were left largely to private enterprise and private endowment. The Development Commission was created in 1909, but it was not until after the war that its activities had any considerable scope. It now makes comparatively large grants to research institutions, to individual research workers, and to the training of such workers.

In many ways the self-governing Dominions and India were ahead of us in this matter, but even there I doubt whether there has been anything comparable to the tremendous efforts that have been made by the Department of Agriculture at Washington or by Germany.

As far as Colonial powers are concerned, the outstanding example of scientific effort in the agricultural field is seen in the work of the Dutch in the Island of Java. Buitenzorg in Java is the central station of activities which, both for scale and quality, are yet unmatched in the British tropical Empire. I am, of course, writing here of our Colonial Empire as distinct from India and the self-governing Dominions. The work, at Pusa, in Bengal, for example, is of the highest order.

The task which lies before us, namely, the development of 2,000,000 square miles (approximately forty times the size of England) and the agricultural activities of 50,000,000 people, is immense. I do not think I need stress any further the paramount importance of the development of more scientific methods of agriculture, not only to the Colonies themselves, but to the Empire as a whole.

What are we doing in the way of organising these great resources?

First and foremost must always come the question of the supply of properly trained and qualified staff. Our Colonial Agricultural Departments have been very largely expanded since the war—for example, the European staff of the Agricultural Department of Nigeria numbered 20 in 1922, and 44 in 1926, while in Uganda the figures are 17 in 1923, and 34 in 1926. This expansion, in some cases long over-due, faced the Secretary of State for the Colonies with the very greatest difficulty in obtaining expert staff with the necessary qualifications. The two principal steps taken by Lord Milner and his successors have been the initiation of the Imperial College of Tropical Agriculture in Trinidad, and the introduction of a system of agricultural scholarships, to which twenty-one Colonies were invited to contribute and sixteen do actually contribute. These scholarships provide for the post-graduate training, in this country and at the Imperial College in Trinidad, of agricultural officers, both for administrative and research posts, who have obtained a degree or agricultural diploma in one of the Universities or recognised agricultural colleges.

I have on two recent occasions addressed our agricultural scholars now undergoing a year's course at Oxford. This year's entry, which will be going on to the Imperial College in Trinidad, is of exceptionally high quality. The men struck me as being above the average not only in scientific training but in general capacity and usefulness. I am fully satisfied that their year at Oxford has been most profitably spent. Both the number and the quality of new entrants are steadily rising, but even so it would appear that the supply coming forward is not yet equal to the demand.

Happily our cadre is growing. We have at this moment serving in the following seventeen principal dependencies a European staff on the strength of the Agricultural Departments of 300, of whom 91 are research officers, the remainder being administrative. In the same seventeen dependencies we now have 100 veterinary officers, of whom 20 may be said to occupy research posts. The seventeen dependencies I refer to are:—

(a) Jamaica, Trinidad, British Guiana, Barbados;
(b) Nigeria, Gold Coast, Sierra Leone;
(c) Kenya, Uganda, Tanganyika, Nyasaland;
(d) Mauritius, Ceylon, British Malaya, Fiji;
(e) Cyprus, Palestine.

Of the 91 research officers, 26 are chemists, 26 entomologists, 19 mycologists, 18 botanists and plant breeders, 1 soil bacteriologist, and 1 microbiologist.

Our only adequately equipped training centre and our principal research institution in the Colonial Empire is the Imperial College of Tropical Agriculture in Trinidad, which was opened in October, 1922. Its professorial staff consists of a Principal with eight Professors and nine Lecturers.

The total capital expenditure, including payments to which the Governing Body is committed, stands at £147,750. Towards this amount upwards of £87,000 was received as a result of Lord Milner's Special Appeal, and contributions from the Imperial Government, the Empire Marketing Board, and the Lancashire Cotton Industry. The Rhodes Trustees contributed the sum of £5,000 towards this Fund, whilst £15,000 has been granted by the Imperial Government towards the erection and equipment of the Hostel, and the Empire Marketing Board contributed £21,000 for various purposes contingent on a similar grant of £21,000 being given by the Lancashire Cotton Industry, largely through the Empire Cotton Growing Corporation, who in this, as in all other matters, have been of great help not only to the Colonies but also in scientific investigation of many important problems. But by far the largest individual contributor to the funds of the College has been the planting community of Trinidad and Tobago, which provided through the Government of the Colony, by means of a special export tax imposed by their special request, £50,000 for building purposes.

Apart from capital expenditure the annual cost of maintaining the College is approximately £25,000 a year. Towards defraying this approximately half of the total amount is provided by a contribution of one-half of one per cent. of their revenues made by Trinidad and Tobago, Barbados, the Windward Islands, and the Leeward Islands. The following Colonies also contribute towards the cost of maintenance: British Guiana £1,000, and British Honduras £50, annually; Nigeria £1,200 annually for five years; Gold Coast £500 annually; the Anglo-Egyptian Sudan £500 annually for five years; Sierra Leone £250 annually; and Southern Rhodesia £100. Other annual contributions include £1,000, expiring in 1929, from the Rockefeller Foundation for a Chair of Tropical Sanitation and Hygiene, and £1,000 from the Carnegie Corporation for the Library, while in addition to making capital grants the Empire Cotton Growing Corporation and the British Cotton Growing Association subscribe £500 and £200 a year respectively.

The College provides a three-years' course for its diploma and a one-year course which is largely followed by the students passing on to the Agricultural Departments in various Colonies. As I have already said,

the College was opened in 1922; in 1923 four students completed the one-year course, six in 1924, thirteen in 1925, and sixteen in 1926. Diplomas at the end of three-year courses were granted to five students in 1925, and three in 1926. There are now forty-two students in residence at the College.

The College has issued a monthly journal since 1st January, 1924, entitled *Tropical Agriculture*, a valuable production the scope of which could, I think, with advantage be extended, if funds and staff permit. In addition to teaching, research work has been commenced on such subjects as the breeding of a variety of bananas immune from Panama disease, the problem of Frog-hopper blight in sugar-cane, Withertip disease in limes, and the study of colloidal soils.

The only other research station of an Imperial or Inter-Colonial character, apart from those maintained for purely local purposes, is the Amani Institute in Tanganyika Territory. This institute, as is well known, was established by the Imperial German Government and had already made considerable contributions to the science of tropical agriculture before the war. The work of this institute is now about to be restarted and has been rendered possible by the co-operation of the six Governments of Tanganyika, Kenya, Uganda, Zanzibar, Northern Rhodesia, and Nyasaland in providing between them annual contributions amounting to £8,000 a year.

In addition to this sum the Empire Marketing Board have decided to make a maintenance grant up to one-third of the total running costs of the Institute not exceeding £6,000 in any one year. The capital expenditure necessary for the rehabilitation and re-equipment of the station, which is being advanced by the Government of Tanganyika, will eventually be charged to East African Guaranteed Loan funds.

The new Director of the Institute is Mr. W. Nowell, D.I.C., appointed to this post from the Directorship of Science and Agriculture in British Guiana. He is now in East Africa; part of the necessary staff to work under him is being appointed and on receipt of his report it is proposed to proceed with the selection of the remainder. The object of this research station will be to undertake projects of long range research to supplement more particularly the research activities of the East African dependencies, and the work there should also throw an important light on cognate problems both in West Africa and in other tropical dependencies. It will form one of a chain of Imperial research stations in the tropical and sub-tropical Empire.

It is obvious that Trinidad and Amani are two of the links in any such chain. The establishment of further links will require discussion. The establishment of a new station in North Queensland is already under discussion with the Government of the Commonwealth of Australia. It would seem clear that three further links will be required, one in West Africa, one in the Middle East, and one in the Far East. I tentatively suggest that Nigeria, Palestine, and Ceylon might be considered as the most suitable *loci*. These research stations need not necessarily be entirely new institutions but could be built up on the basis of existing institutions. One advantage of such a chain is that certain problems of a long range character could be tried out at the same time in different parts of the Empire and the results compared. The Empire Marketing Board is engaged at this moment in making a preliminary survey of the field.

As will be seen from the above summary of the categories of research officers, agricultural research largely depends on the co-operative efforts of botanists, chemists, entomologists, and mycologists, and an important

part of our material machinery in connection with the two latter categories is the existence of the two Imperial Bureaux of Entomology and Mycology.

The Imperial Bureau of Entomology was founded in 1913, for the purpose of encouraging and co-ordinating entomological work throughout the Empire in relation to both human and animal diseases and to agriculture. The head office is at the Natural History Museum in South Kensington, and the Bureau is in the charge of Dr. G. A. K. Marshall, F.R.S. Contributions for the upkeep of this Bureau amount approximately to £12,500 per annum, and are obtained from different Governments of the Empire.

The Bureau publishes a quarterly journal entitled *The Bulletin of Entomological Research* and a monthly journal entitled *The Review of Applied Entomology* in two parts, (*a*) medical and veterinary, and (*b*) agricultural, summarising and reviewing all current entomological literature. Quinquennial conferences of entomologists working in different parts of the Empire are held under the auspices of the Bureau.

The Imperial Bureau of Mycology, which is conducted on similar lines to the older Bureau of Entomology, and is financed in the same way, was founded in 1920. The Bureau is situated at Kew under the charge of Dr. E. J. Butler, F.R.S., late Director of the Research Institute at Pusa in Bengal. It publishes a monthly review and also organises quinquennial conferences.

There are at present no corresponding bureaux dealing with the other two main categories into which agricultural research falls, namely, plant genetics and agricultural chemistry, and the need for such institutions was indicated by Lord Lovat's Committee. Botany is to a certain extent covered by the activities of the Royal Botanic Gardens, Kew. The Director of Kew is Botanical Adviser to the Secretary of State for the Colonies, and Kew has been responsible for the gradual preparation of scientific publications dealing with the flora of different parts of the Empire. The primary function of Kew is systematic and economic botany; and, though Kew has been able to offer advice on matters relating to plant breeding and the economic improvement of types, it is beyond its province to take an active part in researches of this character.

I might add that the Empire Marketing Board are giving assistance to Kew in order to enable some of the staff to tavel, and an Economic Botanist has now been appointed on the Director's Staff, who has held an important agricultural position in India. This should prove of value.

The work of the chemist enters in at practically every form of investigation and is in many ways the most fundamental of all. Soil science, both chemical and physical, is really the basic factor in all advance. I shall have occasion to refer to this later in the memorandum. The outstanding contributions to world knowledge in this field are made by the Rothamsted Experimental Station at Harpenden, in Herts, and are well known, and the Rothamsted publications are of vital importance to every agricultural research worker throughout the Empire.

In another sphere of activity, namely, the examination of agricultural and other products with a view to their use in industry, the Imperial Institute, which is supported by contributions from the Imperial and oversea Governments, has done a great deal of valuable work for the Colonies and other dependencies. As a result of the recommendations of the Imperial Economic Conference of 1923, the organisation and functions of the Imperial Institute have undergone considerable change, and subsequent

to its amalgamation with the Imperial Mineral Resources Bureau its investigations are carried on by a mineral resources department and a plant and animal products department. The latter is under the Chairmanship of Sir David Prain, a former Director of Kew, who is assisted by an Advisory Council. In order to facilitate its work the Council has formed a number of advisory committees to deal with special subjects. The following committees, which include scientific and technical authorities, together with representatives of the trades and industries concerned, have been constituted :—

(1) Silk
(2) Timber
(3) Vegetable fibres
(4) Oils and oilseeds
(5) Essential oils and resin
(6) Tanning materials.

The Department has an Intelligence Section which provides technical and commercial information relating to the production, utilisation, and marketing of Empire raw materials of plant and animal origin; and from time to time the Bulletin of the Imperial Institute reviews the production and marketing of Colonial agricultural products such as groundnuts, flax, palm oil, sugar, &c.

I have dealt with the existing organisations. I now turn to the important question of the arrangements for the collection and dissemination of information and experience gained in these fields.

Lord Lovat's Committee have pointed out that the existing arrangements for collecting and disseminating reports on agricultural work carried out in the non-self-governing Colonies are at present entirely inadequate and, further, that Colonial Governments do not in general possess an adequate system of preserving and indexing the information which they receive. They observe that the results of investigations are wasted if they are not made readily available to all concerned, and that cases have come to light of researches in one Colony being conducted over again in ignorance of the fact that the work had already been done.

They point out that the great exception to this criticism is in the field of entomological and mycological effort. That this is so is due entirely to the operation and guidance of the two Imperial Bureaux and their publications, and to the fact that workers in these subjects all over the Empire are kept in close touch with the work and activities of their colleagues through the machinery of the Bureaux.

I have had ample evidence in touring the Colonies to confirm the Committee's view of the present lack of an effective system of interchange of the knowledge acquired by the work of the different Agricultural Departments. The present system of distribution of Annual Agricultural Reports and Bulletins and other publications is inadequate and should be reviewed by all Colonial Governments.

Dependencies vary a great deal in the quality of the libraries which they maintain and in their accessibility to all members of the staff of the Agricultural Departments. Lord Lovat's Committee have indicated the need for the publication of information by a central authority. I am convinced that some steps should be taken to summarise and review reports of the work that is going on in all the different parts of the Empire, together with the ordinary printed publications received both from within the Empire and from places like the Dutch East Indies, French West-Africa, and the United States of America.

It is, of course, to the Annual Reports of the Agricultural and Veterinary Departments that one looks in the main for some indication of the work that is being conducted in the different Colonies and it would certainly help if these reports could be made as full as possible, and if they could

be produced with the least possible delay at the conclusion of each financial year. I will give an example of our present difficulties. The most recent report available in the Colonial Office regarding agricultural activities in Tanganyika Territory which I have been able to obtain (in March, 1927) is the Annual Report for the year ending 31st December, 1924. The very full and well-arranged report of the Kenya Department for 1925 was available at the Colonial Office more than six months ago.

It is a matter for consideration whether Colonial Governments could not arrange for these annual departmental reports to be framed for the financial year and to ensure that they are printed and published within six months from the end of the financial year in question if this is not already done. Copies of these reports should be sent direct by the Directors of Agriculture concerned in their production to each and every other Director of Agriculture throughout the Colonial Empire as well as to central institutions like the College in Trinidad and the Amani Institute. It would be a help to all libraries if the form *i.e.*, quarto, octavo, &c., of these reports could be assimilated.

In addition to the Annual Reports there are varying practices regarding the publication of activities and results. To mention only a few; excellent bulletins are published for example in Ceylon, Mauritius, Nigeria, and Bermuda. Most of these special bulletins are of a highly technical character and are compiled more for the specialist than the layman. I think it is important that the reports of work contained in them should be summarised in the ordinary Annual Reports of departments. The Department of Agriculture in Ceylon issues a useful "Year Book," the Federated Malay States publish a Malayan Agricultural Journal, but the Director of Agriculture notes that the number of subscribers is "very low." Two years ago the Department of Agriculture in Trinidad published an extremely valuable monograph entitled *Gardening in the Tropics* with special reference to the needs of schools. There was a wide demand for this publication not only within but outside the Colony and the edition was soon sold out. I am not yet aware whether it has been reprinted or whether use has been made of it by the Education as well as the Agricultural Departments of other tropical dependencies. I observe that in 1925 the Gold Coast Department issued pamphlet No. 5, being notes on the cultivation of European vegetables in the tropics. The total number printed was 750. Here again how far this publication is known outside the Gold Coast I have been unable to ascertain.

I think I am right in saying that in only one field of tropical and sub tropical agriculture, namely, cotton growing, is there an annual publication collecting reports received from the experiment stations maintained or assisted by the Empire Cotton Growing Corporation throughout the Empire. Such a comprehensive review forms a most valuable comparative study of all the most recent work and data available.

I think I have said enough to show that while there is already much material of value there is a need for—I cannot avoid the word—co-ordination. Here again Lord Lovat's Committee have made important recommendations.

Next in importance to the adequate production and interchange of published information is the periodical opportunity given by Colonial Governments to officers in their Agricultural Departments to visit other territories. This can be effected in two ways. First by the holding of periodical conferences in groups of Colonies. These are of exceptional value not only in themselves but also by reason of the facilities they provide for workers in similar fields to meet and discuss common problems informally, and to see how those problems are being tackled under varying conditions.

Such conferences have already taken place in the West Indies; there was also a South and East Africa Cotton conference at Nairobi last year; and a West-African agricultural conference at Ibadan in Nigeria in the spring of this year.

In addition to these conferences valuable knowledge may be obtained by the visits of suitable officers to other countries with similar problems. The Governments of Nigeria and the Gold Coast have in my opinion been very wise in sending members of their staffs to pay a combined visit to Java, Sumatra, and Malaya. This visit was made primarily in connection with the investigation of the development of oil-palm plantations in the Far East. But quite apart from its value for this purpose it must have given the officers concerned an opportunity of effecting a personal liaison with workers in tropical agriculture in another area and enabled them to see what was being done in that area over the whole field of agricultural endeavour. I hope it may be possible for other Colonial Governments to arrange for their officers to make similar tours.

I now venture to touch on some of the specific problems of tropical agriculture which are engaging the attention of the Dependencies at the present time. My object in doing so is to bring out the point that although widely scattered in area so many of the problems are common to several Colonies. One has only to consider for a moment the fact that individual tropical products have been so frequently transferred from one part of the tropics to another. Cacao—indigenous in South America—is being produced in Trinidad, Grenada, Jamaica, Gold Coast, Nigeria, and Ceylon. Para rubber was introduced by Sir H. Wickham from the forests of the Amazon via Kew to Malaya and Ceylon, which are now the principal world producers of such rubber. Sisal is a Mexican aloe. Groundnuts are among the principal crops of India, Tanganyika, Nigeria, and the Gambia. The oil-palm of West Africa is just now being developed in the Dutch East Indies and Malaya. The coconut palm of the South Pacific has become almost universal along the coasts of the tropics. One can multiply examples.

Tropical agriculture may be broadly divided into two main divisions: (*a*) the growth of permanent crops, or semi-permanent, such as tea, coffee, cacao, cinchona, the palms, rubber, sisal and fruits such as grape fruit, bananas, oranges, &c., and (*b*) annual or short rotation crops, such as cotton, maize, rice, simsim, cassava, yams, sorghum, millets, groundnuts, peas, beans, and fodder crops, sugar, &c.

In regard to the former—the plantation or semi-plantation crops—there are certain common problems. The same type of plant of this nature is usually subject to very much the same dangers from insect and fungoid pests the world over. The climatic, including altitude, conditions favourable to the successful production of these crops are strictly comparable. The soil conditions and the response to manuring for the purpose of making up soil deficiencies are equally comparable. I note such statements as the following taken from a Trinidad report on their cacao research: "Recording the annual pod yield of individual trees has shown that there are individual trees which are naturally heavy, medium, or poor bearers. These characteristics are not fundamentally affected by manurial treatment or alteration in conditions—but destruction of shade will make good bearers temporarily, at any rate, bad bearers."

From this one deduces that, given the necessary climatic conditions as to rainfall, &c., and in the absence of any special soil types or drainage difficulties, the selection of the plant—*i.e.*, a high-yielding strain—is much

more important than soil conditions. Just as we now breed cattle from high milk-yielding strains, so in cacao the thing to try to establish is a plantation of good bearers, and keep on cutting out the bad bearers. The oil-palm problem is clearly very similar. There are extreme variations between varieties of oil-palm and between individual palms of the same variety, not only in the annual yield of bunches but also with regard to the oil content of the pericarp and of the kernels. Similar problems arise with para rubber, camphor, and indeed almost every economic crop of importance. Scientific selection is therefore the problem of first importance.

Or again in the case of cacao. We know now that in the Eastern Province of the Gold Coast, where the industry has been established longest, there is a definite sign of a falling-off in yield. Apart from more obvious causes such as close planting, is this due to change in the soil or change in the plant due to senility or to weakness from accumulation of disease? If the former, of what plant food is the soil becoming exhausted; if the latter, at what stage should cutting out and replanting take place?

The Dutch investigations into the oil-palm would tend to show that the oil-palm reaches its full yield under cultivation conditions at eleven years, and continues at this full yield till 30 years, after which there is a rapid decline. Similarly I gather that experiments of manuring the oil-palm show that, from the point of view of its food, phosphorus or potash are not factors of any account, but that nitrogen is.

Research in the Federated Malay States shows the very wide variation in the yield of coconut palms on similar land, and a special coconut selection experiment station has been established at Klang. The selection of coconuts, as of other palms, is clearly of wide importance, as is shown by the considerable variation in yield observable in trees in really well-managed plantations.

The more I read about permanent crops the more it would appear that the most important factor is selection—the geneticist and plant breeder's job. I have heard of a case, however, of interest on the chemical side, and that in connection with tea. I was shown at Rothamsted the other day a detailed map of a private tea estate in Ceylon on which the yield of the same variety varied very considerably. Samples of soil from different parts of the estate were sent, and it was found that the low yields ran parallel with the phosphoric content of the soil, and the exact quantities of superphosphate necessary to level up the poorest land to the best on the estate were ascertained with complete success. This is yet another side of a many-sided problem.

Camphor is another instance of a plantation crop of growing commercial importance, that stands in urgent need of scientific investigation. Our knowledge of it at present is most limited.

There is, however, one almost universal factor in the proper cultivation of most of these permanent crops—especially tea, rubber and oil-palms—and that is soil erosion. Soil erosion in the tropics—the effect of very heavy rains and burning sun—is a universal and fundamental problem. I may instance the difficulties which have been experienced in Jamaica, or again in the Gold Coast in this regard. The best method of tackling it is the growth of a cover crop that will grow under and between the trees and will preserve the humus and tilth of the soil and at the same time act as an effective green manure. A lot of experimental work has been undertaken on this, chiefly in Ceylon, as far as the Empire is concerned, and again by the Dutch in the East Indies. Both

for rubber and oil-palm the most successful green dressings of this type that have been established are (1) Dolichos Hosei (*Vigna Oligosperma*) and (2) *Calopogonium mucunoides*. The first of these is coming into use in Ceylon also—but there the most widely introduced green manure cover crop is *Gliricidia maculata*, and on tea estates *Indigofera endecaphylla*.

There is yet another side to the problem of permanent crops. What crops are suitable for introduction into new territory being opened up or in substitution for crops which are no longer economical.

The introduction of a new crop always presents difficulties. I may quote the case of coffee. When in Sierra Leone last spring, the local Chamber of Commerce urged upon me the establishment of coffee growing in that country on a large scale. As I read the reports of the East African Dependencies there seems to be general agreement there that Arabica coffee cannot in Equatorial Africa be grown successfully below 4,500 feet altitude, and that the range of Robusta coffee is between 3,000 and 4,500. Personally I doubt whether even Liberica or Stenophylla coffee will thrive in the climatic conditions of Sierra Leone. But, apart altogether from the limited range within which coffee can be successfully grown, coffee is one of those delicate and continually threatened crops which will always require the closest supervision by scientists, whether official or planters, and it is perhaps not surprising that coffee can and has become "controversial." The Director of Agriculture in Tanganyika has recently laid down the proposition—one coffee one area. This would seem to be the only safe guide, whether from a production or marketing point of view.

I may, in passing, refer to the great losses caused by plant diseases. There are four main methods of dealing with such losses which are at present under investigation. First, natural control by parasites is being examined and there have been successful experiments in Hawaii in this method. Secondly, it is possible to secure direct control by spraying, baits, or steeping the seeds in certain solutions, or by other poison treatment. There is the physiological method of altering the method of cultivation to enable the plant to resist the attack or to grow rapidly through the susceptible stage. Fourthly, there is the possibility of breeding new varieties of plants immune from the disease.

An important field of research in connection with permanent crops is the breeding of varieties immune to special diseases. One example of this kind of problem is the production of a variety of banana resistant to Panama disease. Special work on this is in progress at the Imperial College in Trinidad and is yielding interesting results. Such research should prove of great importance not only to the West Indies but to West Africa as well. Its economic value is obvious.

I have in the few preceding paragraphs only skimmed the surface of the many problems affecting permanent crops.

Turning to annual crops it would seem that what is chiefly required is a greater effort at the fundamental study of soil science in the tropics. Cereal crops, especially maize and wheat, are absolutely dependent on adequate supplies of nitrogen, potash, phosphorus, and in some cases lime, for continuous cropping. Even the so-called virgin soils may rapidly become deficient in essential plant foods. The native agriculturist usually gets over this difficulty by what is known as shifting cultivation, but scientific agriculture knows two better methods of tackling the problem, viz., rotation of crops and manuring. Both of these sooner or later involve mixed farming *i.e.*, the use of domestic stock in agriculture.

Mixed farming is in its infancy in the tropics, but that it is bound to develop I make no doubt. The cultivator must keep stock if only for the manure. The Hausas in Northern Nigeria, who are good and prosperous farmers, compete with one another to get the nomad Fulani with their cattle to come on to their land in the dry season simply on account of the manure so obtained. In the long run mixed farming means fodder crops, and in the tropics too little attention has been given to the establishment of fodder crops for the double purposes of rotation with cereals and food for cattle and sheep. It follows from this that the agricultural and veterinary departments throughout the Colonies must work in the closest possible intimacy.

Our ignorance about the soils of the tropical Empire is profound. The only book on the soils of Tropical Africa is the work of an American. I think it is fair to say that this is an indication that we are behindhand in the acquisition of scientific knowledge of our resources. Sooner or later we must embark on a systematic soil survey of the tropical dependencies on a comparable basis, when comparison is possible. Only thus can we get any guides as how best to make up the deficiencies in plant food that all our new developments are fast creating. A little is being done. Sierra Leone is doing more than most dependencies, and in 1925 six hundred and thirty-nine samples from different parts of the Protectorate were collected and are being systematically analysed and classified. The Ceylon report for 1925 refers to forty-eight soil samples analysed, the Gold Coast to sixteen. The report of the Agricultural Chemist in Kenya for the same year laments that "no routine analysis of soils has been possible." The most serious deficiency from the agricultural point of view in the majority of them is the lack of lime. The importance of lime for neutralizing excessive acidity in soils and maintaining plant life has long been recognised.

In some respects the deterioration of soil seems to take place more rapidly in the tropics than in temperate climates. Nitrogen seems to be lost more easily, but I think it is clear that the study of soils in the tropics with a view to increasing the often low yields per acre of many crops is by no means a straight-forward chemical problem. Soils, especially fertile soils, are fertile not merely because they are so chemically and physically constituted that they contain the food requirements of economic plants but because they are inhabited by teeming millions of micro-organisms-bacteria, amoebae, algae, etc., and the bio-chemistry of soils is now seen to be probably the basic factor in food production.

Why do soils tend to become lateritized nearly everywhere in the tropics and not in temperate climates? I have been told that there is laterite under our feet in London formed at the time when the vegetation and climate of London was similar to that of Lagos! The answer may perhaps be in the field of micro-biology. It has been held, perhaps wrongly, that living organisms that flourish in appropriate types of soil in tropical climates make laterite, and so alter the whole physical character of the soil. I am not defending this view; I am only anxious to point out the wide field for investigation.

One very important problem in soil science of Imperial significance is the salting of soils as a result of irrigation. This has been observed in India, Iraq, Australia, and elsewhere. The old designers of irrigation systems both in Egypt and in India knew the necessity of combining drainage with irrigation in order to obviate salting, but the knowledge had to be rediscovered in America, in Australia, and elsewhere at the cost of the destruction and salting of much good land. The effects of perennial

irrigation are manifold, and their study is in its infancy. Again, the study of dry farming demands serious attention.

Another important and similar problem is that of the mineral deficiencies of natural pastures. The great pioneer work on this subject was done by Sir Arnold Theiler and Dr. Green in South Africa. Their investigations into the effect of phosphate deficiency on the mortality and health of domestic stock is world famous. That "mineral deficiency" is not merely an African problem is now fully recognised. Sheep were found to be dying in the Falkland Islands although there was plenty of grass. Similar phenomena were noted from the Western Hebrides of Scotland. The Rowett Institute at Aberdeen has now taken up the main work on this problem. Animals, as well as human beings, require salt, and not only common salt, but sometimes almost infinitesimal traces of other elements, for resistance to disease and physical efficiency.

Thanks to the Empire Marketing Board, an Empire-wide investigation has now been organised on this particular question and work is proceeding on parallel lines in Scotland, Palestine, Kenya, South Africa, South Australia, and New Zealand. What has to be established is: What are the soil deficiencies, what is the conveying capacity of the different pasture grasses and fodder crops under different conditions, and how can the deficiencies be most cheaply and effectively made up? The answers to these questions will have a tremendous influence on the future of meat and milk production throughout the world. Dr. Orr of the Rowett Institute, Aberdeen, visited Kenya last year to initiate this research there, and out of that visit—primarily in connection with the animal industry of the Colony—has arisen the cognate study of mineral deficiencies in native foods—an important field of medical research arising out of a problem in soil science and veterinary research.

In connection with this research it became possible last year to arrange for Dr. P. J. du Toil, the new Director of the Government of the Union of South Africa's Veterinary Research Station at Onderstepoort, to pay a short visit to Nigeria. Dr. du Toil's report not only on the mineral deficiency problem but on veterinary policy generally in Nigeria is of great interest and value. I think, therefore, that the need for an Imperial bureau of soil science, to which I have already alluded, is urgent, and that its desirability will be seen even more clearly in the near future.

I have already referred to plant genetics in connection with the permanent crops. Plant genetics are almost equally important to the annual crops. In wheat, for example, we owe much to the work of Farrer of Australia, of Saunders in Canada, and the Howards in India, while at the present time the work of Sir R. Biffen and Dr. Engledow at Cambridge on that crop is an indication of the lines on which we may have to proceed in many other food crops. A lot of work of this kind has been going on in the Colonies—chiefly in connection with cotton. Sir R. Biffen, for example, has recently visited Kenya and valuable work has been initiated there. The attempt now being tried out to improve the staple and quality of selected strains of native cotton in Nigeria for growth in areas where American types do not succeed is an excellent example. If Mr. Faulkner and his staff really succeed with their "Improved Ishan" cotton, it will mean literally millions of pounds a year to Nigeria. Our chief difficulty in this field is men. There is only a very small pool of adequately trained plant geneticists in the Empire. The whole science represents practically the newest aspect of economic botany, and one of the chief arguments for the proposed bureau is to secure the enlargement of this pool.

For the proper collection of data and the due examination of these problems, it is essential that research in each Colony should be properly organised. The success of an agricultural research station depends on the effective co-operation of chemists, entomologists, mycologists, and botanists, each contributing a share to what is very often a single problem with four different aspects. I think that wherever it is possible to arrange it the principal research station in each Colony where the specialist research staff is posted, should be under the personal direction of the Director of Agriculture. Where the Director has to live in the capital city and the central laboratories are some distance off it will probably be found convenient for the second man in the Department to live at the research station and become responsible for the direction of the necessary co-operative work.

It is further a good thing if the research laboratories, library, &c., are situated at the principal experimental station where not only are the most important field trials conducted but also the training of subordinate native personnel for future service in the departments is carried on. The research staff should assist in the work of such training, but they should not be asked to become wholly responsible for it. Their job is first and foremost research and investigation rather than teaching. The latter should be in the charge of a whole-time officer or officers in close personal touch with both research and administrative officers of the department.

I may mention in passing a scheme which has recently been set on foot in Mauritius for the establishment of a farm school where boys from the higher classes of the primary schools are to receive a theoretical and practical training in farming and elementary agriculture. They would pass on from this to become cadets in agricultural and forestry departments and possibly in private employment.

Colonies vary very much in the degree to which they have advanced in the training of native agricultural assistants. Ceylon has done more than any other dependency in this direction, primarily no doubt because the central station at Peradeniya has been longer equipped and established than similar centres in other Colonies. I understand there are thirty-five students taking a two-year course there—while a similar school has been recently established at Jaffna in the Tamil area. There are few more important aspects of the duty of all Agricultural Departments than this training of native personnel.

The Department of Agriculture in Ceylon has also done outstanding work in the development of school gardens attached to the ordinary schools throughout the country; and in forming local co-operative societies among native farmers. According to the last report there are no less than 33,630 members of producers' co-operative societies in Ceylon. This figure is of course over and above members of associations of European planters.

Another interesting example of the development of the co-operative movement is the cacao fermenting scheme organised by the Nigerian Department of Agriculture among the native cacao growers in south-western Nigeria. Not only has the working of this scheme resulted in good premiums over ordinary prices being obtained by growers but the educational value of the scheme has resulted in improving the quality of native production and of preparation for market. The success of what is called "native production," which it is generally agreed is all important from the point of view of the social and economic advance of native races, depends in the long run on the efforts of the Agricultural Departments in improving and maintaining the standards of quality in any particular line of produce. This applies to crops like groundnuts, maize, and rice, quite

as much as to cacao, coffee, palm oil. The preparation of such crops for market and transport requires almost as much research as the growing of the crops. Such economic research is actively engaging the attention of the Agricultural Departments of the self-governing Dominions, and the Empire Marketing Board in the case of the products of European-run farms. It is a subject of no less importance to native crops. There are many peculiar and unexplained problems under this head, not the least being the wide disparity in value for market purposes between the similar products of different Colonies. The difference in the value of Sierra Leone and West Indian gingers, Ceylon and West African cacaos, are examples which occur to me.

While the development and improvement of economic crops for sale is rightly regarded as important, we cannot afford to neglect the improvement of local food crops. The costs of production of economic crops are inevitably increased if there is not an adequate supply of cheap locally-grown food, and it is the duty of Agricultural Departments to keep a watchful eye on the maintenance of food supplies for internal markets.

Turning to veterinary research, I should like to re-emphasise the growing interdependence of veterinary and agricultural work. This is daily becoming more apparent, as is the importance of veterinary to medical science. The latter can in all probability only make advances in proportion as veterinary science advances. The whole problem of virus-borne disease—whether of man, domestic animals or plants—turns very largely on the work that the veterinary officers can do for us. Virus-borne diseases like influenza, encephalitis-lethargica in man; foot-and-mouth disease and distemper in animals; mosaic disease in maize, sugar-cane and potatos, and rosette disease in groundnuts, have this in common. They are spread by ultra-microscopical filter-passing viruses. The study of such organisms—if needed they are invariably living organisms at all—is baffling compared to the study of things which you can isolate and see under a microscope. The research required is more like the games the physicists play with the structure of the atom. The whole science of immunology in connection with these virus diseases may be said to be still in its infancy. We are still waiting for someone to achieve in this field what was achieved by Pasteur in the field of bacteriology.

But our somewhat meagre veterinary research staff in the tropical dependencies has a gigantic field quite apart from such a problem in fundamental science.

In Africa, especially, we have rinderpest and the tsetse fly, the tick-borne fevers, helminthic (worm) diseases, and a whole range of problems at which we are only at the commencement of the work. In some veterinary fields we are still in the stage at which medical science was before Sir Patrick Manson and Sir Ronald Ross, *i.e.*, when the curative treatment of the stricken is regarded as more urgent than the development of preventive measures and the increase of physical efficiency in health. Epidemic outbreaks of rinderpest in East and West Africa have absorbed and directed the energies of veterinarians and left them little time to launch out on to the wider problems of animal husbandry and animal genetics. The discovery and application of double inoculation for rinderpest would seem to encourage us to believe that we are now masters of the situation as far as this plague is concerned; and soon we may begin the attack on trypanosomiasis on a more effective scale. We know that the larger antelope are apparently immune though infected; that some cattle and goats—also apparently immune—survive in Southern Nigeria; that tartar emetic and injections of antimony potassium tartarate compounds, so effective in the treatment of yaws in man, are effective in treating cattle infected with some

kinds of trypanosome, but not others. We have scraps of knowledge awaiting investigation by men who will work at the research aspects of the problem which in the judgment of many is a veterinary problem of first-class importance throughout Africa from the Gambia to Zululand.

Kenya has at the moment by far the largest veterinary staff of any dependency. In fact, approximately one-quarter of our whole veterinary cadre in the Colonial Empire is in Kenya; and the East African Governors' Conference suggested that veterinary research in Tropical Africa might as far as possible be centralised at their very well equipped veterinary laboratories at Kabete near Nairobi. Over a great part of the field this is probably the best and most economical arrangement, but trypanosomiasis research will have to be done very largely in Nigeria, and possibly also in Tanganyika where there seems to be an undue variety of both flies and trypanosomes. The research will involve the study of game animals as well as domestic stock of all kinds, sheep and goats as well as cattle. In Northern Rhodesia we are confronted not only with pleuro-pneumonia and trypanosomiasis, but with a new and hitherto unknown cattle disease called "veldt poisoning." We have at present neither the staff nor the equipment for studying this new danger to Africa.

We are, I think, singularly badly off in regard to veterinary publications, though I must call attention to the valuable periodical published by the Bureau of Hygiene and Tropical Diseases, entitled the *Tropical Veterinary Bulletin*. I hope it may be possible to extend Dr. Leiper's work at the London School in agricultural and animal parasitology.

Veterinary research generally on sheep and goats is of great importance in tropical countries—especially to Northern Nigeria, the Gold Coast, East Africa, Palestine, and Cyprus as well. If we are to have these animals at all we may as well have good ones. Most of those we have are—with the exception of a few European-owned flocks in the Kenya highlands—poor and apt to be regarded as unmitigated nuisances. No doubt this is the reason why they have been somewhat neglected from a scientific and economic point of view.

It is not only in the Colonies that veterinary science is rather backward in the Empire. Some hard things are said about us in England in this respect. It is a fact that all too little has been done until quite recently. We now have several research institutions in this country which are engaged in breaking new ground in this important field. To name a few—there is the Institute of Animal Pathology at Cambridge, under Professor J. B. Buxton, the Animal Breeding Research Department, under Dr. F. A. Crew, at Edinburgh University, the Rowett Research Institute, under Dr. Orr, at Aberdeen, the Institute of Research in Dairying at Reading, under Dr. Stenhouse Williams, and the Ministry of Agriculture's Veterinary Research Laboratory at Weybridge.

Germany, Switzerland, America, the Union of South Africa, and Australia seem now more fully alive to the special significance of veterinary science, both for its own sake and in relation to cultivation on the one hand and human medicine on the other. It is probably premature to think of forming an Imperial bureau of veterinary research—though I understand the question may be mooted at the forthcoming Imperial Agricultural Conference. In any case, all I have said about the interchange of knowledge, visits of officers from one Colony to others, in connection with agricultural staff applies equally to veterinarians. As in agriculture so in animal husbandry we have in the tropics our own peculiar field. Experience and research in the temperate zones may help and guide us, but most of the

problems we shall have to work out for ourselves under tropical conditions. Africa provides the greatest field for further veterinary investigation, and I hope it may be possible to undertake at Kabete and elsewhere not only research into the urgent problems that face veterinary treatment and administration, but also those projects of long range research into veterinary science in its widest aspects. We want to attract into the Colonial veterinary services some of the best scientific brains that the Empire can produce. Advances in medical science can often only be made if the scientific veterinarian leads the way.

The conquest of the tropics—the most bountiful areas of all the earth's surface—can only be achieved with the assistance of science. In the tropics nature has been so bountiful in her gifts, both good and evil, that man—and especially the white man—has not yet harnessed one tithe to his use. Britain has, next to France, the largest area of tropical possessions, and if we take the Colonial Empire alone and leave out India we have a tropical population larger than that of the French Colonial Empire, and equal to that of the Dutch. In the exercise of our trust there is no more important field of endeavour than the application of modern science to agriculture. I can only conclude by reiterating what I have written at the beginning of the paper—the first need is the supply of trained and qualified staff. I am convinced that there is no investment more certain of an economic return than in securing a steadily increasing supply of really first-class workers in the fields of both agricultural and veterinary science, and it is to the direct interest of each and every Colonial Government to co-operate fully and generously to this end.

Colonial Office, W. O. G.

April, 1927.