Agriculture and the Empire.¹

By Sir ROBERT B. GREIG.

A PAN-AFRICAN Congress of Agriculture is meeting side by side with the Agriculture Section of the British Association, which is an Imperial body for the advancement of science. The Imperial aspect of agriculture is surely therefore a subject for consideration and discussion. Because the Empire includes so many diverse peoples differing in physical and mental attributes, and because it yields such a variety of natural products, it offers problems political, social, and industrial, of peculiar interest and complexity. Moreover, its political structure is of peculiar advantage. The free nations of the Commonwealth, along with the great non-self-governing territories, can meet without difficulty or embarrassment for the discussion of common problems. They have a focal point or centre in England from which concerted action may, if desired, be taken.

Citizenship of the Empire involves responsibilities. The governments are trustees for rich territories and for hundreds of millions of native populations. These native populations can rise in the scale of civilisation only according as they may be influenced by education, sanitation, law and order. In our colonial Empire in the past we have concentrated chiefly upon administration and we have reason to be proud of the results. But the native populations will judge us in the future not by the excellence of our administration but by the means we take to help them to a higher standard of living and to secure for them some of the benefits of civilisation.

The progress of civilisation depends upon science, not science stated crudely as chemistry or botany, but the scientific spirit applied to all aspects of life. If science is applied to the economics of the Empire, the greatest economic asset to which it can be applied is agriculture. The true wealth of the world, the wealth which determines the standard of living of nations, is limited by the capacity to produce cereals, milk, meat, wool, cotton, hides, and other prime necessities of life of soil origin. Agriculture is also the one great permanent industry, the one which is the foundation of all national or indeed of world wealth.

THE EXTENT OF EMPIRE AGRICULTURE.

The British Dominions, India, and the Colonies cover 24 per cent, or nearly one-quarter of the globe, and they contain 24 per cent, or nearly one-quarter of the world's population. Of this immense area no precise measure of the full extent of land in agricultural use is available, but the proportion is small. The most intensively cultivated of the larger areas is India, the least intensively cultivated is Australia. In the aggregate only 8.7 per cent of the total land surface of Canada, India, the Union of South Africa, Australia, and New Zealand is under arable cultivation. It is difficult to obtain figures indicative of

the possibilities of the tropical and subtropical territories, but the African possessions alone are capable of enormously increased production.

In the nine provinces of Canada the 'possible farmland' is 358 million acres, or about one-quarter of the total land area of the provinces, and five and a half times the present total of both arable and pasture. In India, the most intensively cultivated, it is estimated that the cultivable waste land is equal to half the present cultivated area, or about 153 million acres.

Some evidence of the importance of the grasslands of the Empire is obtainable from the numbers of the world's live stock. Of every hundred head of cattle in the world, forty-four graze on Empire pastures, and of every hundred sheep, thirty-eight are in the Empire.

It is easy to realise the importance of agriculture in Canada or Australia, but in an industrial and mineral country such as Great Britain and in a great mineral-producing country such as South Africa, the place of agriculture is apt to be overlooked. In the three larger Dominions and even in Great Britain, agricultural production is more valuable than mineral production. It may be astonishing to some to learn that Great Britain, including Northern Ireland, produces more agricultural wealth than Australia and four times as much as South Africa. When the value of minerals is combined with the value of manufactures, even then the agriculture of Canada and Australia is more important than minerals and manufactures combined.

The distribution of the population dependent upon agriculture is best shown by such countries as South Africa, India, and Nigeria. In South Africa, in spite of its small agricultural and great mineral production, 37 per cent of the population are engaged in agriculture and only 5 per cent in mining. In India 72 per cent are dependent upon agriculture, and in Nigeria (which is three times the size of Great Britain and one-third of the size of British India) practically the whole population depends on agriculture.

It is obvious that a vast area of the Empire is capable of further production, even if developed only on the present lines with the application of existing knowledge. But if we apply not only the science now at our disposal but also the results of further investigations which are sure to follow, the potentialities become almost incredible.

RELATION OF SCIENCE TO AGRICULTURE.

Agriculture can be regarded as the application of all the sciences to the exploitation of the soil. There is scarcely a branch of pure science which may not contribute some knowledge which agriculture can apply. But agriculture differs from other industries in which a new discovery may be followed by a sudden transformation in methods. Agriculture is old, slow-moving, and conservative. The life cycle

¹ From the presidential address to Section M (Agriculture) of the British Association, delivered at Pretoria on Aug. 1.

of animals runs into years, and even in cropping a rotation of years must often be followed to get the full effects of any change of method. Hence the results of research are absorbed slowly and almost imperceptibly into farming practice. Nevertheless, there have been numerous instances when the advance has been so rapid that the farmers applying the knowledge have been within sight of the source of the knowledge.

The case of 'Marquis Wheat' is well known. This wheat, bred by the Canadian Experimental Station at Ottawa, has by its earlier maturity and superior cropping powers not only ousted the older and inferior varieties of wheat in millions of acres of Canada and the northern United States, but it has also made the cultivation of wheat possible in areas where wheat could not be grown before. A variety of sugar cane has recently been produced in Java by the Dutch plant breeders there; one of its ancestors was not a sugar cane at all, but a wild reed growing in a marsh. Yet this variety, partly of reed ancestry, is greatly superior to any other, giving 15-20 per cent more sugar and resisting local diseases better than any other.

The grasslands of the Empire support at least 500,000,000 animals. If all these animals were suited to their environment, free from disease and sterility, and sufficiently nourished, their value would be far more than doubled or trebled. In discovering the cause of and the means of combating certain insect-borne diseases, Sir Arnold Theiler and his associates have saved the Union of South Africa millions of pounds. Equally spectacular is the biological control of noxious weeds, such as the prickly pear in Australia and the blackberry in New Zealand.

In the field of animal nutrition, it has been discovered that diseases may be caused in farm stock by the absence of minute quantities of iodine, lime, phosphorus, or vitamins. The cure of rickets in pigs, and styfsiekte and lambsiekte in cattle, by the administration of bone meal and salt and other mineral mixtures has already saved hundreds of thousands of pounds to stock farmers. The application of the newer conception of the balanced ration which we now have as the result of the studies of physiologists and biochemists, is yielding its return in increased production.

The intensive management of grassland in such great grazing countries as Australia, New Zealand, and Great Britain is only beginning, but already it is plain that production can be doubled under skilful management.

These great achievements give us the assurance that the application of pure science to agriculture will yield results of a value many times greater than the money expended.

It is clear that there are large economic problems affecting all parts of the Empire which await solution if the Empire is to be properly developed. There is, for example, sterility and abortion in live stock. There is the pasture problem. There are insect-borne diseases. It is almost hopeless for a single individual or even a single institution to attempt the solution of any of these great problems.

Each problem has so many aspects that team work is needed in the widest sense—not only between individuals, but also between institutions and between governments.

The most recent development of the work on pastures has been in connexion with their chemical composition. It has been shown that chemical composition, if it takes account of all known food constituents, is an indication of the feeding value of pastures, and it has been proved independently in various parts of the world that deficiencies of one or other nutrients required only in small amounts, are the cause of definite diseases. Further, it has been shown that if these deficiencies are made good, not only are the diseases prevented, but also production is increased and there is reason to believe that susceptibility to disease generally is decreased, and what is also of great economic importance, animals breed true instead of undergoing the well-known deterioration which takes place in improved breeds when put upon poor pastures.

The better exploitation of the pastures of the Empire is a problem which requires, for a complete investigation, the pathologist and bacteriologist to deal with the diseases which occur in deficient areas; the physiologist and biochemist to deal with the composition of the pasture and to determine to what extent it meets the requirements of the grazing animal. There is needed also the work of the plant breeder and the soil chemist for the improvement of the pasture as a crop.

To bring about a concerted and co-operative attack upon such problems as these a certain procedure seems desirable, and facilities for co-operation are now immeasurably greater than they were even thirty years ago.

EMPIRE RESEARCH.

Provided, then, that we have a large enough conception of Empire development by research the procedure should be:

- (a) to outline the problem;
- (b) to collect all available information concerning it;
- (c) to make a plan of campaign;
- (d) to find the money to finance the research;
- (e) to find the men to do the work.

To carry out this procedure, it so happens that we are in a more favourable position than ever before in the history of the Empire. The urgent problems that arose during the War demanded a solution on immediately practical lines, and tremendous advances were made in some of the applied physical sciences. Following on this war experience, a similar spirit of co-operation has been developed in agricultural science.

In 1925 the British Government set up an Imperial Economic Committee, with an annual grant of £1,000,000 for the purpose of encouraging trade in Empire products in the British Isles. The Imperial Economic Committee recommended that the annual grant should be used, first, to create in the British Isles a voluntary preference for Empire goods, and, second, upon research to improve the

quality and supply of Empire goods for sale in Great Britain. The British Government, after consultation with the Dominion Governments, accepted the report and created the Empire Marketing Board, which is the executive body for the administration of the funds. The Empire Marketing Board early turned its attention to the encouragement of research as the second of its functions. Almost simultaneously with the creation of the Empire Marketing Board was set up the Committee of Civil Research.

It was borne in upon those who had inquired into research in the non-self-governing Colonies that much good work was lost in pigeon holes, that scientific workers were sometimes engaged on the same problems unknown to each other, that overlapping occurred, and that facilities for the exchange of information were inadequate. Accordingly, when the Imperial Agricultural Research Conference was held in London in 1927, it strongly recommended the creation of clearing stations or information bureaux for the collection and distribution of information concerning certain sections of agricultural research, and several of these bureaux are now in operation. They are all, by the unanimous decision of Empire delegates, situated in Britain. They deal with soils, animal nutrition, animal genetics, animal hygiene, plant breeding, animal parasitology, and fruit production. They are not research institutions, but in each case they are attached to research institutions, and their first directors are the directors of the research stations.

Each bureau will focus the information on the subject—will act as a gathering ground for theories and theorists, as an illuminant and expositor, and eventually we may hope, as a finger-post to new and profitable roads and by-paths of research. These bureaux, to which all governments of the Empire have agreed to contribute, embody the first organisation which is Imperially owned and Imperially governed, and which has been set up to serve the Empire. Each Dominion or Colony has its own problems peculiar to its conditions, but the fundamentals of science are everywhere the same.

We have, then, machinery to deal with three of the five necessities for Empire research. We have the bureaux to collect information. We have the Committee of Civil Research to consider the information and plan a campaign, and we have the Empire Marketing Board to provide the funds. As to the men, the great Dominions can and will provide and train their own men. The success of South Africa in the production of research workers whose reputation is world wide is sufficient evidence of what the Dominions can do. The case is different in the Colonies. As a rule, the research workers in the Colonies must be recruited from home or dominion sources and partly trained outside of the Colonies which they serve.

There is one aspect of the man power that must not be lost sight of in considering Empire research, and that is the desirability of exchange of workers. Nothing can be more profitable and stimulating in suitable circumstances than change of environment to the research worker. He obtains a new lease of scientific life, a wider outlook, a wealth of experi-

ence of men and methods denied to him as a limpet in an institution. There are difficulties in the way of exchanging workers on any considerable scale, but these difficulties will decrease as time passes and the temporary exchange of work and of workers will prove of far-reaching benefit.

We have available organisations or machinery capable of doing great things for the development of the Empire. Already much has been achieved. The Empire Marketing Board in two and a half years has made grants up to the end of 1928 aggregating to a million and a half pounds. A fine example of what has already been done in Imperial team work is offered by the grassland research. The headquarters of this research is in Aberdeen and the chief of staff is Dr. J. B. Orr. Under his direction, teams have been investigating the mineral deficiencies of pastures in Kenya, in the Falkland Islands, in Palestine, and in Scotland and England. Arising out of these investigations and those of Sir Arnold Theiler, similar campaigns have been started in Australia and New Zealand. Here in the space of only two or three years we have, through vision and staff work, an Imperial investigation which promises to increase enormously the output of beef and mutton from Imperial grasslands.

As a result of these pasture researches, the workers engaged have been in consultation with each other, and a spontaneous tendency to co-operation is bearing fruit. In consequence, the pioneer work of Onderstepoort is known and appreciated in Great Britain and elsewhere and is being applied successfully. The work of Aston in New Zealand on 'bush sickness' is being applied in East Africa. The Canadian work on the prevention of goitre in grazing animals is a stimulus to work in other countries such as Australia and New Zealand, where there is believed to be a deficiency of iodine in the pastures. If similar developments can take place in other lines of research there is a possibility of great advances during the lifetime of the present generation.

We have the only system of government in the world that can link up research in countries with all kinds of soils and climates. We have the finest and most varied laboratory in the world. We have the nucleus of an organisation and we have the opportunity.

Within the Empire is the Empire's greatest market for agricultural produce and the Empire's greatest source of supply. The development of agriculture would have an enormous influence in the development of Empire trade. Co-operation in research leads to better understanding between the Dominions, the Colonies, and the mother country. Conferences of research workers and administrators lead to the discovery of common aims and ideals, as was shown in the Conference of 1927, and the pursuit of common aims is one of the most enduring of ties. But the scientific man knows no boundaries; he is one of the few real internationalists in the world to-day; the knowledge he obtains is subject to no tariff, receives no bounty, is freely exchangeable throughout the world. As a scientific man—if he is within the British Empire—he may engage in the solution of larger problems than probably any other unit can provide.

What may be the end of this research? One may speculate, but the end should surely include an orderliness, a co-ordination of parts, and a relationship of functions which should make for greater prosperity and for greater stability and freedom from temporary over- or under-production of agricultural commodities. It is not suggested that the exchange of commodities should be intra-Imperial. Even if that were desirable it is not possible. The trade of the Empire is shared almost equally between the Dominions and foreign countries. It is not that the Empire may be a self-contained and self-supporting quarter of the globe that I make these suggestions. To succeed in such an aim would be to end nowhere or to end in destruction. I make these suggestions because the nations which make up the British Empire form a political body which faces an opportunity open to no other system of governments in the world. This opportunity is the possibility that by taking thought and by organising the acquisition and the application of knowledge, the wealth of the Empire can be greatly increased, and thereby, and necessarily, the wealth of the rest of the world will be increased also.

It is a far cry to an organised Empire, but if the object is worth it, the initial step is to adopt the 'view-point' described by General Smuts. With the view-point and the mental field surrounding it come the creative ideas which in the end realise the dream. What I plead for then is the 'view-point'. Even in the prosaic occupation of agriculture, of the earth earthy, I suggest that the Imperial view-point is stimulating and creative.

The conception of an organised agriculture based upon science should, I think, be part of the mental equipment of every statesman and administrator. The same vision should inspire every research worker if, in the words of the late Lord Morley, he is to weave the strands of knowledge into the web of social progress.

If the vision is keen enough, the conception wide enough, the energy enduring, and the courage un-failing, is it not possible that the group of free nations which constitute the British Empire may demonstrate the means and lead the way to that wider world government to which every generous and contemplative mind would look?

The Progress of the Motor Ship.

By Engr. Capt. EDGAR C. SMITH, O.B.E., R.N.

IN NATURE on Mar. 9 a short review was given of the progress of the steamship, and attention was directed to the advances made in the use of high steam pressures, water tube boilers, pulverised coal, and other means by which the efficiency of steam machinery is being improved. It was then stated that of 65,159,413 tons of shipping included in Lloyd's Register Book, 50,045,048 tons were driven by reciprocating steam engines, 9,682,063 tons by steam turbines, and 5,432,302 by oil engines.

The history of the ocean-going steamship extends over a period of about a century; the first turbine vessel was the famous little *Turbinia* of 1894, while the first vessel driven by the modern heavy oil engine was probably a small canal barge built in 1903. In the case of the marine oil engine, as in that of the marine steam turbine, there was much pioneering work to be done before the new machinery secured the favourable opinion of shipbuilders and shipowners, and the development of the motor ship belongs almost entirely to the last twenty years. Of its growing popularity, however, there is no question, and for certain classes of vessels and for certain trades it will probably retain its position whatever advances are made in steam practice.

In 1914 the tonnage of motor ships was only 234,000, but by 1922 this had increased to 1,542,000, and the latest returns of Lloyd's Register show that no less than 40 per cent of the tonnage under construction will be driven by oil engines, and that larger and larger vessels are being supplied with oil engines. Of ships of 8000 tons and upwards now under construction, 27 will be driven by steam and 59 by oil; of ships of 15,000 tons and above, 7 will be steam ships and 14 motor ships. Though

no motor ship yet equals in size the *Majestic*, *Berengaria*, *Leviathan*, *Olympic*, or *Aquitania*, the Italian liners *Augustus*, *Vulcania*, and *Saturnia* are of 32,650, 25,000, and 23,940 tons respectively, the four British ships *Alcantara*, *Asturius*, *Carnarvon Castle*, and *Bermuda* range from 22,181 tons to 19,086 tons, and the new White Star liner *Britannic*, the largest British motor ship, launched on Aug. 6 by Messrs. Harland and Wolff, Ltd., is 680 feet long and has a gross tonnage of 26,840.

All large oil engines as found in motor ships have been developed from the independent inventions of Rudolph Diesel and Herbert Akroyd Stuart, both of whom patented engines in which the compression of the air in the cylinder caused its temperature to rise to the ignition point of the oil. Stuart's patent was taken out in 1890; Diesel's in 1892. Stuart's first engine was made in 1891, Diesel's in 1893, and in that year Diesel published his memoir, "The Theory and Construction of a Rational Heat Motor".

Both inventors used the four-stroke cycle as introduced by Nikolaus Otto. In the Stuart engine fuel oil was sprayed into the air at the end of the compression stroke and was automatically ignited by a hot bulb extension to the cylinder end which was heated previously to the engine being started, but was afterwards kept hot by the explosions. In the Diesel engine, on the other hand, the air was more highly compressed and the fuel oil was injected by compressed air. No previous heating of the cylinder end was required, but the engine was started by compressed air.

The manufacture of engines working according to Stuart's plan, or the 'Akroyd' cycle, was taken up by Messrs. Hornsby, and they were placed upon the market as Hornsby-Akroyd engines. The Diesel