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CONTENTS

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SCIENCE AND PROGRESS IN INDIA

THE extent to which the welfare, prosperity and, indeed, the very existence of a nation depend on scientific research and on the application of scientific knowledge has been brought home to everyone during the present War. Their supreme importance was fortunately realized in time in Great Britain, and between 1939 and 1941 arrangements were made between the United Kingdom, the Dominions and the United States for close co-operation in scientific research and the full interchange of scientific and technical information in all matters connected with the War. As a consequence, there are now scientific missions or representatives of the Dominions and the United States in London: the United Kingdom has a scientific representative at Ottawa; and there is at Washington a British Central Scientific Office that acts jointly for the United Kingdom and the Dominions in maintaining a scientific liaison with the United States. In addition, many special missions have been continually at work in all these countries. An attempt in 1941 to bring India into this picture was, however, unfortunately unsuccessful, as the need of this scientific and industrial collaboration was not then recognized in that country.

To help the continuance of such collaboration after the War, when problems of reconstruction and development for the betterment of the life of the people of the world will arise, the Royal Society in 1941 took the opportunity of the presence in London of scientific representatives of the Dominions to set up a British Commonwealth Science Committee to consider how collaboration in scientific matters throughout the Commonwealth and Empire could be made closer; and in the absence of any Indian men of science in London, the secretary of the Education Department at India House attended. One result of the report of this Committee* is that it is now proposed to call after the War an Imperial Scientific Conference to which scientific representatives of the United Kingdom, India, the Dominions and the Colonies will be invited.

When the Government of India became aware of these activities and of the feeling among British men of science that their Indian colleagues should be taking part, an invitation was sent by the Viceroy, through the Secretary of State for India, to the president of the Royal Society, for Prof. A. V. Hill to go to India as the representative of the Society, in order to discuss the organization of scientific and industrial research as a part of the Indian post-war reconstruction plan, and also current research problems, with visits to universities and other research centres. The Royal Society agreed to the proposal, and Prof. Hill spent from November 1943 to April 1944 in a tour of Indian centres of work connected with science, medicine and technology.

The results of his discussions, visits and contacts with Indian science, industry, medicine and official circles have now been published in a document of

* British Commonwealth Science Committee. (Royal Society, Burlington House, London, W.1. 1943.)

great importance, entitled "Scientific Research in India". A digest of the report, section by section, appears elsewhere in this issue of *Nature* (p. 532). This document, of which the preface is dated August 14, 1944, is all the more important because everywhere he went Prof. Hill was welcomed with the utmost cordiality and given the freest access to information as a representative of the Royal Society and of British science. As a result of his tour, Prof. Hill is convinced that there is no difficulty in the way of full and friendly co-operation between India and Great Britain in the scientific, medical and technical fields. Everywhere the emphatic opinion was expressed that one of the most important needs to-day of Indian science, medicine and technology is better facilities to send the ablest young Indians abroad, particularly to the United Kingdom, for advanced and postgraduate study, for works experience, and for training in research.

In order to understand the implications of this report, it is desirable to know something of the history of the development of the present scientific background in India. This development has followed two parallel lines, official and non-official, each beginning towards the end of the eighteenth century in Calcutta, which was the capital city of the East India Company and later (from 1858) of the Government of India under the Crown, until the removal of the capital to New Delhi in December 1911 as a result of the visit of the King-Emperor to India.

The official line began with the appointment of such officials as the Superintendent of the Botanical Gardens, Sibpur (1788), the Assay Master at the Calcutta Mint (1792), and a Government geologist (1818), and the establishment of the Trigonometrical Survey (1800), and of several astronomical and meteorological observatories (1792–1824); leading ultimately to the formation of the modern survey departments, the Geological Survey (1851), the Meteorological (1875), Survey of India (1878), and the Botanical Survey (1889). This was followed by provision for the applied sciences, mainly in the form of research institutes; for example, agriculture (1885–1903), veterinary (1890–1925), forests (1906), medical (1906), and public health and hygiene (1934). Another phase of official provision has been through the institution of universities, in Bombay, Calcutta and Madras, all dating from 1857, the year of outbreak of the Mutiny, the Punjab (1882), and Allahabad (1887), with several others founded during the present century. The Indian Institute of Science at Bangalore may be conveniently mentioned here, though it owes its inception to the munificence of the Tata family, supplemented by Government aid. Private bequests have, of course, also played a part in the development of the universities of India.

The non-official line of development began with the foundation of the Asiatick Society (now the Royal Asiatic Society of Bengal) by Sir William Jones in 1784. From its activities has sprung the larger part of non-official scientific activity in India (including a portion of the development along the official line), not to mention all its own work for literature, history, archæology and philology. In addition, the Indian Museum, Calcutta (1866) was based originally on the collections of the Asiatic Society; the official Zoological Survey of India (1916) is a descendant of the zoological section of this Museum. The Asiatic Society must also be regarded as the mother of the Indian Science Congress Association, which held its first meeting in 1914, and, as Prof. Hill remarks, the grandmother of the National Institute of Sciences of India, founded by the Indian Science Congress in 1935.

Besides the Royal Asiatic Society, there are now two other academies claiming national scope, namely (*a*) the United Provinces Academy of Sciences, founded at Allahabad in 1930, renamed the National Academy of Sciences, India, in 1936; and (*b*) the Indian Academy of Sciences, founded at Bangalore in 1934.

The growth of scientific activity in India has led also to the formation of a number of specialist all-India societies mainly with their headquarters in Calcutta; for example, mining and geology (1906), mathematics (1907), engineering (1921), botany (1921), chemistry (1924), physics (1934), soil science (1934), and physiology (1934).

From the dates of formation of these non-official academies and specialist societies, it will be realized that during the present century there has been an astonishing efflorescence of science in India as compared with the nineteenth century. This is of course partly due to the growth both in number and stature of the Indian universities, and is best recognized from the wonderful success of the Indian Science Congress, which, with the help of a deputation from the British Association, celebrated its twenty-fifth birthday in 1938. This Congress moves annually from centre to centre on the model of the British Association and is now commonly attended by upwards of a thousand members of all grades; this is all the more surprising in view of the sub-continental size of India and the distances that many of the members must travel in order to attend. This annual assembly of scientific workers is also the venue of the annual meetings of most of the all-India scientific societies, as well as of the National Institute of Sciences of India.

The foregoing summary is but a brief outline of the official and non-official provision for science up to the time of Prof. Hill's visit. It must be remarked, however, that there has been a marked difference in this century between the rates of growth along the official and the non-official lines. Whereas, on the non-official side, growth once it began was on the whole continuously progressive, the same cannot be said of the official side. It is notorious that official science is subject to severe setbacks when official finances become straitened. During this century, there have been two periods of such retrenchment. The first was in 1925, when the Inchcape Committee from Great Britain recommended some measure of retrenchment; and the second was in 1931 when, on the recommendation of an Indian Retrenchment Committee, widespread and disastrous curtailment was effected throughout the Government scientific services. The special selection of science for such slaughter showed how little the Government of India understood or valued such work, and it cannot be

denied that in consequence India faced the onset of the present War much worse equipped scientifically than would otherwise have been the case. The change of heart shown by the Government of India in now calling for the help of British science to strengthen Indian science, both academic and applied, is thus all the more to be welcomed. The sad thought is that it has required the impact of war to produce this change.

Although it was not until 1943 that this call for British scientific advice was made, the Government of India had in fact, in 1940, already taken a notable step with the foundation of the Board of Scientific and Industrial Research, which may be regarded as the Indian equivalent of the Department of Scientific and Industrial Research in Britain; and that the Government of India now takes seriously the need for scientific research is shown by the fact that financial provision was made in the Budget of 1944 for fuel research and glass research, and for national laboratories for physics, chemistry and metallurgy. Also the Government of India gladly accepted the invitation of the British Government, sponsored by the Royal Society, to send a deputation of leading Indian men of science to Great Britain in the autumn of the same year. The members of this deputation were given every privilege and facility to enable them to visit centres of scientific and industrial research in Britain and to make contact with the leading industrial enterprises likely to be helpful to India; and afterwards they went to the United States to make similar contacts there.

The above recital of the past and continuing growth of science in India sounds impressive, so long as India is pictured as one country and its scale is forgotten; but it must be remembered that India is nearly as large as the whole of Europe without the U.S.S.R., and that it has a population approaching 400 millions. Against a background of this magnitude, India's scientific provision is, of course, very small indeed, and there is, as Prof. Hill saw, the need in all directions for great expansion in scientific, medical, and industrial research. This is required for three principal reasons: (1) the improvement of the health of the population; (2) the adequate feeding and employment of this enormous population, which is certain to go on expanding rapidly; (3) the provision of adequate defence forces with modern equipment.

Let us consider further the third reason, though only in general terms. Prof. Hill rightly points out that if India wishes to attain national stature, she must be prepared to provide her own defence forces in the future, without reliance on the British Treasury. An inkling of what this may mean has been given by the present War. In the past, when the cost of a portion of the Forces in India has been defrayed by Britain, on the ground that that part was not maintained for purely Indian reasons, the unofficial members of the Indian Legislative Assembly have consistently opposed the provisions of the military section of the Budget for the maintenance of the remainder. This has appeared as a high proportion of the Central Budget, sometimes as much as 40 per cent; but there are also the budgets of some ten provincial Governments, none of which pays a penny towards defence. If the totals of these be added to the central total, the provision for defence is seen to be a much smaller proportion of India's total income. This should be emphasized, for in the future, as Prof. Hill sees it, there must be a greatly increased expenditure on defence, so as to enable the equipment of Indian Forces, land, air and sea, to keep abreast of that of other countries on the modern elaborate and costly scale. In addition, to ensure a high quality for this equipment, it will be necessary to maintain an adequately appointed scientific research organization within or in affiliation with the Defence Department; Prof. Hill proposes a War Research Board for this purpose.

How is all this expansion—medical, agricultural and defence—to be financed? Only by a great expansion and improvement of India's basic industry, agriculture, and by a great growth of her existing industries, with the addition of new industries. The Bombay plan of a group of Indian industrialists was proposed for such purposes, and even though its very magnitude may seem visionary, yet some such plan must be implemented, at least in part. The Government of India has accordingly now taken this task in hand, and, following Prof. Hill's visit, has formed a new Department, that of Planning and Development, with, for its first member, Sir Ardeshir Dalal, former managing director of the Tata Iron and Steel Co. and one of the authors of the Bombay plan.

The greatest weakness in the Government of India in respect of scientific activities is that responsibility for it is scattered instead of concentrated: for example, meteorology is under the Department of Posts and Air; geological survey under Labour; the Survey of India, and the Botanical and Zoological Surveys, under Education, Health and Lands, which also controls medical and agricultural research in part. What is needed is that all these scientific activities should be grouped under one member of Government, for which the new Member for Production and Development seems appropriate.

Prof. Hill's recommendation is, therefore, that there should be a Central Organization for Scientific Research working under the Honorable Member for Planning and Development, divided into six research boards: medical, agricultural, industrial, surveys and natural resources, engineering, and war. He makes suggestions for the constitution of these boards; and for each of these branches of activity he proposes a director of research, who would be secretary and principal administrator of his own board, and a member *ex-officio* of each of the other boards. The responsibility of these six directors would be for directing, organizing, initiating and co-ordinating research, on a nation-wide scale, so far as constitutional considerations allowed, each in his respective field.

Between these boards jointly there would be a Research Grants Committee, and a Research Studentships Committee. There would also be a Scientific Consultative Committee to advise the Member for Planning and Development on general policy in relation to research, consisting of the six directors of

research, together with six other distinguished men of science.

In advocating this general principle of bringing research into a single organization, Prof. Hill points out that this would still leave the Departments of the Government of India free to make their own arrangements for applying the results of research to the practical problems they have to face. From this point of view, Prof. Hill regards these other Departments of the Government of India as the 'user' Departments, which, charged with the responsibility of applying the results of research, could set up development or improvement councils, with a liaison with the corresponding research boards. Then, to ensure that development as well as research is co-ordinated at a high level, Prof. Hill would set up under the Member for Planning and Development, as an opposite number to the Scientific Consultative Committee, a Development Consultative Council.

If the Government of India acts on Prof. Hill's report, as there is every reason to suppose it will, then India will be provided with a co-ordinating and initiating organization for research in the six fundamentally important fields outlined by Prof. Hill; an organization that should help materially the improvement of the health of India, the necessary expansion of its agricultural resources, and the expansion of its industries, with a resultant higher level of health and of the employment that is so necessary to produce the greatly increased revenue needed for the general welfare, including the defence of India.

Proposals for the expansion of Indian science and industry cannot, however, be implemented unless men, both in numbers and in quality, are forthcoming to carry them out. India's present educational equipment, including that of the universities, technical colleges, and research institutes, is quite inadequate for the purpose. Consequently, pending a great improvement in educational and technical facilities in India, large numbers of graduate students will have to be sent abroad at Government expense for postgraduate training, both scientific and technical. It is understood that the Government of India is making arrangements for this, and that we may expect a considerable number of such students to arrive in Britain this year. Conversely, it will probably be found necessary, as a temporary measure, for India to import from abroad a considerable number of highly qualified men to help in the reorganization of teaching and training in India. These remarks are made without any reflexion on the professors and other teachers in India, who have done splendid work with the insufficient facilities at their disposal, as must be evident to anyone who contemplates the astonishing success of the Indian Science Congress, of which mention has already been made, or the fact that several Indians have been elected to the fellowship of the Royal Society.

The organization for research proposed by Prof. Hill and outlined above will, of course, if adopted, be an official scheme for the co-ordination of scientific research in India, and when carried out it will have to be regarded as a sudden burgeoning on the official line of development, incidentally co-ordinating, so far as possible, activities on the non-official line of growth. There will, however, remain the non-official activities that find their expression in the specialist scientific societies, in the academies, in the Indian Science Congress Association, and in the National Institute of Sciences of India. These non-official developments must be encouraged by Government and helped financially, while still remaining free. Nevertheless, these non-official activities also need co-ordinating. Prof. Hill refers to the fact that Indian men of science have advocated strongly the formation of a National Research Council, and to the formal resolutions on this matter passed by the National Institute of Sciences in 1944. Without enumerating these resolutions, it may be said that they were designed to give Indian science and Indian scientific men a greater and more appropriate part in national affairs. Prof. Hill holds that his proposals are designed to meet the same needs and difficulties as the proposals of the National Institute, and that they will be acceptable to that body. But although Prof. Hill's proposals may render unnecessary the formation of a National Research Council formally so named, they do not remove the necessity for a co-ordinating organization for Indian non-official scientific bodies. The National Institute of Sciences of India was, of course, formed for this very purpose, as Prof. Hill recognizes, and in fact he expresses the hope that formal recognition may be given to its position by Government, for example, by the grant of a Royal Charter such as the Royal Society and the British Academy have.

Incidentally, Prof. Hill comments on the 'odd' name of the National Institute, recognizing, however, that the name chosen was due to a compromise at the time of foundation. The name is, however, not so odd as it sounds, for the organizing committee, in selecting this name, was influenced by the example of the Institute of France, which is a co-ordinating body for the five French academies, both of sciences and letters, and which in an earlier stage of existence was called the National Institute of Sciences and Arts. As the Indian body was to co-ordinate scientific bodies only, it was named the National Institute of Sciences of India, leaving the field open for the foundation at a later date, for example, by the Royal Asiatic Society of Bengal (which is an academy of both science and letters), of a National Institute of Letters to co-ordinate the activities of academies of letters in India, with perhaps also the formation of a National Institute of Arts co-ordinating the activities of academies of arts in India. Once this has happened, the need may arise for co-ordinating the three national institutes into a National Institute of Arts, Letters and Sciences of India as 'The Institute of India', equivalent to the Institute of France in its comprehensive scope. The foundation of the National Institute of Sciences of India, although on an all-India basis, aroused a certain amount of provincial jealousy at the time of foundation, so that the present location of its office in the building of its 'grandmother', the Royal Asiatic Society of Bengal, is perhaps a disadvantage. If with the grant of a Royal Charter its

headquarters is moved to Delhi, this should cause all such jealousies to be dispersed.

In conclusion, it can be emphasized that Prof. Hill's report is a document of the greatest public value, which will provide a first-class stimulus to scientific progress in India. At present few copies are available in England, but it is to be hoped that this deficiency will be rectified later. It is of such importance that it should be studied closely by all who are interested in the welfare of India as conditioned by its scientific progress.

DRY FARMING PROBLEMS

Dry Farming in India

By N. V. Kanitkar. (Imperial Council of Agricultural Research, Scientific Monograph No. 15.) Pp. x+352. (Delhi: Manager of Publications, 1944.) 13.12 rupees; 21*s*. 6*d*.

ON more than one fifth of India's total cultivable area crops have to be grown under conditions of precarious and inadequate rainfall. The area concerned exceeds seventy-seven million acres. A partial crop failure is a serious matter for the sixty million people who live there, and for many others outside who receive their food-grains from the affected areas. The danger has become steadily greater because of the continuous and rapid increase in the total population; not only are there more to be fed, but also the increasing pressure on the land has reduced the average area cultivated by one family on the better lands, and has caused more marginal land to be taken into cultivation and has thus intensified many technical difficulties inherent in the system of husbandry.

During the past ten years, the Imperial Council of Agricultural Research has financed and co-ordinated the work of five special stations set up to examine the scientific and technological problems of dry farming, or crop-growing in low-rainfall areas. The scientific monograph under review is an account of that work. One of the stations, Rohtak, is situated in the north-east Punjab, on the alluvial Indo-Gangetic plain. The other four are in peninsular India and are relatively close together, but cover the two main soil formations. The Sholapur and Bijapur stations in Bombay province are on the Deccan trap, which weathers into the well-known black 'cotton' soils. The remaining two stations are at Hagari in Madras, and Raichur in Hyderabad State. They are on the red and black soils associated with ancient crystalline granite and gneiss.

The monograph contains one or two general chapters, describing the rainfall distribution over India, and the prevalent agricultural practices in dry farming in India and elsewhere, but the greater part deals with the properties of the soils and the behaviour of crops at the five stations. Extensive chemical and physical analyses of the soils were made, but except for easily predictable differences in field behaviour, associated mainly with depth of soil and the degree of heaviness, the results are shown not to have any fundamental bearing on the question whether crop yields can be stabilized or increased. This is to be expected, for the factor that overrides all others in importance is the amount and distribution of the rainfall in any season. The results of the manurial experiments brings out that point. Farmyard and green manures were tried with conflicting results (except possibly on the eroded areas of the peninsular India stations). Thus, the heavier dressing of manure often produced a smaller yield of grain than was obtained with the lighter dressing or no manure at all. The reason was shown to be that the nutrients encourage a greater vegetative growth than the limited moisture supply could bring to maturity. The effect is well known to the cultivators, who say that manure 'dries up' the crops, and are reluctant to use dung as manure, quite apart from their need of it for fuel. The greatest importance, therefore, is attached to the problem of conserving the maximum amount of water in the soil. A great deal of laboratory and field work is discussed, varying from cultivation and run-off experiments to plant transpiration trials. The reduction of run-off water by suitably placed bunds is shown to be of prime importance, and simple methods are described suitable for the cultivators' use. The results of the tillage experiments fall into line with the knowledge now available of the physical factors concerned in the behaviour of soil moisture. Over a period of years deep ploughing is no better, and may be worse, than shallow ploughing, and repeated ploughing is found to be harmful on some soils and ineffective on others. On the other hand, repeated shallow cultivations in the monsoon period do conserve water for the use of the subsequent winter crop, partly through weed destruction and partly by the prevention of deep cracks through which water from the lower levels could escape as vapour.

Developmental studies of the important crop plants were done mainly on the millets that, as sorghum or jowar (*Andropogon sorghum*) and pearl millet or bajra (*Pennisetum typhoideum*), are predominant in these areas. Shallower seeding than the customary is recommended, because the production of the secondary and permanent root system is encouraged; a lower seeding-rate and wider spacing of the rows is also urged, because larger grain yields are obtained, and the wider spacing permits inter-cultivation up to an advanced stage of growth without injury. All this is counter to the usual practice of the cultivator, and it is no criticism of the experimental results to sound a note of caution. There may well be incidental advantages in the customary methods, to be disclosed by experiments covering a longer period of years and a wider variation of climatic conditions. For example, tillering is not desirable in dry farming conditions, and the tendency is discouraged by the close stand of plants given by a heavy seeding-rate. Indeed, an automatic selection of non-tillering types may well have been effected by the practice of close seeding, for it is pointed out in the monograph that the sorghum varieties grown in south India do not usually tiller. Plant-breeding work was outside the scope of the investigation, but promising strains evolved elsewhere were tested against local varieties, with no very significant results, except that early maturity was valuable. It must be recognized that the plant-breeding problems in food crops for dry-farming areas are of peculiar difficulty, not only because of the extreme variation in conditions from season to season, but also because the weight and quality of the stalks and leaves, which are the main fodder supply for the animals, are as important as the yield and quality of the grain.

Another point on which longer trials are needed is the relative value of rotations and the cultivators'