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THE FUTURE OF MYCOLOGICAL RESEARCH IN INDIA

MYCOLOGY touches upon a number of other sciences and in turn is influenced by them. Amongst the applied sciences in which it has long been of importance, first and foremost comes plant pathology, closely followed by soil science. More recently it has begun to play an increasingly large role in chemistry. It is of significance in human nutrition. In medicine, where it has hitherto taken a comparatively minor place, it has in the past three or four years loomed large. As a branch of botany the study of the fungi themselves has long been interesting and important because the fungi provided useful and comparatively easy material for the study of form, of physiology, of specific relationships, and particularly of sexuality, where it has been possible to observe processes taking place in small groups of cells under a high-powered microscope *in vivo*. The classification of fungi is unique inasmuch as they represent the largest group of living things which are classified mainly on the basis of micro-morphology. The result has at times been a tendency to place undue emphasis on minor morphological characters which has often led taxonomy into disrepute, but the realisation in recent years of the immense significance of fungi in a wide range of human activities has compelled the applied mycologist to return to the field of taxonomy with increasing energy and to devote to it a measure of time and skill which was hardly imagined a generation ago.

This diversity of activities of mycologists is to-day giving rise to certain serious and difficult problems of organisation. There is now a need for teams of skilled workers having a profound knowledge of the habits of fungi from entirely different points of view and with bearings on completely different problems. In plant pathology, the mycologist must have a deep insight of plant physiology, agronomy and taxonomy, accompanied by some understanding of both organic and inorganic chemistry, which is called upon constantly for the control of plant diseases by the use of chemicals and by other methods. In soil mycology, a subject sadly neglected in India, an understanding of soil physics and chemistry, as well as bacteriology, is essential. If the useful fungi are to be developed in India, it can only be possible by the collaboration of mycologists with biochemists and nutrition experts. In the realm of fungal therapeutics, there is need for skilled research workers possessing adequate and well-equipped laboratories for research on human and animal medicine, as well as first-class biochemists, all working in teams. Modern inventions of food processing, the fabric industries, leather, timber, and (in rapidly expanding measure) electrical equipment, are facing problems due to fungal damage of a very special nature, requiring a type of technological expert not known a few years ago. These problems would not be difficult to solve were it not for the fact that mycology is in itself a

separate science requiring wide knowledge and the ability to grasp the fundamental relationships of a great range of micro-organisms. The problem of organising research in mycology, is, therefore, one of co-ordinating the activities of specialists in a science who have to be distributed and carry on their work in a number of quite disconnected branches. It is, in fact, a problem of so directing the activities of a group of scientists that their services can be placed at the disposal of a number of unrelated sciences without their losing the unity which they must retain if the science of mycology itself is to advance. It is a problem of how to disperse and yet to integrate.

If anyone does not believe that this is a real problem, let him examine any well-known classification of fungi—that, for instance, of Saccarado, and then read one of the well-known works on medical mycology. If, after mastering the former, he is capable of comprehending the latter after one or even two readings, he will have proved himself to be indeed a master of multiple and confused conceptions. The classification and description and also the terms used to describe the same thing are often quite different; while frequently, on the other hand, the same terms, even the same generic names, are used to designate organisms or organs unrelated both morphologically and physiologically.

We may assume that the nature of the various kinds of work to which we have referred indicate clearly enough that specialist mycologists have to work along with teams of other scientists to which mycology is little more than a name. What we have to decide is the number and nature of the various kinds of specialist mycologists, the type of institution in which they will have to work and how the work of all of them can then be integrated so that unity of terms, conceptions and outlook can be maintained. The organisation and grouping of specialist mycologists proposed here is an attempt to solve this problem.

PLANT PATHOLOGY

Plant pathology is one of the oldest and still the largest of the activities of mycologists. In India it is organised both centrally (at the Imperial Agricultural Research Institute) and provincially in the various agricultural departments. The earliest work was mere observation by workers in foreign countries on materials sent to them from India. The first pathological research of importance was that of Barclay in Simla. Early in this century work became centralised at Pusa, due, mainly to the outstanding achievements of Butler. With one or two notable exceptions there was little done provincially until Butler's students had become scattered over the provinces.

Pusa was fairly well situated for studying a considerable number of plant diseases. Many crops could be grown there including some which were more or less tropical in nature, although not those most characteristically so. Few, of course, of the diseases caused by the cool climate-loving fungi could be studied.

With the removal of the Institute to Delhi, which has a rigorous climate of hot dry summers and rather cold winters, the number of crops which could be worked with was reduced, and even on those on which research was possible, it could be conducted only for a short period of the year. Work under controlled conditions of temperature is impossible apart from a few winter months. The conditions of climate are in fact such that only a dozen or so crops can be studied for any appreciable length of time during the year. The field could be greatly expanded by the addition of a suitable hill sub-station, but none has been provided.

What is true of Delhi is true of any place selected in India, though usually to a lesser degree. There is no one place where all crops can be grown. Plant pathological research requires dispersal on a provincial basis, according to crop geography. The work requires close association with experimental farms, and generally speaking can best be done by agricultural departments of provincial governments.

It is only as a result of recent research that we have appreciated the importance in Northern India of the Himalayas as a possible source of origin of epiphytotics. No province of India consisting mainly of plains with adjacent hills can ignore this possibility, and hill stations for plant pathological research must now be regarded as essential. The extent of India and the variation of climatic conditions as one proceeds from the dry mountains of the west to the eastern hills is such that one single hill station will not suffice. Several will be required.

SOIL SCIENCE

The role of fungi in the soil received much attention at the beginning of the present century in many parts of the world, but not in India. It is a rather remarkable thing that in India, where the soil is low in humus, and where stress is being laid at the moment on green manuring and increasing the organic matter in the soil, little or no attention has been paid to the agents responsible for the first step in making available to plants the green matter which must be applied if the humus content is to be appreciably increased. Major drawbacks in both green manuring and composting are the conditions required to establish the decomposition and the long time required to complete it, which, in the case of green manures at any rate, is a severely restricting factor in its application. Methods that would induce rapid fungal activity in the early stages, whether by inoculation or by chemical treatment, are essential, yet we know little of the kind of fungi inhabiting Indian soils and next to nothing about their selective properties. Perhaps this is due to an overstressing of the chemical aspects of soil science. At any rate, the close association of mycologists with soil scientists seems to be essential if we are to see useful developments along this line. Much of the best soil science work has been done in our Universities,

and doubtless it will continue to be so. There is no reason why mycologists should not be attached to the soil science departments of all Indian Universities where this subject is taken seriously. Again, however, a very wide outlook and thorough experience of the fundamental aspects of mycology are needed.

CHEMISTRY AND NUTRITION

In the applied branches of chemistry mycology can be of great assistance. At the present moment India is converting a large amount of molasses into alcohol, which is required for a number of industrial processes as well as for fuel. Whether alcohol as fuel for combustion engines can compete in normal times with mineral fuels is uncertain, but certainly there are other industries developing in India which will absorb considerable amounts. The alcohol industry of the country will not find it easy to hold its own under the competition to be expected in the post-war period. It is essential that production should be efficient, and that the maximum amount of alcohol be produced from a given quantity of carbohydrates. This is only possible if better biological control of the process is followed than is the case at present, where inoculation is largely a matter of chance and the selection and maintenance of suitable strains of yeast receives no attention.

There are other fermentation industries where mycologists are needed. Vinegar and acetone and acetic acid are often produced with little attention to the proper organisms; a citric acid industry, we believe, does not exist, though in other countries the mycological method of producing the acid has taken the place of natural citric acid from fruit.

In all the chemical industries, factories must be established where the raw products exist. Centralisation is impossible except for the more fundamental aspects of the work.

The fermentation methods of producing readily digestible proteins and of rectifying vitamin deficiencies are now receiving attention in India, as in other countries. The possibilities here are great and fascinating, but exploitation demands heavy capital expenditure and a high degree of biological control. Provided these exist, there is no reason why, after the war, large quantities of molasses, and possibly other crude forms of carbohydrates, should not be converted into food rich in protein and vitamin B, which are exactly what is required to rectify two major deficiencies in the diet of the masses. We are thinking at the moment in terms of waste molasses, but there is no reason to suppose that this is the only source of carbohydrate which will be sufficiently cheap for the purpose. Potatoes and some of our millets which yield well and of which there are in normal times surpluses in certain areas could likewise be used, but there are technical difficulties to be solved before this is possible. Provided food yeast can be profitably manufactured from molasses to start with, and the public can be educated to its use, it should be quite possible to extend production with the use of

other crops. Food yeast production, if it succeeds in the early stages, may well follow the same course as many other fermentation industries, where the bye-product has become so important that it has eventually become the primary product.

Food yeast and yeast extracts may prove to be not only important nutritional aspects of fungi. Many edible fungi grow well under Indian conditions, *Volvaria diplasia* being one example. We have tended to regard fungi as of little importance nutritionally because of our disposition to regard the common English mushroom, *Psalliota campestris*, as the last word in edible fungi, although in many countries it is thought of as a second-rate edible form, and it is neither the most productive nor the simplest to cultivate. It is worth remembering that fungi are amongst the few organisms able to convert cellulose quickly into digestible carbohydrates.

The mycological problems of food yeast production (and they are many) will have to be worked out at factories, which will be located wherever there is a plentiful supply of molasses or other suitable carbohydrates. On the other hand, the cultivation of many fungi and the study of their nutritional value could be investigated quite well at a central place, and in practice is likely to remain a small-scale village industry. All stages of the research could well be done at a central agricultural institute.

MEDICINE

Originally important in medicine chiefly because of their poisonous nature, the value of fungi in pharmacy has been appreciated only during the past century in European countries, though doubtless going back many generations in China and other old civilizations. The production of the drug ergot, of which there is at present a world shortage, has received serious attention in South India, where it is being grown successfully on a commercial scale. Possibilities of the extension of ergot culture, the use of ergots indigenous to India, the risks involved in its culture, and possibilities of artificial culture, are matters deserving attention. Ergot production has to be done at places with a suitable climate, moderately humid and not excessively hot. The assaying and artificial culture can be done in any suitably equipped laboratories.

The most spectacular work in pharmacy in recent years has been the production of the drug, Penicillin. Its commercial production can now be exploited in well-equipped factories. There is much research work remaining to be done. The use of the drug for tropical diseases and the possibility of finding other drugs produced by fungi are specific problems to be worked on in well-equipped medical laboratories with the aid of skilled mycologists. It is the facilities for medical research which should be the criterion for selecting a suitable site for the work. A number of mycologists in India are investigating the problem, but there is some evidence to suggest that the objective

is not clear and that little more is being added to our knowledge than was already known from the work done in other countries. The best use is not, therefore, being made of the workers, who should be engaged on parts of the problem allotted to them by a co-ordinating authority.

INDUSTRIAL MYCOLOGY

The mycology of fabrics, of foodstuffs, leather goods, plastics, insulating material, scientific equipment, and so on, has come to the fore especially during the war. It is a special branch of mycology requiring a thorough knowledge of the fungi commonly known as "moulds", a rather indefinite term covering certain Mucorales, some Ascomycetes such as *Aspergillus* and *Penicillium* and a large number of imperfect fungi of the Moniliaceæ and Dematiaceæ. While some of the work has to be done in factories and godowns, there seems to be no reason why, after the war, much of it should not be done in a central place which would have facilities better than could be provided by the numerous industries concerned acting individually. Such work could perhaps best be centred in one of the large manufacturing cities, and could be associated with a technological laboratory dealing with cotton, jute, or some other fibre.

FUNDAMENTAL MYCOLOGY

All the aspects mentioned above have relation to specific major groups of problems. Each is connected with certain groups of fungi of a rather limited kind. In such work the danger is that the workers concerned will lose contact with other branches of mycology and will become narrow in their outlook, so that they will tend to overlook modern trends and remain unaware of the significance of findings by other branches which are of fundamental importance to their particular branch also. It is this narrowness of outlook, and its consequent limitation of scope and ideas, that has to be guarded against by giving proper attention to mycology itself, by which is meant the study of fungi for what they are themselves

rather than for what is their importance to other sciences or to industry. A central research agency is required which can constantly have experts working on and monographing the various groups of fungi, recording their behaviour and their distribution in nature. Such an agency needs a particularly well-equipped library, first-class laboratories, a good herbarium and a national culture collection. The aim of the mycology section at the Imperial Agricultural Research Institute during recent years has been to build up such an organisation. It has meant a considerable change from the Pusa tradition which was built up, for obvious reasons, with an agricultural bias. Such a change in outlook was inevitable, for, as already pointed out, it could not deal with all, or even a major portion, of India's crop problems. Its facilities, however, are still inadequate, and a crying need is the establishment of a hill station where work can be carried out on the temperate fungi, many of which in all probability are carried yearly or occasionally to the hot plains during the cooler weather.

To summarise, we appear to need groups of mycological workers distributed more or less as follows:—

Plant Pathology: Agricultural experimental stations throughout India under the Government departments of Agriculture. *Soil Science*: Soil Science departments of the Universities. *Chemistry and Nutrition*: Factories, with a central laboratory for fundamental work attached to a nutrition laboratory. *Medicine*: A medical research institute. *Industrial Mycology*: In association with a technological laboratory dealing with fabrics. *Fundamental Mycology*: At a central research institute in association with other sciences and having access to a first-class library.

G. WATTS PADWICK.

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PROFESSOR P. C. MAHALANOBIS, F.R.S.

THE happy announcement of the election of Professor Prasanta Chandra Mahalanobis to the Fellowship of the Royal Society, will be received with supreme satisfaction by his numerous pupils, colleagues and admirers. The distinction is a belated recognition of his pioneering, substantial and enduring contributions to the science of Statistics, in its pure and applied aspects. The Indian Statistical Society and *Sankhya*, its official organ, owe

their inception to his genius, zeal and organising ability. By example and by precept, he has inspired and fostered a strong, flourishing and an internationally recognised school of statistical science in this country. On this auspicious occasion, we wish to tender to the Professor our heartiest felicitations and wish him a long career of greater distinction and achievement.
