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OPENING ADDRESS TO THE PLANT PROTECTION SECOND INTERNATIONAL CONFERENCE

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The following address, which is reproduced by kind permission of the author and of Plant Protection Ltd., opened the Second International Conference on problems of crop protection, which was held at Fernhurst Research Station in June, 1956. This general survey of all aspects of crop protection by an eminent authority will undoubtedly greatly assist all those engaged in this type of work in viewing it in its correct perspective.

Control over crop disorders and damages has been much enlarged by knowledge gained in the past decade. Many crops and countries have benefited, and for the general expectation of even greater progress in the early future there are firm grounds. Not all the new knowledge is to our comfort, however, for disquiet about certain forms of control has become decidedly stronger. Both scientifically and practically, nevertheless, the general prospect is a cheering one. It is much enhanced by the development, now well marked, of a combination in thought and in experimentation on crop protection among the relevant sciences and between science and husbandry.

Costs of protection are running high with some crops, and satisfactory procedures and field equipment are not yet available for others. In asking for improved appliances, the practical man is unlikely to realise the difficulties met in making drops of desired sizes and causing them to move in variously desired ways. The session on producing sprays will, therefore, be welcome, notwithstanding the scientific complexities of the subject.

Agriculturists are content to wait for a steady cheapening and improvement of equipment, and their true disquiet is mainly over two familiar phenomena which look more ugly every year. In checking one pest by chemical means another may be encouraged. The likelihood of this may be unpredictable and only discoverable at the grower's cost. Secondly, there are the cases of swift invasion by formerly unimportant fungus strains in a new crop variety bred to withstand the strain formerly prevalent. The general public, too, is becoming watchful in the matter of plant protection of a possible new aspect of what we have come to call "chemicals in food". This is a very proper concern, though liable to be reprehensibly turned into a confused alarm. To discover underlying principles in all these disquieting issues is the most urgent task in crop protection.

Crop protection practice, particularly chemical methods, is closely pursuing—and at times outrunning—new knowledge which itself is moving fast. A pause is needed for contemplation—contemplation of current practice, of the adequacy of basic knowledge and of the objectives in research. That is why this Second International Conference has been arranged four years after the first. Though its sessions must be limited to but a few topics, its purpose implies a wide outlook, for it is the

task of crop protection to provide controls over all organisms harmful to yield or to quality in every kind of plant useful to man.

The enemy organisms are many times more numerous in kind than the crops they attack. Some of the groups with which this Conference has no concern seem to the agriculturist to need much more attention. Mammals, especially rodents, may be instanced, but birds seem especially neglected. Pigeons in Britain and the beautiful but obnoxious *Queleas*, the Weaver bird, in several parts of Africa signify the seriousness of the avian menace. Neglect of the matter is illustrated by the fact that governments in the African continent have not even begun to unite in surveying the big game, and some of the birds which are known to be concerned in some of the gravest diseases of livestock or in crop damage. Disparate territorial investigations have very limited merits.

Even the insects and fungi harmful to crops have, as yet, only been studied scientifically and tackled practically in piecemeal fashion. Ups and downs in crop loss from pests and diseases have continually distracted research, especially in the tropics where staffs are small. Any big outbreak must be promptly attended to, and records of plant pathology and entomology are heavily marked by unfinished investigations. It might be well and practicable to single out the chief groups and to ensure continuing study on these, unimpeded by currently important outbreaks. This would require not only greater resources for research but, more importantly, a wider conviction among responsible authorities that progress in crop protection must be built on full knowledge of the agents of damage.

It is necessary to bear in mind that there are, at this Conference, not only physical and biological scientists—the initiators of protective methods—but also those who supply advice, materials, equipment and contract services. The growers, however, must take the central place in our concern. They are the first to encounter the trouble, and it is they who pay in money and toil for the protective measures. Some observations from their side will therefore now be made.

In conferences, lectures, text books, control of pests and diseases by certain husbandry practices is enjoined almost rubrically. But what is firmly known of its possibilities? Is there a danger that the specialist in whose province this lies may not give it sufficient experimental attention but may rather wait for the chemist to make husbandry control no longer worth attempting? Agriculturists have increasingly disciplined their traditional beliefs and practices by well designed field experiments. Naturally, then, they ask for rigorous trials of all crop protection substances, the issues being as follows:—the best amount, method and time of application; resulting effects on yield and quality; cost; behaviour of different varieties; locality variations and effectiveness; and, interactions with husbandry practice and, of course, effect on other organisms.

It would be hard to find a more appropriate place than Fernhurst for a critical discussion on the design and execution of field trials. A period of practical use, as well as trials, is always necessary for full answers, but trials fail unless they give ample preliminary guidance on all these issues. In the difficult matter of designing and carrying out these trials, expert opinion seems not always clear nor harmonious. Large numbers of small plots, for instance, allow easy movement of mobile organisms from plot to plot. Small numbers of large plots are statistically unsatisfactory, and large numbers of large plots involve great heterogeneity of soil. How, then, is the best design to be decided upon in any particular case? The trial might be in the midst of a large unsprayed area or in the midst of a large sprayed area; or perhaps there ought to be a trial in the midst of one of each such areas. Which is the better?

There are numerous secondary problems as well; for instance, how to treat plots when testing a substance which is to be applied from the air. It would gratify

agriculturists and do no harm to experts if these questions could be fully argued for a few cases of both large scale and small scale production—let us say, cotton pests or banana diseases. Agriculturists are by no means satisfied with the evidence for the claims made for some protective substances nor at the very early stage at which some of them have been offered for general use. Everyone accepts the necessity for devising more reliable trials for insecticides and fungicides, but who will take action? This matter, though of primary practical consequence, is not one for primary research. Manufacturers may perhaps feel a greater responsibility in it than they have so far exercised: certainly it would be in their long interest if a decisive system of trials were devised and regularly used.

Year-to-year fluctuations in severity of pests and diseases are well known. It is for specialists to judge whether sufficient research is in progress on the nature of these fluctuations and their relations to physical environment. With fuller knowledge it might be possible to predict the likelihood of some attack at any period of the year from the preceding weather data. Omission or reduction of treatments could sometimes then be practised. Place-to-place differences in treatment results in the same year are also known. Jassids on cotton, black pod on cacao and the onion fly are puzzling examples of this, but presumably the phenomenon is connected with the degree of mobility and method of propagation of the organisms and also with localised differences in physical environment.

Existing knowledge about all this is not, however, of much serious practical value. More experimentation under controlled environments, though difficult, seems to be necessary. More ample local repetition of field trials would certainly be helpful; also, if the local experiences of contract spraying were collated every year, suggestive indications might emerge.

Very large continuous areas of the same crop, especially if all of one variety, have been suggested to be pathologically unwise, particularly with perennial crops. This suggestion still remains to be developed into practical recommendations. Organised protection for recognised crop production districts has not yet become at all widely developed. It is familiar, of course, in the close season in some cotton growing areas and in the regulations sometimes made about alternative host plants. The method, however, has many different applications, and seems to merit much further thought.

Agriculturists have strong reasons for concern about those pests and diseases which harbour in the soil. Chemical treatment of only the top seven or eight inches involves about a thousand tons of soil an acre, and harmful plant nematodes, for instance, are found to three times that depth. It is true, for instance, that wireworm, flea beetle and carrot fly may be dealt with effectively by seed treatment; it is when the soil in masses has to be treated that the agriculturists' concern arises. What good or harm may be done by a soil treatment to other than the destined organism is at present purely a matter of guessing. Some indiscriminate destruction of organisms certainly occurs and may eventually favour the agriculturally undesirable forms against which the chemical treatment is applied, or it may favour some quite other undesirable.

Now, fear of cumulative effects from long continuations of certain husbandry practices or from repeated chemical treatment of soils is very widespread among farmers. That, of course, does not refer to the use of chemical fertilisers. The consequence might be far more serious than the occasional loss of even a whole crop for one year.

Now, a final reason for this concern about treatment of the soil relates to crop rotation. Traditionally, this practice of crop rotation is reckoned to assist the economic balance of the farm working, to enable labour to be spread through the year, to

look after the maintenance of soil fertility, the control of weeds, and to avoid the accumulation of soil-harbouring diseases and pests. Various developments in the present century have, in the judgment of very many farmers, taken the force out of all these considerations except the last—that is, crop rotation as a necessary means of preserving the soil from soil-harbouring diseases and pests. Thus, the far greater freedom which may now be used with crop rotation appears to be chiefly limited by the fear of certain soil pests and diseases. The types, numbers and activities of soil arthropods and micro-flora must be amongst the most elusive subjects in the joint field of chemistry and biology. Whilst these matters remain obscure, fears about unpredictable damage through soil treatments are bound to persist. In the agricultural view these organisms should have much more attention and some responsibility for providing this lies with those who concoct and use crop protection and weed control substances. It is therefore particularly gratifying to us on the agricultural side to see that the hazards of various kinds from crop protective substances have a whole session at this Conference.

Because chemists have sometimes been too bold, or farmers too credulous, certain protective substances have been offered for general use without sufficient trial and later withdrawn. Remembering the past confusion caused by similar impetuousness in connection with new varieties of crops, it is to be hoped that all concerned will insist on adequate testing. Farmers have the power to check this irresponsible marketing, if they care to use it, and they have also for their guidance an official approved list of crop protection substances.* Another consequence of new protective substances being frequently issued after only a brief trial is that the farmers' advisers, feeling obliged to make thier own tests, are unduly withdrawn from their normal work. It is now not uncommon for a trained entomologist or plant pathologist to spend most of his time testing proprietory substances. This diversion from fundamental work is most regrettable.

Increasing use of chemical methods has independently confirmed the conviction that progress in crop protection depends on advance in basic knowledge of the harmful organisms. Study of these organisms must now include the organism itself and the reaction to treatment and also the nature of the interaction between organism and host plant. In this urgently needed work both plant physiology and biochemistry are involved. Plant reaction bears also on the genic resistance to disease, and is therefore of interest to plant breeders. It is, indeed, one of the matters in crop protection requiring union among several branches of science. Routine trials, should not be allowed to prevent scientists taking their part in this united work, especially the pathologists and entomologists. We at this Conference, at any rate, will not be left unaware of the complexities of reactions between aggressive organisms and the protective substances. Papers dealing with this and with systemic protectives will not only set out difficulties yet to be solved, but will be able to record some notable achievements.

Most of the agricultural holdings in the world are small. The food of a large portion of its population is grown on tiny patches of land. Europe has many small farming units. In the tropics, where they predominate, they are often diminutive and range from intensive rice growing to the lower output of the shifting cultivator. They obstruct every protective movement, for, besides the inconvenience of smallness, there are ignorance and prejudice, superstition, and poverty of resources.

The needs of these tiny producers should not be forgotten by the manufacturers of crop protective substances and equipment. Crop protective substances are now being energetically marketed in most tropical territories. The extreme sparseness of knowledge of the insect population of these territories lays this venturesomeness

* Crop Protection Products Approval Scheme. Approval List: 1956. Published by the Ministry of Agriculture, Fisheries and Food, United Kingdom.

open to grave risks. It is in these territories also, especially where yields are characteristically low, that over insistence on the benefits of crop protection may lead to neglect of husbandry improvements. Take the case of cotton in some parts of East and West Africa. Early sowings, unsprayed, yield, in spite of insect damage, better than late sowings with repeated sprayings. Now, early sowings and also spraying would have been the right course, but the former—the early sowing—is the first thing to encourage.

Farmers, with scientists, look forward to new substances and methods for crop protection. History is long enough with some crops to make it worthwhile to look backward as well. Insect populations in apple orchards, harmful and beneficial alike, seem to have shown a steady compositional change, probably not unconnected with the change in chemical protectives used; and with, though not necessarily entirely through, these changes total costs of protection have steadily gone up. Must these changes go on unchecked and undirected, the effects of each protective regime being so to change the insect population that a new set of protections is made necessary, and so on and on? All concerned must obviously accept, what is now axiomatic among entomologists, that the entire insect population of a crop—indeed, the locality in which the crop is situated—must be studied. To study and apply protection against obnoxious organisms one at a time, as in the past, is liable to create a new problem everytime an old one is solved. Hopes that protection from disease would eventually be provided in full by resistant varieties have become tempered by proof of the abundance and capacity for rapid spread of biologic strains in many fungal groups. But against this may be set the new resources supplied to breeders by cytogenetics—the power to move genes not only among nearly related forms but among widely related also. It is necessary to ask how this ability and other resources compare with the genetic and breeding work on resistant varieties. That greater resources should be given to the one than to the other must not be assumed, for their claims depend upon the probability of success. The Conference will listen with close attention to the authoritative assessment of the prospects of protection by plant breeding which is to occupy one of its sessions.

The diversity of physical and other circumstances of crop production in the various world climatic regions, the dependence of practical progress in protection upon basic knowledge of inimical organisms and of host plants, and the essentiality and scope for concert among the sciences are the things which seem, from the agricultural point of view, to make up the environment of thought on crop protection.

Chemical control of pests and diseases is now coming into university teaching. In agricultural courses it is essential, its substance there being practical uses with simple explanations of chemical and biological aspects. If more advanced teaching were to be considered, the initial question would be how much scientific knowledge specific to or primarily arising from or concerned with chemical control is available. A body of practical, factual knowledge, even if much greater than that now available, would be no foundation for an advanced university course. For deeper scientific understanding of control, more knowledge of insect physiology and its chemical responses, of insect reproduction and population phenomena and of insect-host relationship is indispensable, with an analogous requirement for diseases. There is not likely to be, for a long time, enough primary knowledge and basic principles in these fields to constitute a subject of advanced teaching. Well trained entomologists and mycologists, strong, also, in chemistry, and good chemists suitably knowledgeable in biology are the best material for basic and applied research in chemical control. The normal honours courses can provide them and they will be attracted to chemical control in measure as this subject moves from empiricism on to firm scientific foundations.