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The Environment and Agriculture

IMPLICATIONS OF THE PESTICIDE AGE

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We are living at a unique and crucial period in time. Many of the problems which face us today have never occurred in the past, and therefore history cannot help us to solve them : we have to study and act without the advantage of past experience. The great issues of the day are essentially ecological ; that is they concern the relationship of populations with each other and with their environment. For practical reasons we think of the population problem, the disease problem, the conservation problem and the pollution problem as being separate, but of course they are all connected and interact with each other. The increasing complexity of science, technology and administration makes it harder than ever to relate these problems, and yet the need to do so becomes increasingly obvious and increasingly urgent. I shall attempt here to relate one technology—the use of pesticides—to the complex of related problems mentioned above.

A number of organisms use toxic substances ; grasses whose roots exude substances which affect competing species, nettles, jellyfish, spiders and snakes are well known examples of organisms which use chemicals to protect themselves or to kill their prey. For centuries human beings have hunted wild animals with poisoned arrows. The insecticidal properties of nicotine were discovered in the 17th century, but man was slow to develop chemical agents in order to control competing species. In fact, one of the first major developments was for intraspecific conflict ; in the first world war poison gases were developed and used, in the second world war they were further developed but happily not used. However, the discovery of organophosphorus insecticides, which were developed originally as war gases, and also the discovery of the organochlorine insecticides DDT and BHC, and of the growth regulating weed killers, all in the second world war, led to a revolution in the fields of preventive medicine and agriculture in the years which followed it. The rapid growth in production and use of herbicides, fungicides, insecticides, rodenticides *etc.*, which today are known collectively as pesticides, was phenomenal. When social historians get further from the past quarter of a century they will probably affirm that the development of pesticides from 1945 onward was one of the turning points in human history.

Boon and Bane

The value of pesticides was and is enormous ; they have saved millions of lives and greatly increased food production and reduced the waste of stored food ; but like all technological advances, they have brought new problems as well as solving old ones, so that today, at least some people believe that the disadvantages of pesticides may even outweigh their advantages.

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A recent scientific symposium in Britain was entitled "Pesticides—Boon or Bane?" Of course, they are both boon *and* bane, and this has been the cause of much controversy. So great are both their advantages *and* their potential dangers that it is not surprising that the pesticide debate has been such a prominent feature of recent years. At times it has been acrimonious, ill-informed and nonscientific, but no one would deny that it is about an important issue ; it is in fact central to the great ecological problem of our age. It is generally accepted that the rapid increase in the world human population is largely due to the reduction of mortality rates, and that this in turn is largely due to the control of disease vectors by insecticides. That the world has been able to feed the vastly increased human population is also due to the widespread use of insecticides and of herbicides and fungicides, although the greater use of fertilizers, irrigation and improved genetic strains had played an equal, if not more important, part. Thus, pesticides have increased the human population and have helped make the agricultural environment more capable of supporting this larger population. On the debit side, pesticides have created new pests, they have destroyed millions of organisms which are harmless or are valuable to man, and, for the first time, chemical substances used as poisons have become global contaminants. How has this come about? To understand the reasons it is essential to consider what pesticides are and what it is they affect.

For practical reasons the farmer tends to think of a pesticide as if it were a medicine administered to his crop ; as with some medicines, it may have undesirable side effects. This view is inadequate and is a totally unscientific way of considering what actually happens when a pesticide is used. Unfortunately, no pesticide is specific to the pest against which it is applied. Different species vary greatly in their response to the same chemical ; even so, each and every pesticide application will result in the death of numerous organisms other than the pest ; in other words, there are always side effects, whether or not they appear important to the man on the spot ; and pesticides are bound to affect the whole ecosystem in which the crop and the pest are living. Even the simplest ecosystem is extremely complex and contains many species of plants and animals. So great is the complexity of all ecosystems that very little is known about the causal factors within them; therefore, whenever a spray is used it is being applied to a system which is very imperfectly understood. There are many types of effect which occur when a pesticide impinges on the population of a species. First, there are the toxicological effects—a proportion of the population will be poisoned and others will suffer sublethal effects, which may make them more susceptible to other deleterious factors, or may affect a future generation by impairing reproduction. Some toxic effects can be delayed, as when a predatory animal is poisoned by obtaining amounts of a persistent insecticide which have been accumulated by the prey animal on which it feeds. Secondly, the normal balance of ecological relationships, for example, those between competing species and between prey and predator, are likely to be upset when the different organisms in the ecosystem vary in susceptibility to the pesticides, as they always do. For example, the mosquito *Anopheles hispaniola* and three other species benefited at the expense of *Anopheles labranchiae* when Sardinia was sprayed with DDT in order to eliminate malaria. Indirect ecological effects of pesticides have had important economic consequences, for example, large sums of money now have to be spent annually in order to control red spider mite and related species ; before pesticides

were used extensively, these animals were adequately controlled by predacious mites and other wild predators, but nonselective sprays have reduced the populations of the latter to such an extent that those of the red spider mite were released from normal control and so became pests.

A new environmental situation

All pesticides are liable to produce problems but since most substances are broken down quite rapidly into harmless metabolites, these effects are usually local and transient. The power of recovery of most ecosystems is strikingly great : it can be assumed that this is a function of complexity. However, organochlorine insecticides produce quite a different sort of problem because they are both highly persistent and soluble in fat. These characteristics enable them to spread outside treated areas and to accumulate in the bodies of animals and hence in food chains. Persistent organochlorine insecticides have been detected in the component parts of all the major ecosystems : on land in soils, plants, insects, birds and mammals, and in rivers and the sea in muds, water, fish and fish-eating birds and mammals. Many vertebrate animals have been analysed for these chemicals and nearly all of them have contained detectable amounts of DDT and its metabolites and of dieldrin ; many also contained heptachlor epoxide and isomers of BHC. The specimens have contained pesticides even when they were obtained from remote parts of the Arctic and Antarctic. Therefore, there is today a totally new environmental situation—practically all life on the earth is now in contact with synthetic organic toxins. The extent to which these substances are having effects depends on the amounts obtained by the different organisms ; the quantities in rainwater and the sea are extremely low and in some cases are undetectable ; they are extremely unlikely to have biological significance as such, but pesticides at these very low levels can be significant if they become concentrated by living creatures. Organomercury fungicides also become widely dispersed and accumulate in food chains ; increasing concern is being voiced about the abnormally high levels of mercury found in wildlife in several countries.

To understand the biological significance of environmental contamination by pesticides, many toxicological and ecological data have to be collected and assessed. In general, the animals which have obtained the largest amounts of persistent compounds have been the most affected, as one would expect. They belong to two classes : first, those animals which live in sprayed areas and so receive large doses directly or by eating heavily contaminated food, and secondly, predator species at the ends of food chains. Local casualties may be considerable but they do not appear to have caused serious damage to most species. However birds of prey, especially those which feed on other birds, such as the peregrine falcon and sparrow hawk, have been very seriously affected by acute toxic effects. In addition, organochlorine insecticides have been shown in the laboratory to produce a number of sublethal effects on birds, including the thinning of eggshells, delay in ovulation, histological changes in the thyroid and effects on steroid hormones. At least some of these effects, notably the thinning of eggshells, have occurred widely in the field in both the United Kingdom and the United States and elsewhere. In some cases there is good evidence that the sublethal effects have caused, or could cause, population declines quite apart from those due to acute effects.

Economic damage

At the present time one can conclude that several species of birds of prey in the northern temperate regions have been seriously affected by persistent organochlorine insecticides. It would be rash to say that no other species have been affected by these substances, but there is not conclusive evidence that they have been. On

the other hand, the existing levels of organochlorine insecticides in many animals, including very sensitive freshwater and marine species of invertebrates, strongly suggest that a moderate increase in contamination by these substances throughout the world could put many species in jeopardy, including those of great economic importance, for example, the food organisms of commercially exploited fish. Thanks largely to the studies on birds of prey, the world has been alerted to great potential dangers, and many nations have taken practical measures to reduce the amounts of organochlorine insecticides used. In some countries the levels in the environment of these substances are no longer increasing and may actually be falling, and so possible disasters have been avoided.

The present time is unique

We have just noted that the study of relatively rare and economically unimportant species of birds of prey provided an early warning of very considerable potential danger. This raises the whole question of conservation ; again the present time is unique ; for many centuries man has had immense effects on the other inhabitants of the earth, but despite his destructiveness and his abundance, the vast majority of animals and plants which existed in early historical times have continued to exist. This is because large areas have remained virtually untouched by man, and because agricultural and pastoral landscapes have still provided suitable habitats for many species. Today, due to the rapid increase in man's population and to new technologies, the wildernesses are rapidly disappearing, and under intensive agriculture, farmland is becoming less and less suitable for most wild species. In the past we had wildlife without planning for it, but very shortly we will only have it if we plan to conserve it, in other words, if we spend money on it. This is forcing conservationists to clarify their aims and to attempt to define the value of wildlife. In practice wildlife is conserved for a variety of different reasons—as a source of food, for greater efficiency in agriculture, for sport, for scientific and educational reasons, for attracting tourists from other countries, and last, but certainly not least, for the immense pleasure wild plants and animals give to peoples of many countries and cultures throughout the world. As man becomes more numerous his appreciation of his environment and of other species tends to increase, and he becomes more aware of what he may lose. Appreciation of wildlife is becoming one of the most accurate indicators of sound cultural development.

Implicit in all conservation practices is the attempt to maintain biological diversity for the present and the future. Conservation is one of the few activities in which specific actions are undertaken now on behalf of future generations. Human societies have always varied greatly in the extent to which exploitation has been balanced by concern for future productivity ; some have created deserts while others have maintained ample resources. However, the implications of the human population explosion and of the destructiveness of some agricultural and industrial technologies should be forcing every responsible person to have a greater concern for husbanding the world's resources ; too few yet realise that these are very far from being limitless.

International aspects

The discovery that organochlorine insecticides had become global contaminants, and in the case of a few species, were already harming populations over very large areas of the earth's surface, was valuable in that is showed that the earth's biological resources could be affected by unconscious pollution as well as by conscious exploitation. So, when polychlorinated biphenyls, which are industrial compounds used

in the plastics and insulating industries, were found recently to be present in wildlife in many parts of the world, no one needed to be told of the significance of the discovery because they had been alerted by previous experience with DDT. Widespread interest in pollution problems became particularly manifest in 1969, two years following the Torrey Canyon disaster,* the year of the endosulphane spillage in the Rhine and of the seabird wreck in the Irish Sea. It is extremely encouraging that an increasing number of governments are concerning themselves with research on pesticide and other pollution problems and with action to prevent damage in the future. Also, throughout the world people are beginning to realize that pollution problems must be tackled internationally as well as nationally. There is a welcome discussion about these issues in the great international agencies such as FAO.

The needs of different countries vary greatly. Everyone would seek to reduce environmental contamination by dieldrin and DDT or indeed by any other toxic substance, but whereas some countries can restrict the uses of these substances for the benefit of themselves and the world community, others cannot possibly do so until adequate substitutes have become available. Nevertheless, much could be done now to increase the efficiency of pesticide use and to decrease avoidable damage ; much is already known, but the information is not always available to the people who most need it. New pests and resistant strains of old ones are being produced unnecessarily as a result of unscientific crop protection. Endrin, a compound which is exceptionally toxic to fish, is still being used in rice fields where fish are an important source of protein for the local inhabitants. Effluents containing appreciable amounts of pesticides are still being discharged into rivers and the shallow seas which also support important stocks of fish. The reasons for all these different forms of misuse are obvious—the excessive zeal of some chemical salesmen, inadequate labelling of some containers, some complacency among national and local authorities and sheer ignorance. Some of the developmental problems are more radical. For example, it does not pay industry to look for and market specific pesticides, or to study new methods of integrated pest control, when these reduce the amounts of pesticides sold, and therefore reduce profits. So, only governments can sponsor adequate research on specific pesticides and integrated control effectively.

Much remains to be done before we can obtain the most efficient use of the pesticides which are already available. Some methods of use which are current today seem naive and dangerously inefficient ; in a few years they may seem reprehensible. The side effects which have caused a new agricultural problem and harm to wildlife have been regrettable, but I believe that they have had very great value in focusing attention on the real nature of the pesticide problem, which as we have seen is part of the much larger ecological problem which mankind faces today. If we pursue a more critical approach to pesticides, there is no reason why they should not save more lives and increase food production further, while at the same time we should be able to reduce the damage done to acceptable levels. But if we do not heed the lessons learned during the last few years, and above all do not connect the component parts of the pollution/environment problem, we shall deserve what we get.

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*The Torrey Canyon, charted by the Union Oil Co., California, ran aground off Cornwall, at the western tip of England, on 18 March 1967 and caused the greatest beach pollution damage on record. In addition, detergents used in the clean-up efforts severely damaged fish, molluscs and marine plants. Birds died by the thousands, choked by oil. By 9 April the oil had reached the French coast of Brittany. Two years later the Union Oil Co. settled out of court with the British and French governments for $7.2 million which was divided equally between them.