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# FUNGICIDES AND THE TROPICAL ENVIRONMENT

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The tremendous upsurge in the production and use of agricultural pesticides during the last quarter century has created some problems. These problems are of two kinds : those concerned with the hazards to human health, livestock and wild life, and those resulting from unexpected and sometimes undesirable side effects that follow action against a particular pest or disease of agricultural importance. Hazards to human and animal health can arise either from the consumption of food containing toxic residues of pesticides or as a result of the pollution of the environment. Residues in harvested crops can be controlled to a large extent, if the users follow strictly the recommendations of the manufacturers and the extension biologists regarding doses and safe intervals, and this problem is, therefore, of minor importance, compared with the more specialized problem of pollution. As regards the problem of side effects resulting from the use of particular pesticides, although one can think of many instances where undesirable side effects have occurred, it is difficult to find an example of a case where the secondary trouble has resulted in more economic loss than the primary one and, therefore, there is invariably a nett gain.

The term pesticide refers to all chemicals used in agriculture today for the control of pests, diseases and, in a broad sense, weeds as well ; thus pesticides include insecticides, miticides, nematicides, fungicides, antibiotics and herbicides. However, when one thinks of pesticides in relation to the pollution of the environment, it is especially insecticides which are uppermost in one's mind, obviously because they are the most hazardous members in the family of pesticides on account of their high toxicity and persistence. Consequently, the effects of insecticides on the terrestrial, freshwater and marine environments have been studied in minute detail and insecticide residues have been detected in a wide spectrum of physical and biological samples, indicating that contamination is widespread. In some instances, harmful effects have been clearly demonstrated but more frequently the effects of such residues are unknown. On the other hand, relatively little is known of the effects of fungicides on the environment, plant and animal life ; the object of this article is to discuss this problem briefly with special reference to the tropics.

## Major diseases and fungicides used

Before discussing the effects fungicides could have on the tropical environment, it may be worthwhile to consider the type of fungicides used to control the major plant diseases of tropical crops. Table 1 summarizes the main diseases of tropical crops that are controlled by fungicides and the fungicides used.

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TABLE 1 — *Important diseases of tropical crops controlled by fungicides and the fungicides used*

| *Crop* | *Disease* | *Fungicide* |
|---|---|---|
| Banana | Leaf Spot (Sigatoka disease) | Oil, combination of oil and copper |
| Citrus | Foot Rot, Scab | Copper |
| | *Oidium* | Sulphur |
| Cocoa | Pod Rot | Copper |
| Coffee | Coffee Rust | Copper |
| | Coffee Berry disease | Copper, organic fungicides |
| Cotton | Damping-off | Mercuric compounds |
| Groundnut | Leaf spots | Copper, sulphur, organic compounds |
| Maize | Seedling Blights | Organic fungicides, mercury compounds |
| Rice | Rice Blast | Copper, antibiotics, organophosphorus compounds |
| Rubber | *Phytophthora* Leaf Fall, Pod Rot | Copper |
| | *Oidium* | Sulphur |
| Tea | Blister Blight | Copper, nickel salts |
| | Root pathogens | Methyl bromide, D-D |
| Tobacco | Wildfire, Blackfire, Blue Mould | Copper |
| | Root diseases | Organic fungicides<br>Methyl bromide, D-D |

The materials used seem to fall into four main groups,

1—copper-based products,
2—sulphur,
3—organic fungicides including antibiotics, and
4—mercuric compounds.

It is clear that the most widely-used fungicides are the copper-based products. Most of the copper used in agriculture is in the form of Bordeaux Mixture, though fixed coppers such as copper oxychloride and cuprous oxide have grown in importance since their introduction in the 1930's, because their preparation for use is much simpler than that of Bordeaux Mixture. Tea is one crop which receives a substantial quantity of copper sprays mainly for the control of Blister Blight. In some plantations in the high country of Ceylon, copper may be sprayed as many as 20 times during the year, although the dosage used is low. A major portion of the copper is probably washed on to the soil and it adheres to the soil particles on the surface. Very little copper is likely to infiltrate into the lower layers of the soil because of the low solubilities of the products sprayed and for the same reason, only small quantities can be removed by surface run-off. The copper adhering to the top soil is apparently washed away during heavy rains and ultimately finds its way into the sea *via* the streams and rivers. No serious attempts have been made to determine the levels of copper in fresh or salt water, but there is nothing to indicate that abnormally high levels of this metal are building up as evidenced by death or injury to fish or other aquatic or marine life.

A recent investigation into the levels of copper in tea soils indicates that there is no likelihood of the copper content of tea soils reaching danger levels due to prolonged spraying for protection against Blister Blight. In an experiment in which plots were sprayed weekly at 140 g/hectare for over three years, the content of copper in the top 15 cm of soil was not significantly different from that of the control. In the same experiment, plots which were sprayed at 280 g/hectare, however, had slightly more copper in the soil than the untreated control, but there were no indications that the growth of the tea on these plots was affected in any way. On the contrary, these plots gave high yields. A high concentration of copper in the soil,

of course, could have detrimental effects on its microflora and fauna and thereby affect its structure and fertility. However, not a single case has yet been reported of the loss of fertility due to the use of fungicides, either copper or other products, on well-managed plantations operated on modern lines. In this context, it is interesting to note that estates and farms which use pesticides extensively are those which produce the highest yields.

Frequent copper spraying could be harmful to certain entomogenous fungi that help keep some insect pests under control, but there is no evidence that this does happen because no pest outbreaks have resulted as a side effect of copper spraying. There is evidence, however, that continued copper spraying can lead to mite outbreaks in tea, especially the Purple Mite, *Calacarus carinatus,* but it has been shown that the build-up of mites is not due to the copper applied but to certain particulate matter used in the formulation of the fungicide.

Sulphur is used in the tropics mainly to control *Oidium* of rubber and citrus, three to four applications being sufficient to control the disease under normal conditions. For control of *Oidium* on rubber, dusting is usually carried out with power-driven machines with a vertical range of 60 to 80 ft and there is little doubt that this will result in at least temporary contamination of the atmosphere. Inhalation of air contaminated with sulphur may be injurious, but there is little published information on this subject. The sulphur drifting into the air probably gets occluded on to dust particles and is scrubbed out by rain while that which is deposited on vegetation will also be washed down by rain on to the soil. The fate of the sulphur that reaches the soil is probably similar to that of copper, but the little that penetrates into the soil is oxidized by biological action to sulphuric acid, which will then react with calcium phosphate and other substances to form sulphates. The sulphates and sulphuric acid thus formed are available for plant growth. Although sulphur is an essential, major element for plant growth, an excess of sulphuric acid can make the soil too acidic and create nutritional problems and the soil may then need treatment with lime. To overcome this difficulty, sometimes lime-sulphur is used instead of pure sulphur.

The organic fungicides based on compounds such as Ziram, Thiram, Ferbam Captan, Zineb and Maneb are steadily making headway, mainly replacing copper fungicides, but their use in the tropics is still somewhat limited probably because under tropical conditions they breakdown more rapidly. They are generally less phytotoxic and more specific than copper fungicides and are therefore likely to be less harmful to crops and microflora. As some recently-developed insecticides (Sevin, Metacil, *etc*) are based on thiocarbamates, it is not unlikely that the dithicarbamate fungicides could have some influence on the insect fauna of orchards and plantations. Fungicides such as Antracol and the latest systemic fungicide Benomyl have been claimed to possess acaricidal properties.

Compounds like Thiram are used widely for treatment of maize, sorghum and groundnuts for protection against seed-borne fungi, and such treatment may bring about changes in the soil fauna and flora but these are rarely detrimental and often normal conditions are restored in a matter of weeks.

Recently a number of antibiotics and organophosphorus fungicides have been developed and used in Japan to control rice diseases. It is claimed that these compounds are of very low toxicity and quite safe for mammals and fish and other aquatic life at the recommended dosages. They have been in use only for a few years and it is too early to say what effects they will have especially on fish life when used over long periods. There is unlikely to be any serious residue problem because of their rapid breakdown and low mammalian toxicity. Their degradation in soil is also rapid.

Where soil is treated with volatile materials like methyl bromide and D-D, for treatment of soil-borne diseases, loss by volatilization is a major factor in their disappearance. Inhalation of air contaminated with these products might present a hazard to man and other animals, but if fumigation is carried out in the open the fumes are quickly dispersed and there is seldom any serious trouble. There is now a good deal of evidence which indicates that soil treatment with volatile disinfectants sometimes results in striking increases in the growth and yield of crops, even in the absence of obvious root-disease parasites. Further, fumigation inhibits soil nitrification without affecting ammonification in the treated soils, so that ammonium compounds accumulate. It also stimulates the growth of certain fungi like *Trichoderma* spp., while suppressing many others. Soil fumigation also checks weed growth for variable periods after treatment, but it must be pointed out that many of these side effects are beneficial and in any case all of them are temporary and the situation returns to normal after some weeks.

The mercurial seed dressings control a wide variety of diseases, among the more important being seedling blights of maize and black arm of cotton. During the last decade, organo-mercurial dusts were used on a large scale in Japan and some South East Asian countries to control rice blast but they have now been replaced by organic fungicides. The danger of cumulative mercury toxicity in soil following repeated use of mercury compounds has been investigated in the past and results indicate that the fear is groundless. The use of mercury as a fungicide is, however, coming to an end. It is being replaced by safer organic fungicides.

Small quantities of nickel and tin compounds are also used for the control of tea Blister Blight and potato Late Blight respectively, but their effects on the environment have not been investigated. The nickel compounds used are mostly the chloride and the sulphate and both being freely soluble should be leached out of the soil rapidly under tropical conditions. The tin fungicides on the other hand, are insoluble and are, therefore, likely to linger in the top soil for longer periods until their eventual removal by erosion with the soil. These fungicides are unlikely to have any significant effect on aquatic life because their concentration in water would indeed be very low. Available information on nickel residues in made tea does not suggest any hazard to human beings who consume tea sprayed with nickel salts. There is also no record of systemic poisoning from nickel salts. Further, it is also highly unlikely that spraying with nickel chloride at the low concentrations required for blister blight control can lead to a build-up of nickel in the soil to levels harmful to plants. The harmful effects, if any, of mineral oil, which is used widely either alone or in combination with copper and zinc fungicides to control banana Leaf Spot are not known.

Finally, a few words on the effects of fungicides on the plant itself. Although a wealth of information exists on the application and effectiveness of a variety of chemicals against certain selected diseases or pests, there is urgent need for information on their effects on plant vigour and growth. This is especially important in the case of perennial crops which may receive repeated applications of the same spray schedule over many years. Since it is known that many pesticide schedules alter the soil-plant rhizosphere interactions, membrane permeability, translocation and transpiration processes, photosynthesis, nucleic acid and protein synthesis, it is obvious that detailed studies in crop physiology are necessary to properly evaluate the phytotoxic effects of pesticides.

It should be evident from the foregoing that at least in so far as fungicides are concerned there is no immediate cause for alarm. There appears to be no danger of the atmosphere being rendered poisonous and made unsuitable for plant and animal life or the soil becoming infertile and unproductive due to the continued use of fungicides for plant disease control. Pollution of the atmosphere, water and soil is a problem of vital importance but it is now clear to everybody that the problems created by industry and the motor vehicle pose a much greater threat to plant, man and animals than are fungicides, the use of which can easily be regulated and if necessary even withdrawn completely.

Although the wide-scale use of fungicides is not likely to confront us with any serious problems in the near future, or perhaps at any time, it is still something to be deplored. More serious thought should be given to other methods of disease control such as modification of cultural practices, use of genetical resistance or tolerance, disease eradication and quarantine and chemical control resorted to only if these methods fail and not *vice versa*.

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