SYMPOSIUM

The Effects of Continued Widespread Use of Organic Insecticides

INTRODUCTION

M. Curtis Wilson, Purdue University

The dominant problem in applied entomology today is the determination of the effects of the use of organic insecticides on the world and civilization. It is a problem which has arisen in very recent times and a problem of great concern. It is a relatively new problem because the organic phosphate and hydrocarbon insecticides did not come into general use until the years following World War II. We are all aware of the stimulus the discovering of the killing powers of DDT had to chemical control of insects.

Following only a few years of insecticidal use, many problems have become apparent and scientists are confronted with many questions which with available data can be answered only in part. In this symposium the general topic has been divided into four parts as follows: The effects of continued widespread use of organic insecticides on, 1. the insect balance of nature; 2. wild life other than insects; 3. plants and soil; and 4. human health.

Effects on the Insect Balance of Nature.[1] Frank N. Young, Indiana University.—The use of organic insecticides against insect pests has been extended so rapidly in recent years that the long range effects of continued widespread use are still unpredictable. The areas involved and the amounts of material used are still too small to effect massive changes in the natural insect fauna of the earth. Even the extensive forest spraying programs, such as those in New England and in southern Canada, do not give us positive evidence that the balance of nature, if such exists, has been seriously upset. Neither the ebullient prognostications that the organic insecticides were the panacea for all our control problems, nor the dire forebodings that they would completely destroy our beautiful and delicate wildlife have been realized. We are gradually achieving a better perspective in regard to the toxic organic compounds as useful tools of the economic entomologist—some better, some poorer than others at his command.

It is quite evident, however, that if we apply organic insecticides or any other highly toxic material in heavy concentrations to a limited area certain disturbances of the insect fauna follow. Often, the most immediate result is that the pest against which we applied the poison increases

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out of all proportion after the insecticide loses its toxicity. Another effect which becomes evident over a period of time is the increased resistance of certain pests to particular insecticides.

The first of these effects is clearly seen in the use of DDT oil or emulsion sprays on small ponds, or catchments. Almost invariably, after a certain lapse of time, pest or disease-carrying mosquitoes increase greatly in such situations so that repeated spraying is necessary. It seems evident that the great increase in the pest insect is due to the reduction of natural competitors, predators, and parasites. The changes in abundance follow Volterra's mathematical generalization that if a population is being destroyed uniformly by an outside agent, eaten animals tend to increase and eaters tend to decrease. If left alone the various organisms return to a relative balance with seasonal and other rhythms dependent upon increases or decreases in the initial conditions. (See appendix in Chapman, *Animal Ecology*, 1931).

The same general principles apply to many insect populations. The use of organic insecticides on citrus and other tree crops almost always results in the subsequent increase of red mites or other pests. Experiments have shown that these increases are largely due to the reduction of predators or parasites, but they may also be partly the result of dispersal of the organisms throughout the area involved. A recent example is the increase of the Oriental fruit moth on peaches in Virginia, following the spraying of orchards with BHC for control of the plum curculio. Here the moth was formerly kept in check by larval parasites which were apparently reduced in numbers by the spray program. (See Bobb, *J. Econ. Ent.*, 44:418-420, 1951.)

Under many conditions, the unbalancing of the population system in a situation is of no importance to the entomologist. For example, on a small army post in a relatively well-drained region it is possible to spray periodically every mosquito breeding situation which cannot be drained or filled. On the other hand, taking a long term view of the results, such an intensive control program may be very dangerous to the human population involved. On the Gold Coast of Africa our elaborately sanitated bases protected for a time a considerable number of natives, who having lost their immunity to malaria (or their chronic infections) were severely affected when the bases were abandoned at the end of the war.

The use of organic insecticides has also been shown to have disadvantageous effects in destroying predators and parasites in field crops under certain conditions. Willie (*J. Econ. Ent.*, 44:13-18, 1951) reports a very interesting result of spraying cotton with various compounds (BHC, toxaphene, DDT, and others) in Peru. He found that under normal conditions the principal cotton pest of the area, *Heliothis virescens*, was rather effectively controlled by various hemipterans which are predators on the eggs of the moth. The bugs destroyed up to 90% of the eggs, while DDT, the most effective poison used, killed only 75% of the eggs, and larvae. Spraying with any of the toxic compounds, however, resulted in increased damage after their toxicity had worn off. He suggests timing of irrigation together with natural controls to minimize damage under the conditions present.

The production of resistant strains by insecticide action may also upset the natural balance, and forms resistant to insecticides may show different behavior patterns and characteristics which lessen the effectiveness of natural predators or parasites. The increased resistance of houseflies to DDT is a well-known example of this phenomenon. We might raise a question in regard to using insecticides with different modes of toxic action on resistant strains: Will continued selection produce super-super resistant insects?

Various suggestions have been made in recent years for lessening the disadvantageous effects of applications of toxic materials and for bringing the chemical control program into better balance with biological control (See DeBach, *J. Econ. Ent.*, 44:443-447, 1951). Selective insecticides which kill the pests, but not their predators or parasites seem to offer a promising lead. Recent experiments have involved such clever techniques as coating DDT pills with hemicellulose making them lethal only to phytophagous insects which have the enzyme hemicellulase to dissolve the covering. Systemic insecticides which are transported by the plant to sap-sucking insects are another possibility. In the latter, however, the problem of toxic, unpleasant, and other residues is important (See Ripper, *et al.*, *J. Econ. Ent.*, 44:448-459, 1951.)

The problems of unbalanced populations resulting from the continued large scale use of organic insecticides are essentially ecological. They involve the problems of the habitat complex and the concept of biotic communities. Many interesting lines of research are indicated, but they all seem to lead toward more intensive cooperation among many different fields. Perhaps we have placed too much emphasis on the complete control of insect pests. The possibility of an intermediate stand in which we give up part of our superfluities in exchange for long-term advantages should be investigated further.

Effects on Wildlife Other Than Insects. WILLIAM D. FITZWATER, JR., U. S. Fish and Wildlife Service, Purdue University.—The history of economic entomology has been a progression more rapid in recent years, from the more innocuous insecticides, such as pyrethrins, to the more dangerous, such as the organic phosphates. The need for these more toxic substances in controlling obnoxious insects in agricultural and forest areas has presented a new hazard to our wildlife resources. The influence of these organic insecticides may be felt in at least four ways:

1. Primary Poisoning

Primary poisoning is the direct destruction of wildlife through skin absorption or the ingestion of poisoned vegetation. Field applications for insect control are generally at concentrations that present little or no danger to vertebrate animals from direct poisoning. Mitchell (J. Wildlife Mgt., **10**:192-194, 1946) found that even at the rate of 5 pounds per acre, DDT sprayed directly over the immediate nest area of various species of birds had no detrimental effect upon the hatching of eggs or the development of young. Other studies (See Stickel, J. Wildlife Mgt., **10**:216-218, 1946) have shown that the actual deposition of insecticide on the vertebrate animals' habitat is a very minute fraction of the actual poundage applied.

Therefore, in the treatment of agricultural and forest crops it seems certain that when minimal amounts are applied the danger of killing vertebrates directly is of minor significance.

This discussion would not be complete without a word concerning the intentional use of organic insecticides in the control of injurious wildlife. Rotenone has been used as a fish poison long before it was utilized for the control of insects. Nicotine has been recommended for controlling unusual snake populations under drought conditions (See Stickel, U. S. F. W. S. Leaf. 345, 1953). Several chlorinated hydrocarbons have shown rodenticidal possibilities as tracking dusts for the control of house mice (See Smith, Unpubl. Ms., Ohio State Univ., 1951). The most recent development has been the use of ground sprays of chlorinated hydrocarbons or organic phosphates for the control of field mice in orchards. While toxaphene, aldrin and dieldrin have shown the most promise in this respect, the concentrations necessary to control mice constitute a real hazard to beneficial wildlife and domestic animals using the same areas.

2. Secondary Poisoning

Secondary poisoning is mortality caused by the consumption of poisoned insects by vertebrate predators. Here the evidence is even more fragmentary under actual field conditions. George and Mitchell (J. Econ. Ent., 40:782-789, 1947) found that in a forested area treated for spruce budworm infestation with DDT, nestlings that received both poisoned and unpoisoned material were not affected. Under controlled conditions where the nestlings were fed exclusively on sprayed material, mortality was high from loss of vitality due to a starvation diet and a high susceptibility to DDT toxicity. Therefore, it is logical to suppose that when young on the nest are fed high portions of DDT-poisoned insects and later receive an insufficient food supply due to the scarcity of insect life, the bird population would suffer markedly.

3. Limitation of Food Supply

The limitation of available food for insectivorous wildlife is a necessary corollary to area treatment with insecticides. This factor is taken advantage of in one of the recommended controls for moles. The formation of barriers with chlordane, DDT, etc., has been found effective in limiting the movements of moles by the creation of foodless areas. Extensive spraying undoubtedly has some influence on bird populations as insect samples have shown that six to seventeen times as many insects are found on unsprayed plots as compared with treated plots (See Mitchell, et al., J. Wildlife Mgt., 17:45-54, 1953). Inasmuch as it takes six to eight weeks before the insect populations return to normal, this must exert a very significant influence on the bird population, particularly when the treatment coincides with the nesting periods.

4. Reduction of Ectoparasites

Lowering natural mortality of wild species by the reduction of their insect parasites is probably of minor importance under field conditions. The use of DDT dust, however, is a recommended supplement to rat control measures in typhus areas to reduce movement of the disease vectors

from dead rats to human hosts (See Hill, et al., Am. J. Pub. Health, **41**: 396-401, 1951).

The value of wildlife is based mostly on intangibles rather than dollars and cents. Therefore, it is inevitable that economic pressure will cause more extensive use of insecticides in direct conflict with the welfare of our wildlife. This conflict can be lessened somewhat if attention is given the following recommendations:

1. Limit the application of insecticides on an area basis to minimal areas. Use insecticides as a rapier not as a broadaxe. Weigh carefully the value to be received from the control measures against the dangers to wildlife. Where possible in the treatment of extensive areas leave sanctuary strips to aid the wildlife in weathering the lean period until the insect population builds up again.

2. Use the minimal amount required to kill the insects. With DDT, for example, it has been found that in tracts sprayed at the rate of five pounds per acre the bird population dropped from 3.2 per acre to 0.5 per acre within two weeks (See Hotchkiss and Pough, J. Wildlife Mgt., **10**:202-207, 1946). On the other hand, where only one pound per acre was used there was no significant change in the avian population. Cottam and Higgins (U. S. F. W. S. Circ. 11, 1946) have recommended that less than 1/5 pound per acre of DDT be used to prevent danger to fish and reptiles while 2 pounds per acre should be the maximum for the safety of birds and mammals.

3. Spray before or after the chief bird nesting periods. Take advantage of the residual effect and treat just before the emergence of leaves and the arrival of birds from the south. When sprays are indicated later in the season they should be delayed until mid-August in Indiana. At that time the main nesting period has passed.

4. Avoid direct application of sprays to bodies of water. Inasmuch as fish have been shown to be very susceptible to DDT, care should be taken in aerial spraying to avoid water areas.

5. Choose oils or wettable powders in preference to emulsions. Emulsions, being more readily absorbed, are more deadly to vertebrate species. Surber (J. Wildlife Mgt., **10**:183-191, 1946) showed that DDT wettable powders killed only a few fish. In ponds treated with DDT in oil, fifty to sixty per cent of bluegills were killed, but only a few bass were lost. However, in ponds treated with emulsions all the fish were killed.

Effects on Plants and Soil. D. W. HAMILTON, U. S. D. A., Agr. Res. Serv., Bureau of Entomology and Plant Quarantine.—Injury to crops from accumulation of insecticides in the soil is not new. Headden (Colo. Agr. Expt. Sta. Bul. 131, 1908) reported symptoms of injury from accumulations of lead arsenate in soils of Colorado orchards. In the Northwest, many growers have used 300 pounds of lead arsenate or more per acre each season for many years.

Boswell (U. S. D. A. Yearbook, pp. 284-296, 1952) reported that as much as 1,400 pounds per acre of arsenic trioxide had been found in the surface 8 inches. However, in general, apple trees were not seriously affected as their roots were below the surface 6 to 8 inches of soil. Serious injury and sometimes crop failures resulted when shallow-rooted cover

crops were planted in such orchards, or when the trees were removed and replaced with other crops. Injury to alfalfa, beans, and peas was especially prevalent. Crops less sensitive but showing some injury were tomatoes, asparagus, and grapes. Fortunately, the high arsenic toxicity of these soils is gradually decreasing.

DDT, the first of the new organic insecticides, was not developed as an insecticide in this country until 1943 and was not extensively used before 1945. Dieldrin, another of the new organic insecticides now being widely used, was not formulated until 1949. Since these insecticides have been used over such a short period, it is difficult to determine accurately the possible amount of plant injury from accumulated residues in the soils.

Immediate determination of the sensitivity of various plants to insecticides can best be made by subjecting them to abnormally high concentrations of insecticides in the soil. If no serious injury is apparent, it can be assumed that accumulations over a period of years are not likely to be detrimental. If small accumulations in the soil produce undesirable results, it is important to determine what plants are sensitive to the chemical and the amounts they can tolerate.

Organic insecticides vary greatly in their stability. Among the least stable are the phosphorus insecticides; DDT is one of the most stable. Persistence of these chemicals often is beneficial for the control of insects, especially those in the soil, but it may also permit a rapid buildup of toxic residues within the soil. High-volume spraying such as that used for the control of orchard insects causes the insecticides to build up the most rapidly in the soil. Chisholm *et al.* (*Jour. Econ. Ent.* 43:941-42, 1950) showed that in southern Indiana, where an average of seven applications of DDT were made on apples each year, accumulation of DDT in the soil and surface debris after 5 years of spraying was as much as 194 pounds per acre. Like the arsenicals, most of the DDT was near the surface of the soil, as shown in samples collected under apple trees; 90.7 percent was in the surface debris, 6.7 percent in the top 3 inches of soil, and 2.6 percent in a layer 3 to 6 inches deep. Deposits are not found below the top 6 or 8 inches of soil unless carried there and redistributed during cultivation or plowing.

Hoyt (U. S. D. A. Ann. Rpt. p. 75, 1952) reported that Japanese beetle investigations showed that average losses of DDT in the soil after 2 years was 8 percent, after 6 years 64 percent, and after 7 years 71 percent. A summary of the effects of residues in soils on plants by Boswell (1952) shows that germination and stands of corn were reduced where DDT was used at 100 to 400 pounds per acre, but they were exceptional cases. In other instances dosages of 1,000 pounds per acre had no effect. Residues from dosages of 50 to 100 pounds of DDT per acre reduced the growth of Abruzzi rye. It formed a poor cover crop in a peach orchard where DDT had been used for 4 years. Potatoes were highly tolerant to DDT in the soil. Cabbage, broccoli, collards, and turnips were not adversely affected by dosages up to 400 pounds. Legume plants reacted differently to DDT in soils. Snapbeans and lima beans were sensitive, some kinds very much so. Stringless Black Valentine snapbeans were heavily injured by as little as 25 to 50 pounds of DDT to the acre, and

yields were reduced as much as 50 percent with 200 pounds of DDT to the acre. Spinach, beets, and tomatoes are all sensitive to DDT in the soil. Cucurbits, such as pumpkins, squash, and cucumbers, are highly sensitive to DDT, although there are numerous exceptions. Muskmelons are less sensitive than other cucurbits.

Among the fruits, peach is known to be sensitive when its feeding roots are exposed to DDT. Several investigators have reported that strawberries are highly sensitive, light dust having prevented the formation of young plants in some instances. Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951) have shown that cotton is unaffected by DDT in the soil. In their studies tobacco showed chlorosis and the yield and burning quality were reduced slightly when it was grown in soil containing 100 pounds of DDT per acre.

Fleming (Bur. Ent. and Pl. Quar. E-737, 1948) reported that numerous species of plants subjected to normal dosages of DDT used for grub-proofing soil—25 pounds per acre—were not affected by DDT. Out of 963 plant species observed 958 were unaffected.

The reaction of plants to DDT in the soil is no indication of their response to other organic insecticides. Despite the sensitivity of certain plants to DDT many others appear to be tolerant. However, plants are less tolerant to BHC than to DDT. Boswell (U. S. D. A. Yearbook pp. 284-296, 1952) reported that Honey Dew melons were especially sensitive to BHC, whereas strawberries appeared to be tolerant. Germination of a large number of plant seeds was inhibited when they were coated with BHC or left in contact with it in the soil even where dosages were light—1 to 6 pounds of technical BHC per acre. Technical BHC in soil at 3 p.p.m. was harmful to red clover, soybean, and vetch, and at 30 p.p.m. caused serious injury. At 50 pounds per acre BHC was harmful to most crops grown in the soil the year it was applied, but was not harmful to cotton or tobacco grown the following year. Applications of 100 to 200 pounds of technical BHC consistently ruined the plantings of test crops.

While BHC has not been widely recommended for use as a soil insecticide, Dawson *et al.* (Agr. and Food Chem. 1:399-403, 1953), Gilpin and Geissenhainer (Food Technol. 7:137-138, 1953), Stitt and Evanson (Jour. Econ. Ent. 42:614-617, 1949), Greenwood (1947) and others showed that the presence of BHC in the soil is likely to cause off-flavor of vegetables, especially root crops, sometimes resulting in a complete loss. Owing to its tendency to cause off-flavor, BHC should never be used on soils in which potatoes, sweet potatoes, carrots, beets, other root crops or peanuts are to be grown. Off-flavor in tomatoes and lima beans also occurred where BHC was used. Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951 and U. S. D. A. Tech. Bul., 1953—at press) showed that when applied to the soil, both BHC and toxaphene caused off-flavor in tobacco that is objectionable to cigarette manufacturers. Annual light dosages were more objectionable than heavy dosages that had leached for 6 years.

Boswell (U. S. D. A. Yearbook pp. 284-296, 1952) reported that lindane, the gamma isomer of BHC, has little, if any, harmful effect on germination, although it tends to be about as toxic to later growth of plants, pound for pound, as BHC. However, it is less likely to cause off-

flavor. Gould and Hamstead (Jour. Econ. Ent. 44:713-717, 1951) showed that BHC applied to peach and apple replants appeared to stimulate their growth, if it did not come in direct contact with the tender rootlets. At the same time it reduced weed growth.

In tests made by Allen *et al.* (U. S. D. A. Tech. Bul. 1047, 1951) increased yields of cowpeas also followed the use of BHC. Stimulation of growth on these crops where BHC has been applied to the soil cannot be accounted for in its entirety. These investigators believe it is due to improved control of weeds, and of root aphids, nematodes, and certain other soil organisms, although available data have not always borne out these possibilities.

Stone *et al.* (U. S. D. A. Cir. 926, 1953) reported that toxaphene reduced yields of Fordhook lima beans, celery, carrots, and potatoes after three annual applications at 20 pounds per acre. Potatoes grown in this soil were off flavor. Fleming *et al.* (Bur. Ent. and Pl. Quar. E-829, 1951) showed that more than 50 percent of the initial deposits of toxaphene in the soil were lost after 40 months. At this rate of breakdown excessive residues of toxaphene when applied at the present recommended dosages seem unlikely.

Chlordane was not so persistent as DDT in soils treated for Japanese beetle control as reported by Fleming *et al.* Only 30 percent of the chlordane remained in turf treated with 10 pounds per acre after 1½ years of weathering. Accumulations in the soil except in orchards would probably be slow. Chlordane at high concentrations will reduce the germination of certain seeds as evidenced by its recommendation for crab grass control at 10 pounds per acre prior to the time of sprouting. Investigators have found that many plants, including strawberries, that are adversely affected by DDT, are highly tolerant to chlordane. Off-flavor has been reported in root crops treated with chlordane, but it is not general.

Aldrin breaks down rapidly when applied to soil. Fleming *et al.* also reported that only 33 percent remained after 1 year. Stone *et al.* (U. S. D. A. Cir. 926, 1953) reported off-flavor in potatoes grown in soil treated with aldrin, an indication that it may cause off-flavor to certain root crops.

Dieldrin is less likely to break down in soils than the organic insecticides previously discussed, except DDT. Fleming *et al.* (Bur. Ent. and Pl. Quar. E-829, 1951) reported that 67 percent remained in the soil after 1 year. Data on the toxic effects of dieldrin on plants are still limited, owing to its short period of use. Off-flavor in root crops does not seem to be a problem where dieldrin is used.

Isodrin, endrin, methoxychlor, and Strobane have not been tested extensively enough to secure reliable information as to their accumulation in the soil or their effects on plants.

Fahey *et al.* (Jour. Econ. Ent. 45:700-3, 1952) have demonstrated that EPN, the most stable of the organic phosphorus insecticides, disintegrated within 3 months. Any plant injury occurring from the use of TEPP, parathion, EPN, malathion, and Diazinon is caused by direct contact and is not long lasting.

Studies on the effects of organic insecticides on soil organisms have been limited. Wilson and Choudhri (Jour. Agr. Res. 77:25-32, 1948) found

that BHC killed certain soil algae and urea-decomposing micro-organisms but had no effect on nitrogen-producing bacteria and fungi. Jones (Utah Agr. Expt. Sta. Farm and Home Sci. 11:58-59, 1950) found that ammonifiers that break down organic matter were affected by DDT, chlordane, and BHC at concentrations above 0.1 percent, but that nitrogen-fixing organisms were unaffected. According to Gould and Hamstead (Jour. Econ. Ent. 44:713-717, 1951) arthropod populations were heavily reduced where BHC and chlordane were applied to the soil at comparatively high concentrations in young peach and apple plantings in West Virginia. DDT was less toxic to arthropods than the other two insecticides. Treatments of soils with organic insecticides do not appear to affect seriously the normal functioning of the micro-organisms.

The following facts relative to the effects of organic insecticides on soils and plants are apparent from present knowledge: the dosages normally recommended are not generally high enough to result in immediate buildup of residues that may be detrimental to the growth of crops, except in orchards where high dosages are applied annually. Certain organic insecticides, especially DDT and dieldrin, are highly stable in the soils and at high dosages, perhaps the 100-pound level, may reduce some crop yields. This is especially likely where shallow rooted plants are present, since the accumulated residues remain close to the surface and are carried into the soil only by cultivation. Certain organic insecticides cause off-flavor in root crops grown in soils treated with them, particularly BHC even though used in small amounts. New insecticides must be carefully screened to avoid soil contamination with such insecticides. No single factor has contributed to the greatness of America more than her fertile soils which at all times have assured adequate food for all her inhabitants and allies. It is our duty to protect this productivity by the development and use of non-accumulative insecticides and by limiting recommendations to as light dosages as possible. Whenever certain plants cease to grow or develop, we cannot move to virgin soils, as was often done during the pioneer days of our country.

Effects on Human Health. JOHN V. OSMUN, Department of Entomology, Purdue University.—This is a symposium on the effects of continued use of our newer insecticides, and stated as such, there is an implication that possible hazards exist. We all recognize the good derived from the use of insecticides, but it is well to take stock of what adverse situations may accompany their use, and be alert to toxicological areas that need continued investigation.

The problem of human hazards associated with insecticides is not a new one, but it has grown more serious with the advent of synthetic organic insecticides (Hayes: Advan. Chem. Ser. 1:56-60, 1950). This situation arises from the fact that these insecticides are more widespread in their use, are varied in their physiological mode of action, and by their very chemical nature, are often difficult to utilize properly within the bound of desirable exploitation. Numerous papers have been prepared in recent years on the real and potential effects on human health. Some of them are based on reliable experimental and observational data, while others have been perpetrated by scare mongers and political aspirants.

If mammalian toxicity is a consideration, the value of the insecticide must be a relative thing. A decision must be made between the value of the insecticide in terms of preserving crops and protecting human life, and the possible jeopardy to the health of those applying the material and others who may directly or indirectly be exposed to it. It is the latter problem with which we are concerned in this part of the symposium.

Organic insecticides can adversely affect human health both as acute and chronic poisons. Although the acute poisonings are more spectacular and usually remembered, it is chronic poisoning with its insidious actions that probably presents the greater hazard. None of the organic insecticides are entirely free of toxicology problems, but for illustration, only a few representatives of different chemical groups will be mentioned here.

1. Acute Toxicity Problems

Most of the synthetic organic insecticides now in use are less acutely toxic than many of the older materials such as nicotine, the arsenicals, or sodium fluoride. Acute poisoning in man has resulted, however, from excessive dermal and oral exposure to organic insecticides.

DDT has not been known to cause acute poisoning in routine use, but Barnes (Bull. World Hlth. Org. 8:419-490, 1953) reports several cases apparently resulting from accidental poisoning. In these cases, dizziness, weakness, and irritability were noted, followed by convulsions and sensory disturbances of the limbs. Such severe exposures usually produce visible changes in the liver and sometimes other tissues.

Parathion, which possesses unusual and severe toxic properties due to its ability to inactivate chlolinesterase, is one of the most acutely dangerous products in common use. Either single heavy exposure or a succession of smaller exposures may lead to intoxication. The application of such insecticides by unprotected personnel has resulted in sickness after absorption through the skin, swallowing, and inhalation (Hamblin and Golz: Amer. Cyan. Co. 1953). The latter is not a vapor toxicity problem according to Barnes (Barnes: 1953), but one of dust and fine particle intake into the respiratory system. It must be noted that many insecticides penetrate undetected and without irritation (Hamblin and Golz: 1953). Examples of such poisoning have been recorded among some workers hired to harvest pears and grapes (Barnes: 1953). Contact occurred as the men worked through the previously sprayed foliage. Although parathion is in a class by itself, it serves to illustrate the potential acute hazards associated with continued use of the newer toxic insecticides.

2. Chronic Toxicity Problems

Many of the synthetic organic insecticides are to some degree chronically toxic. The great problem arises from our inability to detect such occurrences and to know at what levels the insecticides are chemically dangerous. Any of us, whether we work with insecticides intimately or contact them as unobtrusively as does the layman, may possess symptoms of chronic toxicity. Such effects might be slight, as manifested by an allergy; others could be more pronounced. The effects of some minimal exposures may not be apparent for years to come.

It is the repeated contact of the body with small dosages of the synthetic organic insecticides which causes chronic poisoning. Such exposure may occur to those applying the insecticide, to anyone inhaling the vapor, to laborers working with products and plants that have been insecticide-treated, and to people consuming food that still bears traces of the chemical.

Although the first method of contact is an obvious one, it is also a difficult one to prevent. Even trained personnel tend to get careless when spraying or dusting since no immediate adverse effects are noticed, and little thought is given to a material spilled on hands or clothing. Intake by inhalation of vapors is restricted to a few insecticides, one of which is lindane. Lindane electric vaporizers are common today, and although this insecticide is not stored in the body, it is considered hazardous to inhale repeated quantities of the material (Conley: Jour. Amer. Med. Assoc. 149:367-369, 1952). As J. R. Wilson (Paper, Amer. Chem. Soc. 1952) of the Council of Food and Nutrition so aptly put it, "It is highly questionable whether one man has the right to contaminate another man's air." With the exception of the organic phosphates, few of the newer organic insecticides are readily absorbed through the skin.

One of the primary problems today is that of insecticide contaminated food. Although no evidence exists that small quantities of insecticides in common use have produced any recognized poison symptoms or tissue changes in man, no one can yet say that ingestion of small quantities of DDT or other insecticides over the life-span of a man is entirely harmless. Although generally considered remote and at present without foundation, carcinogenic growth is a possibility resulting from adverse stimulation of body tissues. DDT in small quantities is frequently ingested along with food which has been previously exposed to the insecticide (Barnes: 1953). Storage is in fat. Although presence in fat is not necessarily an indication that a material is better able to produce chronic toxic effects, the very presence in the system is potentially hazardous, especially if a person were to draw suddenly upon his fat reserve. It is difficult to escape repeated exposures of insecticides.

It is notable that no Federal residue tolerances have been set on the new synthetic organics. There has been a tendency to criticize the Food and Drug Administration for this, but it must be remembered that there is no sure physiological study which will reveal the long range possibilities of chronic poisoning. In man, the situation superficially seems encouraging, but on the other hand, injury has been significant with repeated exposures in laboratory animals. Too liberal a tolerance could be a serious mistake.

It would seem that considerable promise can be expected with the thoughtful development of new materials. The remarkable development of malathion, for example, points the way to chemicals which are safer from the standpoint of mammalian toxicity, while still potent insecticidally. Residue problems can be decreased not only by improved chemicals, but by changes in the adjuvants which go into formulations, and by properly timed applications.

There has been a tendency in this paper to place the emphasis on the hazards created by new insecticides from the human health standpoint. This is justifiable not only in view of the topic assigned, but because of the lack of critical information on many of the toxicology problems. It is not that fear should stem from ignorance, but rather that intelligent precautions and thorough investigations should accompany the introduction of any chemical that finds its way to men as frequently as does an insecticide. There is no doubt that insecticides have proved a great value both in the control of insect-borne diseases and in the protection of crops. It remains only to achieve a proper balance between this value and the maintenance of the health of our nation.