PROBLEMS OF INSECTICIDES IN FOODS*

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The necessity for using insecticides for the growing and protection of food and fiber crops has been established. We do not have effective insecticidal chemicals for the control of all plant pests and old compounds must be improved or new compounds developed. Residues in foods must be avoided and the control of all plant pests and old compounds must be improved or new compounds developed. Residues in foods must be avoided and used to employ insecticidal chemicals efficiently and safely. Education of farmers and others in the proper use of insecticidal chemicals is presently of paramount importance.

In 1915, Dr. S. A. Forbes, first State Entomologist of the State of Illinois, wrote, "The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures." This struggle is due to the fact that both man and insects must have food in order to survive and that both want the same food. Insects have first access to our food supply for they attack plants as soon as they are planted in the soil and even attack the seeds as soon as they are sown. If there is to be food for human and animal consumption, crops must be protected in some manner from the time the seeds are sown or young plants transplanted in the field until the edible portion is ready for consumption. The period required to produce edible food may cover three or four months or more. During all this time, crops are subject to insect attack, not by one or two species of the pests but by as many as ten, twenty, or even 100 different species. Were it not for insect control, man would have to survive on what is left after the insects had obtained all they wanted. He would have to be satisfied to eat varying amounts of insect fragments and excrement from the insects and numerous fungi and bacteria developing in the insect-damaged tissues.

Recent figures have shown that at the time this country was settled, out of every ten inhabitants nine were required to produce food for the group. By 1940 this had been reversed and one man was producing enough food for himself and nine other individuals. Now each food producer must produce enough for himself and fourteen others. This increase in efficiency in food production has been due to many factors one of which has been the intelligent use of insecticides along with other insect control measures. As our country developed in agriculture we were able to move westward into new territory as rapidly as soil fertility was depleted and use long rotations of crops to reduce losses from insects. We no longer follow this plan and with an increase in population of 6 to 7 thousand per day we must make more efficient use of our productive land. As agriculture becomes more intensified we must encourage insect development. We must therefore look forward to the increased use of chemicals for insect and disease control as well as their use for weed control, for producing color, for making fruit stick, for defoliants, etc.

Necessity for Using Insecticides

This group is fully aware of the necessity for using insecticides. Insect species that damage crops run into the thousands. In spite of great effort to control insects by cultural, mechanical, ecological and biological control methods it is agreed by the best informed men in the country that the use of insecticides is essential. Man must make intelligent use of all these methods if we are to insure an adequate food supply for our ever increasing population.

Our efforts to control injurious insects have been puny compared to reductions in insect populations by meteorological phenomena. Man has never eradicated a single insect species by employing every means at his command, the combined use of cultural, mechanical, ecological, biological, and chemical control methods. Our prospects for so doing seem dim at present.

Great progress has been made in the development and use of insecticidal chemicals and the greater part of this progress has been made in the past ten years. I quote from the report of the Food Protection Committee of the National Academy of Sciences, December 1952, "Today, approximately 100 pesticide chemicals are in use or available for use, and over 30,000 pesticide formulations have been registered for labeling and use by the Insecticide Division of the U.S. Department of Agriculture. Each pesticidal chemical and each pesticide has its distinct advantages, disadvantages, and special uses. Therefore, just as the physician and the pharmacist require a generous assortment of pharmaceuticals for the compounding of prescriptions, so, too, the agriculturist and the pesticide dealer should have ready access to the largest possible assortment of chemicals so that they may likewise prescribe specific treatments to fit specific conditions. Many new pesticides have been developed which are more effective for specific purposes than are the materials previously used for those same purposes. The use of these new chemicals in agriculture parallels developments in the field.
of medicine where sulfa drugs and the new antibiotics are now frequently recommended and used in the place of the less efficient drugs which were in common use a few years ago."

**Use of Different Insecticides Necessary**

The problem of insect control with chemicals would be much less complicated if we could employ a single poison to control all pests. This is not possible since different species of insects vary greatly in their susceptibility to insecticidal chemicals. Insecticides that are highly effective in the control of certain insect species are totally ineffective in controlling other species. For example, at a given rate of application DDT will kill a very high percentage of the tomato hornworm, *Protoparce quinquemaculata*, but is almost completely ineffective against the tobacco hornworm, *Protoparce sexta*. Here we have two species of insects belonging to the same genus, looking so much alike only entomologists can tell them apart; indeed the larvae of both species are normally found feeding on the same tobacco plant at the same time over much of the tobacco growing areas of the United States. There are innumerable examples of marked differences in insect susceptibility to insecticides. We do not yet understand just why this difference in species susceptibility occurs.

Laymen and entomologists alike are well aware that numerous insecticidal chemicals are required to give adequate control of the various pests and to produce crops of the quantity and quality desired. Insecticidal chemicals that give adequate and economical control of many of our major pests are now on the market. Other major pests are still troublesome because present chemicals are inadequate for one reason or another. New chemicals are being developed and will continue to be developed that will be more satisfactory for controlling certain insects and perform satisfactorily against those pests that are not handled well by present day insecticides. Time will not permit enumerating here the many requirements of an insecticide other than its property of killing insects for our time today must be devoted to problems more closely associated with residues with which this paper is primarily concerned.

**Development of New Insecticidal Chemicals**

Less than ten years ago we were dependent upon a few rather unstable botanicals such as pyrethrum and rotenone and a number of staple and very persistent metallic salts such as arsenic lead, calcium arsenate, sodium fluorosilicate, etc. These insecticides were effective in controlling some of our troublesome pests but left much to be desired in controlling many others. It was necessary to employ these older insecticides at relatively high application rates with the result that residues presented a serious problem. The newer insecticides starting with DDT followed by a rather imposing list of chlorinated hydrocarbons, phosphates, and so forth, have given us much better tools to work with in that they are little, if any, more hazardous to use than many of the older insecticides and are generally much more effective in controlling insects. Each one has its own particular and peculiar properties and most of them have found important places in agriculture. Present day insecticides are less stable or more volatile than those derived from metallic salts with the result that residues diminish from the time of application.

The newer insecticides vary materially in their toxicity to warm-blooded animals. For many purposes however the inherent toxicity of a given compound when examined from the standpoint of actual use is not indicative of its relative safety. The Food Protection Committee of the National Academy of Sciences states as follows: "The inherent toxicity of a pesticide or pesticidal chemical to warm-blooded animals may have little or no direct bearing on the final food hazard. Many of the more toxic materials are applied at times when the edible portion of the crop is not exposed. As a rule, such chemicals are applied in proportionately smaller amounts than are less toxic materials and frequently the more toxic compounds are short-lived. In other words, they may be quickly destroyed through chemical change or lost through decomposition or evaporation. It would not, therefore, be in the public interest to unduly restrict the use of these valuable pesticides strictly on the basis of their inherent toxicity to warm-blooded animals. Fruit and vegetable growers should not be denied the right to use a pesticidal chemical, no matter how poisonous, provided its use as recommended does not present a hazard to plant life, individuals, or the public health."

**Insect Resistance to Insecticides**

To complicate the picture further we are running into instances of insects becoming resistant to certain of the new chemicals or even to several chemicals. This is not too surprising for insects have long been known to build up a tolerance to certain chemicals. Many years ago the black scale in California developed a tolerance to hydrocyanic acid gas, the San Jose scale built up tolerance to lime sulfur, and the codling moth to arsenate of lead. The common house fly in the past few years has built up a strong resistance to DDT, and once developed this resistance is rather quickly extended to include the other chlorinated hydrocarbons. Among agricultural pests the Colorado potato beetle and the imported cabbage worm seem to have developed a certain amount of resistance to DDT. I do not believe these examples indicate that all insects will eventually build up resistance to any one insecticide or that any one pest will build up a resistance to all insecticides. The matter of resistance in insects adds one more problem to those we already have and points to additional justification for the availability of an assortment of insecticidal chemicals and insecticide formulations for use in insect control programs.

**Problem of Flavor Changes**

This is somewhat of a controversial subject since off-flavor in fruits and vegetables attributable to the use of pesticides is of rare rather than a common occurrence. That distinctively objectionable off-flavors have occurred with certain chemicals cannot be denied. Minute changes in flavor have occurred where the differences were not objectionable and did not affect the edibility or marketability of the product. Off-flavor may be defined as any gross departure from the normal in a fruit or vegetable to be eaten fresh or cooked, canned or frozen, which would render it unacceptable to the consumer.
Minute variations in taste which are as often judged superior as judged inferior by a taste panel could hardly be classified as objectionable. Variations in taste between varieties of fruits and vegetables, variations in taste of fruits and vegetables grown in different sections of the country, and year to year variations in fruits and vegetables grown in any section of the country are recognized. Irish potatoes grown in New England, Florida, or Idaho have certain taste variations. Apples, citrus fruits, and many others are noted for variations in tastes. Insecticides can hardly be held responsible for variations less than normally occur in the foregoing situations.

Flavor changes are not always evident in the fresh fruit or vegetable but may be evident after processing such as canning, freezing, or storing. Certain chemicals have been known to react with metal containers to produce off-flavors and spoilage through action of the chemical on the metal causing corrosion. Off-flavors are not often caused as a direct result of insecticidal residues, and the possibility of their occurring in the future will be greatly reduced once tolerances are established for specific chemicals. Taste evaluations are but one of the requirements that an insecticidal chemical must meet before it can be marketed. The agricultural chemical industry is aware of this problem and has already taken steps to determine possibility of off-flavor through cooperative studies with the food technologists of several of our leading state universities. It should be gratifying to food sanitarians to know that specific data have been and will be accumulated relative to the possible effect of insecticidal chemicals on food flavors.

**Residues in Foods**

Residues in foods including feed and forage for animals as well as in food and food products to be consumed by humans presents problems of great importance. We have made notable strides in the past few years not only in avoiding food and forage contamination by the proper use of insecticides but also in developing analytical methods for the determination of residues.

Dr. Geo. C. Decker, Entomologist and Head, Illinois Natural History Survey, Urbana, Illinois, has fully discussed "The Significance of Pesticide Residues" in a paper presented at the meeting of the American Chemical Society held in Milwaukee, Wisconsin, April 3, 1952. Since this paper is to be published, it will not be necessary to repeat here all the factors that enter into the matter of insecticide residues in foods.

Numerous factors, however, enter into the presence and magnitude of residues on food and forage crops. The time of application with respect to stage of plant growth and interval between last application and harvest is perhaps of greatest importance where insecticides must be applied directly to plants. The number of applications may be a factor associated with time of application but in the light of recent studies it is the interval between the last application and harvest that largely determines the magnitude of the residue. The rate of application has a bearing on the amount of residue present at any given time. The dangers attending the use of chemicals highly toxic to warm-blooded animals is mitigated by the fact that the more toxic chemicals are generally employed at dosages proportionately lower than the effective dosages of less toxic chemicals. We have previously shown that the inherent toxicity of a pesticidal chemical may not be a true indication of the final hazard on food.

Evaporation and decomposition as affected by temperature, moisture, sunlight, and foreign substances such as dust on the foliage have a bearing on the extent of residue on plants. Winds and rains tend to reduce residues or scatter sprays and dusts where they are not wanted. Residue dilution through expansion of treated surfaces due to plant growth materially reduces residues. Residues may also be reduced or eliminated by normal washing, scrubbing, or peeling before eating or processing.

All the foregoing factors have a bearing on the presence or absence of residues on food or forage at the time of harvest, eating, or processing. Recent developments in the use of insecticides in such ways as to preclude the presence of residues are of utmost importance.

I refer to the application of insecticidal chemicals to the soil before planting not only to control soil inhabiting insects but many species of plant feeders that spend a portion of their life cycle in the soil and are killed when they drop to the soil or enter the soil for pupation or hibernation. Significant strides have already been made in this direction.

Perhaps of equal or even greater importance is the development of new principles in formulations. Until very recently insecticides were applied as aqueous sprays derived from emulsifiable concentrates or wettable powders or dusts. Various factors determine the amount of insecticide adhering to the foliage initially and the length of time residues remain as we have previously noted. Control measures designed to eliminate initial residues are being developed and practical applications are being made through the use of granular formulations. Granular formulations are prepared by impregnating or coating an inert carrier of granular consistency, usually 30-60 mesh with the insecticidal chemical to be employed. Such formulations are easily applied, will not drift with the wind, and will not remain on the foliage. Dr. M. D. Farrar has pioneered in this work and has shown that a rather wide range of insects can be controlled by the application of granular insecticide formulations (Journal of Economic Entomology, Vol. 46, No. 2, 1953). Insecticides employed in such a way as to avoid initial residues will not leave residues at harvest.

Thus far we have been discussing insecticidal residues on food and forage with the principal emphasis on food for human consumption. Residues on forage are of almost equal importance for they may result in residues in milk, milk products, and animal tissues. The same precautions must be exercised for forage that are necessary for crops intended for human food. Applications of insecticides that will avoid residues at any time are greatly to be desired. It is worthy of note here that granular formulations are proving very effective in controlling some of the major forage crop pests.

Nothing has been said concerning the determination or removal of
Milk Differences

In analyzing the results of this comparative study, it was observed that there also was considerable variation in the counts obtained with the various media with different milks on different days regardless of whether the milk was raw or pasteurized. It can be seen in table 3 that with some samples the differences between the experimental media and the standard media are greater in some instances than in others, for example, samples 8 and 9. In this instance sample 8 was a laboratory pasteurized sample checked immediately after pasteurization while sample 9 was a commercially pasteurized milk sample which had been refrigerated for several days after pasteurization and undoubtedly had an entirely different flora (probably psychrophiles) than the first sample. The same observation can be made on pasteurized milk samples 1 and 2 where the first was a laboratory pasteurized high quality milk from a local farm tested within 5 hours after milking and the second was a laboratory pasteurized poor quality milk sample from upper New York State which was anywhere from 24 to 48-hours old at the time of testing.

Note also milk sample 4, a fresh local raw milk in which the raw counts on the new media also indicates that there is this nutrient difference. These observations would indicate that there is need for further investigation concerning the ability of the new media to support growth of different types of bacteria which may be present in both raw and pasteurized milk.

BIBLIOGRAPHY


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residues when they are suspected in damaging or questionable amounts at harvest. Residue removal is to be avoided except as a means of last resort. Some studies in residue removal are in progress. There is some reason to believe, for example, that the toxic properties of certain insecticidal chemicals may be eliminated by the heat encountered during the canning process.

Important progress has been made in developing satisfactory analytical methods for determining residues. Chemical analyses, infrared spectrophotometry, and bio-assays are available for most insecticidal chemicals. Each method has its strong points. Most satisfactory results are probably obtained where bio-assays are run in conjunction with other methods. In many cases methods now in use are sensitive to 1 part or less in 10,000,000.

The many problems associated with residues resulting from the use of insecticides for the control of insects are by no means completely solved but tremendous progress has been made in the last few years. Education of farmers in the proper use of insecticides will greatly reduce these hazards remaining. With more efficient insecticidal chemicals now coming into use, applications for insect control can generally be made at a time and at a rate of application coupled with the use of proper formulations to preclude largely the possibility of trace residues at harvest.

BILL BRYANT HOSPITALIZED

Mr. C. B. A. (Bill) Bryant is hospitalized at the Community Health Center, Hillsdale, Michigan, suffering with a case of pneumonia. This situation necessitates the cancellation of his many speaking engagements for the next two months. Now is the chance for his many friends to drop him a line of greeting specifying "no answer expected."