# Insecticide Resistance in Greenhouses

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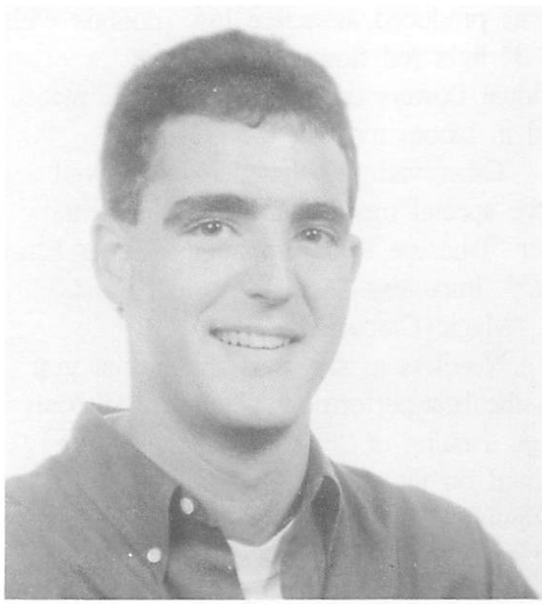
Insecticide resistance is marked by a genetic change in a pest population that may impair control in response selection by toxicants (Ford et al., 1987). As pesticides are used, they work both for and against the goal of applying them in the first place. When used correctly, pesticides eliminate a large percentage of the target pest population. The



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insects having some genetic resistance tend to be the survivors. Since the majority of the portion of the population containing this defense are left to interbreed, a strain of resistant insects with the ability to resist certain chemical toxicants may arise by grower selection. Genetic resistance may occur by natural mutation or from the genetic memory of a species (NRCBA, 1986). It is now apparent that most classes of insecticides can be resisted by pests, possibly in several ways. Resistance may include altered penetration or transportation of the toxicant, metabolic breakdown of the compound or a physiological change in the site of action. A combination of changes is also possible (Ford et al., 1987). Since many of the presently used pesticides come from four closely related groups, acquired resistance of one pesticide may deem the other pesticides in the same chemical group also useless; this is termed "cross resistance."

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Resistance should concern anyone in any industry in which pesticides are used. It seems as though it is only a matter of time until the chemicals presently being used will not be effective in control. The amount of time before the available chemicals become ineffectual depends on how quickly the resistant genes within a population can unite. The gene pool of most of our pest species already contain genes that circumvent the toxic effect of many of the presently used chemicals (NRCBA, 1986). Usually, these genes are relatively rare in the pest population. Otherwise, the pest would be naturally resistant to the insecticide to start with. Moreover, pesticides may give consistently satisfactory results against a particular pest for many months, even years, before unexpectedly becoming practically ineffective in the space of as few as two or three additional applications. The suddenness of which a chemical loses its usefulness is the main reason that we cannot wait for the resistance problem to arise to try to solve it. Firms that start experimenting with alternate control possibilities will be in a position to profit from their foresight when most chemicals become obsolete as control options.

There are two characteristics which differentiate the problem of resistance within greenhouses as compared to a similar problem in field crops. An insect introduced into a greenhouse finds almost all environmental variables to its favor. This, along with a highly uniform host population, leads to rapid population increases (Hussey et al., 1969). Field crops have an advantage in that aspects such as weather, natural predators, seasonal changes and large pest populations that absorb genetic mutations help hold off resistance pressures. Within greenhouses, an almost opposite environment exists. Constant environmental control, exclusion of predators and a relatively isolated pest population exists.

The second problem with development of resistance in greenhouse pests lies in the intense spray programs that are commonly used. Such intense spray programs, acting on all developmental stages of successive generations, exert a powerful selection pressure in favor of individuals with genes for resistance (Hussey et al., 1969). Thus, if resistant genes exist, and they usually do (Ford et al., 1987), they will surface due to a given selection pressure in an isolated population.

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Another characteristic of greenhouse insect resistance is the possible development of unique strains of pests within separate houses. Although the selection pressure may remain constant, each mutation may circumvent the action of the chemical in a different way. Strain differentiation is most marked when the species is confined, perhaps by greenhouse walls or weak flying skills, and also when an insect's reproductive mechanisms restrict genetic recombination. This occurs, for example, in asexual reproduction in aphids or by homozygous egg reproduction by females. So now it is possible to have not only a range of greenhouses with insects resisting insecticide control, but also have them resisting the control in different ways in different houses. This really complicates the possible course of action for growers.

Field crops have yet another advantage over greenhouse crops in that with outdoor crops there is usually a relatively high acceptable level of infestation. There are many cases in which the insect presence on a crop does not reduce yield to the extent that the insecticide application would be cost efficient. This "tolerable" level of pests reduces the intensity of spray programs and allows a larger population to dilute resistant strains of insects. On the contrary, greenhouse ornamental crops have a standard of "zero tolerance" (R.A. Larson, personal communication, 1989). For instance, a poinsettia with any visible insects or blemishes left by them will be rejected by most consumers. Thus, growers aim to eliminate all insects by increased spray programs. This not only increases resistant selection pressures, but also leaves smaller groups where mutations interbreed more readily.

Because of the obvious effect of insecticide resistance, several strategies have been devised to help slow the progression of resistance. One such proposal is the use of rotational spray programs, the idea being if insects become resistant due to repetitive exposure to the same chemical, then changing the chemical toxicant may enhance long term control. It is believed that rotational programs may delay or prevent resistance providing the absence of cross resistance and may allow the reversion from resistance to susceptibility in one complete rotation of the program (Hussey et al., 1969). So to devise an effective rotational spray program, growers must use chemicals with different toxic mechanisms and use enough variety of them within one program cycle to circumvent all genetic defenses an insect species might develop. Although this is a theoretically sound proposal, it is at this time a practical impossibility. This strategy assumes growers know each insecticide's mode of action, that all resistant strains are known, that cross resistance cannot develop within one program cycle and that enough variety of insecticides are available to formulate an effective rotation program. Much of the information necessary for the successful implementation of a rotational insecticide program is unavailable. Even if it were, to consider all the information would require a great deal of the grower's time. When possible, rotation is not a bad idea, but rotational spray programs cannot be the sole basis for a resistance management program.

A more feasible strategy for dealing with resistance management is the development of an Integrated Pest Management (IPM) program. An IPM program is a more realistic alternative because such in-depth knowledge of the insects and chemicals to be dealt with is not as crucial. However, "it is important to realize that IPM will not succeed in the hands of a careless or inexperienced practitioner" (G. Ferrentino, personal communication, 1990). IPM has four basic principles: ① pest identification, ② pest monitoring, ③ pesticide application timing, and ④ record keeping. The program's goal is to withhold insecticide application until it will result in optimum pest control. The result in terms of resistance management is less use of pesticides and consequently less selection pressure toward insecticide resistance. It also preserves natural predators (whether introduced accidentally or artificially), reduces environmental contamination and reduces costs (NRCBA, 1986).

Future expansions of IPM may include biological controls. This avenue of control may also be a key in resistance management in the future. The idea revolves around the introduction of the natural enemies of pest insects into greenhouse ranges. For example, the parasitic wasp *Encarsia formosa* has been introduced to combat the greenhouse whitefly. The important aspect relating to resistance management is that the development of resistance to attack from this wasp is impossible (Stimmel and Wheeler, 1988). The problems with using such biological controls center around providing an environment where the parasites can survive and whether insecticide applications will affect these nontarget parasites. Future use of such biological controls in association with IPM look to become increasingly valuable.

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Perhaps the simplest solution to resistance in the greenhouse is prevention of pest infestations in the first place. Growers should expect and accept nothing short of insect free plants. Don't allow your supplier's insect problem to become your insect problem. If enough consumers send the message that any infestation is not tolerable, more attention would be paid to eliminating them. After all, when shipping infested plants really means decreased profits, propagators will take notice.

Once you have started with clean stock, sanitation and screening techniques help fight off invading insects from being introduced to your crop. Vent and entry area screening has shown excellent results in the prevention of insects and specifically thrips (Baker and Jones, 1989).

There are certainly areas that require more attention to deal with the increasing amount of resistance. One such area is a dwindling range of insecticides available. Due to increased costs of research, registration, production and greater competition, the range of available insecticides is narrowing, not widening. Public outcry against pesticides has grown on Capitol Hill to the point that Cornell's IPM coordinator says "pesticides are on the endangered list" (Hamrick, 1989). Counting on a constant flow of new miracle insecticides to deal with pests that have become resistant is futile. The dwindling supply of pesticides also hurts growers who feel rotational spray programs have validity.

We must make better use of the pesticides already available. More practical and understandable information about what stages of development pesticides are most effective, better application advice and suggestions for complementary tactics should accompany pesticide shipments. Many users of these chemicals in the industry do not have the information they need to properly use them. Applicators are not risking human health, but instead they are risking needless excessive quantities and increased rates of resistance. This information, organized as decision making protocols, would not only forewarn growers of inadequate performance of an insecticide, but would also detail specific alternative controls and management practices (Ford et al., 1987).

The expertise to deal with effective pesticide use and insecticide resistance is not always available in greenhouse ranges. After all, in many operations the grower is also the owner, manager, salesperson, shipper and maintenance person. There are enough problems for these people to deal with without worrying about a problem they might encounter in the future, one like insecticide resistance. Larger ranges can afford to have a staff pest management expert to monitor and analyze pests daily and prescribe feasible control methods for them. But what about the countless small "mom and pop" operations? Perhaps an expert insect control service could be formed. This group of trained pest management specialists could follow routes, stopping at each small operation once or twice a week to monitor, analyze and prescribe control needs for each range. The service would have all the required information pertinent to crops, insect and disease types and the best control practices for different situations.

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Who could set up such a service? Perhaps local greenhouse supply companies. These companies benefit by selling the products (i.e., pesticides, screening material, sticky cards, etc.), yet are not biased to one control option since they supply them all. As with any service, the economies of scale make equipment and expertise cheaper the more they are used. In other words, the more an input is used, the less expensive it is to obtain. A business that makes money by being informed on the best techniques of eliminating insects has an incentive to become expert in that field. Thus, growers would benefit by the elimination of one of their ongoing problems, and the service company would be compensated by a participation fee. Such a service would also evolve as new technology involving IPM, biological controls and new advances in technology arise. The setting up of such programs nationwide has many promising points:

- *It's a service that growers would be willing to pay for.*
- *Since there is an economic incentive, the government would not be required to set up the program.*
- *Such a program would get information to the place it is needed most, the thousands of small operations across the United States.*
- *Such a program provides an avenue to get technology advances and programs designed to deal with industry programs such as insecticide resistance to the grower who could implement them.*

Dealing with the problem of insecticide resistance in greenhouses is going to take a combination of existing and updated strategies along with research to determine the best course of action for specific cases. The first major improvement needs to be an increased awareness of the problem and communication of the presently existing programs to deal with them. After all, the available information is useless if it isn't in the hands of the growers.

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