Integrated pest management in the United States

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Integrated control has been used increasingly on many types of crops, nationwide. With the use of computers, scientists are coming to some surprising conclusions.

In their continuing battle with more than 10,000 insect pest species, scientists and growers in the United States achieved some striking successes against many pests, mainly with broad-spectrum insecticides. Unfortunately, those pesticides have had detrimental side effects: Pest insects developed resistance to formerly lethal materials; natural enemies of pests were destroyed; previously innocuous insects became major pests; chemical residues appeared in crop produce; public health problems developed.

The only way out of this dilemma is to rethink our whole approach to pest control. We must develop a multifactorial approach—one that combines chemical, cultural, and biological strategies or tactics—to reduce the heavy costs and harmful effects of complete reliance on chemicals.

It is time to stop relying on chemicals to solve all of man's insect problems. An ecological approach is needed. To achieve such an approach, many universities and scientific groups are developing ecologically-based systems designed to manage pest populations with minimal damage to the environment and optimum returns to the grower.

Recently systems analysis has been added to this approach, enabling researchers to build a huge library of computer models that contain detailed information—from many disciplines—about crops and their pests. The range of results arising from the complexity of interactions involved can be tested and appraised with the help of these tools.

What has emanated from the integration of pest management with these new tools? Let us examine developments in integrated pest management (IPM) on some crops that carry heavy pesticide loads, or the potential for such, and are of great importance in food and fiber production.

Cotton

Half a billion dollars in insect-caused losses occur annually in the U.S. cotton crop, and $150 million is spent on insecticides—almost half the total used in agriculture.

Cotton insect control programs that use pesticides are plagued with problems: resistance in insects has made some controls ineffective; environmental problems abound; and costs are enormously high.

Now, however, new tactics are being developed for use against cotton insects. Plant resistance to various insects is being genetically built in to certain cotton varieties. Their use, combined with crop residue destruction, may help to manage or avoid some pests (and diseases), reducing pesticide costs significantly. Computer models are being developed to deal with all aspects of cotton production, with high levels of attainment being reached in Mississippi, Texas, Arkansas, Arizona, California, and several other states.

In Texas, a new integrated control strategy is providing economic and environmental benefits. The program features boll-weevil control with a fall diapause program; fleahopper control with low dosages of insecticides applied early in the season; termination of fleahopper treatments quickly to allow natural enemies to build up and control bollworm and tobacco budworm; careful sampling to make certain that treatments aren't started too early; and early harvesting of the crop and destruction of residues. This program brought a decline in insecticide use in one area from 12 to 6.4 pounds per acre, while cotton yields increased greatly.

Apples

Apples receive more pesticides than any other stone or pome fruit and on a per-acre basis more than any other U.S. crop. Only cotton and corn receive more total pesticides. In Washington, New York, and Pennsylvania, where more than 70 percent of the U.S. apple crop is grown, integrated control programs have been rapidly established.

In Michigan, computer models representing information on European red mites and their predators and on codling moths have been constructed from data based on samples taken from sex-lure traps. The models are used to send insect data into the computer and to obtain predictions which are transmitted to Cooperative Extension personnel. Forecasts of biological control of spider mites and codling moth numbers, as well as information on a wide variety of disease, insect, weed, and nematode pests, are delivered to growers as part of an Extension information system. Considerable success has been achieved in reducing the pesticide load and costs for control of the entire complex of apple pests.

In Washington, integrated programs have reduced pesticide use by 50 percent. In the Midwest and the East a reduction of 20 to 30 percent has already been realized by a program which started only recently.

Alfalfa

This major U.S. crop does not receive large amounts of pesticide, but insects associated with it often move into and feed upon crops such as cotton and soybeans. Beneficial predatory and parasitic insects also build up in alfalfa fields, then move to other crops. The management of alfalfa pests therefore affects other crops.

Integration of pest control in alfalfa is among the most advanced in the U.S. Integrated pest management has long been accepted by alfalfa entomologists, and chemical control has become prohibitively costly. These two facts led to the rapid integration of cultural, chemical, biological, and resistant-plant techniques for alfalfa-pest control.

For example, growers may spray or cut alfalfa earlier than normal, before severe damage from pests has occurred, and destroy the weevil larvae that might damage the next crop. Growers time the first cutting precisely so that many weevil larvae and eggs are killed, and apply a stubble spray, if needed, after first harvest to clean up remaining larvae.

Biological control of the alfalfa weevil has succeeded in many areas through the use of natural enemies. In California, however, the appearance of the closely related Egyptian alfalfa weevil raised havoc with biological control, because it is not effectively parasitized by the same larval parasite that destroys the original alfalfa weevil.

As with apple pest control, computer models coupling plant, insect, parasite, and economic data have been used in California and the Midwest with promising results.

Corn

Only cotton exceeds our $12-billion-a-year corn crop in total use of pesticides, and no crop exceeds corn in use of herbicides. Corn is the most valuable crop grown in the U.S. Integrated insect control in corn relies heavily on host-plant resistance, crop rotation, and other cultural measures, as well as intensive monitoring of corn insect populations. Resistant varieties of corn are the main barriers to the European corn borer and the corn leaf aphid. In addition, early planting has aided in controlling 15 to 20 insect pests by reducing the time available for growth by insects. Integrated pest management projects are being developed in Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio for corn.

Pine forests

Nearly all U.S. pine forests have major problems caused by bark beetles, of which there are three principal species: the western pine beetle, the mountain pine beetle, and the southern pine beetle.

Researchers are not looking for a flat recommendation for bark beetle control that omits other features of forest management. Rather, they are trying to obtain an understanding of the beetles' role in forest ecosystems and develop strategies for minimizing their adverse effects with minimal disruption of the ecosystem and minimal environmental harm so that forest managers will be provided better guidance.

The pine bark beetle ecosystem is so complex that computer analysts are hard pressed to construct computer models that are accurate. When the theoretical modeler reduces the enormous complexity of biological systems to a model that is understandable, the model often no longer represents the real world.

In California modeling studies, researchers have developed a flexible computer language, with groups of submodels, equations, and mathematical procedures which represent the structure and dynamics of beetle populations in their environment. The analysts, in modeling the relationship between the western pine beetle and root disease, found that the fungus-caused disease often precedes heavy bark beetle attacks.

The highly sophisticated, computer-aided study of pine bark beetles will probably produce four useful tools when the project comes to an end:

- How to manipulate forest stands with cutting treatments and beetle management, perhaps by use of pheromones or other devices.
- Predictions of stand growth over space and time.
- Predictions of beetle outbreaks.
- Correction of erroneous ideas that now hamper foresters' bark beetle management operations.

Cereals

A great effort has been made to integrate control of cereal pests. On the $6-billion-a-year wheat crop, for example, successful programs are directed against the hessian fly, the wheat stem sawfly, the greenbug, and the cereal leaf beetle.

About 9½ million acres of wheat resistant to the hessian fly and to the wheat stem sawfly were planted in 1969. Other wheat varieties have been developed incorporating resistance to the greenbug, and progress is being made toward similar resistance to the cereal leaf beetle.

Biological control measures have been successful. An integrated control system for managing the cereal leaf beetle makes use of: parasites imported from Europe; tolerant varieties of oats and wheat; native natural enemies; chemicals at planting time; and, finally, if the pest populations become seriously high on the growing crop, the pesticides carbaryl or malathion.

Citrus

Although biological control has scored phenomenal successes against citrus pests, insecticides have continued to be widely used—well over 11,000,000 pounds a year on the U.S. citrus crop. One of the main pests is the citrus thrip, which damages fruit rind and affects yield. The packing industry uses a sliding scale in culling thrip-damaged fruits, a scale that depends upon supply and demand. This dismays the systems ecologist trying to develop a management-decision model for citrus insect control, and the significant cosmetic aspect of thrip damage to citrus is a problem of concern to those who regulate insecticide usage.

Thus, management/decision modeling has been greatly hampered. In California, computer modeling is mainly restricted to the population dynamics of California red scale and its parasites in the San Joaquin Valley. In Florida, models for predicting citrus tree growth and phenology and for management of citrus rust mites are being developed. In Texas, Florida, and California practical systems of integrated control are now operating only in limited areas. In the future, IPM methods need to be more fully developed so that implementation can be extended to the entire crop.

Conclusion

In most of the IPM work, the emphasis has been on insect pests; there has been only a limited inclusion of pathogens of plant diseases. The next step is to bring plant diseases, nematodes, and weeds into this pattern of researching and developing solutions to our crop protection problem. The farmer must, certainly, deal with all of them as a complex. Modern systems technology is making it possible to forecast accurately the nature of pest populations and to remove some of the risks and uncertainties a farmer faces in profitable, productive farming.

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