Applying systems analysis to integrated control

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Systems analysis — the child of mathematics, engineering and the computer age — only recently has been applied effectively to solving the complex problems of integrated pest management (IPM). The computer and the evolving science of ecosystem analysis are well suited to such complex problems. But a word of caution is in order. Systems analysis is not a panacea, any more than DDT was the end of all insect pest problems. The basic recipe for using systems analysis (or any new technology) in an agroecosystem is enlightened common sense.

Systems analysis depends heavily on mathematical models, in the form of lengthy equations, for the solution of pest control problems. The usefulness of the models is restricted only by the adequacy of the data employed in their formulation.

Mathematical models in systems analysis are highly reduced descriptions of processes that can be observed or theorized. They are coded libraries containing information about some systems. They have no intrinsic value and, if formulated on a poor data base, can be useless or even misleading. Yet well-designed models are extremely useful. Studies by the University of California and 18 other cooperating universities (the IPM/NSF-EPA-sponsored Huffaker projects) have revealed that models are of immense value in helping researchers organize their facts, find conceptual and actual data gaps, interpret pest management problems, and apply the conclusions to field situations.

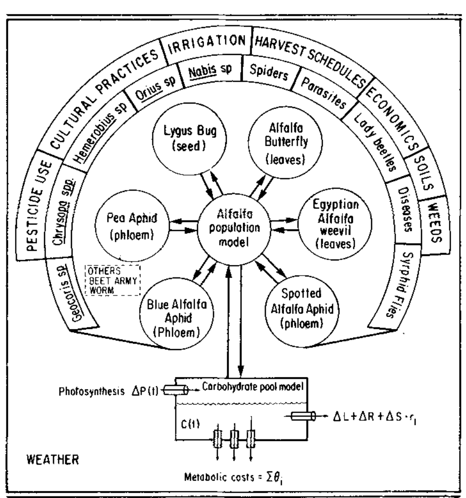
The application of integrated control to situations involving the risk of crop loss puts an awesome responsibility on the person directing an IPM program. There are many subtle interactions among the crop, pests, and natural enemies — moderated by cultural practices and weather — that must be considered. Serious losses to farmers can occur if the integrated pest control manager makes the wrong decision.

Because the pest problems are complex and there are risks of crop loss, farmers commonly use toxic chemicals to kill pests. At the governmental level, the desire to assure a stable food supply has allowed and even encouraged pesticide-oriented control to flourish. New outbreaks of the target pest and previously controlled secondary pests have occurred because of the pesticide-induced agroecosystem disruptions and because one pest after another became resistant to chemical controls. It is a well-known scenario, world-wide.

To end the pesticide-overuse/resistance syndrome, integrated control strategies were developed which emphasize the use of natural and cultural pest control measures, including resistant or tolerant plants, with pesticides applied only as the last resort.

Many pest control specialists contend that even a simple crop ecosystem cannot be represented by an analytical model; others believe that an ecosystem can be described by a series of differential equations. Actually, both views are probably partially right. It took nearly five years for University of California scientists to set up the model representing the cotton cropand some of its pests and their natural enemies. Cooperating scientists from many disciplines — agronomy, computer science, entomology, mathematics, physiology, plant pathology, and more — were required to gather data efficiently. They had to investigate many biological relationships (how the pest affects its host, for example), pest fecundity, development, mortality rates, and so on.

The cotton model has proved to be invaluable for examining biotic and abiotic factors affecting yields in the San Joaquin Valley. It puts the dynamics of the cotton plant into a manageable perspective and provides a means of investigating the biology and ecology of cotton pests, their impact, and the economics of various pest control strategies.



The possible interactions of the plant/pest/natural enemies as modified by man's activities and the weather.

Of what practical value are pest/host models? These models enable us to examine complex biological relationships as affected by plant development and the age structure of the fruits. Models can also determine the optimal pest control strategy for a pest problem. In one or at most a few computer runs the equation can be solved and the optimal solutions revealed. For example, in 1976 scientists using a computer model confirmed earlier speculation that the usual time for applying controls for the Egyptian alfalfa weevil should be shifted from spring to mid-winter. Models also enabled them to determine the optimal quantity and timing of pesticide applications.

Models can be used to plan for minimizing the development of pesticide resistance and to determine the best pest control policy from society's as well as the farmer's standpoint. The two policies may differ radically.

Although integrated control can operate at fairly unsophisticated levels, there are many cases (*e.g.*, pink bollworm on cotton, codling moth on apples) where IPM may be enhanced by the use of models and computerized delivery systems. Some research groups centralize these pest management aids in large, university-centered computers. This is costly. Other groups, such as some in Texas, use mini-computers that are cheaper and easier to operate. Mini-computers require error-proof yet simple programs and a well-trained cadre of pest management specialists. Ultimately, integrated control must be weaned from the researchers and put in the field. Mini-computers appear to provide the necessary link.

Integrated pest control, by whatever method, is already proving itself. Active programs in many states have greatly reduced pesticide use. More important, perhaps, is the fact that workers are beginning to understand pest problems in much greater detail. Systems analysis as used in integrated control has truly reintroduced the science of ecology into pest control.

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