Integrated control of insect pests in San Joaquin Valley cotton

Louis A. Falcon Robert van den Bosch

Historically, San Joaquin Valley cotton has been affected by relatively minor insect problems. However, in the middle and late 1960s this pattern changed when serious bollworm (*Heliothis zea* [Boddie]) infestations erupted in many of the valley's cotton fields. The problem seemed related to the transition from the persistent, environmentally mobile organochlorine insecticides (particularly DDT) to the more ephemeral, less mobile organophosphates, which was forced by increasing legal restrictions on the use of DDT.

The root of the problem appeared to lie in the persistence of the organophosphates, and their generally lower toxicity to bollworm than that of the previously favored DDT-toxaphene mixture. Mid-season lygus bug (*Lygus hesperus* Knight) control, with the organophosphates in particular, led to the secondary outbreaks of the bollworm and other caterpillar pests (*e.g.*, cabbage looper and beet armyworm) because the insecticides destroyed the caterpillar's natural enemies and lacked the persistence to suppress the larvae (caterpillars) that developed in the predator-free fields. Such secondary pest outbreaks have plagued insecticide use in most of the cotton growing areas of the world.

University entomologists working on the problem recognized that lygus control was the key to the bollworm enigma. They undertook in-depth studies of lygus biology, ecology, phenology (seasonal trends), damage potential, and control to determine the way to manage this best. During this period, research responsibility was partitioned among a group of investigators who met periodically to discuss their findings and to assemble an integrated control program.

Perhaps the most important finding was that during the growing season susceptibility of cotton to serious lygus bug injury only occurs in the limited period from square initiation until peak squaring—usually roughly the month of June—and that even in this high-hazard period, significant lygus damage occurs only where the pest's populations maintain high levels. Previously, lygus control had been recommended at any time from square initiation to late mid-season (roughly mid-August) whenever populations reached 10 bugs per 50 net sweeps.

Concurrent studies on bollworm phenology (seasonal activity) clearly revealed that the mid-season lygus treatments, in addition to being worthless, were often counterproductive: they destroyed natural enemy populations just when major bollworm (moth) egg laying occurred. Without predators to destroy the eggs and small larvae, damaging bollworm infestations frequently erupted in the biotic vacuum created by the lygus treatments. Severe outbreaks of the cabbage looper and beet armyworm were similarly triggered by the mid-season lygus bug treatments. Even the potent and persistent DDT-toxaphene mixture caused caterpillar outbreaks when the treatments were improperly timed.

During the research phase of the cotton integrated control program, considerable attention was given to the assessment of cotton plant growth and fruiting characteristics, particularly the interrelationship between plant growth and fruiting, and insect damage. Many important findings resulted from these studies. For example, it was discovered that lygus feeding, if it occurred during periods of heavy squaring or in the boll formation period, had virtually no effect on crop yield or quality; therefore, high lygus populations could be tolerated once the critical early square formation period had passed.

Studies on the bollworm revealed that in fields where heavy predator populations occurred, mortality to the bollworm eggs and larvae frequently exceeded 90 percent. In these fields, economic infestations of the bollworm never developed. Studies on the defoliating caterpillars revealed similar mortalities. It was also found that the bollworm larvae have a characteristic distribution pattern on the cotton plant: they are largely confined to the upper third of the plant and much of their feeding occurs on excess squares and small bolls destined for natural shedding. These findings encouraged the development of a more rapid sampling method for bollworm, and raising the bollworm economic threshold.

The program

The concerted multi-faceted research program in San Joaquin Valley cotton led very quickly to the development of an effective integrated control program for that crop. The program entails continuous assessment of cotton plant growth and fruiting performance in

SEX DISRUPTION AIDS IPM IN COTTON

A new technique—disruption of male/female communication with pheromones—has been introduced into California's cotton pest management system.

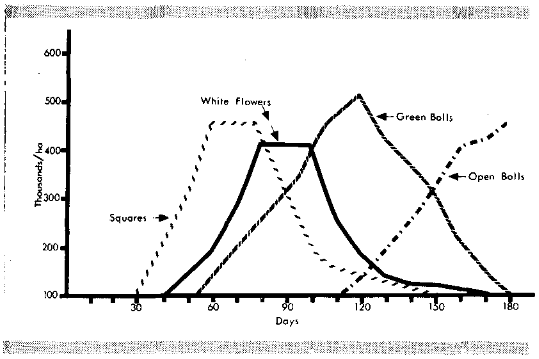
Harry H. Shorey and Lyle K. Gaston, scientists at the University of California, Riverside, have capped six years of laboratory and field study with a highly successful, inexpensive, and non-polluting method of controlling the pink bollworm, one of cotton's most serious pests.

After observing male moth behavior and analyzing female moth attractant chemicals, the scientists produced a synthetic compound that closely approximated the chemical makeup of the female attractant. This synthetic "gossyplure," when released in cotton fields, confused the male moths and prevented their finding the females and procreating.

The degree of suppression of the population of pink bollworm larvae infesting cotton bolls in the three fields that were tested was equal to that achieved by conventional insecticides in ten test cotton fields. The cost was $26 per hectare, about the same as for two applications of insecticide.

A pheromone-based pest control program reduces the need for insecticide applications and has little adverse effect on non-target organisms.

—R. Boardman



Seasonal growth of flowering and fruiting parts of cotton plant. Graphs such as this can show number of fruiting parts "at risk" at any time of season and can give an estimate of yield.

relation to climate, insect populations, irrigation, fertilization, cultivation, and, to some extent, disease. The pest management advisor or grower visits fields at frequent intervals from mid-May until the end of September, where he measures plant growth, notes fruiting performance, assesses insect populations (both noxious and beneficial), records pest injury, and notes weather conditions and crop production practices (*e.g.*, irrigation, cultivation, fertilization). At the same time, he plots actual crop performance and compares it to optimum performance for the Acala variety under cultivation. Deviations from optimum performance call for an assessment of the spectrum of factors that might be hampering plant performance. This takes much of the guesswork out of pest control decision-making. In San Joaquin Valley cotton, insects have too often been blamed for crop loss when poor agronomic practices, or adverse weather conditions, have been the cause.

Economic thresholds

Under the integrated control program the guesswork about insect injury has been even further reduced by refined economic thresholds (the point at which insect injury is sufficient to justify artificial control measures) for lygus, bollworms, and the defoliating caterpillars.

For example, the refined lygus economic threshold restricts spraying for the pest to the early season (usually the month of June), and to the few fields where the pest becomes sufficiently abundant to pose a threat. As a result, there has been a reduction in overall spraying for lygus in San Joaquin Valley cotton, and a strong reduction of mid-season spraying. Spray costs are therefore lower, lygus control is more efficient, and the bollworm has virtually disappeared as a secondary outbreak pest.

Through integrated control, the bollworm, the most severe insect pest of cotton in the 1960s, is no longer an economic problem in the San Joaquin Valley. Furthermore, the integrated pest control program permits the grower to use the organophosphate substitutes for DDT in an efficient and nondisruptive way. Finally, there has been a benefit to the general environment, which now receives a substantially lower pesticide load under the integrated control program.

The future

Research on integrated control in San Joaquin Valley cotton continues. For example, a refinement of the lygus economic threshold has been developed: the static ten bugs per 50 net sweep threshold has been replaced by a flexible number which relates lygus density (as determined by sweeping) to square load (number of squares per acre). Under this system, as square load increases, so does the number of lygus that can be tolerated.

Intensive studies of spider mites, the one pest group that has until now been poorly understood, are under way. Already considerable light has been shed on the phenologies of the three spider mite species, their in-field and on-plant distributions, their damage potentials, their natural enemies and their artificial control. A tangible benefit has been the development of a rapid and efficient spider mite sampling method.

Finally, the cotton plant model is adding insight into cotton performance and is already helping to refine the existing integrated control program into a scientifically reliable, highly sophisticated pest management system.

Louis A. Falcon is Professor, Department of Entomological Sciences and Associate Insect Pathologist in the Experiment Station, University of California, Berkeley. Robert van den Bosch is Professor, Department of Entomological Sciences and Chairman, Biological Control, Experiment Station, University of California, Berkeley.

HEAT ACCUMULATION METHOD AIDS COTTON PEST MANAGEMENT

A heat accumulation method of predicting pest outbreaks has proved simple, practical, and efficient in the management of two pests of cotton—lygus bug and pink bollworm.

By totaling heat units based on daily maximum and minimum temperatures, starting January 1, researchers have gathered data permitting accurate prediction of pink bollworm emergence and of lygus bug movement from safflower into cotton. The latter prediction has enabled California growers to apply a single, areawide insecticide application, largely eliminating the lygus bug threat in the San Joaquin Valley for the remainder of the growing season. The forecasting system also accurately predicts pink bollworm overwintering, emergence, and subsequent generation peaks in Imperial and Palo Verde valleys.

The thermal accumulation method depends upon three factors in the calculation and accumulation of heat units: the temperature threshold(s) for the development of the organism; the relevant period in its life cycle; and the method(s) of calculating the heat units.

Most weather stations keep records only for daily maximum and minimum temperatures. Therefore, a practical heat summation method requires only those values. The daily maximum and minimum temperatures, when checked against a computer-produced table, can be expressed as degree-days. It was found that 50 percent of the pink bollworm population emerges at the accumulation of about 13,600 degree-days. Peak emergence occurs at about 16,200 degree-days. Subsequent generations appear in predictable peaks about 35 to 40 days apart, depending on prevailing temperatures (or 23,200 degree-day intervals from peak emergence).

Similar prediction methods are being developed for monitoring the growth of the cotton plant and for cabbage looper and lettuce root aphids on lettuce.

Heat accumulation techniques in pest management are not only simple and practical but lend themselves admirably to computer technology and analytical methods already available and in use.

Vahram Sevacherian is Assistant Professor of Entomology and Statistics, Nick C. Toscano is Extension Entomologist, and Robert A. Van Steenwyk is Assistant Professor, Division of Economic Entomology, Department of Entomology, University of California, Riverside.