Summary of Progress:

At the Yuma Experiment Farm three studies were conducted on pest management and environmental improvement. These studies involved: 1) strip-cutting all alfalfa on the farm; 2) diversifying the cotton agroecosystem with grain sorghum and soybeans; and 3) achieving selective action of a broad spectrum insecticide by selective placement of the spray.

The data are not completely summarized in any of the studies. However, partial summaries permit certain generalizations. In both areas of the farm strip-cutting the alfalfa effectively herded lygus back and forth into adjacent half-grown alfalfa strips. In area 1, adult lygus exceeded the treatment level twice during the growing season but both times the populations declined within 2 to 3 days as the lygus apparently migrated back into the alfalfa. The treatment level was exceeded only once in cotton in area No. 2. Large fields of alfalfa adjacent to both areas were solid-cut during the season which resulted in part of the lygus problem in the cotton.

Predator populations in cotton peaked at about the same time as they did in the alfalfa but at much lower levels. Sweep-net sampling showing seasonal trends indicated that Orius sp. was the most abundant predator (of those examined to date) in alfalfa, followed by Geocoris sp. and then Nabis sp. In cotton Geocoris sp. was by far the most abundant predator for most of the season. Orius sp. was intermediate in numbers until early August at which time it equalled Geocoris numbers. Nabis species, of the 3 predators studied, was found in lowest numbers.

Soybeans and grain sorghum were planted near cotton in an effort to determine the occurrence of pest and beneficial species that also occur on cotton. Both crops were planted later than planned; late-season sampling was initiated. It appeared that soybeans were a favorable host for lygus and might serve as a more manageable crop in a row-crop scheme than does alfalfa. Sampling to date indicates a striking preference for certain predators for one crop or the other. For example, in the sample collected on October 10, Nabis sp. were taken in soybeans but not in sorghum; while few Orius sp. were taken in soybeans much higher numbers occurred in sorghum.

A pilot study was initiated to determine the effects of spray-nozzle arrangement on pink bollworm infestations and predaceous insects. The treatments were 1) untreated check, 2) normal spray pattern of 3 nozzles/row and, 3) two nozzles/row directed at the lower 2/3 of the plant.

Results indicated that pink bollworm infestations can be maintained below the economic threshold by using only 2 nozzles per row and at the same time conserve considerably more predators in the terminal area than where 3 nozzles are used.

BIOLOGICAL CONTROL INVESTIGATIONS

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Objective: To develop parasites and predators for control of cotton pest and to integrate them into a total management system.

Summary of Progress:

In past years, the Cotton Insects Biological Control Laboratory has screened and developed several parasites of the pink bollworm and the bollworm, as well as other cotton pest. Concurrently, background information on many of the cotton pests has been developed and means of assessing both pest and beneficial insect populations have been developed. In addition, bioclimatic studies of the situations in a cotton field have been made and the modification by the cotton plant on temperature has been evaluated. These studies have provided adequate interpretive, analytic, and production information for the introduction of parasites for the control of the pink bollworm and bollworm on large acreages.

In 1971 and 1972, two hymenopterous parasites, *Bracon kirkpatricki* and *Chelonus blackburni*, were tested as control organisms for the pink bollworm in approximately 100 acres of irrigated upland cotton near Tucson. The introductions of the parasites apparently reduced the number of insecticide applications required for the pink bollworm. The pink bollworm populations were suppressed in the early season by releases of *B. kirkpatricki*, but *C. blackburni* was somewhat less effective in the later portions of the season.

Earlier research also indicated that a cropping sequence of small grain, early sorghum, cotton, and late sorghum, along with naturally occurring winter and summer weeds, provides a large population of predators. These predators have been shown to move from one crop to another as the earlier crop or weeds mature.

Field Experiments:

An experiment was conducted in Marana on a 10-acre block that was planted to cotton with the exception of the center 2 acres which were planted with early sorghum. *B. kirkpatricki* was introduced from June 15 to August 24 at the rate of about 6,000/acre and *C. blackburni* was introduced from June 15 to September 28 at the rate of about 5,400/acre weekly. Assessments of the predator populations, pink bollworms in the blooms and bolls were made at weekly intervals, and pink bollworm adult flights were monitored with Hexalure traps. The cotton losses to pink bollworm were assessed just prior to the picking of the cotton.

About one third of the pink bollworms in the blooms were parasitized by either *B. kirkpatricki* or *C. blackburni* between July 12 and August 2. During the month of August about 7% of the pink bollworms in the blooms were parasitized. Larval infestations in bolls were about 50 per 1000 vulnerable bolls during July, about 80 per 1000 bolls during August, and about 150 per 1000 bolls during early September. Parasitism by *C. blackburni* was about 8 pink bollworms per 1000 bolls from mid-July to mid-August, and then declined. Between May 21 and the end of August the Hexalure trap catches averaged less than 0.5 moths per trap per week.

The results indicated that to be effective the parasite introductions must be made on very low levels of pink bollworms. The data also indicated that the effectiveness of the introduced parasites is highly affected by the area or volume of the cotton canopy that needs to be searched. The Hexalure trap catches indicated that trap catches of very low level may not reflect the true intensity of the pink bollworm infestation. Data on the predators indicated that large populations of predators may develop in sorghum infested with Biotype C of the greenbug, but their movement into adjacent cotton may be curtailed if more attractive aphid infestations persist in the sorghum.

An experiment conducted in Yuma consisted of two replicates of four blocks with each replicate encompassing two 2-acre blocks of cotton, one 2-acre block of early sorghum, and one 2-acre block of small grain followed by late sorghum. A large block of alfalfa was adjacent. B. kirkpatricki was introduced in the cotton at the rate of about 9900 parasites per acre per week between June 14 and August 16. C. blackburni was introduced at the rate of about 6600 per acre per week between June 14 and August 23. Assessments were made in a manner similar to those in the Marana experiment.

Populations of pink bollworms in the cotton blooms failed to develop above levels of 50 per acre per day and generally were below 20. Infestations in the bolls remained at about 30 per 1000 bolls from early July until late August. In late August the numbers of vulnerable bolls declined and the pink bollworms concentrated in the small number of available bolls and approached about 1000 pink bollworms per 1000 bolls. Catches of adults in Hexalure traps were rare. About 1% of the open cotton was damaged when 80% of the cotton was open.

The high temperatures apparently suppressed the pink bollworm populations throughout most of the growing season because the canopy failed to close and modify the environment within the plant adequately for the optimum development of the pink bollworm. Low levels of parasitism by the introduced parasites indicated that the high temperatures were detrimental to the effective behavior of the parasites. Although relatively large populations of predators developed in the grain sorghum, they dissipated because the food source was not available in the adjacent crop.

For the Yuma experiment, a method of transporting parasites over short distances was developed. The parasites were transported in an insulated camper from Tucson to Yuma, a distance of approximately 240 miles over hot desert areas in a large dough-proofing tray converted into a large ice chest.

In a continuing study of the immediate destruction of cotton crop residue after cotton harvest followed by plowing for winter grain or for cotton in the subsequent year, evaluations similar to those listed above for the Marana and Yuma experiments were employed. In the study no cotton land was left unplowed and all land planted to cotton in a given year is utilized to grow winter grain or cotton in the subsequent year.

In 1973 very small numbers of emerging moths were captured in Hexalure traps throughout the ranch area during the early season. Hexalure trap catches in 1973 were about one fortieth of the catches in 1972. The largest infestations of pink bollworms, although small, were adjacent to 1972 cotton fields. At the end of August the infestation of pink bollworms was at about one tenth of the 1972 level.

The experiment indicated that early cotton crop residue destruction followed by total planting of cotton land in the following season with small grain or cotton reduced the emergence of pink bollworms. The effectiveness is dependent upon the plowing and the seal of the soil surface by the irrigations or winter rains. These management practices appear to result in the low populations of pink bollworms prerequisite for successful parasite introduction. The data also indicated that pink bollworms disperse freely until fruiting cotton becomes available. The pink bollworms apparently moved only short distances if fruiting cotton was available. This trend was apparent although the emergence in 1973 was small as compared to 1972 when the trend was very distinct.

The 1973 experimentation confirmed that it is essential to make a detailed analysis of climatic factors, that proper timing of the cropping sequence is essential, that constant parasite pressure must be applied, that detailed analysis of all mortality factors associated with the target population is essential, that proper population assessment is extremely necessary, that the relationship between insects and crop plants must be established, and that undetected major factors apparently influence populations of insects, and that studies of population genetics will be necessary for full evaluation of parasite introductions and associated management practices.

A pilot test to evaluate the concurrent use of strip cutting of alfalfa, the herding of predators from winter small grain to early sorghum and cotton, and thence to late sorghum which follows winter grain in the cotton sequence has been initiated. The land for the experiment is divided into four replicates of four 10-acre blocks of basic crops (alfalfa, early grain sorghum, cotton, and wheat followed by late grain sorghum). The alfalfa and wheat have been planted and it is expected that by the planting time of the spring crops that adequate numbers of predators will have developed in the young alfalfa and the winter grain to allow the herding of the predators from crop to crop. In addition to the cultural methods employed in the experiment, B. kirkpatricki and C. blackburni will be introduced as control agents for the pink bollworm.

Interpretive Information:

Ecology and Biology of Cotton Pests: Developmental studies of the cotton leafperforator, Buccalatrix thurberiella, indicated that the egg stage of the perforator ranges from about 4 days at 35° C to about 9 days at 20° C. The larval-pupal period ranged from about 10 days at 35° C to about 25 days at 20° C. The fecundity of the female perforators ranged from 0 at 35° C to about 100 eggs at 20° C. The results indicted that the cotton leafperforator is a warm, but not hot weather insect. Thus, some insight was gained in regard to the rapid increase in populations in late summer when the canopies of the cotton modify the air temperatures. The lower temperatures permit a greater part of the female's reproductive potential to be expressed. The developmental data have been translated into physiological units for use in model construction.

Population Assessments: Data previously obtained are under analysis to provide improved confidence intervals for mean population estimates.

Plant Response: Initial plant measurements and collections have been made for the evaluation of the cotton plant model, SIMCOT, by Dr. Don Baker, ARS, under Arizona conditions. Plant maps of Deltapine-16 and Stoneville-213 cottons were made in 1973 and the photosynthate production is being assessed.

Modeling: The development of cotton insect population models from previous data on development and mortality is continuing. An outline of the requirements of such models has been made and is in the process of publication. The discussion concerns itself with the factors essential in the model and the experimental requirements for data production for model use as well as noting pitfalls which modelers may encounter.

Development and Rearing:

Parasites: Parasierola emigrata--This small hymenopterous parasite of pink bollworms needed only 7-1/2 days to develop from egg to adult at a constant temperature of 95° F. At lower temperatures, the time required for development increased, e.g., 23 days at 68° F, 13 days at 77° F, and 9 days at 86° F. Survival of the various developmental stages was not reduced appreciably by the higher temperature.

Thirty-five mated females at 76-78° F and 20-30% R.H. lived an average of about 53 days, and after a preoviposition period of 6 days, laid 129 eggs on 18 pink bollworms for an average of 7.3 eggs per host. Of these eggs, 62.7% survived producing 81 adult parasites. The sex ratio of these progeny averaged 1 male to 5.9 females. Twelve unmated females, when held under the same conditions, lived an average of 23 days and deposited 114 eggs on 13 pink bollworms. Eighty-four per cent of the eggs survived to produce an average of 96.4 progeny/female. All progeny from the unmated parasites were males.

Chelonus blackburni--The time required for the development of this parasite was studied at constant temperatures of 68°, 77°, 86°, 90°, and 95° F to determine the optimum temperature for mass rearing procedures. Development from egg to adult decreased from 54.5 days at 68° F to 23.0 days at 86° F and to 22.2 days at 90° F. A slightly longer time (23.6 days) was required at 95° F, evidence that this temperature is above the optimum. The number of parasites produced/host egg exposed was greatest at 77° F and poorest at 95° F. When both the survival of the parasite from egg to adult and the time for development are considered, a temperature of 86° F appears to be the most satisfactory. Previous studies have shown that Chelonus blackburni will parasitize the eggs of pink bollworms, tobacco budworms, cotton bollworms, cabbage loopers, and beet armyworms. Previous evidence also has shown that they cannot distinguish between unparasitized eggs and those previously parasitized, resulting in some eggs being parasitized several times. A test was conducted to determine the suitability of the various species as a host for this parasite. Several samples of eggs of each species were exposed to the parasites for varying lengths of time, resulting in the eggs in each sample being parasitized a different number of times. The percentages of the eggs hatching and of the resulting larvae producing parasites were used as criteria of suitability for each species.

The pink bollworm proved to be the most suitable host with a good egg hatch, and 67% of the larvae produced parasites. However, more than 3 parasite eggs/host egg resulted in overparasitization and a reduction in hatch.

Cotton bollworms and cabbage loopers were also suitable hosts. The percentage of egg hatch was good at a rate of 8 or fewer parasites/host egg for the bollworm and 3 or fewer parasites/host egg for the cabbage looper. Maximum parasite production was 46% and 49% for the bollworm and cabbage looper, respectively.

Beet armyworms were much less suitable hosts and tobacco budworms were totally unsuitable hosts. Three or more parasites/beet armyworm egg reduced the hatch considerably and about 20% of the parasitized larvae died prematurely, and only an occasional parasite was produced.

Different age pink bollworm eggs were exposed to the parasites to check for acceptability by the parasite and the effect of parasitization on the host eggs and larvae. Eggs 0-24 hours, 24-48 hours, 48-72 hours, and 72-96 hours old were exposed. There was little difference in the results when eggs less than 72 hours old were used. But after 72 hours there were fewer eggs parasitized and more host larvae died without producing parasites.