51ST ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

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Foreword

In 1997, there were approximately 13,446,500 acres of cotton (Upland and Pima) harvested in the U.S. with an average yield of 1.40 bales per acre (480-lb bales) amounting to an 18,825,100 bale production (USDA -- December 11, 1997 report). Harvested acreage declined about 1% and yield was the same, indicating only a slight decrease in total production over 1996. Arthropod pests reduced overall yield by 9.42% in 1997 in spite of control measures which cost an average of over $58.00 per acre; loss in yield to insects in the 1997 crop was over $53.00/acre, yielding a total cost from insects in the 1997 crop of about $111.00/acre (almost $1.5 billion). The boll weevil was the number one pest at 4.02%, even though it was absent from 9 states (58% of U.S. acreage infested). Seventy-nine percent (79%) of the U.S. cotton acreage was infested with bollworm/budworm in 1997 requiring an average of 0.9 applications/acre, 78% of this acreage was infested with bollworm, and the two combined for a 2.01% reduction in yield. The 2.27 million acres of *B.t.* cotton in 1997, along with boll weevil eradication in 9 states have brought shifts in pests and reduced the effect of tobacco budworm. *Lygus* (0.91%), aphids (0.75%), and thrips (0.47%) complete the top five insect pests of 1997. (See M. R. Williams, these proceedings.)

Crop and Arthropod Pest Conditions

Alabama

Record-breaking cool, wet weather was experienced in North Alabama during May and June which severely retarded cotton development. (Many fields did not bloom until the latter half of July.) *Ascochyta* sp. blight was prevalent in late May and early June. In fields where the cotton aphid had been flared, this disease was responsible for major plant mortality. The cotton aphid appeared to be important as a facultative vector of *Ascochyta* sp. blight. Due to the poor condition of the crop, ca. 100,000 acres were destroyed, most of these being in Madison and Limestone Counties. Yields from the remaining 125,000 acres should be near 600 lbs.

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The tarnished plant bug was the major pest problem of the year, causing chronic damage throughout July and much of August. Low numbers of corn earworms, tobacco budworms and fall armyworms were present from mid July until harvest. Significant infestations of European corn borers occurred on a limited acreage in northwest Alabama in early August.

This season began with one of the coolest springs on record. The rainfall situation varied from one extreme to the other several times during the season. By June 20-25 a critical situation had developed in the Tennessee Valley area of North Alabama. Cool wet weather and diseases had taken its toll on cotton growth, development and stands. During the month of July, decisions were made to plow under approximately 100,000 acres of the 200,000 acres planted in North Alabama. This was due to the stunted growth and delayed maturity (4 to 8 weeks behind schedule). After the widespread weather fronts of June, only scattered thunderstorms occurred from about July 1 to August 15. From August 15 to October 1 basically no rainfall occurred statewide. This caused the shedding of most fruit on the plants except the mature bolls. The square set period of 1997 was only about 4-5 weeks long.

Thrips pressure was moderate in 1997 but the thrips injury susceptible period was extended due to the adverse growing conditions. Most systemic insecticides did not hold long enough. Due to the cloudy wet June, plant bug numbers flourished along field borders resulting in an extended migration into cotton. Early square set was poor due both to plant bugs and cool, cloudy weather and waterlogged soils. Yellow striped armyworms were common on presquare cotton and populations persisted season long in low spray environment. Their damage was primarily foliage feeding, but some fruit feeding was reported and a few fields were treated.

About 65% of the initial acreage was planted to Bollgard varieties. Several regions of the state (N., C. and SW) planted near 90% Bollgard while others (SE) planted only about 10-25%. Tobacco budworm (TBW) pressure was light in June but intensified about July 5-10 with a second generation occurring in early August. TBW control with pyrethroids and other tank mixtures was disappointing, and significant damage occurred in the SE region where limited acres of Bollgard were planted. Tracer performed well where timing, coverage and appropriate rates were used. It appeared that the TBW was definitely resistant to pyrethroids in this area. One significant event occurred in 1997. Two moderate to heavy generations of TBW's occurred in central Alabama where the entire region had 80-90% Bollgard cotton.

The bollworm (BW) appeared about mid July and infestations were moderate to heavy depending on the field and location. Very little supplemental spraying was required on Bollgard varieties. However, escape larvae were not difficult to find. Pyrethroids gave good control of BW on conventional varieties. The eggs deposited by the TBW moths were near the terminal and on the top surface of leaves where they were highly visible. Bollworm eggs were, again in 1997, deposited down in the canopy and were difficult for scouts to find. This difficulty in finding eggs will make it hard to utilize the Lepton test kit when it becomes commercially available. In summary, the BW and TBW combined resulted in a 30 day plus egg lay in many fields in C. and S. Alabama.

Fall armyworm (FAW) populations developed early and heavy in the Gulf Coast area (SW) and later spread at economic levels over much of the central and southern parts of the state. Detectable numbers occurred statewide for the second consecutive year. FAW's made up part of the worm complex for most of July and August in most S. and C. Alabama fields. However, fruit damage was minimal since the FAW does not damage many fruit per larvae. It does appear that the higher thresholds (2X) of FAW over BW are justified. Where controls were applied for FAW's, mixed or limited effectiveness was observed. Coverage continues to be a major problem in controlling this caterpillar since they feed between the boll bract and the boll in the early to mid instars.

The southern armyworm was more widespread than any time during the past 25 years. This caterpillar species is a slow feeder and consumes a limited amount of foliage. The majority of their feeding is confined to the foliage or bloom petals. Their damage was not thought to be economic, but their numbers were scary to growers who have experienced beet armyworms. Soybean loopers occurred in late season and were more widespread than in recent years.

Stink bugs (SB) were observed in cotton as early as June. However, their increased numbers and visible damage did not occur until late July-early August (bollset). Populations were widespread in August, and most fields were treated at least one time. Scouts and growers did a better job of preventing boll damage by SB than in 1996. However, we still have a ways to go in dealing with this pest since many growers do not want to kill beneficial populations as they treat for SB. Once controls were applied, it appeared to take about three weeks for SB numbers to rebound and in many instances the top harvestable bolls were mature by then. The thresholds of one SB per 6 row feet seemed to be on target. The drop cloth survey technique appeared satisfactory. In field tests, most phosphate insecticides did an excellent job (90-100%) of controlling SB while pyrethroids gave 80-90% control.

Aphids were heavy (clustering on all plants) in many fields from late June to mid July. Few insecticides were applied and populations eventually crashed from the naturally occurring fungal disease (*Neozygites fresenii*). Aphid populations rebounded in numerous fields in September along with a buildup of whiteflies. Some sticky cotton was observed as the honeydew secreted by both pests fell on open bolls. Heavy populations of the sweet potato or silverleaf whitefly were identified in Mobile county (Gulf Coast) in September. Several fields were completely defoliated.

Beneficial insects were not as abundant in 1997 as 1996, even before any foliar insecticides were applied. This indicates that factors yet to be identified may also be regulating beneficial populations.

Boll weevils emerged in two rather confined areas in the spring of 1997, which correlated to where numbers were trapped the previous Fall. Eradication personnel concentrated on these areas (less than 5% of state) with foliar malathion sprays. Weevil numbers were non-detectable throughout most of the season in the majority of the state. However, in early September, weevils were captured in several areas for the first time all season. This may indicate that achieving final and complete eradication may be very difficult in communities that plant a high percent Bollgard cotton, which results in little to no foliar spraying by growers.

In general, Bollgard cotton was treated from 2 to 4 times in 1997, primarily for thrips, plant bugs, SB, FAW or aphids. Conventional varieties were treated 3 to 6 or more times for TBW, BW, FAW and SB. The big difference between *B.t.* and conventional varieties was not the number of applications but the cost per application. TBW control on conventional varieties ranged from $10 to $15 per application, depending on the rates used or the choices of chemicals for the tank mixtures. In most instances, some TBW damage occurred on top of the control cost. Applications to control insects on *B.t.* cotton usually range from $3 to 6 per acre per application.

Arkansas

The majority of the crop in northeast Arkansas was planted within the normal window. However, cold, wet weather in late May delayed growth. Weather in June and July was ideal for growth, and the crop recovered and set a high number of squares. Many fields set heavy fruit loads going into August. Overall conditions were good throughout the remainder of the season for good growth and boll fill. Many fields cutout in early August, with yields being slightly above average.

Overall insect pressure was light. Thrips numbers were extremely low, with very few foliar applications being needed for this pest. Boll weevil numbers were also light. Pheromone traps were effectively used to monitor emerging weevil numbers and timely applications were made to control this insect. Weevil pressure remained light for the remainder of the season, with localized areas requiring some applications in early August.

Plant bugs were generally light, with a few areas requiring treatment for this pest in early July. Bollworm populations were also light with most growers making 1-2 applications throughout the season for this pest. Budworm numbers were extremely low. Cotton aphids were a problem in localized areas. However, only a few acres were treated. The fungus, which attacks the aphid, reduced populations below treatable levels. Spider mite numbers were light and extremely spotty. Those areas that were infested did not require treatment until late in the season. Very few applications were needed for this pest.

There were unusually large numbers of yellowstriped armyworms early in the season. This insect could be found in almost all fields. However, only a few fields required treatment due to large numbers causing significant defoliation. There were also a few isolated spots with garden webworms that required control early in the season. Fall armyworms were also prevalent in a few areas later in the season.

The crop year got off to a cold, wet, and slow start. Cotton was delayed in getting planted and grew slowly in May and early June. The weather improved greatly in June, and the crop responded to the warm sunny weather by setting a high percentage of squares. By mid-July the cotton was short in stature, heavily fruiting, and moving toward an early cutout. The combination of heavy fruit load and a poorly developed root system (a result of the cold wet spring) pushed the crop to an early cutout despite the late, slow start. Boll shed was experienced in most fields after a brief period of cloudy weather in early August.

In mid and late August, many small bolls dried up and stuck to the plant in some fields. An elliptical scar was formed where the peduncle dried up. This condition, which some have associated with the *Phomopsis* organism, is being called "boll dangle". It is associated strongly with certain cotton varieties and with stress. During August and into September many fields showed signs of nitrogen stress which may have been the result of N leaching, N denitrification, and/or the poorly developed root system. The cold, wet spring was in all probability, the source of the problem. The warm weather continued through September providing late bolls with sufficient heat units for full maturation. Yields have been above average.

Insect pest conditions in Southeast Arkansas cotton in 1997 were light. Thrips were disadvantaged by the frequent rains in the spring, and when the weather warmed up, the cotton quickly responded and grew to beyond the stage where thrips could cause damage. Boll weevils were numerous in early spring, but the delayed crop and good use of overwintered weevil treatments had strong effects on their populations. Plant bugs were present and required insecticide applications in many fields, but populations were not universally large, and some fields were not sprayed for plant bugs. Plant bugs were not much of a factor, as cotton plants set a very high percentage of their fruit.

Bollworm and budworm populations were light, but most fields needed 1-4 applications. The *B.t.* cotton varieties worked well, though some *B.t.* fields did require bollworm insecticide treatments.

Cotton aphids and spider mites showed up in large numbers on very late-planted cotton in late August and September but did not cause important losses in yields. Unusual pests were yellow striped armyworms, which were heavier than normal in the spring and fall armyworms, which could be found in most fields in late summer.

California

In 1997 1,079,215 acres of cotton were planted in California with 18% percent dedicated to Pima which represents a 16% decline in planted acres from 1996. The San Joaquin Valley cultivated the bulk (1,051,155 acres) with Sacramento Valley planting 10,635 acres and Imperial Valley planting 17,425 acres.

For the San Joaquin Valley, the 1997 season can be rated as another good but not exceptional year with yields estimated at 1200 lbs. for upland and 1150 lbs. for Pima. Yields were excellent in many locations (3.5-4.0 bales) and off in others (2.5-3.0 bales) The season began with great promise, but during early April, cool, windy conditions prevailed for weeks. However, once temperatures increased, the accumulated degree days for planting moved into the exceptional range. Cotton was planted in a normal time frame with most cotton planted by April 30. Warm conditions continued through plant emergence and early development. Temperatures were ideal from May through July with warm days and cool nights. Fruiting branches developed early with the first being at node 5 or 6. Fruit retention was exceptional with bottom retention in the 60-70% range. High temperatures were not as problematic in 1997 as in 1996. However, a heat spell in August probably stressed some fields depending on planting date and irrigation schedules. Crop termination occurred beginning in late August, and harvest commenced in late September. Conditions were excellent for harvest which was completed in record time.

Depending on location in the San Joaquin Valley, insects were light to severe. The northern cotton counties experienced very little pressure from spider mites, Lygus bugs, or aphids. Insecticide use was minimal. The mid-Fresno County area had moderate to severe pressure from aphids and beet armyworm (2-3 tank mixed applications). The eastern part of the Valley from Tulare County through the southern part of Kern County contended with the worse silverleaf whitefly densities yet experienced and required 2-3 applications of insecticides. The Lake Bottom region of Kings County faced pressure from repeated Lygus bug migrations, beet armyworm, and aphids. Yield loss and insecticide use are estimated elsewhere in this conference.

As a result of some detailed pest and plant monitoring in the Sacramento Valley in 1997, some unrecognized pest is suspected of removing significant fruit at the flower stage of fruit development in some fields. We suspect *Dibrotica* sp., but will watch closely for unrecognized pests in 1998. Phenoxy herbicide drift, from applications to significant portions of 400,000 acres of rice, was the biggest problem faced by the new cotton acreage in the Sacramento Valley of California in 1997.

Georgia

The spring of 1997 was one of the coolest on record. Seedlings struggled due to poor growing conditions and thrips injury compounded the problems of getting this crop started. Plant bug problems were more common in late June and early July than in recent years. Aphids built in some areas but few fields were treated and the naturally occurring fungus eventually caused populations to crash.

Tobacco budworm pressure was light in June but intensified in July and August. Tobacco budworm infestations were difficult to control, due in part to heavy pressure, especially in southwest Georgia. Several field collections were made and screened for susceptibility to pyrethroids. Preliminary indications suggest increased tolerance or resistance to pyrethroids in some tobacco budworm collections. *B.t.* cotton performed well against tobacco budworm. Corn earworm appeared in mid-July and infestations were moderate to high depending on location. Supplemental insecticide sprays were needed on *B.t.* cotton to control corn earworm in some areas. Fall armyworms were observed at detectable levels in most of the Coastal Plain of Georgia, and infestations were high during late July and August in the southern and eastern parts of the state. Control of fall armyworm was difficult and erratic with all available insecticides. Beet armyworm required treatment in some localized areas.

Stink bug populations were high in some fields during August, especially those which had not been treated with a broad spectrum insecticide recently. Boll injury from stink bugs was first observed in late July and continued to increase as the season progressed. Damage became more apparent as harvest neared and bolls began to open. Soybean loopers and whiteflies were also sporadic pests. High populations of silverleaf whitefly were observed in a localized area. Southern armyworm infestations were common during August and some fruit feeding was observed, but treatment of southern armyworm was not needed. A single cotton leafworm was also collected in southwest Georgia.

Boll weevils were detected in four counties during September, including Jenkins, Lowndes, Grady, and Thomas. Reproduction was occurring at the Lowndes county site. Boll weevil eradication personnel reacted promptly by intensifying trapping efforts and treating with insecticide where needed.

Late summer and fall weather was not conducive for cotton production. Lack of moisture in August, and excessive rains in September and October lowered yields and quality of the crop. A below average crop of about 700 lbs lint/acre will be harvested from 1,435,000 acres.

Florida

Although soil moisture was generally adequate during the early planting season cool soil temperatures during April and early May led to marginal stand establishment and growth. Below normal temperatures through mid June and wet conditions through July delayed fruit set. Most of the crop was set during late July and early August. Dry conditions during late August and September prevented the typical loss to boll rot this year.

Thrips populations ranged from normal (western panhandle) to higher than average (central and eastern panhandle). In general granular insecticides and/or seed treatments provided adequate control.

Plant bug populations were generally higher than normal. Physiological square shed combined with plant bug feeding resulted in many fields receiving treatments and missing fruiting positions low on the plant.

Aphid infestations ranged from low to high levels during July. The beneficial fungus disease, *Neozygites* spp., decimated populations by the third week of July. Infestations reappeared in some non-*B.t.* fields during mid to late August that had received insecticide applications for tobacco budworm. The beneficial fungus eliminated these infestations during early September.

In the western panhandle, bollworm populations were low all season and did not cause problems in conventional or *B.t.* cotton. Tobacco budworm infestations required multiple applications in some conventional fields during August. Some control problems occurred with pyrethroid insecticides. Subsequent applications with phosphates, or phosphate tank mixes, provided adequate control. In the eastern panhandle, budworms were common on non-*B.t.* cotton early in the season. These populations were replaced by largely bollworm infestations on both *B.t.* and non-*B.t.* cotton in late July. On *B.t.* cotton, numerous fields required treatment for threshold populations of small larvae (10 ¼" long larvae per 100 plants). In some fields the threshold was met and treatments were required up to four times during the season.

Fall armyworm infestations were scattered during mid to late season. Infestations first appeared during the third week of July. Highest populations were lower than observed in 1996 and early detection was once again a problem. Approximately one-third of fields received an application for fall armyworms. Beet armyworm populations were very low all season with no reports of treatable infestations. Southern armyworm populations were found at low to moderate levels in most fields during late August and early September. Feeding was confined to leaves and blooms with no economic injury observed.

Banded-wing whiteflies began building in some non-*B.t.* fields during late August and early September. However, parasitic wasps, *Eretomcerus* spp., provided control and prevented the use of insecticides.

The cotton leafworm was again present in approximately 2000 acres in the eastern part of the cotton production area. Several hundred acres required treatment.

Stink bugs were present in low numbers through mid season. Populations increased during mid to late September with approximately 20% of fields receiving an application for stink bugs.

In the western panhandle insect pest pressure was generally low during the season. This fact, along with high numbers of beneficials and the widespread use of Bollgard varieties (approximately 80-85% of the acreage), resulted in fields averaging only one in-season insecticide application for pest insects. On an average, yields of 770 lbs lint per acre are expected in the western panhandle. In the central and eastern panhandle higher insect pressure resulted in 5 to 6 applications of insecticides per acre and a yield of 600 lbs of lint per acre. State wide average yield is expected to be 720 lbs of lint per acre.

Louisiana

Cool and wet conditions during April resulted in most of the 1997 crop being planted between during early to mid May. Most of the cotton acreage was cutout by mid August and most of the state experienced favorable harvest conditions through October. Louisiana cotton yields are estimated to be approximately 725 pounds of lint per acre on 625,800 acres. 1997 yield reductions were attributed to the following: weather 8.5%, insects 7.1%, other pests 3.3%, weeds 4.2%, and chemical injury 1.6%.

Early-season insect pest infestations were variable. Thrips populations were extremely high over most of the state. Cutworm infestations were light with most high risk fields receiving a prophylactic treatment for cutworm control. Yellow striped armyworms and saltmarsh caterpillars were present in many fields, but most did not require treatment.

Overwintered boll weevil populations were moderate. Most fields received at least one pinhead square treatment. After pinhead square, boll weevil populations were light until late-July. From late July to harvest boll weevils were present at treatment levels in most fields. A boll weevil eradication program was started in the Red River Valley with a fall diapause control program. First diapause applications were made during the week of August 18 with 12 oz/acre malathion applications.

Tarnished plant bug populations were low prior to bloom. Most fields required only a few treatments prior to early July. During late-July and August, tarnished plant bug populations were extremely high. Control of these populations was only achieved when treated on a three to four day interval.

Bollworm populations were low during the most of the season, although the major cotton growing region of the state had a significant increase in corn acreage. Most non-*B.t.* cotton fields required 2 to 3 pyrethroid applications for bollworm. Tobacco budworm populations were generally light during 1996, with heavy infestations developing only in scattered fields. Fields with heavy infestations of tobacco budworms experienced populations in excess of one larvae per plant for periods of two to three weeks. Although growers with these populations were able to control them without much yield loss, control was only achieved at a high expense. Pyrethroid resistance levels in tobacco budworm populations were the highest ever observed. Pyrethroid use in June was also the highest observed since the 1980's.

B.t.-cotton was planted on approximately 38% of the total acreage. Tobacco budworm populations were such that no evaluation could be made on the activity of *B.t.*-cotton on tobacco budworm. Approximately 90% of the *B.t.*-cotton acreage was treated for bollworm. Approximately 1.5 insecticide applications were applied to control bollworm after first bloom.

Mississippi

Mississippi cotton growers harvested approximately 960,000 acres of cotton in 1997, marking the first year since 1983 that acreage dropped to less than 1,000,000 acres. Approximately 45% of this acreage was planted to *B.t.*-transgenic varieties, representing only a slight increase from the portion of acreage planted to *B.t.*-cotton in 1996. As in 1996, adoption of *B.t.*-cotton was higher in the hill region of the state (approximately 60%) than in the delta (approximately 30%).

Weather conditions during planting and seedling establishment were unusually cool and wet. Less than 10% of the crop was planted in April, and most of the cotton that was planted during this month required replanting. The majority of the crop was planted during the first two weeks of May, but seedling development was slowed by average weekly statewide temperatures that ranged from 2° to 5° below normal throughout May and the first half of June. Many areas of the state also experienced unusually heavy rainfall during this time that resulted in saturated soils and further delayed crop development. As a result, only 7% of the crop was squaring by June 15, compared to the 5-year average of 51% of the crop squaring by this date.

Despite the slow seedling development and prolonged period of seedling vulnerability, thrips were not unusually severe in 1997, although some fields did require supplemental foliar treatments. Cutworm problems were increased on some fields where wet field conditions prevented optimum seed bed preparation, but statewide damage from cutworms was also low.

Because the winter of 1996-97 was one of the mildest on record during the past 20 years, survival of overwintered boll weevils was expected to be high. Early season pheromone trap captures verified this expectation. However, because of the delay in crop development, most overwintered weevils had emerged by the time pin-head square treatments were applied. As a result, pin-head square treatments were highly effective in 1997, and weevil problems for the remainder of the season were rated low to moderate. Even though the window of greatest susceptibility to tarnished plant bug was prolonged in 1997, problems from this pest were also rated as low to moderate. However, some fields, especially fields planted to *B.t.*-cotton, did experience damaging populations of plant bugs during mid and late season. Tarnished plant bug continued to exhibit high levels of insecticide resistance in much of the delta region of the state. As in 1996, *B.t.*-cotton fields were found to require significantly more treatments for plant bugs and boll weevils as a result of the reduction in treatments for caterpillar pests.

Cotton aphid populations began increasing during late June and had built to high populations in many fields by July 10. Where treatments were applied, Bidrin or Provado provided most consistent control, but this pest continued to exhibit resistance to most available insecticides. Many growers opted to rely on natural control by the *Neozygites* fungal disease, which began providing control of aphid infestations in many fields by the second week of July. During 1997 Mississippi participated in a cooperative project with the University of Arkansas designed to provide early detection of this fungal disease, and results of these assays were useful in making aphid treatment decisions.

Tobacco budworm populations continued to be unusually low for the second year in a row. It is possible that this is at least partially due to an area wide effect of the wide scale planting of *B.t.*-transgenic varieties. However, there were isolated areas of the state that experienced heavy populations of tobacco budworm on non-*B.t.*. cotton during June and July. In such situations control was difficult to achieve with products other than Tracer, indicating that resistant tobacco budworm is still a threat. Some areas of the state experienced late season infestations of tobacco budworm on non-*B.t.* cotton, but unlike 1996, these late season infestations were less common and less severe than normal. This was the first year of commercial availability of the new insecticide Tracer. Although supplies of this product were limited, it performed well when applied against tobacco budworm.

Bollworm populations were considerably lower than in 1996. This was partially due to a slight reduction in corn acreage, but early season pheromone trap captures were also much lower than in 1996, suggesting that other factors also influenced bollworm numbers. Still, this pest was more abundant than tobacco budworm in 1997 and accounted for the majority of treatments targeted against this complex of caterpillars. As observed in 1996, *B.t.*-cotton continued to be susceptible to economic damage from bollworms under certain conditions, and approximately 41% of the *B.t.*-cotton fields in the state received at least one treatment for bollworms. However, results of a statewide survey indicated that *B.t.* fields sustained significantly less boll damage than non-*B.t.* fields (1.9% vs 2.7%) and received significantly fewer bollworm/budworm treatments per acre (0.85 vs 3.14). Pyrethroids continued to provide excellent, cost effective control of bollworms when treatment was necessary in either non-*B.t.* or *B.t.*-cotton.

Beet armyworms were absent or present only in low numbers in most fields in the state in 1997, and very few acres required treatment for this pest. However, fall armyworm was more abundant than normal, and many fields, particularly those planted to *B.t.*-cotton varieties, sustained low levels of boll damage from this pest. In most cases, given the expense and difficulty of controlling fall armyworm, this boll damage was considered to be at sub-economic levels. However treatment was required on some fields and boll damage in excess of 10% was observed in some situations.

Yellow striped armyworm was another pest that was observed to be consistently more abundant on *B.t.*-cotton, but not at economically damaging levels. Low numbers of southern armyworm were also detected in some fields in 1997, with some collections being made as far north as the Starkville area. Low levels of boll damage by European corn borer were also noted in a few non-*B.t.* fields in the northern portion of the state. Saltmarsh caterpillar was another uncommon pest that was observed to be more abundant than normal in 1997, although seldom at numbers that required treatment.

Although stink bugs do not normally require treatment in most Mississippi cotton, they are a consistent problem in cotton grown in the relatively boll weevil free area of the extreme southern portion of the state, particularly in fields that are also planted to *B.t.*-cotton. Following the exceptionally mild winter, stink bugs were more abundant and some fields in this region required as many as three treatments to control this pest. Few treatments were applied to control stink bugs in the remainder of the state, but this pest is expected to become more important following boll weevil eradication.

Bandedwinged whitefly required treatment on a limited number of fields in 1997, and an economically damaging infestation of silverleaf whitefly was documented in a few fields in the extreme southern portion of the state. During late August, and early September, populations of bandedwinged whitefly and cotton aphids were observed to be generally higher on acreage inside the boll weevil eradication program. However, these late season infestations and associated honey dew and sooty mold did not appear to adversely affect yield or lint quality.

The hill portion of the state, approximately 340,000 acres, initiated a Boll Weevil Eradication Program in the late summer. The program began during the first week of August with a series of fall diapause applications of ULV malathion applied at a rate of 10 oz. per acre. Treatments were maintained at 5 to 10 day intervals until the crop was harvested and stalks destroyed or until weevil activity was terminated by frost. Approximately 10.5 treatments per acre were applied as part of this aggressive fall diapause program. Fall pheromone trap capture results indicate that this approach was effective in reducing weevil populations to very low numbers in the eradication area. The program will continue with full season trapping and treatment of infested fields in 1998.

Despite the late planting and unfavorable conditions during seedling development, the crop fruited rapidly once squaring began, and growing conditions during mid and late season were good to excellent in most regions of the state. Although the crop matured later than normal, above average temperatures during September and early October allowed many fields to mature bolls that would not normally be harvested. In the hill region of the state, this late maturing fruit would normally be subject to heavy damage by boll weevils. However, boll weevil eradication treatments helped minimize late season fruit damage and yield loss to boll weevils this season.

In summary, 1997 was an excellent production year for most of Mississippi, despite the late start and poor early growing conditions. Statewide yields averaged approximately 900 lbs of lint per acre (December NASS estimate) breaking the previous record high of 888 lbs set in 1991. Overall insect problems were considerably less than normal, primarily due to unusually low levels of tobacco budworms. However, costs of insect control were still alarmingly high, and, including the $32/acre license fee for that portion of the acreage planted to *B.t.*-cotton, were estimated at $88/acre. Insect induced yield losses were estimated at 6.8%, with budworm/bollworm, boll weevil, and tarnished plant bug ranking respectively as the three most damaging pests.

Missouri

Early-season planting weather was abnormally cool which resulted in weather- induced seedling mortality. Several thousand acres of cotton required replanting or these fields were converted to other crops. Cumulative DD60 values for Portageville remained below the previous three-year average until late July. Weather conditions for the remainder of the growing season were relatively favorable, and harvest conditions generally were excellent.

Overall, pest pressure in Missouri was moderate in 1997. Thrips pressure was light in most areas. Plant bug infestations were very sporadic but moderately heavy in some areas. Aphid populations were low and economic infestations were limited to a few fields. Boll weevil numbers were greater than in 1996, with ≈60% of Missouri's cotton acreage requiring one insecticide application for boll weevil infestations. Bollworm pressure was localized but some fields did require an insecticide treatment. Tobacco budworms were rarely collected in 1997. There were some localized, economic infestations of European corn borers late in the growing season, and a few cotton fields adjacent to corn were treated with insecticides.

New Mexico

Agronomically, 1997 was an average year for cotton production in most areas of New Mexico. Spring temperatures were below normal. However, an exceptionally warm September brought the total number of heat units up to average. Average yields are estimated to be 670 lbs/acre. Insect pest pressure, overall, was lighter than last year. However, boll weevil captures were up dramatically and spring captures were common in most cotton growing areas of the state. The most damaging insect pests continued to be bollworm and pink bollworm. Aphids and beet armyworm, which can be significant problems, were less prevalent this year. Significant boll weevil damage is expected next year. Attempts to pass boll weevil referenda in the Mesilla Valley in central New Mexico and Lea Co. in eastern New Mexico were unsuccessful.

Boll weevil monitoring programs were continued this year and expanded. Traps for over 20,000 acres of cotton were monitored at least biweekly. Trapping was conducted by New Mexico State University and USDA/APHIS. Funding to support this effort was provided by the Mesilla Valley Pest Management Association, the New Mexico Department of Agriculture, The Pecos Valley Farmers Association and USDA/APHIS Voluntary bale assessments were collected by the Mesilla Valley Pest Management Association and the Pecos Valley Farmers Association. A state organization of cotton farmers, the New Mexico Cotton Farmers Association, was formed in January 1997, in part, to address the boll weevil issue. Approximately 3,000 acres of cotton were treated for boll weevil in the Mesilla Valley. Another referendum will likely be attempted in 1998.

Whitefly, which is rarely seen in New Mexico cotton, was noted in some fields treated for boll weevil. Aphids were also noted in some of those fields but were less prevalent than usual in the Pecos Valley.

In the Pecos Valley, the highest numbers of boll weevils were located in south Eddy County by the Texas border. Average trap captures, by town, in June ranged from 0.1-0.3/trap. The northern end of Pecos Valley had fewer boll weevils with a total of 29 weevils during the month of June. By the last week of October mean trap captures by town increased to 26-40 weevils per trap in south Eddy Co. and 3-15 per trap in the northern portion of the Pecos Valley. High boll weevil numbers were found in Lea Co. throughout the season with up to 700 boll weevils per trap by November.

As usual, pink bollworm pressure was highest in the Mesilla Valley in south central New Mexico and the southern end of the Pecos Valley in SE New Mexico. There was little control needed in other areas of the state. Bollworm pressure was somewhat lighter than usual but still required anywhere from 1-4 applications in many locations. Beet armyworm infestations were very light with only a few hundred acres treated much. Early thrips populations were low. Plant bug populations were light again this year. Stink bug populations were isolated, but very high in some areas, notably south Eddy Co.

Compared to other states there was very little Bollgard cotton (≈ 4200 acres) in New Mexico. Bollgard cotton was also planted in variety trials with DP90 producing the highest yield. Paymaster 1330 and 1215 matured much earlier than DP90B, DP35B, and DP33B and were ready for picking by September 8. The amount of Bollgard cotton planted next year will likely increase slightly. Insect pressure in many locations is low, and there is some concern about quality losses compared to the Acalas that are grown in much of New Mexico. Also, the incursion of boll weevil will make insecticide applications necessary, eliminating some of the treatment savings.

North Carolina

Carolina's major cotton insect pest, the bollworm, was on the light side, as evidenced by generally late, low moth numbers, low to moderate egg lay and low to moderate bollworm establishment over much of the state.

European corn borers and tobacco budworms were the lightest since our statewide damaged boll survey began in 1985, although fall armyworms were higher than average, especially in some of the southeastern coastal plain counties. Thrips, plant bug, spider mite and cotton aphid population levels were extremely high by North Carolina standards. At-planting insecticide treatments for thrips had to be supplemented with foliar applications on over half of the state's cotton acreage, some of it two or three times. In a number of cases these treatments either created or exacerbated aphid problems. Although a relatively small proportion of North Carolina's cotton acreage had to be treated for plant bugs, spider mites or cotton aphids, this treated acreage was many-fold greater than in recent memory. Approximately 8,000 cotton acres were treated for plant bugs in 1997, for example, which is several-fold higher than in other years. These very high early-season insect levels are largely the result of unusually cool wet weather conditions and do not likely indicate a trend.

Tobacco budworms were low in cotton in the June (second) generation, and did not make up much of the third generation (July/August population) as was the case in 1996. In 1997, the tobacco budworm's status as a cotton pest in our newly- expanded acreage decreased. No budworm or bollworm resistance to pyrethroids has been detected yet in North Carolina. Very few control difficulties were noted in 1997, although treatment decisions were often difficult with our late, light bollworm moth flights.

Bollworm populations and their resulting damage to conventional cotton were just less than average in 1997 with an estimae of 3.75 percent year-end damaged bolls across the state compared with a 13-year average of 3.95 percent. Given our very late, light bollworm populations, a number of producers probably under responded to bollworms in 1997. European corn borer damage to cotton bolls was again very low, with a 1997 statewide damaged boll level of just 0.16 percent, compared with our 13-year mean of 1.46 percent. Boll damage from stink bugs, at 0.53 percent in non-transgenic cotton, was very close to our long-term average of 0.56 percent.

The cotton aphid persisted at easily detectable levels in a large number of cotton fields throughout much of the growing season, particularly in the early season, though the mummifying braconid wasp parasites (primarily two species) did a good-to-fair job of holding cotton aphids at sub-economic levels during the mid-season. The common fungus parasite, *N. fresenii*, appeared to be generally effective in reducing mid to late-season aphid populations this past year, and again held aphids in check once significant cotton opening was underway. We continued to advise cotton producers not to treat for cotton aphids except for very high populations with the plants under drought stress and little evidence of beneficial insects or fungus. Our 1997 tests confirmed that, even under the above conditions, control of aphids was generally poor, although a few producer applications were reported to be effective.

Fall armyworms were present in a number of our state's cotton-growing areas and at times reached treatable levels, more commonly in the middle and southeastern coastal plain. In 1997, fall armyworm damaged bolls were at 0.86% across the state, as opposed to 0.09 % in 1996. This compares with the long-term average of 0.66% damaged bolls across the state over the past 13 years. As of this writing (late November), 153 boll weevils have been found in North Carolina in 1997, all in Pender County on a single farm, apparently brought in on a module truck from Texas in the fall of 1996.

By most standards, this year was a tough one for many cotton producers. Cool, wet conditions and other factors resulted in a one to three week delay in crop development in the early season. This delay was only partially made up, and the potential for a good top crop was additionally hurt by a very dry August over most of the state. Cotton harvest was very late in general, with mediocre yields presently projected at around 590 lbs. of lint per acre.

Oklahoma

Favorable weather conditions allowed this year's planting of 200,000 acres to go uninterrupted. The boll weevil was responsible for the sharp reduction in planting intentions in 1997. This trend was apparent across Southwest Oklahoma, as producers continued to abandon cotton in favor of a less risky crop. Heat unit accumulations (2776 hu) nearly equaled the 40-yr. average of 2832hu accumulated between May 1 and October 1. Heat units lagged much of the summer, but above average temperatures in September made the difference. The State production average is projected at 525 lbs. of lint per acre, the best crop in several years.

Thrips infestations caused isolated damage because of widespread use of at-planting insecticides and over-the-top sprays. Cotton fleahoppers and boll weevils were targets of many insecticide applications applied before bloom. A mild winter allowed boll weevils to overwinter successfully statewide. Economically damaging populations developed by mid-August. To prevent economic loss, irrigated cotton averaged 8 insecticide applications, while dryland cotton averaged 3 insecticide applications where yield expectations justified treating. Oklahoma producers, tired of sharing profits with the weevil, overwhelmingly passed the Boll Weevil Eradication Referendum with 88% support on October 15, 1997. Actual startup depends on the Northern Rolling Plains of Texas scheduled to vote in early 1998. If approved in Texas, Oklahoma plans to start in the fall of 1998.

Bollworm populations did not approach the level experienced in 1996, but damaging infestations existed in all production regions of the state. Approximately 14,000 acres of Bollgard varieties of cotton were planted to minimize bollworm damage. Less than 30% of the Bollgard acreage fields needed additional bollworm protection in 1997. Non-Bollgard fields required up to 4 insecticide applications to prevent economic loss.

Cotton aphid infestations built across the state with every insecticide application. Damaging infestations were widespread by mid-August. Heaviest infestations occurred in cotton under intense management. Most of the spraying occurred in Harmon, Jackson, and Tillman Counties in Southwest Oklahoma. Fields averaged two to three insecticide applications to control aphids, and Furadan was the product of choice, once the Oklahoma Department of Agriculture granted a 24C label for its use on August 15, 1997. Severe yield loss would have occurred if Furadan had not been available for use.

South Carolina

The cotton growing season got off to an extremely slow start in 1997. Cotton planting was timely for the most part, but cool temperatures persisted well into June, resulting in delayed emergence and slow growing condition. To make matters worse, most areas of the state experienced drought in July and August. Crop maturity was delayed considerably, and growers did little harvesting until October. Cool rainy weather caused further delays in harvest, and most of the cotton was actually harvested in November, with 10 to 15% of the crop still in the field by the first of December.

Yields are expected to average about 675 lbs lint/acre on some 290,000 harvested acres. This would be down considerably from the 791 lbs lint/acre harvested on 282,000 acres in 1996. Cotton yields in 1997 were not bad considering the slow growing conditions and the problems with harvesting.

With the slow growing conditions in late May and the first half of June, thrips infestations were damaging in cotton for a longer period of time than expected. By the middle of June thrips appeared to be causing damage to some cotton that had been growing quite slowly in the cool soils.

Because of the delays in cotton growth due to cool temperatures and/or thrips damage, some farmers treated what would normally be considered sub-economic levels of plant bugs, expecting further delays in maturity if they were allowed to remove pinhead squares. In many cases, this may have caused more problems than were prevented. Removing beneficial insects, especially in *B.t.* cotton has been shown to be counterproductive in several research studies in South Carolina. This opens the door for bollworm/budworm problems, where there would have been none, if adequate levels of beneficials were maintained during the early part of the season.

Tobacco budworm problems were few in cotton, and even in tobacco, infestations were at the lowest levels seen in many years. Generally the few budworms observed were found a week to 10 days later than usual. We did get several hundred moths in pheromone traps to conduct vial tests for pyrethroid resistance, but there did not appear to be any decreased mortality at the 5 μg level of cypermethrin, compared with observations from last years tests.

As usual, the bollworm was the major insect pest in cotton, although infestations were running at least a week behind the normal occurrence. For example, in an area where the July generation of bollworms usually hits around the 15th, it was common to find initial infestations between the 24th and 27th in 1997. Infestations of bollworms were generally much higher in the Savannah Valley than in the Pee Dee area. Conventional cotton received up to 8 insecticide applications for bollworm control, and 0-5 applications in *B.t.* cotton in the Savannah Valley, but only 2-4 applications were needed on conventional cotton, and 0-2 applications to *B.t.* cotton in the Pee Dee area.

Pyrethroid resistance was documented in both bollworm moths collected in pheromone traps and moths reared from bollworms collected in fields where there were control problems. Larvae were collected and reared to adults from one field near Holly Hill, and from one field near Cameron. Only 20% or less mortality was observed when the moths were exposed to cyhalothrin @ 2.5 μg/vial--a dosage that kills 100% of the individuals in a susceptible population. Mortalities of moths collected in pheromone traps in the Savannah Valley area averaged about 80%, indicating there were more susceptible individuals than in the problem fields. The two cotton fields with resistant bollworms were located about 50 miles north of the fields where the initial resistant bollworms were found near Luray in 1996.

Fall armyworms problems were widespread, as most cotton fields had anywhere from a light to heavy infestation of these insects. Insecticides were generally not effective in controlling fall armyworms, except where pyrethroid applications coincided with hatchouts of larvae. The presence of a pyrethroid residue when eggs are laid, appears to do a fairly good job of killing the tiny worms as they crawl away from the egg masses, but rescue treatments with insecticides were generally less effective. Beet armyworms did not pose a problem in cotton, although sufficient numbers were found in a Lee county field to trigger a Section-18 label statewide for Confirm™ and for Pirate™.

Stink bugs caused a considerable amount of damage, especially in *B.t.* cotton, although damage appeared to be less than last year. There is more and more concern each year by consultants about the problems associated with this pest, including the need for improved scouting techniques. Although our economic threshold of 1 stink bug/6 row feet, has been substantiated by research studies, scouts are still reporting problems in finding the insects. It's not unusual to find economically important damage in a field where few stink bugs could be found utilizing normal scouting procedures, and using a beat cloth as prescribed.

Aphids infestations were certainly not a welcome occurrence, especially with cotton growth already delayed. Infestations were heavy in some fields, but as we have observed in the last few years, the fungi that attack and kill aphids, arrived on the scene again, just in time to prevent serious problems. Spider mite infestations were light for the most part.

South Carolina is presently in a containment phase of boll weevil eradication. This year a total of 4,115 boll weevils were trapped from 1,440 acres. The great majority of these came from two fields in Calhoun County. This is more weevils than were caught last year, but the acreage is much smaller and the fact that in-field traps were used greatly escalated the numbers over last years counts which were obtained exclusively from perimeter trapping. The cumulative acreage treated was 27,586, which is considerably less than the 1996 cumulative acreage of 47,601. Reproduction is thought to have occurred in only three fields this year, as multiple catches were only made in four fields.

Tennessee

Tennessee planted 510,000 acres in 1997 which was down 20,000 acres from 1996. Corn and soybeans took most of this acreage as the new farm bill was initiated. Insect losses ranked second only to weather. Cool, damp weather was the dominant factor during planting and early development of the crop. Temperatures averaged 54, 64 and 73 degrees for April, May and June respectively at Jackson - West TN Exp. Station. These are 5, 3 and 2 degrees below normal.

Rainfall totaled 5.6, 3.2 and 9.8 inches for the same period which collectively was 4.0 inches above normal with most of the excess in June. As a result of this unfavorable weather, very little cotton was planted in April. Conditions did improve during early May which provided a window in which most of the crop was planted. Unfortunately, poor growing conditions returned with even a lack of moisture briefly in some areas. Rain did return and cause some flooding and subsequent losses. Approximately 2000 acres were lost in Middle TN from water. Hail damage claimed several hundred acres in Haywood and Crockett counties which were replanted.

Thrips infestations were normal to above normal. Higher populations caused terminal damage which persisted through the 5-6 node stage. Poor growing conditions which resulted in poor root development was the primary reason. Poor root uptake reduced systemic action of seed treatments and in-furrow insecticides which required some additional foliar applications. Growers relying totally on foliar applications saw excessive damage and stunting in some fields. Most applications are applied with ground equipment and were delayed by wet conditions.

Overwintered boll weevil survival was greater than expected in West TN. Pheromone trap captures were higher than previous '95-'96 records. Cool temperatures delayed weevil emergence. A significant increase in trap capture was not seen until late May and early June with peak emergence occurring June 20-27. This peak was about 14-21 days later than normal. Pinhead applications were recommended on all acreage with some areas encouraged to make two treatments, based on high trap captures. During peak emergence, the average number of weevils per trap ranged from 1.5 to 207 in Lake and Hardeman counties respectively. Some growers did not apply overwintered weevil sprays because of the dismal condition of the crop in the early stages. Although this caused some earlier F_1 development, populations remained below standard economic thresholds on much of the acreage. Some of this was attributed to early plant bug applications which also gave boll weevil control. Boll weevil trap captures and in-season infestations remain consistent with higher numbers in the southern counties and lower populations in northern counties in West TN. Again for 1997, boll weevil will be ranked as the number one pest problem. Middle Tennessee counties (7800 ac.) are weevil free after starting the eradication program in the fall of 1994.

Plant bug numbers thrived on the lush alternate host plants around field borders which also benefited from rain. These high populations never completely left these hosts and moved into cotton, resulting in higher infestations than 1996. Sweep net counts in bordering vegetation produced 100 plus plant bugs per 25 sweeps in some fields. Some early applications were targeted specifically for plant bugs but most were directed at boll weevil or the combination of the two.

Pre-bloom infestations of bollworm/budworm were minimal with very few acres treated during this time. Pheromone traps indicated a 70/30 ratio of bollworm/budworm pre-bloom and a 60/40 ratio post-bloom with a peak around August 10-15. Average trap captures were down approximately 80% for bollworm but up 65% for budworm from 1996. Treatable levels of larvae developed over more acres in late July and early August. Control was achieved with one application in most cases and where numbers persisted, a second treatment gave satisfactory control. Pyrethroid control failures were not reported, but many growers who have experienced problems in the past were making more tank mixtures with ovicides, phosphates or carbamates. Infestations were consistently higher in southern versus northern counties. *B.t.* cotton varieties accounted for about 15,000 acres. This was only 3.0% of total acres but was an increase from 10,000 reported in 1996. As seed for earlier maturing varieties is more available, acreage in the "worm problem" areas will likely increase. Bollworm control in *B.t.* has been good and yields have been comparable to conventional varieties.

Very light aphid populations required little to no treatments. The pathogenic fungus *Neozygites* helped naturally control most infestations. Yellowstriped armyworm persisted throughout most of the season. Some feeding in squares but mostly in blooms was observed. Larval numbers were sometimes included in treatment thresholds. European corn borer was reported to cause terminal damage with a few in bolls. Fall armyworms were scattered with low numbers with very few acres treated.

In summary, 1997 produced an above average crop and was well received after the negative outlook earlier. Statewide yields averaged approximately 635 lbs of lint per acre compared to a sixteen year average of 551. Yield losses to insects averaged about 8.5% or 75 lbs. lint. This is comparable to a 10% and 60 lb loss average from 1984-1995. Overall, it was an average insect pressure year. Boll weevil, plant bugs and bollworm/budworm were ranked 1,2 and 3 for yield losses followed by thrips, stink bugs and aphids.

Texas

Crop and insect situations varied across the state in 1997, but there were a few events in common for most of Texas. Early season, wet and cool weather conditions delayed the planting of much of the crop, delaying squaring as well. This maximized suicidal emergence of boll weevils and limited somewhat the boll weevil problem until later in the season. The abundant rainfall did significantly increase yield potential for the large dryland acreage, which was realized where later dry conditions were not too limiting and late boll weevil infestations were either controlled or not a factor. Above average temperatures in September and October allowed the late crop to regain heat units, set higher yields and allow an unimpeded harvest in the south.

Boll weevils were a significant factor in all areas except south Texas and the Southern Rolling Plains. This was the result of a mild winter, record numbers of emerging overwintered boll weevils, and good growing conditions for much of the acreage. The exception areas had low boll weevil numbers because of either an active eradication program and/or high suicidal emergence. The boll weevil was the number one pest in Texas in 1997. Texas has been slow to embrace eradication, partially due to the high cost and partially due to earlier successes in dealing with the boll weevil utilizing a proven IPM approach featuring cultural control. The Lower Rio Grande Valley is still not interested in eradication; but the Southern Rolling Plains, Rolling Plains Central and South Texas programs are strongly supported. The High Plains area has yet to find the right combination of assessment rates and collection mechanisms to cause the majority of producers to accept an eradication program. This area, along with the remainder of the Rolling Plains and Blacklands areas probably will be much more amenable to eradication following such a tough boll weevil year. There is considerable interest in establishing smaller, more homogeneous zones.

1997 was also a bad fleahopper year for much of the area. Where producers addressed this pest in a suitable and timely manner, losses were held to a minimum. This year was generally not much of a problem year for beet armyworms, whiteflies, aphids or Heliothines, although aphid problems did develop in the Rolling Plains area following multiple applications for boll weevils or pyrethroid applications for bollworms. The Texas Department of Agriculture granted a 24C label for Furadan 4F mainly for these areas. There were no reports of an aphid-induced sticky cotton problem, probably because of the late, honeydew-washing rains.

B.t. cotton acreage increased somewhat but still accounts for no more than 4% of the acreage. Some isolated areas where tobacco budworms or pink bollworms are an annual problem are planting a higher percentage of *B.t.* cotton. Any significant increases in acreage will require both a reduction in technology cost and the availability of stripper varieties for west Texas. With the right program, *B.t.* cottons could occupy as much as 25% of Texas' acreage.

This year's cotton season in the Lower Rio Grande Valley (LRGV) was different than past seasons due to the uniqueness of the pest, beneficial arthropod dynamics, and the weather conditions experienced during the season. Similarities to the 1996 season were found in the lighter-than-usual boll weevil activity and the very hot and dry conditions during June, July and August. No other similarities to 1996 or any other recent crop season were noted during 1997.

Very wet conditions prevailed during most March (rainfall records were broken in several areas) and all of April. All of the rain delayed, and in many situations prevented, cotton planting for the entire season. The early part of the season was very cool along with the rains. The months of March, April and May had 10%, 25% and 68% respectively, below normal heat unit accumulations. The balance of the crop season was hot and dry with June, July and August average monthly heat units recorded at 1%, 6% and 11% respectively, above normal. Normal high rainfall in August did not occur and allowed the very late planted cotton to be harvested without weather interference. Due to the late start, the Texas Department of Agriculture granted a requested two week blanket extension for stalk destruction in the LRGV. Growers were allowed to continue to harvest their fields until midnight, September 14, 1997. All but few fields were reportedly harvested and then all stalks completely destroyed by the September 14 date.

Cotton fleahoppers were reported in very large infestations. The heavy rainfall in the spring resulted in large populations of fleahopper wild hosts to survive much longer into the cotton season and provided fleahoppers with excellent reproduction sites. Frequent movement of adult fleahoppers from the wild host weeds to cotton was noted sometimes following one or two days after an insecticide application. Some individual fields were treated three to four times to prevent fleahopper damage to the early setting pinhead squares. Most fields had some level of fleahopper infestation, and the majority of fields required at least one insecticide application.

Boll weevil infestations were very light, particularly early in the season, and remained almost non-existent on many farms in 1997. Pheromone traps caught steady numbers of weevils from late December, 1996, to late April, 1997. Then weevil numbers spiraled down and remained low until the end of July. Increased weevil trappings were tied to cotton maturity and crop destruction. The delayed cotton planting along with some very cold temperatures which killed most regrowth cotton available to weevils late in the winter of 1996 probably aided in the reduction of early season weevils in most areas of the LRGV.

Bollworm and tobacco budworms made their appearance felt in many fields in 1997. By mid-May, some fields had increasing tobacco budworm feeding damage, but light infestations of eggs and worms in most fields. By early June, egg, worm and damaged square observations were very high in some fields and damage to small and medium sized bolls became more apparent each week. The June infestation was determined to be primarily bollworm, based on larval examinations made at that time of the season. The third week of June saw worm counts drop, and they never increased to damaging levels again in the balance of the 1997 season.

Beet armyworm infestations were much higher in many fields, especially along the Rio Grande than in 1996. Infestations required one to three applications along the Rio Grande, but were very seldom needed in other cotton areas of the LRGV in 1997.

Aphid infestations were slightly increased in 1997 compared to 1996. However, while some fields suffered from localized, heavy aphid infestations, most fields had relatively minor damage from aphid feeding during the season. As in 1996, aphid infestations which started to build in the early stages of cotton production were largely destroyed by parasites and predators in most fields before any long term damage, thus preventing the need for insecticides and saving beneficial insects. The fields which had heavier than normal aphid infestations and which were controlled too late by beneficials, were out numbered by the fields which had early and adequate aphid control with natural enemies. Aphid infestations came under additional natural control twice within the 1997 season. In mid May and later in mid to late June, aphids were attacked by the fungus *Neozygites fresenii*. Complete field control of aphids was observed. In many cases, whole aphid colonies within fields were destroyed in as little as 7 days while a range of 7 to 14 days was common for complete control of most aphid infestations.

Silverleaf whiteflies (SLWF) were light in most fields. Some mid-Valley area cotton fields which were in the vicinity of late melon crops had heavy infestations of SLWF by the end of the season. However, compared to the initial SLWF year of 1991, most fields did not have any damage from feeding in 1997.

Beneficial insects were in large numbers in 1997. However, the overall populations of the major beneficials such as lady beetles, lacewing larvae and some larval parasites did not appear to be as large in number as in 1996. Still, in those fields which did not have early, repeated insecticide treatments for boll weevils, (which was most fields), “beneficials” were adequate to deal with most secondary pests. Some fields which had repeated light rates of insecticides for cotton fleahoppers, bollworms and budworms were of concern and in some situations required treatment. Generally, as the season progressed, more beneficial arthropods appeared and helped control worm pests in the fields. Grain sorghum acreage was again high in the LRGV due to reduced cotton acres. The maturing grain sorghum probably aided in the increase in “beneficials”. As the sorghum crop matured, the “beneficials” moved to other crops such as cotton with potentially more prey than was found in the sorghum fields. However, unlike 1996, the 1997 sorghum crop had lower levels of cornleaf aphids and greenbugs and thus provided fewer beneficials to move from the maturing sorghum to cotton.

Coastal Bend (CB) cotton was generally late planted due to wet soil conditions. Heat units accumulated slower than normal after emergence. Cotton aphids increased to damaging numbers on young cotton but did not persist at those levels for more than two weeks. Some producers successfully controlled these aphids with standard insecticides. Predators, parasitic wasps and the fungus disease kept aphid numbers from reaching high numbers or persisting for long periods. Fleahoppers moved from wild host plants to vulnerable stage cotton and increased to damaging numbers throughout the region. Generally, two insecticide treatments were made for fleahoppers. Due to the temporary shutdown of the boll weevil eradication program, nearly all cotton producers treated for the overwintered generation at matchhead square stage. Boll weevil numbers remained very low until after cutout with limited damage to the crop. The boll weevil eradication effort resumed at first open boll. Heliothine populations increased as cotton progressed from 1/3 grown square to bloom with early infestations consisting of about 18% tobacco budworm. A portion of the acreage was treated and the early infestation subsided. Two weeks into bloom, Heliothine populations increased again and this time tobacco budworms made up the majority of the larvae in some fields. Generally, these infestations declined without causing serious damage. However, exceptions did exist in some fields which sustained damage and required multiple insecticide applications for a combination of bollworm and tobacco budworm. Cutout occurred two weeks early due to drought, and yields were subsequently reduced. Initial stalk destruction was very good.

In the Southern Blacklands (SB), cotton yields in the Brazos and Trinity River areas were improved in 1997, ranging from 700 to 865 pounds per acre. Boll weevil populations continued to increase at a rapid pace. Some producers treated fields up to 12 times for boll weevils. *B.t.* cotton continues to yield well and gave excellent reductions in Heliothine populations. *B.t.* cotton was only sprayed one time for bollworms. We expect cotton acreage to continue to decline in 1998, and boll weevil eradication is planned for the area in the fall of 1998, if a referendum is passed.

In the Northern Blacklands (NB), boll weevil was the most significant insect pest in this region during 1997. Numbers of overwintering weevils were very high in many areas of the Blacklands and continued to emerge in significant numbers into early July. Most fields received treatments for overwintering weevils which helped suppress populations. However, in-season applications were often required. Economic infestations of bollworms were much less common than usual in the NB and very few fields required treatment for this pest. Due to the lack of bollworm/budworm infestations, the yield advantage of *B.t.* cottons was much less than in 1996 when these pests were more widespread and damaging. Tobacco budworms were a problem in some areas of the southern Blacklands. Aphid infestations were spotty and often restricted to field margins. The *Neozygites* fungus was observed in early July and in combination with beneficial insects apparently held aphid infestations in check as few fields required treatment. Tarnished plant bugs were a threat in some areas. As usual, thrips and fleahoppers were important and widespread early season pests.

Southern Rolling Plains (SRP) area had a productive 1997 season. The total area planted 360,000 acres and 325,000 will be harvested. The majority of the crop was planted during the third week in May due to cool, wet conditions. Some acres were destroyed with heavy rainfall in early June. Planting moisture was excellent and subsoil moisture was above average for the season. The SRP included 186,000 acres in the fourth year of eradication (third year of full season applications). The remaining acreage (Fisher, Jones, Nolan) is in the second year of an eradication program (two years of diapause applications).

The season started off well since most of the area was forced by weather to plant during warm temperatures. This avoided any problems with thrips. Cotton fleahoppers were present and a few producers with irrigated acreage treated, but the populations were not sustained. The shutdown of the boll weevil eradication program resulted in many producers making at least one overwintered boll weevil insecticide application. In general, early season problems were light except for low square sets due to cool, cloudy and wet conditions through the month of June.

Bollworm/tobacco budworm pressure was scattered through the month of July. Early flights consisted of both bollworm and tobacco budworms which is unusual for the area. Scattered fields required treatment, but the month of July was noted more for the dry conditions than insect pressure. The overwintered boll weevil insecticide applications did flare cotton aphids but very few treatments were made for aphids during July. Scattered outbreaks of beet armyworms occurred in the Vancourt area of Tom Green County, but the infestation was isolated.

The August insect situation was intense. High numbers of bollworms were present in most fields and required treatment. Most producers chose to use a pyrethroid so aphids became a problem in many fields after the pyrethroid applications. Control of bollworms was good but yield losses of up to 60% occurred when producers chose not to treat. The aphid populations were controllable but usually required multiple applications until Furadan7 received its 24 C label.

Late August and September were highlighted by high tobacco budworm numbers. Irrigated fields and fields receiving a rain required at least one treatment with either Tracer or Pirate. Problems were worse in Nolan, Fisher and Jones counties where cotton was a little later and not as much *B.t.* cotton was planted.

Boll weevil eradication started back in July. In-season applications increased as the season progressed and some fields near overwintered habitat or where trap tampering occurred required up to six applications. Most fields had less than one application by August 17. The Foundation decided to intensify diapause applications in 1997 and so more acreage was treated for diapausing weevils in late August and September. The applications did cause some mealybug and whitefly increases but no fields were treated for either pest. Treatments in the Rolling Plains Central also started up in late August for their diapausing weevil treatments.

In the Northern Rolling Plains (NRP), cotton planting was late with most of the cotton planted between May 26 and June 14 and continuing through the end of June. On June 16, sustained high winds of up to 70 mph over most of the area damaged cotton that was up, slowing plant development and resulting in late cotton replanting. The damage was heaviest in sandier parts of the area. Some producers chose not to replant cotton, planting grain sorghum or mung beans instead. Cool conditions during May and early June further slowed plant development. During May and June at Chillicothe the average minimum temperatures were 55.2 and 64.9º F and the average maximum temperatures were 80.2 and 90.8ºF. During the first 10 days of June the average minimum temperature was 59.5ºF.

During mid June, thrips damaged the terminals of the young, slow growing cotton plants. By the last week of June the cotton was responding to the warmer conditions and was out growing earlier thrips damage. During the first week of July, cotton was late, ranging from the 4- leaf stage with about 15% of the older cotton beginning to square. Fleahoppers were heavy in many fields, causing excessive damage as cotton begin to square. Where there were higher fleahopper numbers, cotton was delayed another week to 2 weeks.

This was the first full year of the boll weevil eradication program in the Rolling Plains Central Eradication Zone (RPCEZ) (southern area of the NRP). A fall program to destroy diapausing boll weevils was conducted starting in late September 1996. In 1997 there were about 155,000 planted cotton acres and 132,000 harvested acres in this zone. The cost of the program was $10/acre for the 1997 program. Because of the challenge in the Texas Supreme Court, the program was delayed and did not start until late August, and an average of 6.8 insecticide applications were applied per acre from late August through early November.

Boll weevils moved into squaring cotton in large numbers through mid-July in the northern part of the area. Boll weevil traplines were established in the RPCEZ and in

Wilbarger County. Boll weevil trap catches were much lighter in the part of the area that is in the RPCEZ. Above average numbers of overwintered boll weevils were captured in traps during June and July in the RPCEZ and in Wilbarger County, but numbers captured per trap in Wilbarger County were 1.7 times greater in June and 4.4 times greater in July than the numbers captured in Knox County. In many fields in the NRP, two or more early season applications were needed to prevent overwintered boll weevils from causing excessive damage. In scattered "hot spots" of the RPCEZ, one or two overwintered boll weevil applications were needed. During August and September 17.1 and 21.5 boll weevils per trap-day were captured in Wilbarger and Foard counties in the NRP, and in Knox and Haskell Counties in the RPCEZ, 0.2 and 1.24 boll weevils per trap-day were captured. Boll weevils prevented cotton from being set in the top of the plants in the NRP while cotton in the RPCEZ set undamaged bolls in the top of plants. Cotton in the RPCEZ was able to utilize the heat units available during September to mature the cotton crop. During September, the maximum and minimum temperatures at Chillicothe averaged 89.9 and 63.6^{o}F.

In mid-July, bollworms were causing 10 to 30% square damage in more heavily infested fields. Bollworms continued to be a problem, mostly in irrigated fields during the remainder of the cotton production season. Tobacco budworms increased to damaging levels in Knox County during mid-August and constituted 60 to 75% of the Heliothine larvae in fields where difficulty was encountered in obtaining insecticidal control. During the last week of August, damaging tobacco budworm infestations were observed in irrigated cotton fields in the NRP. Dryland cotton was less susceptible to Heliothines because the availability of squares was much reduced by dry conditions and the large boll weevil infestations.

Cotton aphids began building in late July and were in large numbers in some fields in the second week of August. By August 28, aphid populations appeared to be declining, but infestations continued to develop in some fields. A Section 24 (c) label for Furadan was granted by the Texas Department of Agricultural and was used from the latter part of August into September.

Beet armyworms were found in large numbers in a field in Knox County the second week of August and in scattered fields the following week. Late in the season, numbers did build in some fields but damaging infestations were not widespread.

Cotton square borers infested cotton fields at levels higher than usual during July. In some fields the numbers of square borers and their damage, if confused with bollworms and their damage, could have resulted in an insecticidal application for bollworms. In Dickens County during the week of July 31, most of the square damage was caused by cotton square borers and not bollworms. Through August 21, cotton square borer damage continued to be found, especially in the western part of the area.

Cotton yields are expected to be above average and cotton quality is anticipated to be good. Warm conditions during September and early October allowed the entire crop to mature. Boll weevils heavily damaged the cotton in the top of plants in the NRP. The yield is estimated to average 347 lbs/acre over the entire area, 329 lbs/acre in the NRP and 380 lbs/acre in the RPCEZ.

Far West Texas (FWT) cotton producers experienced an unusually wet and cool spring in 1997, ensuring slow cottonseed germination and cotton plant growth. Slow growth combined with high winds and hailstorms from frequent spring and early summer storms reduced stands and made replanting necessary for many producers, especially those in the eastern and northeastern cotton producing regions. Temperatures normalized in late June and remained normal or slightly above normal for the remainder of the growing season. Surviving cotton recovered well with surplus subsurface moisture and normal temperatures. However, weather conditions went from wet to dry beginning in early summer and remained dry for the remainder of the growing season. Persistent dry conditions caused early cutout of dryland cotton in the northeastern region. Nevertheless, average yields and acres harvested for the region were higher than 1996.

Insect pest populations generally did not reach economically damaging levels throughout the growing season, and were especially low in the eastern and northeastern regions. Bollworm, budworm, stinkbug, and aphid populations were generally low. Furadan 4F use was authorized on aphids in August and extended through September, and bollworm and budworm populations were locally high in non-*B.t.* cotton. Because of early cool and rainy conditions, thrips were also occasionally a problem. Foliar insecticides were generally not applied for thrips control, and cotton apparently recovered quite well. Pink bollworm was more of a problem in the western region where most of the pima cotton is produced. *B.t.* cotton increased substantially from 1996, primarily because of its effectiveness against pink bollworm, bollworm, and budworm. Stinkbug populations reached economically damaging levels in localized areas of the eastern region and required pesticide applications to manage this pest. Boll weevils caused significant damage in the east and northeast parts of the region, which prompted the deployment of boll weevil diapause programs in the eastern and northeastern regions and the initiation of a boll weevil eradication program in the northeastern region.

Adult weevils were consistently trapped in several new areas in the central and western regions, causing increasing concern among producers.

In the High Plains (HP), the 1997 season got off to a wet start with rainfall accumulations 200% above average. This provided excellent subsoil moisture and the potential for a record dryland crop. The rains shut off after July 4^{th} and did not return until scattered showers roamed the plains in mid August. The lack of mid summer rains reduced the need for plant growth regulators such as Pix. It again turned dry in late August and through September. Rains again returned in late September and early October, causing regrowth and leaf grade problems with fields that had received earlier harvest aid treatments. The use of harvest aid chemicals was up again compared to historical averages.

Cool temperatures associated with early wet conditions delayed planting in some instances but mainly slowed plant growth and square initiation. This delay was enhanced by severe wet weather blight even into the squaring period, with some fields exhibiting almost complete defoliation. Acreage lost to weather amounted to only 250,000 to 300,000 acres with approximately 100,000 replanted back to cotton. Average daily temperatures were 2.5^0 F below normal in May, 0.7^0 F below in June, 0.8^0 F below in July, 1.0^0 F above in August and 3.5^0 F above in September. So, while heat unit accumulations ran behind historical norms for much of the growing season, the late summer early fall warm temperatures compensated for most of this.

Except for boll weevils and perhaps cotton fleahoppers, insect pressure was lighter than last year. Boll weevils emerged from overwintering sites in record numbers in all cotton producing counties of the HP. Survival in the best habitats was estimated above 10%. While significant mortality occurred in December 1996 when habitat temperatures dipped down to the low 20's, snow cover during the January 1997 cold spell provided sufficient insulation to prevent temperatures from falling much below 32^0 F. Research has demonstrated that temperatures in overwintering sites must drop to the low 20's for several hours before significant mortality is realized.

Peak boll weevil emergence occurred during the first 3 weeks of June, which in more normal years would have created a severe early season boll weevil problem. Since squaring was significantly delayed, suicidal emergence was enhanced. This, combined with aggressive overwintered boll weevil control on the part of producers and consultants, resulted in a significant reduction in boll weevil problems for most areas until later into August. The exception to this was in fields closely associated with prime overwintering habitat, especially around towns. Some fields actually required no boll weevil control while the worst fields had as many as 16 applications.

Cotton fleahoppers were a problem in many fields across the entire HP region, and many producers were late in discovering this problem. However, square retention still remained relatively high in most cases. Lygus bugs were also a more troublesome pest this yea with more fields infested and treated than ever before.

Cotton aphid numbers were low early in the season and only became a problem once producers switched from alternative chemistry and started using pyrethroids for heavier bollworm and boll weevil control situations. Beneficial insect numbers were low this year and did not play a large role in controlling pests. Overwintered boll weevil control applications did not appear to trigger any secondary pest outbreaks. Texas was denied a Section 18 for Furadan 4F use on cotton for aphid control by EPA, but the Commissioner of Agriculture declared a 24© SLN for Furadan use in the state anyway, much to the chagrin of EPA. This move helped producers in avoiding the need for second and third applications for this pest. EPA eventually revoked the 24(c), but not until the end of the growing season.

Bollworm problems were much lighter this year but in many cases eventually required a pyrethroid application to obtain high level residual control. Tobacco budworms were virtually nonexistent. Most pyrethroid applications targeted the combination of bollworms and boll weevils.

Except for fields near the prime overwintering sites, boll weevils were not much of a problem until after mid August when large numbers appeared and fanned out across the HP in record numbers. With a late summer/fall warm spell, cotton fields with adequate moisture matured many late bolls, adding 20% more to yields. Areas that had heavy, late boll weevil infestations failed to realize this late yield bonus. Boll weevils reduced yields by 13.6% and cost producers an extra $36 million in control costs. Much of the yield loss occurred late in the growing season. Over 5 times more late season boll weevils were caught in traps than last year, indicating the potential for a severe boll weevil problem for 1998. In some areas, an early harvest may have sent boll weevils into overwintering sites without sufficient fat reserves to survive until the next year's squaring crop.

1997 was the first year without an area-wide diapause program since the boll weevil first attempted to invade the HP in 1963. An eradication referendum to replace the 1995 referendum that was struck down earlier by the Texas State Supreme Court failed to pass in the spring because of lack of consensus on the seriousness of the boll weevil problem and the assessment amount. Another attempt is underway to establish three new eradication zones which cover the area of the original, larger zone. Smaller zones may finally provide enough homogeneity to foster a successful referendum.

Virginia

Approximately 101,000 acres of cotton were grown, with an expected increase to 105,000 acres in 1998. Five gins are currently operating, and a sixth is in the planning stage for Eastern Shore. The common cultivars grown were DP 51 and Stoneville 474, making up an estimated 70%, with SureGrow 125, DP 5409, and 4 Paymaster Roundup-Ready lines making up the remaining 30%. Less than 200 acres of *B.t.* cotton were planted. 1997 weather and growing conditions were considered difficult. Planting was delayed by about one week to 10 days due to cool early conditions. Temperatures were relatively cooler with cumulative DD 60's below the average for the previous three years by 100-200 per month. Rainfall was below normal. Abou 27.5 inches occur normally for the period between May-October. In 1997, 15.5 inches accumulated during this same period (2.0 in May, 0.5 in June, 9+ in July, 1.0 in Aug). The onset of picking was delayed by one week to 10 days. Overall, weather was considered the primary factor responsible for reduced yields.

Thrips populations were high and pressure was severe, especially in combination with slow seedling growth due to the cool, dry weather. Aphid populations occurred in some fields early (ca. 50,000 acres), but few fields were sprayed and beneficials eventually reduced populations. Some aphids were present after bollworm sprays, but again, no fields were treated and beneficials eliminated them. Cutworms, mostly granulate or black, cut seedlings in about 1,700 acres, all in minimum till fields with 'heavier' soils, and 1,500 of those acres were treated. About 3,000 acres were infested with light to moderate levels of spider mite and 2,000 were treated. European corn borer and stink bug infested an estimated 5,500 acres, 4,500 of which were treated. With the corn earworm/cotton bollworm advisory, a statewide survey of field corn in mid-July revealed an average of 40% ears infested which indicated moderate to severe levels to be expected in cotton and soybeans. However, corn maturity was delayed some three weeks by drought; rain in July caused corn regrowth which suckered out second ears, and bollworm populations recycled in corn rather than moving to alternate host crops. The result was low flight activity and reduced worm pressure in cotton. Low bollworm pressure combined with the shedding of the top fruit crop due to dry conditions resulted in fewer sprays than normal (1.25 - 1.5 per acre) with 35-40% of growers spraying only one time, compared with an average of two sprays per acre for the past three years.

Research Progress and Accomplishments

Alabama

Research projects were conducted in the following areas: (1) thrips control on cotton; (2) evaluation of new chemistry for bollworm, tobacco budworm and fall armyworm control; (3) evaluation of reduced rates of pyrethroids for bollworm control and selectivity toward beneficial insects; (4) evaluation of several insecticides for plant bugs and stink bug control and selectivity toward beneficial insects; (5) economic comparison of Bollgard variety compared to conventional variety when over sprayed with soft (Tracer) and hard (pyrethroid) chemistry; (6) evaluation of all varieties with Bollgard (including stacked RR gene) for bollworm/budworm effectiveness; and (7) comparison of Tracer broadcast versus banded application. **(Alabama Cooperative Extension Service, Auburn University, Auburn, AL)**

Arizona

Insecticide action threshold studies for silverleaf whitefly management showed few differences in immature whitefly populations among action thresholds of 2.5, 5 and 10 adults/leaf. Adult population densities differed little between thresholds of 2.5, and 5 adults/leaf, or between 5 and 10 adults/leaf depending on site. In the first year, cotton yields at locations did not differ among thresholds of 2.5, 5 and 10 adults/leaf, but yields declined significantly when left untreated or treated at 20 adults/leaf. In a second year, yields did not differ among any of the treatments at 3 different locations. A simple economic analysis assuming ca. $24.00/A for a spray treatment, $0.85/lb. for lint and an $0.08/lb. discount for thermodetector ratings >5 suggests that the net return was generally highest for action thresholds of 5-10 adults/leaf.

Sampling distribution based on 6 different sample units (all open bolls on 1, 2, 5, 10, 20 or 30 consecutive plants) suggests that lint stickiness is uniformly to randomly distributed within cotton fields. Partitioning of variance components indicated most of variability is associated with differences between sample unit in field with little variation between multiple thermodetector assays of same sample unit. It would be more efficient to allocate resources to collect more individual sample units from the field rather than replicate thermodetector assays in laboratory. There was little difference in variability of stickiness readings among 6 sample units. Small reductions in variation with larger sample units was not offset by much greater cost (time) of collecting a larger sample unit. The 2-plant sample unit was most highly correlated with stickiness readings from bulk harvest samples. A precision 0.10 or 0.25 could be achieved by collecting about 24 or 4 sample units per field. Field collection time would range from 5-30 minutes. Life table studies revealed predation and weather were major mortality factors for whitefly eggs and nymphs.

A feeding model defined relationships between whitefly feeding apparatus and vascular structure of host leaves. Whiteflies use leaf surface features such as elongated epidermal cells to find minor veins. Number, density and closeness to the undersurface of the leaf determine the host suitability. Eggs are deposited in epidermal cells close to vascular bundles.

In Imperial Valley, CA an extensive set of bioassay data from field-collected whiteflies indicates that whiteflies remain susceptible in Imperial Valley, CA to many of the most commonly applied insecticides, especially when used as mixtures. The resistance monitoring data do not show any sustained progression toward insecticide resistance in whitefly populations. Failures of synergized pyrethroid insecticides in Arizona necessitated development of a fundamentally new approach to whitefly control in cotton. This need was confirmed by research showing the rapid buildup of resistance to Danitol + Orthene and by the findings of cross-resistance among all the pyrethroid insecticides evaluated. The new resistance management approach involved use of insect growth regulators (IGRs) as new chemistry classes to avoid continuing pyrethroid resistance development. Results suggest that the IGRs gave highly effective control with no indication of resistance development. Natural enemy numbers appeared higher than normal in IGR-treated plots with a sharp decline after the Lygus sprays. Whitefly parasitism rates were highest in the IGR plots relative to the conventionally treated plots.

Studies to keep current on the responsiveness of whitefly populations to various insecticides showed that Capture, Thiodan, Capture + Thiodan, Danitol, Orthene, Danitol + Orthene, and Lorsban susceptibility to the insecticides listed has remained stable in the Imperial Valley. In the Palo Verde and San Joaquin Valleys insecticide dose concentration have had to be increased to achieve 100% mortality of adult whiteflies, suggesting that some materials may not continue to be effective for whitefly control. The studies have also shown that by alternating different classes of insecticides against whiteflies, resistance in whitefly populations can be delayed.

A newly developed adult whitefly trap has potential to replace the widely used yellow sticky card traps for monitoring whitefly activities inside and outside of crop fields. It may also be used as a whitefly control device in greenhouses without reducing released parasites.

Several unknown sugars were discovered and characterized in *Bemisia argentifolii* honeydew. One of these, which was named bemisiotetrose, was isolated from honeydew-contaminated cotton lint and its structure determined by GC/MS and 2D NMR spectroscopy. This honeydew was also found to contain significant amounts of the quaternary amine, glycine betaine.

In replicated field trials, Pyriproxifen applied biweekly to cotton, or alternated every other week with fenpropathrin plus acephate or Mycotral significantly reduced whitefly adults, eggs and nymphs and increased cotton yields compared with untreated control plots.

Imidiclorprid sprayed 4 times on cotton (0.23 lb. [AI]/acre) had significantly fewer SPW nymphs (2.7 and 1.9/1.55 - inch squared leaf disk, respectively) as compared to the untreated plots 94.6/1.55-inch squared leaf disk). Average seed cotton yield from the imidiclorprid-treated plots was significantly higher than from untreated cotton.

The physiological role for synthesis of trehalulose was identified in silverleaf whiteflies. The gene and protein for a unique aldose reductase enzyme were isolated and implicated in thermal regulation by the insect. This research provides a fundamental basis for developing novel strategies for biocontrol of whiteflies which will be of interest to scientists and producers.

Work continues on using pest-specific antibodies to sweetpotato whitefly (SPW) and pink bollworm (PBW) for predator gut content immunoassays. An enormous effort has been made to standardize the gut content immunoassays. The gut contents of three species of insect predators that were fed PBW eggs were assayed by an indirect enzyme-linked immunosorbent assay (ELISA). The assay sensitivity was dependent on the predator species examined, number of prey consumed, elapsed time after feeding, and temperature at which the predators were held. Five different immunoassay formats have been developed for examining predator gut contents for PBW. The assays are the direct, indirect, and sandwich ELISA, dot blot and western blot. Data indicate that the sandwich ELISA, dot blot and western blot are the most sensitive assays. Field studies were conducted comparing the predatory activity of commercial *Hippodamia convergens* with their wild counterparts on SPW. Results suggest that the commercial predators feed on SPW as frequently as their indigenous counterparts. A novel immunological mark-release-recapture (M-R-R) method was field tested for efficacy. Data indicate that the immunomarked predators had a longer retention time than those marked with DayGlo. This immunomarking technique can be combined with predator gut content immunoassays for SPW, PBW, and *lygus* leading to the simultaneous evaluation of commercially-reared predators and their indigenous counterparts.

Egg and meat-based semi-solid diet was developed and used to produce 14 continuous generations of *Chrysopa carnea*. The diet is unique in its composition, texture and the fact that it produces predators that compare favorably with natural hosts in terms of body weight, fecundity, fertility and development time. Also, the predators produced on the diet were tested with natural prey after each generation and were found to consume prey voraciously.

Predators that digest prey before consuming them tend to prefer relatively large prey. Some predators depend on plants for moisture and nutrients if prey abundance declines. More than 10 generations of *Orius insidiosus* have been reared using artificial oviposition packets instead of green beans or other plants.

Steinernema riobravis was released at a rate of 2.6 billion/acre in a cotton field in furrow irrigation water. Pink bollworm (PBW) % mortalities on Day 0, 14 and 39 following application showed that *S. riobravis* moved 6 inches downward into the furrow and upward into the top of the row bed to find host PBW larvae. *S. riobravis* in Arizona was also applied at the rate of 1 billion per acre, using a spray rig followed immediately by irrigation and in Texas at a rate of 1.3 billion per acre in an irrigation channel during field irrigation. Excellent distribution of the nematodes over the treated areas resulted from both application procedures. In Arizona, nematodes persisted for 19 days in large numbers, and could still be recovered from furrows after 75 days. PBW infested bolls were significantly reduced and cotton yields were 19% higher than in untreated plots. In Texas nematodes persisted for 16 days in large numbers, and could still be recovered from rows and furrows after 50 days. Optimal conditions were tentatively established for short-term storage of *Trichogrammatoidae bactrae*. Life history of *Chelonus curvimaculatus*, an egg-larval parasitoid of PBW, was studied in relation to temperature and photoperiod. Higher levels of natural enemies were found in transgenic cotton plots compared to normal cotton plots. Short season cotton management systems in Imperial Valley, CA have suppressed PBW populations to a nonsignificant level that do not require insecticide control. Lint yields and quality increased.

Continued long-term field monitoring of transgenic *B.t.* cotton indicated the transgenic approach is an effective component of integrated pest management programs. Some boll damage due to very high populations of pink bollworm moths was observed, indicating that continued monitoring for *B.t.* resistance is necessary. **(USDA, ARS, Western Cotton Research Laboratory, Phoenix, AZ)**

<u>Arkansas</u>

Insecticide efficacy trials were conducted against thrips, plant bugs, cotton aphids, boll weevils, bollworms, budworms, and spider mites. One area of new research has been looking at thrips control methods in ultra-narrow row cotton.

The program monitoring the entomopathogenic fungus *Neozygites fressini* was expanded to include samples from Mississippi and Louisiana as well as Arkansas.

Research continues on boll weevil habitat qualification for use in the eradication program in the future. Results are promising on alternative methods for control in areas of low quality habitat, such as is found in Northeast Arkansas. **(Extension Service, University of Arkansas, Keiser, AR)**

<u>California</u>

On Lygus bugs, Regent provided good-excellent Lygus bug control to 21 days after treatment. Mycotrol combined with a ½ rate of Provado provided excellent Lygus control for 7-10 days; the combination treatment worked considerable better then the individual treatments, i.e., Mycotrol or ½ rate of Provado. Regent had moderate effects on beneficials with ~60 % reduction at 4 days after treatment. Populations quickly recovered thereafter.

Field demonstrations were conducted to evaluate cowpea strips as a buffer against Lygus migration. This crop fit well with cotton production. Populations of Lygus were low but cowpea was more attractive than cotton and held the population from moving into cotton.

Zephyr and Zephyr + Savey provided good spider mite control at 21 days after treatment. Among the experimental compounds, CM-007 (with oil) showed good activity. The other registered miticides (Kelthane, Comite, and Ovasyn) showed significant control, but were less efficacious then the best treatments. Seed cotton yields were reduced in the untreated areas by spider mites by 800 lbs./A in this test. The Zephyr + Savey and CM-006 (20 and 40 oz./A + oil) numerically yielded the best at >4000 lbs./A.

A cotton aphid control test was conducted in Tulare county with 32 treatments. Applications were made on 19 June to a high aphid density (300 aphids per leaf). The best control seen was ~70% with Furadan. Many other registered materials gave only <50% control. A second aphid test was done at the West Side Research and Extension Center. Aphid control with acetamiphrid was good to 20 days after treatment, although not quite as good as that seen in 1996 with this product.

Cotton aphid build-up was monitored on individual plants following treatment with either 1) Capture, 2) Baythroid, 3)

Provado, 4) Knack, or 5) untreated. Treatments were applied to a low infestation (2-10 aphids per leaf). Results showed that the aphid population increased more rapidly over a 3-week period in the Capture and Baythroid treatments then in the untreated. The Provado treatment provided aphid “control” and the density in the Knack treatment remained constant with the untreated.

The activity of insect growth regulators Knack and Applaud was studied on cotton aphids. Applaud had very little effect on cotton aphid survival or reproduction. When applied to cotton aphid adults, Knack reduced reproduction by 20 to 50%. Knack applied to first instar cotton aphids resulted in nearly 100% reduction in the number of offspring produced. In most cases, the nymphs treated with Knack did not reach adulthood, but it the cases where the nymphs lived for several days, offspring were not produced.

The influence of mid-season cotton aphid on cotton yield was studied. Aphid densities increased in all plots to ~15 per leaf on 2 July and to ~100 per leaf on 8 July. For the aphid density study, Furadan and three rates of Lorsban were used to alter aphid densities. Aphid-day accumulations ranged from 1400 to 8000 in this study. For the timing study, sequential applications of Furadan 4F were used. Applications dates were 9 July, 18 July, 30 July, and 8 August. Aphid-day accumulations ranged from 800 to 4000. Yield, plant mapping data, lint quality, etc. were assessed.

Several experiments were conducted to determine if agronomic and environmental factors influence the susceptibility of cotton aphids to Capture, Furadan, Lorsban, Provado, and Thiodan. Aphids from a pyrethroid-resistant clonal colony were confined in field cages under different field conditions and then bioassayed using a petri-dish technique. The effects of cotton plant age, nitrogen level, irrigation regime, and boll load were studied. Cotton aphids become more susceptible to Capture and Provado when they fed on cotton plants with low nitrogen levels compared to plants with high levels of nitrogen. The opposite result was observed for Thiodan; no differences were found for Lorsban and Furadan. With respect to boll load of plants, no differences in susceptibility were found between aphids reared on cotton plants with high and low boll load for any of the pesticides used. In addition to these field experiments, a laboratory experiment was conducted to test if the aphid morph has an effect on the susceptibility to insecticides. The dark morph was less susceptible to most insecticides (Capture, Lorsban, Furadan, and Provado) compared to the light morph. No differences in response were found for Thiodan.

An area wide project for the management of silverleaf whitefly commenced in Kern County in 1997. The goal of this project is to examine the impact of an area-wide pest management program on insecticide resistance, cotton lint, and pest management efficacy and costs. In conjunction with this project, an intensive educational program was initiated. Two large areas of 7500 and 3800 acres were compared in which one area was intensively managed for whitefly using early intervention of IGRs, increased scouting and resistance monitoring, cultural management of all crops, and early termination compared to “standard” grower practices. Preliminary results indicate positive results in minimizing whitefly populations as well as preventing sticky cotton lint. **(Cooperative Extension Service, Kern Co., Tulare Co., Kings Co., Kearney Agricultural Center, Parlier; UC, Davis; and UC, Riverside)**

<u>Georgia</u>

Stink bug management has become a concern in Georgia due to lower insecticide use. The commercialization of *B.t.* cotton has furthered reduced insecticide use following the elimination of the boll weevil as an economic pest. Mid and late season insecticide applications targeting tobacco budworm and boll weevil have historically suppressed stink bug numbers below damaging levels. Once considered only a late season pest, stink bugs were observed in fields prior to bloom in 1997. Injury to developing bolls was evident in late July and early August, with some fields exhibiting greater than 20% damage to 20 day old bolls. A large plot insecticide trial was conducted evaluating two pyrethroids and two organophosphates for efficacy against stink bugs. Results suggested that infestations can be controlled fairly easily as control ranged from 74 to 100 percent.

A preliminary field study investigated the impact stink bug feeding has on yield. Bolls with external symptoms of stink bug feeding (small sunken purple spots) and undamaged bolls were tagged four weeks prior to harvest. Both damaged and undamaged bolls were hand harvested and rated for injury. Ratings included bolls with no damaged locks and one to five damaged locks. A lock was considered damaged if localized discoloration was present. Each rating class was ginned and percent lint and lint per boll was determined. Both percent lint and lint per boll decreased as the number of damaged locks increased. Of the damaged bolls which had external signs of stink bug feeding, 33 percent exhibited no obvious damage to the lint, 24 percent had one damaged lock, 16 percent had two damaged locks, 10 percent had three damaged locks, and 17 percent had four or five damaged locks. Obvious differences in lint color were also noted. In summary, preliminary data suggest that symptoms of stink bug feeding on the external surface of a boll lowered lint yield of that boll by 24 percent. It is believed that this loss is dependent upon environmental conditions which may be conducive for additional boll rot organisms.

Two additional field trials were conducted to investigate the effects of insecticide treatment of *B.t.* cotton on stink bug injury. Two applications of methyl parathion, cyhalothrin, and spinosad were made during late July and early August. Damaged boll counts were made on four dates during August. Bolls of approximately 20 days of age were randomly selected from each treatment and examined internally for puncture sites. Damaged boll means from the weekly samples were highest in the untreated and spinosad plots, 35 and 24 percent boll damage respectively. The methyl parathion and cyhalothrin had 12 and 8 percent boll damage, respectively. Thus, during 1997 stink bugs were an economic pests in some fields. Additional research characterizing damage and yield losses from stink bugs is needed. **(Cooperative Extension Service, Tifton, GA)**

Resistance in tobacco budworm populations to pyrethroid insecticides was confirmed in 1997. A 35 fold increase in resistance compared to a historical (18 year) baseline was found in Decatur Co. Ga cotton. This is the first confirmation of tobacco budworm resistance in Georgia. Several other locations tested little change to a four fold decrease in susceptibility.

Studies were conducted to determine the influence of timing of foliar applications of insecticides for thrips control. There were dramatic differences in thrips injury depending upon the time of initiation of applications following seedling emergence. The best treatment was an in furrow application of Temik at planting. Of the foliar appliations, least damage was observed in plots receiving sprays seven and 14 days after emergence. Significant differences in damage rating and plant height were observed. No difference was in time to initiation of squaring, time to first bloom or in yield were found. (**University of Georgia, Tifton, GA**)

Louisiana

Field cage studies were conducted to measure the effects of late season beet armyworm, *Spodoptera exigua* (Hübner), infestations (0, 1, 3, and 6 egg masses per 5.1 row m) on defoliation, fruit damage, and yield of cotton. Light penetration through the canopy was significantly higher in infested plots. Although a trend for increased numbers of damaged fruiting forms with increases in egg mass density was observed, there were no significant differences between infested and control plots. There were no significant differences in the cumulative number of shed fruiting forms or yield between infested and control plots.

Field tests conducted to evaluate the effectiveness of selected insecticides against native populations of beet armyworms showed that chlorfenapyr, spinosad, and tebfenozide provided satisfactory control (83-91%). Chlorpyrifos provided adquate (70-80%) control, while thiodicarb and Spod-X did not provide adequate control (<60%).

Susceptibility of field-collected beet armyworm larvae to registered and experimental insecticides was evaluated in a diet overlay bioassay using 2-d old larvae and third instars (30-45 mg). Larvae were collected from cotton fields throughout the U.S. and from Rio Bravo, Mexico. Susceptibility of field strains was compared with a laboratory strain. In chlorpyrifos bioassays of 2-d old larvae, 7 of 11 field strains had significantly higher LC_{50}s, while in third instar bioassays all field strains had significantly higher LC_{50}s. In thiodicarb bioassays, 3 of 10 and 5 of 8 field strains had significantly higher LC_{50}s in 2-d old and third instar bioassays, respectively. In bioassays of 2-d old larvae and third instars with chlorfenapyr, 1 of 9 and 5 of 8 field strains had significantly higher LC_{50}s. With spinosad, 3 of 10 field strains tested as 2-d old larvae had significantly lower LC_{50}s, while 1 of 7 strains tested as third instars had significantly higher LC_{50}s. With tebfenozide, 1 of 10 and 2 of 7 field strains had significantly higher LC_{50}s in 2-d old and third instar bioassays, respectively. Emamectin benzoate and methoxyfenozide were only evaluated in third instar bioassays, where 5 of 7 had significantly lower LC_{50}s and 1 of 7 strains had significantly higher LC_{50}s, respectively.

A total of 785 tobacco budworm male moths captured in pheromone-baited cone traps located throughout cotton production areas was tested at the 10 μg cypermethrin/vial discriminating dose for pyrethroid resistance throughout 1997. Moths surviving this dose are considered to be resistant. The average survival for May, June, July, and August was 26, 51, 51, and 63%, respectively. The average survival for 1997 was 56%, which is the highest survival recorded over the 11 years that the pyrethroid resistance monitoring program has been conducted. The previous highest survival was 48% in 1993, whereas survival in all other years was no higher than 40%. Increased use of pyrethroids against early season pests of cotton (indicated by 51% average survival for moths captured in June compared to previous survival data for June which ranged from 5-29%) may be responsible for the overall increased survival of tobacco budworm moths during 1997.

Over 1860 bollworm male moths captured in pheromone-baited cone traps were tested with cypermethrin at 5 μg/vial. Survival during May, June, July, and August was 4, 4, 14, and 7%, respectively. Mean survival for bollworm moths during 1997 was 9%, which is similar to survival during 1991-1996. However, survival during July 1997 (14%) is the highest recorded over the period of 1987-1997. The apparent increase in pyrethroid resistance exhibited by bollworm moths during 1997 may be due to the use of pyrethroids on hosts of bollworms other than cotton. **(Department of Entomology, Louisiana State University, Baton Rouge, LA)**

Mississippi

The second year of field research to measure the efficacy of genetically modified baculoviruses for control of corn earworm and tobacco budworm on cotton was completed. Baculoviruses modified to express insect-specific toxins tended to kill susceptible caterpillars faster than native, non-modified viruses. Efficacy of the modified baculoviruses in field studies was more similar to the pattern of activity of *Bacillus thuringiensis* than that of native baculoviruses. Activity was not comparable to that obtained with spinosad.

A project to define the relative activity of different commercial formulations of *Bacillus thuringiensis* and better define the role of foliar applications of *B. thuringiensis* in cotton insect management was completed during the summer of 1997. Results of the study illustrate the importance of using standardized assay procedures and including reference standards in studies designed to measure or compare activity of *B. thuringiensis* formulations.

A project designed to measure the amount of interplant movement of tobacco budworm larvae in mixed planting of *B.t.* and non-*B.t.* cotton completed during the spring of 1997 showed that larvae do move from plant to plant. Larger larvae move more than smaller, younger larvae. These results were influential in the decision to abandon the seed mixture strategy for management of resistance to *B.t.* cotton. However, results of the study indicate that the mixtures may have some limited value against highly susceptible species under conditions of high resistant gene frequencies.

Data collection has been completed on a project to develop a trap crop system for tarnished plant bug that would also serve as a refugia for tobacco budworm susceptible to *Bacillus thuringiensis* endotoxin. During 1996, studies were completed that identified a group of plants to be included in 1997 field studies. The plants chosen from a large group of candidate species in greenhouse, cage and field studies were velvetleaf and sesame as host plants for tobacco budworm and redroot pigweed and kenaf as hosts for tarnished plant bug. Field tests were established with five different farmers in the Mississippi Delta during 1997 (C. Craig, F. Mitchner, K. Hood, W. Jack, and B. Lamensdorf). One site was abandoned early in the study. At each study site 8 rows of the trap crop/refuge crop mixture (2 rows of each species) were planted with standard cotton planting equipment about the time of cotton planting. Growth of the plants and infestation by insects were followed weekly from emergence to flowering stage of cotton crop development. Insect densities and fruit damage were monitored at a series of four distances from the trap crop. Half of the trap crop was oversprayed with imidacloprid to kill plant bugs and beneficial species. Half was left unsprayed. By spraying the plots, we hope to lower population growth of tarnished plant bug and increase population growth of tobacco budworms susceptible to endotoxin (i.e. reduce natural mortality from beneficials). During late July and early August the trap crop/refuge crop was oversprayed with glyphosate to reduce seed germination next season. Results are preliminary and data are still being analyzed. The trap crops definitely had higher densities of tarnished plant bug and tobacco budworm than the surrounding cotton. Densities in the cotton were almost non-detectable. Further research in large, unsprayed cotton may be necessary to accurately measure the benefits of the trap crop/refuge crop system. Based on final data analyses, we will determine the need to solicit additional support to continue development of this cultural practice.

A series of artificial infestation studies were conducted on the Plant Science Research Farm at Mississippi State to measure cotton fruit loss due to tarnished plant bug and tobacco budworm. During most weeks of the growing season, plots were covered with large (6 X 6 meter) field cages and adult tarnished plant bugs that had been collected from wild host plants and on green beans were released inside the cages. Densities of bugs released ranged from 0 to 600 per cage (0, 20, 60, 200, and 600 per cage). Cages were removed one week following release. Data were collected and 3 rows within the plot were infested with tobacco budworm at densities of 5 larvae on every third plant (33% infestation assuming 1 larva survives), 5 larvae on every tenth plant (10% infestation), and 5 larvae on every thirty-third plant (3% infestation). Three rows within each plot remained uninfested. The plots were monitored for 2 to 3 weeks following infestation to record insect survival and fruit loss. Additional studies were conducted each week to measure the impact of artificial infestations of corn earworm and tobacco budworm on cotton fruit retention. Paired plots were infested with both species at densities of 0 larvae per plant (0%), 5 larvae on one plant in one hundred (1%), 5 larvae on every thirty-third plant (3%), 5 larvae on every tenth plant (10%), 5 larvae on every third plant (33%), and 5 larvae on every plant (100%). We are currently recording the number of open and harvestable bolls within each study. If differences in insect survival, fruit loss or boll counts are observed, 10 row feet of each treatment-plot will be box mapped to determine impact of the infestations on fruiting patterns at different times in the season.

A large-plot field study was conducted on Reece Makamson’s farm in Morgan City, Mississippi. This is a continuation of a 3-year study to compare cotton insect management strategies in "on-farm" situations. The study is a single replicate of the state-wide experiment being replicated at other sites which study compared current insect control strategies on a grower chosen variety to NuCotn 33 managed on the basis of extension recommendations. A third treatment that involved early season applications of acephate to NuCotn 33 was also included. At the Morgan City site in 1997, four additional plots were monitored and included different *B.t.* cotton varieties and different planting dates. Results of these studies and those of previous years are being organized for data analyses and publication. They are also being made available to several agricultural economists interested in the value of transgenic crops.

The second year of a project designed to measure the possible temporal relationships between corn earworm population growth and selection on corn to that on cotton was completed. The project has included a comparison of *B.t.* corn and non-*B.t.* corn grown in close proximity to *B.t.* cotton and non-*B.t.* cotton plots in the Mississippi Delta. Several varieties of *B.t.* corn with a wide range of toxin expression have been included in the studies. Populations of corn earworm were much lower in 1997 than in 1996. Numbers of pupae under the different corn lines varied, although pupae were found under most. Data collection is still in progress. We hope to relate temporal patterns of corn earworm population densities to the wide range of host plants in the region. The impact of *B.t.* corn and *B.t.* cotton on these trends will be emphasized in the data analyses.

A project to relate within season densities of cotton insects, especially tobacco budworm, corn earworm and tarnished plant bug, to end-of-season box maps of cotton has been initiated and includes more than 100 different sets of data with both within season and end-of-season observations. The objective is to relate differences in insect numbers to end-of-season retention of cotton fruit at different positions on the plant. These different fruiting positions represent different periods of time. Likewise, we hope to identify differences between samples at different time periods recorded on the plant maps and then examine the seasonal insect scouting data to determine what insects were present at this point in time. Data analyses will be extremely complex and will be initiated this fall and winter.

Studies were initiated in cooperation with scientists at the USDA/ARS Crop Simulation Laboratory to examine the value of different sampling procedures and estimate the optimum scale of insect management units. This work was conducted as a component of the MAFES Spatial Technologies Research Group and was funded by a Special Funds Grant from the USDA. Half-acre research plots at Mississippi State compared random sampling to a transect method. Typical time and motion data were also recorded as a basis for comparing sample costs. Data are still being collected. Another study conducted on Kenneth Hood's farm in the Mississippi Delta aimed to describe insect spatial distributions and possibly relate spatial distribution patterns to other data. These are preliminary studies. Our goal is to investigate the potential value of defining sample units and sampling procedures in cooperation with scientists in the Agricultural Economics Department. Once we have a better understanding of the potential advantages of spatial data to insect management, we hope to obtain additional funds to support a Ph.D student project and concentrate our cooperative work in the spatial technologies area.

Work is continuing on the development of CIC-EM, an expert system for determining the need for cotton insect control action, and CIM, a simulation model of cotton and important cotton herbivores. The expert system has been modified with a user friendly--Windows based interface. It now includes some rules from several cotton experts. CIM has been adapted to run in the Windows 95 environment. We are interested in using CIM as an experimental simulator. Future work will involve revision of some herbivore-cotton routines and validation of the simulated predictions.

In cooperation with colleagues in Agricultural Economics, we are beginning to examine economic differences among cotton insect management strategies. This is a developing research program. Some initial progress has been made in examining the potential economic differences between *B.t.* and non-*B.t.* cotton, and we are beginning to get involved with national policy issues in this area.

In the second year of experiments intended to test the design of unsprayed refuges for resistance management in *B.t.*-cotton, we examined small (17-24m wide), medium (36-48m wide) and large (72-94m wide) refuges on four different farms in Mississippi. Theoretical modeling has suggested that if refuges are made too small, source-sink dynamics will render them ineffective as tools for delaying the evolution of resistance. Our results in 1997 showed that the large refuges had egg densities twice as large as small refuges, suggesting that such refuges would be much more effective for managing resistance. Egg densities were also sampled up to 120m away from the refuges into *B.t.*-cotton. For eggs identified as *Heliothis virescens*, the egg density dropped by 50% from the refuge to the 120m samples, while little decline was seen in *Helicoverpa zea* eggs. The latter was expected as *H. zea* moves into cotton in large numbers in July after increasing on corn, and no response to the refuge patchiness would be seen until the August generation. These results suggest that 4% unsprayed refuges should be at least 50m, and preferably 100-150m wide to produce sufficient moths to adequately manage resistance in *H. virescens*.

Densities of lepidoptera pupae in five or six randomly chosen overwintering sites in each of 30 fields randomly chosen from the 88 untilled fields (both transgenic *B.t.* and nontransgenic cotton) near all-weather roads in a 40 section area in southeast Monroe Co., MS, were sampled on 6 Saturdays from January 25, 1997 to April 5, 1997. A total of 6,194 row-meters were sampled with a shovel. Cutworms were present at an average density of 188 ha^{-1}, and armyworms were present at a density of 41 ha^{-1}. No *Heliothis virescens* (TBW) pupae were observed overwintering in 1997. Pheromone trap catches of the overwintering generation of TBW, as assayed with six wire-mesh traps were ca. 20% of the catches at identical locations in 1996 when overwintering densities of 325 ha^{-1} were observed. Sampling of pupae overwintering in cotton fields in this area is planned for January-April 1998.

Sampling of wild host plants in southeast Monroe Co., MS, between September and 12 November 1997 revealed the presence of locally high densities of larvae of *Heliothis virescens* and *Helicoverpa zea* (up to 50 larvae per 50 sweeps) on several different species of uncultivated plants at a number of sites. Rearing for species identification and parasitism status is in progress. Sampling of pupae overwintering in these sites is planned for January-April 1998.

Replicated fields in four locations within Mississippi were used to evaluate the concept of aggressive early season management of tarnished plant bugs on transgenic (*B.t.*) cotton and to compare the *B.t.* cotton to conventional, non-*B.t.* cotton. Fields were located in Itawamba, Leflore, Madison and Tallahatchie counties. Population densities of this pest were again low during 1997 and differences in yield or other parameters are not expected as a result of 3 scheduled applications of acephate applied at weekly intervals beginning at the 4th true leaf stage of cotton growth. Overall economic benefit of *B.t.*-transgenic cotton for heliothine control is expected to be lower than that of conventional cotton again in 1997 because of relatively low densities of tobacco budworm and bollworm. This is a cooperative project involving R. G. Luttrell, S. Stewart, F. A. Harris and J. T. Reed.

Small plot pesticide evaluations indicated that all currently registered compounds recommended for tarnished plant bug (*Lygus lineolaris*) control were efficacious in both caged and laboratory evaluations in early season tests. The boll weevil eradication sprays of ULV malathion appeared to have controlled tarnished plant bugs well during late season boll weevil diapause control applications in northeast Mississippi. Several attempts at evaluation of insecticides for fall armyworm (*Spodoptera frugiperda*) near Hattiesburg resulted in rain following application. In those trials, only the pyrethroid, lambda-cyhalothrin (the only pyrethroid in the trials), was effective at reducing populations. Experimental compounds tested were ineffective when rain followed application of insecticide. Profenofos at several volumetric application rates 3, 5 and 20 gal/acre, at 1 pound active ingredient per acre failed to reduce fall armyworm populations appreciatively under the rainy conditions. A trial including dicrotophos, endosulfan and carbofuran at mid-recommended rates at 3, 5 and 10 gal/acre volumetric application rates indicated that three gal/acre was as or more effective than higher volumes for all three compounds for aphid control. This correlates well with previous trials indicating that cost reductions could be obtained for ground-applied insecticides for aphid control by using a smaller nozzle size with less total gallons per acre than commonly used. Evaluation of the effect of aphid-control insecticide applications on beneficials and 1st generation heliothine larval populations in 1/3 acre replicated plots indicated that under the conditions of the trial (low heliothine densities), beneficials allowed to build on untreated aphid populations significantly reduced heliothine larval damage as compared with plots treated with dicrotophos/imidacloprid.

Evaluation of the COTMAN expert system program for validation of recommendation of termination of sprays was initiated on both transgenic (*B.t.*) and nontransgenic cotton fields. Low heliothine numbers precluded spray termination evaluation in 1997; however, the late, warm fall allowed late cotton to mature, and the weather oriented rules of the COTMAN program indicated dates of defoliation and harvest earlier than growers were willing to comply. **(Department of Entomology, Mississippi State University, Mississippi State, MS)**

Nectariless cotton (DPL 5415-NE) was compared to its near-parent isoline (DPL 5415) and transgenic *B.t.* cotton (NuCotn 33B) to determine the potential impact of the nectariless trait and the *B.t.* cotton on infestations and management of tarnished plant bug populations. Only the most severe square removal treatment (all squares prior to bloom) caused a reduction in yield. The location of yield on the plant was related to the degree of square removal. The impact on other pest and beneficial arthropod populations was also evaluated.

Different levels of early-season square removal (manual and insect-induced) were made to *B.t.* and conventional varieties of cotton (Nucotn 33B, PM1220-BG and PM1220). Effects of square-removal treatment and variety showed no significant interactions between varieties and the different square removal treatments. **(Central Mississippi Research & Extension Center, Raymond, MS)**

Research on temperature and food relationships to weevils attaining diapause resulted in an earlier start date for the fall diapause sprays in the boll weevil eradication program in Mississippi in 1997.

Work on confocal and fluorescence imaging of whitefly feeding sheaths was completed and showed that the whiteflies fed invariably on phloem tissue, and that they often made a sinuous course through the extra-cellular spaces in cotton leaf tissue.

Research on feeding characteristics (on cotton aphids and tobacco budworm larvae) of domesticated (reared on artificial diet) versus feral *Geocoris punctipes* was completed. The domesticated predators were equal in every aspect of their feeding physiology (size of prey accepted, consumption rates, total amount extracted, and handling times). The domesticated predators were significantly smaller than their feral counterparts.

Trichogramma spp. was found to use extra-oral digestion to process solid materials in host (*Helicoverpa zea*) eggs. The extra-oral digestion was evidenced by the breakdown of casein labeled with a fluorescent marker that is liberated and fluoresces only after proteolysis has occurred. Direct observations revealed that the *Trichogramma* ingest solid substances that they break off from larger solids in their hosts.

Increasing the scale of diet production for *Chrysoperla carnea* from 0.5 kg to 25 kg demonstrated a savings in labor amounting to about $30/kg. The *C. carnea* diet can be freeze dried with no evident deterioration in quality as determined by bioassay.

A new holding cart was developed for mass rearing lepidopterous insects that provides for 58% more 32 cell PVC rearing trays per square foot of floor area than the cart currently being used. The new cart is 70% less expensive to fabricate than the current cart and simplifies insect tray handling. **(USDA, ARS, Biological Control and Mass Rearing Research Unit, Mississippi State, MS)**

Research into extensions of line-intercept sampling concepts suggests that the drop cloth technique can be utilized with this sampling method to create a highly precise sampling technique. Plant bugs at populations of 500-600 per acre can be rapidly detected. As populations densities increase, the technique can be even more efficient and require even less sampling time. Furthermore, if remote sensing images of the crop are available, these images can be used to stratify the field into homogenous management units. This technology essentially helps the field consultant to define strata so that data can be quickly collected and analyzed using a stratified sampling plan in combination with a line-intercept/drop cloth sampling technique. The sample data of this season indicate that for a significant portion of the growing season, plant bugs do aggregate at different densities in the strata delineated by remote sensing images. Other pests like aphids may do the same, but knowledge of this effect for boll weevils and Heliothines was not collected, as populations were too low to obtain any information.

Other research continues into developing non-replicated analysis techniques for simulation models and into applications of speech recognition software for improving the collection of plant mapping data. A temperature-dependent model describing the prediapause period in square-fed boll weevils was formulated and predicts the time required for prediapausing adults to develop the characteristics associated with diapause. It was used in 1997 by the Technical Advisory Committee, Mississippi Boll Weevil Eradication Management Corporation to formulate a diapause control spray schedule for the Mississippi Program. Experimental research examined the effect of boll feeding on fat body development of prediapausing weevils. Preliminary results indicate that boll-fed adults develop the characteristics associated with diapause at about the same rate as square-fed adults. The new results will be incorporated into the existing model as soon as they become available. Research also examined the effects of leaf-feeding and boll size (age) on the timing of diapause intensification. Tests were conducted to evaluate the respiration rates of prediapausing and reproductive adults, and to assess changes in respiration rates with adult age. This work should provide a better understanding of the duration of prediapause, and thus how long prediapausing adults stay in the field before they leave cotton in search of overwintering sites. Studies were also conducted to assess the physiological status of overwintering weevils; e.g., to determine whether weevils overwinters in diapause per se or in a state of post-diapause quiescence. This information is critical to our understanding of overwintering survival, and how we approach fall diapause and pinhead square applications. It has significant implications on the "early-in/late-out" theory. (**USDA, ARS, Crop Simulation Research Unit, Mississippi State, MS**).

Production of insects for USDA--ARS research by the Stoneville Insect Rearing Unit required maintenance of seven insects species: *Heliothis virescens, Helicoverpa zea, Anticarsia gemmatalis, Pseudoplusia includens, Spodoptera exigua, Cardiochiles nigriceps,* and *Cotesia kazak*. Support of USDA--ARS scientists at Stoneville and laboratories in Weslaco, TX; Tifton, GA; Mississippi State, MS; College Station, TX; and Gainesville, FL, required production of 153,000 *H. virescens* pupae, 144,000 *H. zea* pupae, 166,720 *P. includens* pupae, 91,200 *A. gemmatalis* pupae, 91,800 *Spodoptera exigua* pupae, 40,590 *Cardiochiles nigriceps* cocoons, 75,874 *C. kazak* cocoons, 38,250,000 *H. virescens* eggs, 36,000,000 *H. zea* eggs, 14,064,000 *P. includens* eggs, 9,525,900 *A. gemmatalis* eggs, and 5,178,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 67,740 30 ml cups and 601 3.8 liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1997 was 13,670 liters. Several short courses in insect rearing techniques were given to employees of Thermo Trilogy Laboratory, Columbia, MD, and K-I Chemical USA, Inc., Leland, MS. Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in the Cotton Foundation and United Soybean Board Insect Distribution Programs.

A third and final year study of boll weevil emergence and movement in the mid-Delta of Mississippi showed again that (1) from a start of low to moderate levels in the spring, late season numbers were extremely high; and (2) considerable movement of overwintered and first generation weevils occurred after bloom as detected by pheromone traps, especially 1-3 miles from the closest cotton. Sex ratios are still being determined, but trends indicate approximately 55:45 female:male ratio in traps from March through June and August 10 to frost, with over 90% females from July 1 - August 10.

Boll weevil adults captured from March 1996 through January 1997 were analyzed for pollen to determine alternative foraging resources. For analyses, samples were divided by season: Spring = March, April, and May; Summer - June, July, August; Fall = September, October, and November; and Winter = December and January. Boll weevils captured at 821 site-dates were processed; of those only 23 occurred in winter. Over 5,000 boll weevil adults were processed; most of which were collected in Fall. Boll weevils in Spring had a higher percentage of pollen (96%) than other seasons, and weevils captured in Winter had the lowest percent pollen (61%). Overall, 301 pollen types, 81 families, 132 genera, and 28 species were encountered in the site-date samples. Fall contained more pollen types (187) than other seasons. Both Summer and Fall samples contained pollen from the greatest number of plant families, with more genera (89) represented in Fall samples. Mean number of pollen grains in Fall (80) was double that of any other season. Spring contained the largest mean number of pollen types (7), but Summer had the most types per site-date. Fabaceae (bean family) pollen accounted for more pollen types in Spring and Summer. In Fall and Winter, more Asteraceae pollen types occurred.

Studies were initiated in 1997 in a portion of the boll weevil eradication zone near Collins, Mississippi, to determine the feasibility of substituting bait sticks (BWACT®-boll weevil attract and control tubes) for pinhead square and/or fall diapause sprays in support of boll weevil eradication. Results were inconclusive but plans are to repeat the test with minor modifications in 1998.

Preliminary *B.t.* resistance monitoring in cotton in populations of cotton bollworm (CBW) and tobacco budworm (TBW) was initiated in 1996 by subjecting 23 different populations of these insects collected in Arkansas, Mississippi, Oklahoma, and Texas to field doses of MVP II biological insecticide in spray chamber bioassays (the toxic protein in MVP II is the closest in toxicological properties of all *B.t.* insecticides to the Cry I A© protein expressed in transgenic cotton). These tests were expanded in 1997 by subjecting 67 colonies (24 tobacco budworm, 43 cotton bollworm) submitted by 27 cooperators from 9 states to MVP II overlays in diet. As in 1996, the data showed no dramatic shifts in development of resistance of these insects to *B.t.* insecticide proteins in diet (and by inference, to *B.t.* cotton).

Furadan at 0.25 lb AI/A and Provado at 0.047 lb AI/A provided significant reductions in cotton aphid numbers at 3, 6, and 9 days after treatment when aphids were sampled in the top and middle portions of the plant. Bidrin at 0.4 LB AI/A and a kaolin powder (25 lb/100 gal water) reduced aphid numbers when compared to an untreated check but not significantly.

Several proprietary compounds from Uniroyal Chemical Company and Helena Chemical Company were tested against cotton bollworm/tobacco budworm larvae and eggs, respectively; yield records were obtained where possible. No counts were taken for boll weevil, stink bugs, or aphids due to low numbers, but some data were recorded for tarnished plant bug. All data have been forwarded to both companies.

Moth trap records in 1997 compared to 1996 collected at the same trap sites showed that: (1) beet armyworm numbers were 85% as high; and (2) cotton bollworms and tobacco budworms were reduced almost 70%. Reduced bollworm numbers may in part be due to a 20% reduction in corn acres in 1997 compared to 1996. In 1996, tobacco budworms reduced over 60% compared to 1995, so numbers of these insects continue to decline, perhaps partially due to plantings of *B.t.* cotton.

Results from a second year test of two insecticide treatments (7 days apart) for cotton aphid on NuCotn 33B and Sure-Grow 125 at three different growth stages (pre-pinhead square, full-grown square, first bloom) showed that (1) all 3 treatment stages in NuCotn 33 yielded more cotton than an untreated check, but bloom treatment was best; (2) no treatment of Sure-Grow 125 yielded significantly higher than the untreated check; and (3) NuCotn 33 yielded 67 lb lint per acre more than Sure-Grow 125. Sure-Grow 125 was treated twice for bollworm/budworm; NuCotn 33 was not treated for worms; and both varieties received 8 treatments (2 at pinhead square; 6 in August) for boll weevil and tarnished plant bug. The test will be repeated in 1998.

A large field plot study to determine the effects of seed treatments in-furrow and sidedress treatments of aldicarb on early populations and yield was evaluated in DPL 33B and Sure Grow 125 cotton varieties. Populations of thrips and tarnished plant bugs were low in 1997 and were not influenced by any treatment. Plant bug populations were not any higher in 33B than found in Sure Grow 125 cotton. Because of low, early-season insect pressure, no yield response was observed in treatments with aldicarb. In this study, plant bug nymphs and young adults were caged in sleeve cages on plants with aldicarb in-furrow plus sidedress and on cotton without aldicarb. Higher mortality occurred in cotton treated with aldicarb as compared to the untreated check.

A large field plot study to compare sampling (sweep net, drop cloth, and visual) and economic thresholds for tarnished plant bug control currently recommended in the Mississippi Insect Control Guide were studied in 33B cotton. For the third consecutive year, extremely low populations of plant bugs occurred in test fields for the entire season.

Fipronil was evaluated in 3-acre replicated plots for control of the tarnished plant bug and boll weevil. Fipronil treatments were applied under Section 18 and were compared to Vydate and Karate. There was not an untreated control. All treatments were very effective in controlling the plant bug and boll weevil. Fipronil treatment had higher yields than both Vydate and Baythroid.

An economic and entomological study of growing *B.t.* and non-*B.t.* cotton on 15 farms throughout the Mississippi Delta began in 1997. This is a cooperative study between ARS and the Delta Research and Extension Center. Partial funding from Cotton Incorporated will begin in January 1998. Project will run for three years; 1997 was used to establish cooperators and to purchase needed equipment.

Spray table tests were conducted to further evaluate Fipronil and other promising new insecticides on boll weevil mortality. Fipronil applied at 0.05, 0.038, and 0.019 lb AI/ac gave excellent mortality of boll weevils and was equal to that of Vydate at 0.25.

In a separate weevil test, Fipronil and a Fiprol-molecule (61096A) was evaluated for weevil mortality using spray table tests. Fipronil gave excellent mortality applied at rates of 0.05, 0.038, and 0.019 lbs AI/ac. Mortality with 61096A applied at rates of 0.1, 0.076, and 0.038 was not as effective as Fipronil.

Plant bug (susceptible) mortality when exposed to Fipronil (0.05, 0.038), Monitor (0.33), Vydate (0.25), Orthene (0.33), and Sevin (1.0) lbs AI/ac was evaluated using spray table tests. Higher mortality was observed with Fipronil, Monitor, Vydate, and Orthene than with Sevin.

Plant bug (resistant) mortality exposed to Fipronil (0.05, 0.038), Provado (0.047), Monitor (0.33, (Vydate (0.25), Orthene (0.33), and Sevin (1.0) lbs AI/ac was determined using spray table tests. Fipronil and Monitor provided excellent mortality when compared to other insecticides.

The effects of thirteen different insecticides were evaluated for boll weevil and tarnished plant bug control in 33B cotton. Plots were 80' x 16 rows. Treatments were compared to an untreated check. The better plant bug suppression was seen in plots sprayed with Regent, Monitor, and Karate. Highest yields were in the Regent treatment.

Research was focused on the development of biological control for the management of the *Bemisia* complex of whiteflies infesting key agronomic crops in the United States (i.e. cotton, vegetables, ornamentals, etc.). Studies have concentrated on the evaluation of the factors affecting parasitoid efficacy, specifically temperature and host plant. Initial studies (1994-1995) provided evidence for two climatic strains of *Encarsia formosa*, the most widely utilized and commercially available parasitoid of whiteflies throughout the world. These studies clearly indicated the importance of searching for parasitoids which originate from areas with climates similar to those in the targeted areas for release or introduction.

Subsequent studies (1995-1997) evaluated the effect of host plant on parasitoid efficacy. These studies included four strains of *E. formosa* (Greece, Egypt, Commercial, Beltsville), and a diverse group of economically important host plants. Both biological parameters of the parasitoids and percent parasitism were evaluated. Host plant characteristics (leaf area and hair density) were measured as potential factors which may affect searching efficacy of the adult parasitoids, and therefore the various biological parameters. Data analysis is in progress.

In concert with these parasitoid evaluations, a survey of the whitefly and associated parasitoid species in Mississippi was initiated in 1995, and continued in 1996 and 1997. This study is being conducted through the cooperation of USDA-APHIS and Mississippi State University Agricultural Extension Service. This study will serve as a prerequisite for the development of both preventative and direct control strategies for the silverleaf whitefly, as well as a prerequisite for subsequent field evaluation and release program of parasitoids for control of whitefly pest species in Mississippi. This survey has encompassed the four principle growing regions of Mississippi (Delta, Hills, Coastal Plain and the Black Prairie). In the 1995 survey, 175 samples were collected, 97.7% of which were infested with whiteflies. Whiteflies found among the whitefly-infested samples included *Trialeurodes abutilonea* (29.6%), *Trialeurodes vaporariorum* (10.5%), and *Bemisia* spp. (51.7%), as well as a group of unidentified whitefly species (9.3%). Among the *Bemisia* infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 19.2% of the samples. Implications of these results are under further investigation. Whiteflies were found infesting cotton, soybeans, vegetables (17 species), and ornamentals (16 species), comprising 18.0%, 14.5%, 29.6%, and 37.8%, respectively, of the infested samples, across 19 counties. Parasitoids were collected from 48.6% of the infested samples, and tentatively identified as (% of parasitized whitefly samples): *Amitus* sp. (0.9%), *Encarsia* sp. (33.9%), including *Encarsia americana, Encarsia cubensis, Encarsia meritoria, Encarsia nigricephala, Encarsia pergandiella, Encarsia quaintancei*, *Eretmocerus* sp. (47.8%), *Metaphycus* sp. (1.7%), *Signiphora* sp. (4.4%), and unidentified species (13.0%). In the 1996 survey, 284 samples were collected, 95.8% of which were infested with whiteflies. Whitefly species found among the whitefly-infested samples included *T. abutilonea* {46.3%), *T. vaporariorum* (14.0%), *Bemisia* spp.(27.6%), as well as a group of unidentified whitefly species (16.5%). Again, among the *Bemisia*-infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 15.9% of the samples. Whiteflies were again found infesting cotton, soybean, 6 vegetable species, and 26 ornamental species, comprising 41.9%, 11.8%, 9.2%, and 37.1%, respectively, of the infested samples, across 26 counties. Parasitoids were collected from 10.4% of the infested samples, and tentatively identified as (% of parasitized whitefly samples): *Amitus* sp. (2.8%), *Encarsia* sp. (33.3%), including *E. americana, E. meritoria, E. nigricephala, E. pergandiella, E. quaintancei*, *Eretmocerus* sp. (41.7%), *Metaphycus* sp. (2.8%), *Signiphora* sp. (2.8%), and unidentified species (13.9%). In the 1997 survey, 744 samples were collected, 58.1% of which were infested with whiteflies. The lower percentage of samples infested with whitefly is due in large part to the fact that sampling was initiated much earlier in the growing season, particularly in cotton, in an effort to more precisely detect the lower early season whitefly populations. Whitefly species found among the whitefly-infested samples included *T. abutilonea* (14.1%), *T. vaporariorum* (50.5%), and *Bemisia* spp. (39.8%), as well as a group of unidentified whitefly species (3.9%). Again, among the *Bemisia*-infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 12.3% of the samples. Whiteflies were again found infesting cotton, soybean, 9 vegetable species, and 27 ornamental species, comprising 41.9%, 11.8%, 9.2%, and 37.1%, respectively, of the infested samples, across 38 counties. Whitefly density among the various host plants, as well as parasitoid sampling data are currently being compiled and analyzed. It is important to note that *Bemisia argentifolii* was found infesting cotton in 3 southern counties: George (7 fields) and Jackson (4 fields) counties in Mississippi and Mobile (5 fields) county in Alabama. These 16 fields comprise approximately 674 acres. Infestation levels were high enough to cause premature defoliation on 242 acres (5 fields) of the 674 acres. With the exception of a 29.2 acre field located in George County, MS, defoliation generally ranged from less than 2% to approximately 5%. However, the 29.2 acre field had approximately 65% defoliation, with sooty mold totally covering the remaining foliage. It is apparent that premature defoliation resulting from silverleaf whitefly infestations resulted in yield reductions of 39.2%, 13.9%, and 20.9%. It should also be noted that most heavily damaged fields were planted to NuCotn33 (*B.t.* transgenic). Dr. Greg Evans (whitefly parasitoid taxonomist at the University of Florida, Gainesville) assisted with the identification of parasitoid specimens collected during this project.

A colony of plant bugs having unusual bright red eyes was reared through 1997 in the laboratory. To determine the frequency of occurance of this recessive mutation in wild populations in the Delta, all adults and nymphs collected in the resistance survey of the Delta (discussed above) during the fall of 1995 and the spring and fall of 1996 and 1997 were examined for the red-eyed trait. A total of 23,735 adults and 12,936 nymphs were examined, and no red-eyed individuals were found. In a large cage field test red-eyed adults were found to be able to mate and produce offspring in cotton.

Compounds with possible activity against the tarnished plant bug are being tested in laboratory bioassays this fall and winter. The compounds are from Mycogen Corporation and are being tested under a secrecy agreement.

A survey of the Arkansas, Louisiana, and Mississippi Delta was conducted again in the spring (April-May) and fall (September-October) of 1997 to determine how widespread pyrethroid resistance was in tarnished plant bug populations in the Delta. The study was a repeat of surveys conducted in 1995 and 1996, and used the same collection locations and time periods in all three years. At least 50 adult tarnished plant bugs from each of 71 locations (6 in Louisiana, 17 in Arkansas, and 48 in Mississippi) were tested for pyrethroid resistance in the spring and again in the fall. Adult bugs were exposed in glass vials (2 adults per vial) treated with a discriminating dose of 15 ug of permethrin for a 3-h period after which mortality was determined. Susceptible populations (mortalities >90%) were about the same in number in the spring in all three years (30, 32, and 29 locations in 1995, 1996, and 1997, respectively). In the fall of each year resistance increased, and only 11, 7, and 21 of the test populations were susceptible in the fall of 1995, 1996, and 1997, respectively. These results showed that pyrethroid resistance was widespread in the Delta, and that pyrethroid use during the cotton growing season increased resistance in populations as measured in the fall of each year. The decrease in resistance found each year in the spring was due to resistance being recessive and the production of 3-4 generations of plant bugs on wild hosts out of cotton during September-November and April-May of the following year.

A large plot field test designed to evaluate treatment thresholds (as recommended by the Mississippi Cooperative Extension Service) for the control of plant bugs in cotton, was conducted on a growers farm near Indianola, MS. Plant bug numbers found in the test during June and July were too low to properly evaluate the test.

Although virgin female tarnished plant bugs have been used as bait to attract males to traps in several studies, no research has been performed that measures trap capture in traps baited with different numbers of females. During this summer we compared the response of plant bugs to sticky traps baited with 1, 5, or 10 virgin females. Traps baited with 10 females captured significantly higher numbers of plant bugs than check traps or traps baited with 1 or 5 females. Traps baited with five females captured significantly more bugs than check traps, and traps baited with 1 female captured higher mean numbers than the check although the difference was not significant. These results demonstrate that increasing the amount of pheromone (number of females) increases trap capture. This information will be useful if a synthetic female pheromone for use in traps is ever developed.

An area-wide management program with *Helicoverpa zea* nucleopolyhedrovirus (HzSNPV) has been conducted in the Delta since 1990 to control the first generation of bollworm and tobacco budworm in geranium before movement to cotton can occur in the later generations. A study was conducted with HzSNPV to evaluate a lower virus application rate. A circular study area encompassing approximately 40,500 ha was treated in early May with virus to coincide with the larval emergence of bollworms and tobacco budworms. Adult emergence, moth numbers, and virus persistence were monitored to assess the impact of the virus. Adult emergence was reduced significantly (82.7%) in naturally-infested enclosure cages treated with the virus. Pheromone trap data suggested that total moth emergence was reduced 47% when compared with moth emergence in untreated areas. Wild geranium treated with the virus retained >50% of the original activity 3 days after virus application.

Insect virus formulation is an area of considerable interest because viruses can lose residual virus activity due to ultraviolet inactivation or host plant inactivation. Dr. Michael McGuire's research unit (Plant Polymer Research, NCAUR, USDA/ARS, Peoria, IL) has recently developed adjuvants containing starch or lignin as additives to spray formulations that may increase virus persistence. Our collaborative research with Dr. McGuire evaluated field persistence of AcMNPV on cotton using lignin and starch formulations. Inactivation of AcMNPV on cotton foliage was delayed using lignin formulations that extended virus activity to >40% of the original remaining activity (OAR) at two days post application.

Preliminary protocols for moth rearing, diet concentrations, and genetic crosses have been evaluated since June 1997. Based on this work, discriminating doses of *B.t.* toxins will be in place for next season's analyses of field populations of *Heliothis virescens* and *Helicoverpa zea*. Further strategies to improve the percentage of successful single-pair matings will be tested before next year's populations of moths are tested. In addition, the lab was equipped for both moth rearing and genetic analyses. **(USDA, ARS, Southern Insect Management Research Unit, Stoneville, MS)**

<u>Missouri</u>

A study to determine the impact of warm-season, native, perennial, grass strips (utilized to minimize wind erosion and sandblasting of cotton seedlings) on cotton arthropod populations was completed in 1997. Insect diversity was generally greater in cotton plots with vegetative strips, and this greater diversity was most apparent early in the growing season. Ants, ground beetles, and tiger beetles were beneficial insects closely associated with these strips. Ant populations were greater in plots with vegetative strips, and ants present were were more abundant closest to the strips. Tiger beetles were also more prevalent closer to the grass strips. Thrips populations were greater in plots with rye strips as compared to the other treatments; however, throughout this study, thrips and other pest populations did not cause significantly more injury in cotton plots with vegetative strips than in those without strips. No significant differences in yield were observed among treatments.

Both experimental and registered cotton insecticides were evaluated in four field trials. These tests included: at-planting and early-season, foliar treatments for thrips management, control of plant bugs and impact on beneficial insects, and bollworm control. Two additional, large-plot tests were conducted to evaluate boll weevil control and the economic viability of *Bacillus thuringiensis*-transgenic cotton. **(University of Missouri, Agricultural Experiment Station, Delta Center, Portageville, Missouri)**

<u>New Mexico</u>

The successful overwintering of boll weevil in the Pecos and Mesilla valleys was the driving force behind the initiation of a number of boll weevil research projects. The influence of habitat on overwintering success was examined. Based on the first year's results, urban habitats are expected to be the most significant source of successful overwintering boll weevils. Tests are in place to evaluate overwintering survival under New Mexico conditions and emergence profiles of various cohorts.

Field tests were also conducted to evaluate the activity of new insecticides including Confirm and Tracer on non-target arthropods. Insectovac samplers were used to collect samples in field plots, prior to and post treatment. Results are being analyzed, but both Confirm and Tracer clearly have less impact on beneficial insects than the synthetic pyrethroid standards.

Effects on expression of resistance in *B.t.* cotton were also investigated. Differences in resistance were noted among varieties, with lower mortality in beet armyworm feeding on DP90B compared to DP33B. Plant nitrate levels were found to have some effect on the level of beet armyworm resistance. Neonate diet consistently influenced mortality of beet armyworm feeding on *B.t.* cotton with often low to no mortality in beet armyworms fed artificial diet as neonates. Beet armyworm was, overall, less sensitive than expected. Only first instar beet armyworms were consistently susceptible to *B.t.* cotton.

The expression of resistance to pink bollworm in *B.t.* cotton under stress was also evaluated. Three irrigation regimes were tested: normal, drought levels and excess moisture. In all three treatments, there was no reduction in pink bollworm mortality with approximately 50% infested bolls in the recurrent parent, and 0% infested bolls in the *B.t.* cotton.

The effect of *B.t.* cotton on beneficials was evaluated by collecting Insectovac samples from strip trials of *B.t.* cultivars and recurrent parents. Samples are being analyzed. Early squaring information was collected from a number of varieties of *B.t.* cotton to determine if we could select cultivars with early squaring in developing a *B.t.* trap crop for pink bollworm. The effect of plant spacing on early squaring of *B.t.* varieties was also tested. There was no increase in total number of early squares when plants were thinned to 3.0, 1.5, or 0.75 plants/row foot, although there were increases on a per plant basis.

Variety trials of *B.t.* varieties and their recurrent parents were planted at a number of locations in New Mexico. The data are not yet compiled, but it is expected to be a more accurate representation of performance compared to last year, which was exceptional.

The use of intercropping alfalfa and cotton to enhance populations of beneficial insect was also evaluated in one field trial with the objective of reducing pest populations in organic cotton. **(Cooperative Extension Service and Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Artesia and Las Cruces, NM)**

<u>North Carolina</u>

In a large-scale comparison of Bollgard vs. conventional (pyrethroid-protected) fields under producer conditions, 115 Bollgard (mostly NuCOTN 33B) fields were compared with 115 conventionally treated paired fields, either managed by the same producer and/or in close proximity. This 'acid test' of the efficacy of *B.t.* (Bollgard) cotton has now been undertaken for two years, 1996 and 1997. Of 115 producer-managed Bollgard fields surveyed for boll damage in 1997, the Bollgard fields sustained approximately one fourth as much damage from bollworms: 0.97% percent versus 3.75% boll damage in the conventional fields. Stink bug damage in the conventional cotton fields averaged 0.53% vs. 2.23% in the Bollgard fields. European corn borer (ECB) and fall armyworm damage in the Bollgard fields were 3% and 38% of the boll damage found, respectively, in the conventional fields. Across the state in 1997, conventional and Bollgard cotton fields were treated approximately 1.99 and 0.48 times, respectively, (in most cases for bollworms- very few treatments on Bollgard cotton were used for other pests, such as stink bugs or plant bugs). Overall damage for both protection systems, including stink bugs, favored the Bollgard fields, 4.49% vs. 5.57% over the conventionally-protected fields. This is in keeping with last year's survey of conventional and Bollgard fields. Economically, the overall 1996-1997 average cost of insect control in Bollgard cotton, including the $32.00/acre technology fee was $39.32 vs. $23.13 for conventional cotton. This translates into Bollgard being approximately a break even proposition, insect control-wise, for producers who treated more than an average of 3.5 times for caterpillars in 1996-1997 (not including our limited early season applications for thrips, etc., which would be the same for either Bollgard or conventional cotton).

A survey of North Carolina's licensed independent crop consultants working on cotton was conducted again 1997 to gather data on how second generation (June and early July) tobacco budworm populations, aphids, thrips cotton aphids and Bollgard cotton were being and managed by these individuals. An extremely low (0.5 % of the 298,000 acres managed by consultants) amount was treated for budworms, all with pyrethroids. They collectively reported over 50% of their managed acreage was in need of supplemental foliar control for thrips, 3.2% for plant bugs, and 2.6% for the cotton aphid, all several-fold higher than in recent years. Of their clients' Bollgard acreage, 54% was untreated, 44% treated once and 2% treated three times.

Two early-season tobacco budworm management tests were conducted in 1997 to evaluate pyrethroid alternatives and the effect of early fruit and terminal loss on cotton maturity and yield in southern North Carolina. The fruit loss test confirmed the compensatory ability of cotton plants to overcome high June fruit and terminal losses. In four years, no numerical or statistically significant difference has been uncovered between 50% square and terminal loss, pyrethroid- protected, or untreated plots.

Three at-planting insecticide screening test for thrips control were conducted in Halifax, Union and Edgecombe counties with our 1997 conditions of prolonged cool wet weather and lengthy, often high thrips levels, Temik stood out as the clear material of choice.

Three *B.t.* transgenic cotton tests were evaluated in 1997 which addressed 1) bollworm thresholds, 2) the efficacy of various *B.t.* and Roundup Ready combinations, and 3) the efficacy of various insecticides on sting bugs and caterpillar species in *B.t.* cotton. The threshold test continued to suggest that a response to very low bollworm populations and even certain levels of bollworm eggs can result in yield responses of up to a hundred or more pounds of lint per acre. The addition of the Roundup Ready gene to the Bollgard gene has resulted in no quality, maturity or yield penalties. Very low bollworm and stink bug pressure (only 8% damage in the *B.t.* check, and an average of 1.5% damage averaged over the various treatments) precluded any chemical separation. However, the pyrethroid-protected treatments still average approximately 100 lb. of lint per acre more than the untreated Bollgard. **(Cotton Extension IPM Project, Department of Entomology, North Carolina State University, Raleigh, NC)**

Oklahoma

Several Bollgard trials were conducted in 1997 to determine the value of this technology under Oklahoma conditions. Bollgard cotton provided excellent bollworm control, produced exceptional yields in 1997, and out-yielded standard cotton varieties, regardless of the spray regime. Planting intentions in 1998 should favor Bollgard varieties as producers attempt to reduce the number of over-the-top applications to preserve beneficial insects important in regulating secondary pests, i.e., cotton aphids.

Research in 1996 and 1997 indicates that planting date is critical in areas heavily infested with boll weevils, regardless of management scheme. May-planted cotton outperformed June-planted cotton treated the same by at least 164.5 lbs lint per acre. Two overwintering insecticide applications for boll weevils produced the most lint with the least inputs compared to in-season and full season (overwintering sprays plus in-season) control. **(Oklahoma Cooperative Extension Service, Altus, OK)**

South Carolina

A field study was conducted to determine the effectiveness of pyrethroid applications based on bollworm (*Helicoverpa zea*) egg and larval treatment thresholds in *B.t.* cotton and to assess the impact of prior applications of insecticides on beneficial arthropod populations and the subsequent impact on bollworm and fall armyworm (*Spodoptera frugiperda*) populations and damage. Applications of acephate to NuCOTN 33B prior to bollworm oviposition in July reduced populations of beneficial arthropods, resulting in increased survival of bollworm and fall armyworm larvae and increased damage to bolls. Egg thresholds appeared superior to larval thresholds, reducing damage to bolls. Yields, however, were not affected by thresholds.

A study was initiated to determine the combined effects of double cropping, conservation tillage, and rotation on population dynamics and management of arthropods in cotton in southeastern SC. Densities of adult thrips were significantly reduced in no-till plots compared with disked plots in cotton in the one-true-leaf stage of development but not in three-leaf-stage cotton. In three-leaf-stage cotton which had received no insecticide treatment for thrips, densities of immature thrips were reduced significantly in no-till plots compared with disked plots, and in no-till cotton following rye compared with no-till monocropped cotton. Neither surface tillage nor double cropping significantly affected densities or damage for lepidopterous pests.

Larvicidal rates of DPX-MP062 1.25SC, TD 2344-02 0.83EC, TD2344-02 + Penncap-M 2F, FCR 4545 1EC, Karate 2CS, Karate 1CS, and Decis Gel 1L were compared with Baythroid 2EC, Karate 1EC, and Decis 1.5EC for mid-season control of bollworms/tobacco budworms (*Heliothis virescens*). All treatments were relatively effective against a heavy infestation comprised primarily of bollworms. DPX-MP062 was slightly less disruptive to beneficial arthropods than the other materials.

Selected rates of Tracer 4SC, Intrepid 80WP, and Proclaim 5SG were evaluated as foliar applications in cotton against a heavy infestation comprised primarily of bollworms. All treatments were relatively effective, but none were as effective as the pyrethroid standard, Karate. In a second test, Tracer, Intrepid, and Proclaim were less disruptive to beneficial arthropods than the carbamate Larvin and the pyrethroids Baythroid, Asana, Karate, Decis, Scout, and Fury; all treatments significantly increased yields compared with the untreated control. **(Clemson University Pee Dee Research and Education Center, Florence, SC)**

Tennessee

Early season thrips control was evaluated with Thimet insecticide at three rates (0, 0.75, 1.5 lb AI/acre) under two herbicide programs (Roundup Ultra vs. Prowl + Cotoran) using Roundup Ready cotton seed. At Memphis, there were no significant differences among treatments for thrips numbers, damage, bloom counts, plant height, stand, leaf area, node of first position square or yield. At Jackson, thrips numbers were affected by insecticide treatment on several of the dates. Main plot herbicides rarely affected thrips numbers. Plant heights were significantly shorter in standard herbicide plots compared to the Roundup Ultra plots. Bloom counts on two of three dates were lower in the standard herbicide plots. First harvest yields were reduced in the plots treated with standard herbicides.

Temik, Gaucho, and Admire (0.125 lb AI/acre) produced comparable numbers of early blooms and significantly more than a half rate of Admire. The half rate also had more thrips damage than the other treatments, less leaf area than plants treated with Temik, and a higher first position fruit node than other Admire treatment. Yields did not differ.

Gaucho, Temik and an in-furrow spray of Furadan + Di-Syston (0.5 + 0.75 lb AI/acre) produced similar results for thrips control, bloom count, plant height, and yield and were generally different from the untreated control.

Six early-season thrips control treatments did not differ from the untreated for control until 31 days after planting. Stand, leaf area, and node of first position square did not differ between treatments and the untreated control. Early bloom counts in Payload and Temik plots were higher than in the untreated plot. Other treatments did not differ from the untreated. Total bloom counts and first harvest yields did not differ among treatments and the untreated.

Gaucho, Temik, Payload, and an Orthene in-furrow spray were compared for thrips control, plant effects, and yield. Differences in thrips control were noted among treatments with Gaucho having generally more adults present. Thrips larval numbers were lower on the treated plots compared to the untreated until 35 days after planting when only Temik differed from the untreated. Thrips damage was lowest on the Orthene treatment, but all were different from the untreated. Plant height and node of first position square were not affected by treatment. Early bloom counts were higher in Orthene- and Payload-treated plots and total bloom count was highest in the Orthene-treated plot, but did not differ from the Payload or Temik treatment. First harvest yields were highest in the Orthene plot, but did not differ from Payload and Temik. All insecticide treatments differed from the untreated in first harvest yield. The same relationships existed for total yield.

Twelve early-season thrips control treatments, including Garlic Barrier, were evaluated for their effects on thrips numbers, plant effects and yield. The Garlic Barrier applied in-furrow and as several foliar sprays did not differ from the untreated control. Thrips control varied among the insecticide treatments. The addition of a Bidrin foliar spray to Gaucho seed treatment was not beneficial. Significant differences were noted among treatments for thrips damage, plant height, and node of first position square which was higher in Thimet plots and first bloom counts were lower. First harvest and total yields differed among treatments. All were different from the untreated and Garlic Barrier treatments.

Knack IGR treatments applied against a developing aphid population did not affect yield.

Ten foliar insecticide treatments were compared to Temik for thrips control and plant effects. Post-treatment counts indicated that the sprays reduced thrips larval numbers comparable to the untreated control, but plant heights were significantly higher in Temik plots 50 days after planting. First bloom counts, total bloom counts and yield in Temik-treated plots were significantly higher than foliar spray plots or the untreated plot. Foliar spray plots did not differ from the untreated.

Foliar sprays of Tracer and Orthene were compared to Temik for control of thrips, effect on bloom count and yield. Generally, Tracer did not differ from the Orthene treatment and both were less than the Temik treatment in yield.

Sixteen foliar treatments were evaluated for control of the tarnished plant bug. There were no significant differences in plant bug numbers or in yield compared to the untreated control.

Foliar treatments of Bidrin and Guthion were compared for control of the boll weevil. There were no differences in feeding or oviposition damage and yields were not affected by treatment.

Several *B.t.* cotton cultivars (DPL 20BG, DPL 50BG, PM 1215BG, PM 1220BG and STV BG4740) were compared to their recurrent parents for efficacy and yield performance. Bollworm and tobacco budworm pressure was very light and conventional varieties did not require insecticide treatment for these pests. Generally, the *B.t.* varieties out yielded the conventional varieties with the exception of the STV BG4740 which was planted with counter-seasonal seed produced in Africa in 1997. **(University of Tennessee, West Tennessee Experiment Station, Jackson, TN)**

Texas

Relay strip intercropping continued into a second year as a means to enhance predator numbers in cotton. Fall planted strip crops evaluated included wheat, canola, and vetch. Spring evaluated strip crops evaluated included canola, forage and grain sorghum. Attractants such as sugar + wheast were also evaluated as a means to attract and hold predators in cotton. A Cotton Incorporated study is underway to investigate factors that influence late aphid buildup and associated sticky cotton problems. Studies continue to investigate planting date, row spacing and plant density as a boll weevil cultural management strategy. Studies also continue to investigate cold-hardiness and diapause termination in overwintering boll weevils and to evaluate Dr. El-Zik's MAR cotton lines for insect resistance. **(TAEX, Vernon. TX)**

A study was conducted in and around a 64-ha dryland cotton production area near Caldwell, Texas, to investigate the effect of prevailing wind direction on the angular distribution of the daily capture of boll weevils. Sixty-seven pheromone traps were deployed around the perimeter of cotton fields, in concentric rings at a 2- and 4-mile range, and at a 5-, 6-, 7-, 8- and 9-mile range along a northeast line from the approximate center of the dryland cotton production area. Traps were assigned to eight sectors that were centered on north and at 45-degree intervals. The non-uniform distribution of mean capture of boll weevils by sector was significant using analysis of variance (df = 7, F = 19.13, $P<0.0001$). Logistic regression established a significant positive relationship between the daily relative frequency of wind heading and the proportion of daily mean capture by sector ($P^2 = 26.19$, $P<0.05$). The results of this study should lead to improved strategies for monitoring and management of boll weevils that are moving from cotton into overwintering habitats.

Field studies were conducted to determine the migratory flight activity of the bollworm at several locations in south-central Texas, emphasizing identification of flying organisms. One study was conducted to monitor the relative activity of long-distance and local flight of bollworms from senescent field corn in the Brazos Valley. Pupae were excavated to determine bollworm infestation levels in corn fields, and re-buried to determine the cycle of adult emergence. A scanning entomological radar measured concentrations of airborne organisms at 11 different elevation scans every 15 minutes on successive nights of the bollworm emergence cycle. A tracking entomological radar measured trajectories of individual targets on several nights during the bollworm emergence cycle. A second study was conducted to confirm the identity of insects migrating to the Winter Garden area, perhaps from the Lower Rio Grande Valley. Three hot-air balloon flights were undertaken during pre-dawn hours on successive dates in June. The hot-air balloon towed a bollworm pheromone trap and a blacklight trap, and an infrared-illuminated, intensified videographic system was carried on board. No insects were captured during approximately six hours of flight, but several bats and bollworm-size moths were observed at approximately 700 m above ground level using a one-million candle-power quartz beam spotlight. A third study was conducted to confirm the identity of insects migrating from the Winter Garden area during peak emergence of bollworms. An 8-square-meter parafoil kite towed a blacklight trap and 1-square-meter insect net to approximately 500 m above ground level. No bollworms were captured, but one green lacewing was captured in the insect net during 10 hours of sampling.

Over 5,000 adult boll weevils captured from March 1996 through January 1997 in Mississippi were analyzed for pollen to determine pollen feeding and alternative foraging resources. Boll weevils were chemically treated to dissolve the insect body but not the pollen. Overall, 301 pollen types were encountered in the boll weevil residue. Pollen from 81 families, 132 genera, and 28 species was identified from the samples. More Fabaceae (bean family) pollen types were found in spring and summer than any other family. In fall and winter, Asteraceae (sunflower family) pollen occurred most frequently. More spring boll weevils (96%) foraged on pollen than those captured in other seasons. Fewer boll weevils foraged on pollen (61%) in winter. Fall boll weevils foraged on the greatest diversity of pollen and winter boll weevils foraged on the least. Mississippi boll weevils forage on a wide variety of pollen throughout the year, except in winter when alternative foraging resources are limited.

Three sex pheromone traps each for bollworm and tobacco budworm operated at the same locations for 14 years in a cotton-growing area in the Brazos River Valley were operated in 1997. Compared to the 1996 pattern of captures when bollworm was a major problem on *B.t.* cotton in the area, 1997 captures were generally lower overall and the major difference was the absence of sustained high captures during June and July. Mean numbers of bollworm moths captured per trap per night were greater than 100 only seven times in 1997 compared to 20 times in 1996 during the June and July period. A peak of about 150 moths per trap per night was observed in August in 1996 that was not observed in 1997. Late season (September and early October) captures were higher in 1996 than in 1997. Tobacco budworm captures were higher early in the season (May and June) in 1997 than in 1996. In July, captures were similar in timing and magnitude both years. Late season captures of tobacco budworms were consistently higher in 1997 than in 1996.

Beet armyworm adult activity was monitored with sex pheromone traps in 1997 as in 1996 in a Brazos River Valley cotton growing area. Captures from February through August were considerably lower in 1997 than 1996. A dramatic increase in captures observed in mid-February in 1996 was not observed in 1997. Mean numbers of male beet armyworms captured per trap per night exceeded five only once (early April) from January until late June 1997. Between early July and mid-August, captures increased gradually from less than five per trap per night to about 17. Starting about August 20, captures increased to a peak of close to 100 per trap per night and continued to be greater than 20 males per night until cooler temperatures were observed in November.

Sex pheromone lures from IPM Technologies, Inc. (Portland, OR) were compared to Hercon® lures (Hercon Environmental Co. Emigsville, PA) for trapping beet armyworms. IPM technologies lures were equal in efficacy to the Hercon lures and also had consistently higher captures for a longer period of time than the Hercon lures.

A green collapsible nylon mesh trap developed by Australian scientists for sex pheromone trapping of *Heliothis/Helicoverpa* was compared to a Texas wire cone trap and a Scentry mesh trap for bollworm and tobacco budworm. For both species, the Australian trap captured similar numbers to those captured with the Scentry trap and significantly less than the Texas wire cone trap.

Considerable progress was made in laboratory and field evaluation of insecticides mixed with a feeding stimulant and used alone or in conjunction with a feeding attractant for inducing feeding and toxicity to adult bollworms in corn and cotton. Some commercially-available insecticides have been identified that show considerable potential for use in adult bollworm control using feeding attractants/stimulants and will be evaluated in larger scale tests in 1998.

Results of field experiments indicated that the recently developed portable keep-it-simple sampler (KISS), constructed by modifying a conventional engine-driven leaf blower, is a reliable device for sampling early-season boll weevil populations in cotton. The numbers of feral weevils collected in prebloom cotton with the KISS and a tractor-mounted pressure/vacuum sampler (TMS) both followed field population trends even though the KISS collected only about 50% as many weevils as did the TMS. Man times required per sample were comparable for the KISS and the TMS, and the man times for both of these methods were about one-tenth that required for whole-plant hand sampling. The greater portability and lower equipment costs of the KISS, in comparison to the TMS, should make it the preferred method in many sampling applications.

Volatile chemicals have been identified from three plant species attractive to cotton fleahopper. A total of 26 chemicals were identified from croton, 33 from horsemint, and 15 from ragweed. These chemicals have been identified from headspace volatiles and extracts of freshly collected plant material. Not all of the chemicals have been available in quantities sufficient for bioassays, but mixtures of available identified chemicals were tested for activity in olfactometers with variable response. Headspace volatiles collected from the three species have been consistently attractive in the olfactometer. Work is continuing on obtaining additional chemicals for testing in the olfactometer.

A season-long commercial scale application and efficacy study was conducted to determine the most effective aerial application methods for Tracer, compared to EC producer-standard formulations. Spray coverage, canopy deposition at top and mid canopy, droplet size, and field and laboratory bioassay efficacy on Heliothis virescens / Helicoverpa zea were performance criteria. Spray rates of 2 and 5 gpa and droplet sizes of 200 and 400 μm, DV0.5, were used for both Tracer and the producer standard formulations. The eight-treatment – three-replication study was conducted on 200 acres of cotton in Burleson county, Texas. Spray deposits were sampled with water-sensitive paper and with fluorometric dye tracer washed from cotton leaves. Whole plant assays for eggs and larval instars were conducted in all plots on 3-4 a day sampling schedule. Laboratory bioassays of leaf samples were conducted on the day of treatment and three days post-treatment. Sub-plots of ¾ acre were harvested for yield and lint turnout. The 5 gpa – 200 μm treatment gave the highest top and mid-canopy droplet densities, the best efficacy, and trended to higher yields for Tracer. Spray coverage was lower with Tracer than the producer standard formulations, but there was no difference in simulated active ingredient (fluorescent dye) deposits between Tracer and the producer standard formulations. The 5 gpa – 200 μm Tracer treatment gave greater mortality on H. virescens larvae at 24 hours after application in the laboratory bioassay and lower larval numbers 3-4 days after application, than the producer standard treatments. Cotton yields trended higher for the 2 gpa – 200 μm treatment with the producer standard formulation applications.

Aerial electrostatic sprays of malathion were compared to ULV malathion applications for control of boll weevil in early, mid, and late season cotton canopies. Studies in 1996 indicated that spray mixes of malathion for the electrostatic applications were not charging adequately for optimum effectiveness. Electrostatic sprays at 1 gpa with malathion and Primeoil II at 1 and 2 pints per acre charged satisfactorily in pre-season laboratory studies. Five treatments, including the two electrostatically charged sprays noted above, plus the same 1 gpa sprays uncharged, plus the TBWEF standard boom and ULV malathion were used in the study. Spray mixes for all treatments contained 12 oz/acre of ULV malathion. Field deposition measured with water and oil sensitive cards, laboratory bioassays, and field counts with KISS and tractor blower samplers did not reveal significant differences between the five treatments used in the study. **(USDA, ARS, Southern Crops Research Laboratory, College Station, TX)**

A moldboard plow system with either a rotary mower plus a stalk puller or a flail shredder plus a stalk puller were compared as to effectiveness in controlling regrowth cotton and in reducing weed (especially volunteer cotton) and boll weevil populations. The use of a cotton stalk puller is a quick and efficient way to destroy cotton stalks and leave boll weevil pupae and larvae and cotton seed within the top 2 cm of the soil surface where soil temperatures can reach 54 C or more. High soil temperature combined with dry conditions can desiccate immature boll weevils and reduce the germination and establishment of volunteer cotton. Plowing the cotton stalk residue places the boll weevil larvae and pupae in a dark, generally moist environment which may be conducive for overwintering in south Texas and northeastern Mexico. Using a flail shredder and stalk puller reduced crop destruction and subsequent field preparation for planting costs about $98/ha. The stalk puller can be operated at 8-10 mph at a cost of about $5/ha and 15 to 20 acres can be pulled per hour depending on equipment width and ground speed. The moldboard plow costs about $30/ha to operate and only 3-4 acres can be plowed per hour. Using the stalk puller reduced fall seedling cotton populations in 2 of 4 years when compared with the moldboard plow system, increased timeliness of cotton plant termination and decreased costs of stalk destruction and subsequent land preparation for the following crop.

The relative tolerance of *Catolaccus grandis* strains to selected insecticides and selection of strains with resistance to insecticides were evaluated. Of the ten insecticides evaluated in concentration-mortality studies on *C. grandis* females reared in vivo, endosulfan, azinphosmethyl, and fipronil were the least toxic; malathion and cyfluthrin were moderately toxic; and methyl parathion was 440 times more toxic than endosulfan (the least toxic insecticide). The LC_{50} for methyl parathion was in the nanogram range. Therefore, in a field situation this insecticide would theoretically be exceptionally detrimental to *C. grandis* releases. Future plans call for exposing C. grandis to residues of formulated insecticides using a spray chamber bioassay. Testing of the same insecticides on *C. grandis* females reared in vitro has revealed no major differences in toxicity compared with the data on females reared in vivo, although not all chemicals have been evaluated to date. Testing was begun on *C. grandis* (i.e. the Sinaloa strain) recently collected from cotton. Two parental lines of *C. grandis* reared in vivo have received selection pressure with azinphos methyl in preparation for continued selection in an attempt to produce an insecticide resistant strain. There appears to be considerable heterogencity of response to insecticide selection pressure, lending promise to the goal of producing a strain resistant to organophosphorus and carbamate insecticides. Selection with Ops usually imparts AchE resistance of Ops and carbamates.

Ten insecticides were tested for toxicity to four species of predatory insects using a spray chamber residual bioassay on cotton. Adult insidious flower bugs, *Orius insidiosus*, big-eyed bug, *Geocoris punctipes*, convergent lady beetle, *Hippodamia convergens*, and green lacewing, *Chrysoperla carnea*, were tested. Formulated insecticides tested were Tracer, Pirate, Regent, Guthion, Baythroid, Vydate, Phaser, Provado, Curacron, and Malathion (ULV). Residual tests showed that Orius, Tracer, Guthion, and Provado were least toxic and malathion and Curacron were most toxic. For Geocoris, Baythroid, Tracer, Vydate, Phaser, Curacron, Guthion, and Provado produced no or little toxicity, and Regent was most toxic. For Hippodamia, Vydate, Tracer, Regent and Pirate caused less than 10% mortality, and Baythroid, Guthion, and malathion were highly toxic. For Chrysoperla, most insecticides were highly toxic with the exception of Baythroid and Tracer.

Continued trapping studies sin northeastern Mexico suggest interchange of boll weevils among cotton production regions of northern Mexico and southern Texas is probable. More than 60,000 overwintering boll weevils were removed from a 4,000-acre mass trapping area, with distinct differences in trap captures among trapping habitat types. Results should facilitate improvements in efficiency and cost effectiveness of future mass trapping efforts. Preliminary results of studies to define early-season colonization patterns of overwintering boll weevils do not indicate a strong colonization pattern in either adult collections or presence of infested fruit, and do not suggest the use of edge treatments in future eradication efforts. Cooperative studies with the University of Texas/Pan American demonstrated the presence in adult boll weevils of a glutathion-s-transferase that is unusual in substrate specificity relative to that in other studied insects. Boll weevil diapause induction studies showed the boll weevil in the subtropics does not enter reproductive dormancy in response to photoperiod and temperature, and identified feeding regime as the primary dormancy inducing factor. These results are consistent with known patterns of weevil movement in response to host phenology, can be used to explain the many contradictions in the past 38 years of boll weevil diapause research, and suggest potential for improvement in the timing of diapause treatments by eradication programs. Investigation of the mechanisms of bait stick activity failed to indicate advantages of the bait stick over traps for boll weevil population suppression. Bait sticks coated with adhesive captured about twice as many weevils as did coated traps, and detrimental effects of competition from bait sticks on trap captures were not demonstrated. However, observations of behavioral and mortality responses of weevils attracted to the bait stick indicated a very low level of efficacy. Population responses of secondary pests, including cotton aphid, beet armyworm, silverleaf whitefly, spider mites, and thrips, to applications of ULV malathion were demonstrated in experimental plots. A higher survivorship of beet armyworm cohorts in malathion treated plots (~10%) than in untreated plots (<1%) was attributed to a substantially higher level of natural enemy activity within the untreated plots. New, more efficient boll weevil pheromone trap designs were evaluated, and assay techniques and a carrier were devised for evaluation of boll weevil control using photoactive dyes. **(USDA, ARS, Subtropical Agricultural Research Laboratory, Weslaco, TX)**

Virginia

COTMAN Insecticide Termination Study results showed that additional sprays at NAWF=5 +200, +350 and +500 DD 60's did not improve the level of insect control, boll damage or lint yield compared with the standard 2-spray system (the first at egg threshold and a second in 5-7 days). In bollworm insecticide/spray schedule tests, standard and high rates of Baythroid and Karate were applied in different rate combinations and using different spray schedules. Bollworm pressure was light with only 7% boll damage in the untreated plots. Single high-rate treatments of both materials performed as well as double sprays, except for the 10-day interval spray with Baythroid which resulted in 4% damage. All other treatments resulted in 2% or less boll damage and higher yields than the untreated control. In other trials, all recommended pyrethroids, Larvin, Tracer and two experimental compounds successfully controlled bollworm and limited boll damage to 3% or less compared with 20% in the untreated control. In thrips trials, a single postemergence foliar spray of Orthene 75S @ 3.0 oz/acre banded over the row at first true leaf stage improved thrips control, number of open bolls and lint yield for most in-furrow applied insecticides tested. In other thrips trials, results showed that in the absence of stress by wind/sand burn, all treatments (including Temik 15G, Gaucho 480, Di-Syston 15G, Payload 15G, and Thimet 20G) resulted in significant leels of thrips control, more open bolls, and increased yield compared with untreated controls.

Additions to Insecticides/Miticides Registered for Cotton Pest Control

New products registered for use against cotton pests are listed in Table 1 by the reporting state.

Changes in State Recommendations for Arthropod Pest Control in Cotton

Additions and deletions of recommended pesticides by state extension organizations for the 1997 crop year are listed in Table 2. Included also are changes in thresholds or indications for certain pests.

Insecticides/Miticides Screened in Field Tests

Pesticides (experimental materials or pesticides not labeled/recommended for use yet on certain pests) tested by state and federal researchers during the 1997 crop year for control of arthropod pests of cotton are listed in Table 3 by the reporting state.

Table 1. New products registered for use against cotton arthropod pests in 1997.

State	Pesticide (lbs AI/A)	Target Pest
Alabama	None reported	
Arizona	No new products registered other than Tracer	
California	Section 18 for: Knack Applaud Alert Savey	
Georgia	None reported	
Louisiana	Tracer 4SC	Lepidopteran control
Mississippi	None reported	
Missouri	None	
New Mexico	None reported	
North Carolina	Tracer Danitol	Cotton pests Cotton pests
South Carolina	Tracer Confirm (Sec 18) Pirate (Sec 18)	Lepidopteran pests Beet armyworm Beet armyworm
Tennessee	None reported	
Texas	Tracer	Bollworm, Tobacco budworm, beet armyworm
	Confirm (Section 18) Pirate (Section 18) Furadan 4F (24c--revoked)	Beet armyworm Beet armyworm Aphids
Virginia	None reported	

Table 2. Changes in state recommendations for treatment for arthropod pests of cotton for 1997.

State	Pesticide	Target Pest
Alabama	None reported	
Arizona		
Additions	Tracer (0.067-0.089)	Beet armyworm
	Tracer (0.045-0.089)	Bollworm/ budworm
	Tracer (0.067-0.089)	Fall armyworm
	Tracer (0.067-0.089)	Soybean looper
	Provado (0.025-0.047)	Cotton aphid
	Provado (0.047)	Plant Bugs/ Fleahoppers
	Dimilin (0.06-0.125)	Fall armyworm
	Vydate (0.125-0.25)	Plant bugs/ Fleahoppers
	Gaucho (seed treatment)	Thrips
	Pyrethroids (labelled rates)	Stink bugs
Deletions	Larvin	Soybean looper
	Larvin + Ovasyn	Soybean looper
	Larvin + *B.t.*	Soybean looper
Arkansas		
Additions	Provado (lower 2 oz/acre)	Aphids
	Monitor (foliar spray)	Thrips
Changes	Section 18 will be persued in 1998 for:	
	Furadan	Aphids
	Pirate	Tobacco budworm
	Confirm	Tobacco budworm
California		
Changes	Section 18:	
	Knack at label rates	Silverleaf whitefly
	Applaud at label rates	Silverleaf whitefly
	Savy at label rates	Spider mites
	Alert at label rates	Spider mites
Georgia		
Additions	Tracer 4	Beet armyworm Bollworm Tobacco budworm Fall armyworm Soybean looper
	Decis 1.5	Stink bugs
	Fury 1.5	Stink bugs
	Gaucho 480	Thrips
	Capture 2	Silverleaf whitefly
	Danitol 2.4	Silverleaf whitefly
	endosulfan 3	Silverleaf whitefly
	Provado 1.6	Silverleaf whitefly
	Orthene 90	Silverleaf whitefly
	Ovasyn 1.5	Silverleaf whitefly
Louisiana	No significant changes	
Mississippi	None reported	

Table 2 Cont.

State	Pesticide	Target Pest
Missouri		
Additions	Lannate LV 2.4E	Bollworms
	Methyl parathrion 4E	Plant bugs
	Methyl parathion 4E + Thiodan	Aphid, bollweevils
	Monitor 4	Aphid, whiteflies
	Encapsulated formulations of methyl parathion (Penncap-M 2E)	Boll weevils
	Ovasyn 1.5E (as an ovicide)	Bollworms
Deletions	Bolstar 6E	Plant bugs
	Thimet (seed treatment)	Thrips
Changes	None	
New Mexico	None reported	
N. Carolina	Tracer (0.045)	June budworms
	Tracer (0.067-0.089)	Bollworms Beet armyworms Fall armyworms
	Danitol (10.7-16 fl oz) [2(ee) registration]	Spider mites
S. Carolina		
Additions	Condor	Bollworm
	Biocot XLP	Bollworm
	Tracer	Bollworm
Tennessee	None reported	
Texas		
Deletions	Methyl parathion (0.17-0.25)	Aphids
	Parathion (0.25-0.37)	Aphids
	Dimethoate (0.11-0.25)	Aphids
Virginia		
Additions	Baythroid 2EC (0.8-1.6)	Thrips
	Danitol 2.4EC (10.6-16)	Spider mites
	Decis 1.5EC (1.62-2.56)	Bollworm/ budworm
	Provado 1.6F (2.0-3.75)	Aphids
Deletions	Thimet 15G	All uses

Table 3. Promising pesticides screened in 1997 for control of cotton arthropod pests.

State/Pesticide (lbs AI/A)	Target Pest(s)
Alabama	None reported
Arizona	
Intrepid (0.35)	bollworm,
Intrepid+Larvin (0.25 + 0.25)	tobacco budworm,
Proclaim (0.075 and 0.01)	fall armyworm
Pirate (0.25 and 0.35)	
Pirate + Curacron (0.25 + 0.5)	
F-1002 (Uniroyal) (0.125 and 0.25)	
F-1904 (Uniroyal) (0.125 and 0.25)	
TD2344-02 (Alf Atochem) (0.025 and 0.03)	
Arkansas	
DPX-MP062	Bollworm/budworm
	Loopers
FCR 4545	Thrips
	Boll weevils
Mk-936 (abamectin) mK-244	Bollworm/budworm
	Beet armyworms
Exp80667A	Thrips, Aphids, Boll
Exp61096A	weevils
Intrepid 80W	Thrips, plant bugs
Naturalis-L	Bollworm/budworm
	Boll weevils, aphids,
	bollworm, cabbage looper,
	Lygus, stink bug, whitefly,
	tobacco budworm, leaf
LS184	perforator
Knack	Thrips
	Thrips
California	
S-1283 3.0FL (1.3-1.9 oz)	Spider mites
CM-006 (20 and 40 oz with and without oil)	Spider mites
CM-007 (20 and 40 oz with and without oil)	Spider mites
EXP80667A (0.0125, 0.025, 0.038)	Cotton aphid
EXP61096A (0.2)	Cotton aphid
Mycotrol (1 qt/A)	Cotton aphid, Lygus
Knack 0.86EC (0.054)	Cotton aphid
EXP61096A (0.05, 0.1)	Lygus bugs
Applaud 70WP (8 oz.)	Cotton aphid
Furadan 4F (0.25)	cotton aphid
Aphistar (0.375, 0.5)	Cotton aphid
BAS 700 75WP (0.2, 0.3)	Cotton aphid
S-1283 3.0FL (0.045)	Cotton aphid
TD-2344 .83EC (0.04)	Cotton aphid
CGA 215944 50 WP (0.094)	Cotton aphid
Knack (8 fl oz)	Silverleaf whitefly
Applaud 70 WP (.5)	Silverleaf whitefly
Applaud 70WP + Phaser (.5 + .2 pts)	Silverleaf whitefly
Hexythiazox (Savey) (.06, .09, .12)	Spider mites
Hexythiazox + dicofol (.06 + .84)	Spider mites
Alert (.2)	Spider mites
Louisiana	None evaluated

Table 3. Continued

Stage/Pesticide (lbs AI/A)	Target Pest(s)
Missouri	
Decis	Bollworms
Tracer 4SC (0.07)	Bollworms
CGA-215944 50WP (0.089)	Plant bugs
EXP 61096A 0.83E (0.05, 0.1)	Plant bugs
Provado 1.6F (0.025, 0.047)	Plant bugs
RH-2485 80WP (0.35)	Plant bugs
Regent 2.5E (0.05)	Plant bugs
Baythroid 2E (0.5)	Thrips
Decis 1.5E (0.025, 0.03)	Thrips
Gaucho 480 seed trt (8 oz/cwt)	Thrips
EXP 61096A 0.83E (0.05, 0.1)	Thrips
ICIA0321 2CS (0.025)	Thrips
Regent 2.5E (0.025)	Thrips
New Mexico	None reported
North Carolina	None
Oklahoma	
Decis	Bollworm
Tracer	Bollworm
Ovasyn	Cotton aphid
FCR-4545	Bollworm/boll weevil
Exp61096a	Boll weevil/cotton fleahopper
Mp6022	Bollworm
Regent	Boll weevil
Karate 2.09 EC	Bollworm/boll weevil
Karate 1.0 CS	Bollworm/boll weevil
Carbofuran 4.0 CS	Cotton aphid
Tennessee	
Admire 2F (.0625-.125)	Thrips
Garlic Barrier (3.2-6.4 oz)	Thrips
RP EXP 61096 .83EC (.05-.1)	Thrips
Regent 2.5EC (0.25-.038)	Thrips
Elf TD 2344 1E (.02)	Thrips
Tracer 4SC (.022-.089)	Thrips
MP 062 1.25SC (.055-.11)	Plant bugs
Regent 2.5EC (.038-.05)	Plant bugs
RP EXP 61096 .83EC (.05-.1)	Plant bugs

Table 3 Cont.

State/Pesticide (lbs AI/A)	Target Pest(s)
Texas	Tobacco budworm
Pirate 3SC (0.35)	Tobacco budworm
Steward 1.25SC (DPX-	Tobacco budworm
MP062) (0.09)	Tobacco budworm
Condor XL (16 oz)	Tobacco budworm
Mattch (48 oz)	Tobacco budworm
Xentari AS (48 oz)	Tobacco budworm
Lepinox WDG (16 oz)	Bollworm
Intrepid 80W (0.022)	Bollworm
Tracer 4SC (0.015-0.063)	Bollworm
Condor XL (16 oz)	Bollworm
Mattch (48 oz)	Bollworm
Xentari AS (48 oz)	Bollworm
Lepinox WDG (16 oz)	
Steward 1.25SC (DPX-	Bollworm
MP062)	Bollworm
(0.055-0.11)	Bollworm
Intrepid 80W (0.022-0.35)	Bollworm
Proclaim 5SG (0.0075-0.01)	Bollworm
Pirate 3SC (0.28)	Pink bollworm
Karate 2.09CS (0.039)	Pink bollworm
Karate 2CS (0.039)	Pink bollworm
Confirm 2F (0.125)	Aphids
Tracer 4SC (0.0625)	Aphids
Decis 1.5E (0.025)	Aphids
Fulfill 50WP (0.094)	Aphids
CGA293343 (0.022-0.046)	Aphids
Furadan 4F (0.5)	Aphids
Aphistar 50W (0.06)	Aphids
Regent 2.5EC (0.05)	Cotton fleahopper
Provado 1.6F (0.025-0.047)	Cotton fleahopper
Provado 1.6F (0.023)	Cotton fleahopper
Provado 1.6F (0.023)	Cotton fleahopper
Regent 2.5EC (0.025-0.05)	Plant bug
RP61096 0.83EC (0.05-0.1)	
Fulfill 50 WP (0.187)	Plant bug
Steward 1.25SC (DPX-	Plant bug
MP062)	Thrips
(0.055-0.11)	Thrips
Regent 2.5EC (0.025-0.05)	Thrips
RP61096 0.83EC (0.05-0.1)	
Gaucho 40 seed trt (8 oz/cwt)	
Regent 2.5EC (0.025-0.05)	
RP61096 0.83EC (0.05-0.1)	
Virginia	None reported