53RD ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

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Foreword

There were 14,855,000 acres of U.S. Cotton (Upland and Pima) planted in 1999, 13,381,000acres were harvested with an average of 596pounds of lint per acre (USDA - January, 2000 report).

Arthropod pests of cotton reduced yield by 7.66% in 1999. Cotton fleahopper, exhibiting extremely heavy damage to cotton in Texas, became the top pest of 1999 with 2.36% loss to the US cotton crop. Boll weevil is still a pest on 57% of our US acreage and continues to be the second most damaging pest at 2.20% loss. The bollworm/budworm complex reduced yields by 1.05%. The bollworm was the predominant species to attack cotton in 1999. Bollworms were estimated to make up 71% of the population. *Lygus* (0.93%), Stink Bugs (0.37%), Thrips (0.27%), and aphids(0.22%) rounded out the top seven cotton insect pests for the year. Beltwide, direct insect management costs amounted to $50.59 per acre and losses were $42.75. Cost plus loss is estimated at $1.269 billion. (see M. R. Williams, this proceedings).

Crop and Arthropod Pest Conditions

Alabama

The 1999 cotton production season in Alabama could best be described overall as one of widely fluctuating weather extremes and very light insect pressure. The 1998-99 winter season was mild and dry, with the drought extending to about mid-May. Excessive rainfall occurred from mid-May to mid-July. No further rainfall occurred until mid-September. Therefore, the lack of moisture was a dominant factor during the blooming and boll set period of the season. Adequate rainfall then occurred during the harvest season, and many fields greened back up. Harvest season began in late August in the Tennessee Valley area of North Alabama and continued through November along the Gulf Coast. Statewide yields will be in the neighborhood of 500 lbs lint/A and the quality is below normal.

Overall, insect populations were light. Thrips were very heavy, especially in the dry early spring. The late May-June rainfall freshened up wild host plants along field borders, resulting in a large movement of adult plant bugs into cotton about mid-June. This movement corresponded to the time that many fields were just beginning to square and also overlapped with a 7 to 10 day period of frequent rainfall, cloudy weather and water-logged soils. Hence square set was near zero for about 10 days at which time cotton was in the 7 to 10 node stage. Aphids built slower than normal and crashed later due to the natural fungus, *Neozygites fresenii*. Few aphid controls were applied. Subthreshold numbers of bollworms (BW) and tobacco budworms (TBW) occurred during June and July. Conventional varieties did incur some level of damage during this period but it was difficult to know when to make an insecticide application. The only significant population increase of BW and TBW occurred after August 15 at which time growers and consultants had been lulled to sleep. Not a single field statewide had economic levels of fall or beet armyworms. However, soybean loopers occurred at heavy levels (40 or more/6 row feet) in scattered fields in south and central Alabama in late August and early September. Only Tracer at the 2 oz./A and higher gave acceptable control. The southern armyworm was common in low insecticide input fields in south Alabama in late season. A few fields were treated in 1999 where excessive foliage and some fruit loss occurred. Overall, 1999 will go down as one of the lightest worm years on record. Stink bugs were found in fields as early as June. However, populations did not increase during the season with the exception of cotton fields in the peanut area of southeastern Alabama. In areas where both cotton and peanuts are grown, excessive numbers of stink bugs and damage were noted as the top bolls began to open in late September and October. It is suspected that peanut maturity and harvesting may be causing a movement of stink bugs from peanut to cotton fields. Many cotton fields in Alabama were not treated with insecticides all season in 1999. **(Central and South Alabama)**

In North Alabama, April-planted cotton got off to a good start, but a heavy rain on May 6 caused some problems for the later planted crop. Thrips populations were generally normal, but some problems developed in late May. The problems were associated with cotton old enough (5-6 leaves) to normally be thought of as A thrips free@. Cool temperatures apparently retarded plant growth and the aforementioned rain had dissipated much of the aldicarb applied at planting. Plant bugs were somewhat above average and required widespread treatments in June and again in July. Cotton aphid populations increased noticeably in late June and early July, but never exploded. Few aphid controls were applied and populations crashed in mid July due to infection

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from the fungus, *Neozygites fresenii*. Aphid populations were dramatically higher in reduced tillage fields due to Atending@ by fire ants. Moisture was more than ample and temperatures were optimum into July, and by the middle of that month a record-breaking crop seemed almost a certainty. Beginning in mid-July, temperatures were reaching the high 90's each day and rainfall ceased. Heat stress devastated the crop and the ensuing drought finished it off. Some budworms and bollworms were encountered in late-July and early-August, but the young larvae had great difficulty in becoming established on the stressed crop. Few insecticide applications were made for caterpillar pests. Two-spotted spider mites became widespread in August but were ignored. Bandedwinged whiteflies threatened to build in late season, but populations fizzled. Armyworms and loopers were virtually absent throughout the year. Final yields will be somewhat less than 500 lbs, lint/A and quality was substandard. **(North Alabama)**

Arkansas

Crop growing conditions were excellent in the early season and continued until mid-July. Cotton plants responded by setting a high percentage of squares. After mid-July conditions changed to hot and dry and remained that way the rest of the season. Dryland cotton stressed pretty severely and shed much of the fruit that had been set. Pivot-irrigated fields also stressed as growers found it difficult to put enough water on them.Row irrigated fields shuddered with the high fruit loads and heat. They did shed fruit, but fruit sheds were generally not severe if growers pumped enough water. The crop matured quickly statewide. Regrowth problems were minor in most cases.

The first diapause applications in the Boll Weevil Eradication Program for the Southeast part of the state went smoothly. Communications problems between the program people and growers, consultants and agents were the most significant problems.

Statewide, about 16% of the crop was Bt cotton and about 7.8% was Roundup Ready. About 50% of the acreage in Southeast Arkansas was Bt cotton. About 940,000 acres of cotton were planted in the state. Yields were estimated at 665 lbs/acre, with near 1 bale yields in the Northeast and near 900 lbs yields in the Southeast. Bt cotton yields were generally 100-150 lbs below non-Bt cotton yields. High mike and short staple problems occurred in some of the crop.

Thrips pressure was especially strong this spring. Untreated cotton and cotton which relied on foliar sprays was damaged. The good soil moisture conditions allowed the in-furrow and seed treatment materials to be picked up by plants, and they worked well.

Boll weevil pressure was heavy as indicated in April and May by traps, but pinhead square treatments and suicidal emergence apparently caused high mortality, and boll weevils were not especially bad in most areas until the crop was almost made (late July and early August).

Plant bug pressure was generally spotty and light. The ample rainfall until mid-July apparently held the plant bugs in the alternate weed hosts through early squaring. Plant bug populations were present but lower than normal during most of the year. Little square loss caused by plant bugs was seen.

Tobacco budworm made its traditional low level appearance in June and then virtually disappeared for the rest of the season.

Bollworm was present in most fields in July at low to moderate levels in Southeast. Most non-Bt and many Bt fields were sprayed. Bollworm pressure was moderately heavy in a few localized spots, but was generally light. North East Arkansas had low levels of bollworm activity, and many fields never received a worm application.

Aphids came on early in many areas (after the first week of June). The pathogenic fungus, *Neozygites fresenii*, began showing up ahead of schedule the 3rd week of June. Many fields were treated. Bidrin and provado were most commonly used, and control was generally good.

Spider mites arrived in June in the Northeast and July in the Southeast. Most fields has observable mite damage on the leaves by the last week of July. Mite populations intensified and caused serious losses in 4 counties in Northeast Arkansas but caused little damage in Southeast Arkansas. Except in Northeast Arkansas, few treatments were made, but in some areas of Northeast Arkansas, up to 3 applications were made with some growers spending in excess of $30/acre. Currently labeled products gave less than adequate control.

Bandedwinged whiteflies came on strong in August in many areas of the state but did little damage. Very few treatments were applied to control them.

Soybean loopers, cabbage loopers and salt marsh caterpillars built up to high levels in September and early October in Southeast Arkansas. They defoliated group 5 & 6 soybeans but did little harm to cotton.

California

There were 821,080 acres of cotton planted in 1999. Pima acreage continues to increase and accounted for 32% of the acreage planted. Acala occupied 52% of the planted acres and other upland varieties accounted for 16%. Cool temperatures dominated the early production season, but dry weather prevented diseases from creating widespread stand losses. Temperatures were cooler through the duration of 1999, especially at night. Fruit retention was excellent throughout the fruiting cycle, but the season was delayed. September and October provided an open fall in which the crop matured. Upland yield is estimated at 1240 lbs/A, while Pima yield estimates are 1110 lbs/A.

Insect pressure was the lightest in five years. Dry spring conditions reduced the available *Lygus* habitat resulting in it not being a factor in 1999, except in very limited locations. Spider mites were not a major factor. Beet armyworms were a localized problem in western Fresno and Kings Counties. Silverleaf whitefly populations were low through the critical portions of the season, but populations did build during fall in Kern and Tulane Counties.

Florida

Fields planted in late April and early May generally had enough soil moisture to establish a stand. However, dry conditions during May delayed crop emergence until June in other fields. Growing conditions were hot and dry throughout the season which resulted in rapid crop development with reduced yields in many early planted fields. Fiber staple was short from many of these early maturing fields.

Thrips populations were at below average to normal levels. Granular insecticides were used on most fields at planting and provided adequate control. *Lygus* bug populations were low all season throughout the area, and only 6% of the acreage received an application for *Lygus*. Early season square set was generally high. Heavy aphid infestations developed in most fields during late June and early July. The beneficial fungus disease, *Neozygites* spp., began reducing populations the second week of July. The fungus was slow to develop due to dry conditions. Low levels of aphids persisted for the remainder of the season but did not result in yield or quality losses.

Beneficials were at high levels all season where insecticides were not used. They developed on the early aphid population and helped provide control of worm pests. Fire ants were abundant all season in fields grown under strip-tillage. (Approximately 50% of the fields were grown using this method of conservation tillage.) Bollworm and tobacco budworm populations were extremely low all season and did not cause problems in either conventional or Bt cotton. Conventional varieties averaged less than one application for these pests. Many fields did not require treatment. Both beet and fall armyworm infestations were very low all season. Few, if any, fields required treatment for these pests.

Southern armyworms were found in scattered fields throughout the area during mid-season. Feeding was confined mainly to leaves and blooms with no economic injury observed. Approximately 200 acres were treated once with organophosphates or pyrethroids. Stink bugs were present in low to moderate numbers through mid season. Populations increased to damaging levels in many fields following migration from corn in August and peanuts in September. Highest infestations occurred in field borders adjacent to peanuts. Approximately 70% of fields received an application for stink bugs.

Overall, this was the lightest cotton pest year with the fewest number of insecticide applications in at least 23 seasons. State yields are expected to average 520 lbs lint/acre.

Georgia

The winter and early spring months preceding planting were generally dry. Needed moisture was available for emergence, but droughty conditions persisted in May and early June. Thrips problems were higher than normal during early season due to high populations which were compounded by limited soil moisture to allow uptake of preventive insecticides. As a result more acres than normal received foliar treatment for early season thrips.

Much needed rainfall was received during June and early July. However, drought, high temperatures and humidity during late July and August devastated a once promising crop. Severe stress during bloom and boll maturation severely affected yields. Plant bug populations were generally light with only isolated infestations reported. Aphid populations built to high numbers earlier than normal, but soon populations crashed due to a fungal epizootic.

Tobacco budworm and corn earworm populations were very low when the state was considered as a whole, but high numbers were observed in isolated areas. Control of tobacco budworm with pyrethroids proved to be difficult in some areas, and resistance was suspected. Bt cotton provided excellent control of tobacco budworm and good control of corn earworm. Only a limited acreage of Bt cotton required treatment for corn earworm. Beet armyworm and fall armyworm populations were also very low. Southern armyworm infestations were common in South Georgia, primarily in fields which had not been treated with insecticide, and a limited number of fields required treatment. Soybean loopers infested some fields late in the season, but few fields required treatment.

Stink bug populations were moderate during July and early August but increased significantly during late August and September. Due to low populations of caterpillar pests, mid-season insecticide applications, especially pyrethroids, were not widespread. In the absence of broad spectrum sprays stink bugs were not suppressed as in years past which led to an increase in acres needing treatment for stink bugs.

High populations of silverleaf whitefly were observed in a five-county area near Tifton. Premature defoliation occurred in fields which were heavily infested. The area where infestations were worst includes intense vegetable production and greenhouses.

Infestations of boll weevils were detected in two areas. One hundred-eighteen boll weevils were captured in Hart County and more than 3,000 were captured in the Crisp County area. Boll Weevil Eradication personnel reacted quickly and effectively to these reinfestations, intensifying trapping and initiating insecticide applications to prevent its spread.

Overall, Georgia will harvest a below average crop of about 530 lbs lint/acre on 1,450,000 acres.

Louisiana

Dry conditions during early April resulted in most of the crop being planted during the last week of April and the first two weeks of May. Below average yields are expected in 1999 due to hot, dry environmental conditions during June and July. Louisiana planted approximately 608,000 acres of cotton with an average state yield expected to be slightly over 700 lbs lint/acre.

Insect pest populations were extremely low during 1999. Consequently, insect control costs were extremely low in 1999. Reports across the state indicate that insect control costs were as much as one-half of the normal insect control costs. This was unusual considering that most insect pest (thrips, bollworm and tobacco budworm) populations were high during spring.

Early-season insect populations were high in many areas of the state. Thrips populations were heavy in most areas of the state. Fields without in-furrow insecticides required as many as four foliar insecticide applications for thrips control.

Overwintered boll weevil populations were moderate in Northeast Louisiana. Most fields received at least one pinhead square application for overwintered boll weevil control. Populations were light until late-July/early-August when boll weevil populations reached high levels in many fields. Boll weevil eradication was initiated in Northeast Louisiana on August 2 with mist blowers spraying all field borders. Aerial applications for boll weevil eradication were initiated on August 9.

The Red River Boll Weevil Eradication Program completed the third year of the program. Boll weevil populations in the Red River zone were extremely low during 1999. Very few insecticide applications, for any insect pest, were made during 1999, further supporting the success of the program. Indications are that cotton acreage in the Red River zone will increase by 50% in 2000.

Tarnished plant bug populations almost non-existent early-season and only moderate late-season long. Few fields were treated prior to bloom for tarnished plant bug populations. Populations near field corn were high in many cases. However, this phenomenon did not extend much more than 200 ft from the edge of the corn fields.

Bollworm populations were light during most of the season. Most non-Bt cotton fields required 1 to 3 insecticide applications for bollworm control, while most Bt-cotton fields received none to two. Resistance monitoring of bollworm populations indicated little change in susceptibility to pyrethroid insecticides.

Tobacco budworm populations were generally light during 1999, with heavy infestations developing in some pockets of the state. Pyrethroid resistance levels in May and June were the highest ever observed. Pyrethroid resistance is such that pyrethroids are no longer an effective control means for tobacco budworms.

Bt-cotton was planted on approximately 64% of the state acreage (predominately D&PL 33B). Approximately 85% of the Bt-cotton acreage was treated for bollworm.

Mississippi

Mississippi cotton producers planted approximately 1.16 million acres of cotton in 1999, which represented a substantial increase over the 930,000 acres planted in 1998. Approximately 65% of this acreage was planted to transgenic Bt varieties, which also represents an increase over 1998. Overall insect pressure experienced during 1999 was extremely low, and yield losses attributed to insects were lower than in any year since 1991.

By August of 1999 all cotton growing areas of the state were involved in some phase of boll weevil eradication. The Hill Region of the state, approximately 443,000 acres, began eradication efforts in the fall of 1997, and thus was in the third season of eradication. The South Delta Region, approximately 189,000 acres, began eradication efforts in the fall of 1998, and a boll weevil eradication program was initiated the first week of August on the approximately 530,000 acres of cotton grown in the North Delta Region. ULV malathion, applied at a rate of 10 fl. ozs. per acre, is the treatment used in Mississippi's boll weevil eradication programs, and fields in the Hill Region, South Delta, and North Delta received an average of 8.0, 8.0, and 8.7 applications of ULV Malathion, respectively, this season. The 8.0 treatments in the Hill region were considerably higher than normal for an area in the third year of eradication, but because winters have been unusually mild since boll weevil eradication began in this region, this high number of treatments was not unexpected.

Boll weevil populations were extremely low in the Hill Region in 1999, and there were no measurable yield losses to boll weevils in this region. However, low numbers of boll weevils were detected in pheromone traps around most fields in this region, and trap captures were sufficient to trigger treatment to approximately 40 to 60% of total acreage in the region each week. Although the South Delta Region was only in the second year of boll weevil eradication efforts, the percent of acreage treated each week was similar to that of the Hill Region, and the average number of weevils trapped per acre per week was lower than that of the Hill Region, 0.11 vs 0.22. Thus it appears that, despite a series of unusually mild winters which favored survival of overwintering weevils, excellent progress has been made toward eradicating the boll weevil in both of these regions.

Although high pheromone trap captures from the previous fall, combined with a mild winter, suggested that boll weevil populations would be unusually high in the North Delta Region during the early portion 1999, this was not the case. North Delta producers applied relatively few treatments for boll weevils during June and July of 1999. The fall diapause phase of the boll weevil eradication program began on August 2 and ran smoothly until terminated by frost. Initially treatments were applied at 5 day intervals, but treatment intervals were increased to 7, 10, and 14 days as the crop progressed and temperatures declined. This fall diapause program appears to have been very effective and it is anticipated that overwintered boll weevil populations will be relatively low in this region in 2000.

The 1999 cotton crop was planted on schedule under conditions that were generally favorable. Thrips populations were unusually heavy during 1999 due to windy conditions that favored heavy migration from alternate hosts. This situation was exacerbated somewhat by the fact that acephate treated seed were not available in 1999. However, thrips populations were heavy enough in some areas that many fields that had received an in-furrow systemic insecticide at planting were also treated with a supplemental foliar treatment.

Fortunately, thrips were one of the few insect pests that were more abundant than usual, and populations of most other pests were unusually low. Populations of overwintering and first generation tobacco budworms were higher than normal in some areas of the state, and many fields of non-Bt cotton experienced substantial pre-bloom infestations of tobacco budworm. However, following this June generation, tobacco budworm populations were unusually low in non-Bt cotton in most regions of the state for the remainder of the season. Bollworm populations were also unusually low throughout the state during 1999. This is partially attributed to a reduction in corn acreage, from the 515,000 acres grown in 1998 to approximately 320,000 acres in 1999.

Results of an end of season survey of 93 fields documented that Heliothine populations were much lower than normal. Non-Bt fields averaged 2.47 treatments for control of budworm/bollworm in 1999, compared to an average of 5.2 sprays in a similar survey conducted in 1998. Bt fields also averaged fewer bollworm sprays per field than in 1998, 0.44 vs. 1.22, and only 34.5 % of Bt fields received a supplemental treatment to control bollworms in 1999, compared to 79% in 1998. This survey also found that the percent of worm damaged bolls was lower in 1999 than in 1998 in both Bt (1.48% vs. 2.55%) and non-Bt cotton (3.44% vs.4.81%).

Because the early years of boll weevil eradication programs are considered high risk years for beet armyworm outbreaks, Mississippi sought and obtained conditional approval of Section 18 Emergency Exemptions to allow the use of Pirate (chlorfenapyr), Confirm (tebufenozide), and Denim (emamectin benzoate). Fortunately, beet armyworms were extremely uncommon in 1999 and there was relatively little need to use these products. This low incidence of beet armyworms was especially noteworthy because the area of the state where beet armyworm problems are normally most common, the South Delta, was involved in the second season of boll weevil eradication.

Fall armyworms were relatively uncommon and few treatments were required specifically to control fall armyworms. However, low populations of fall armyworms were present in many fields, and some boll damage was sustained to this pest. As in recent past years, yellowstriped armyworms were observed to be somewhat more common than normal, especially in fields of Bt-cotton, but these seldom occurred at damaging levels. Southern armyworms were also observed to be much more common than normal, and many scouts and consultants had their first experience in identifying this caterpillar, but treatments were rarely required. A few fields, including some fields of Bt-cotton, were treated for loopers during late August, but overall looper populations were relatively low.

Although tarnished plant bugs were present at low levels in most fields, and many Delta fields received treatments to control plant bugs, overall population levels were considered to be low to moderate, and seasonal yield losses to this pest were below average. Coincidental control of tarnished plant bug by applications of ULV malathion applied as part of boll weevil eradication efforts is a primary reason for the low plant bug pressure experienced during 1999. However, there were some fields in the Hill Region that experienced unusually heavy infestations of tarnished plant bugs. Invariably, these were fields that did not require early season boll weevil eradication treatments. This experience suggests that producers in the Hill Region will need to be more concerned about tarnished plant bug infestations as this area becomes weevil free.

Aphids were abundant enough in the Delta portion of the state that most fields received at least one aphicide treatment. Furadan, which was available for use under a Section 18 Emergency Exemption, was the most commonly used aphicide. Only about 15% of fields in the Hill portion of the state were treated for aphids, and populations crashed in both areas in early to mid-July due to an epizootic of the *Neozygites fresenii* fungal disease. As in 1998, flaring of aphid infestations was especially evident in the region of the state which was involved in the second season of boll weevil eradication.

Flaring of bandedwinged whitefly infestations by boll weevil eradication efforts was also observed again in 1999. Fortunately,overall whitefly populations were less severe than in 1998 and were more easily controlled. Silverleaf whitefly was again detected in an isolated cotton production area located in the extreme southeastern portion of the state where cotton is grown in close proximity to a number of commercial ornamental plant nurseries. Spidermites were somewhat more common than usual and a number of fields required treatment for this pest, especially in the Delta portion of the state.

The 1999 season was unusually dry and many areas of the state, especially the northeast portion, suffered lower yields as a result. However, a warm dry fall facilitated efficient, early harvest and statewide yields were estimated at approximately 708 lbs of lint/acre (November 1 yield estimate), which is slightly below the past 5-year average yield of 777 lbs/acre. Although this yield is only slightly below average, prices paid for the 1999 crop were well below normal, and this combination of low prices and reduced yield resulted in a disappointing year for many producers.

In summarizing the 1999 insect season, it can be characterized as a year of unusually low cotton insect pressure. Yield losses attributed to insects in Mississippi were estimated to be approximately 3.9%, which compares to the 8.4% yield loss estimated for 1998, and is lower than for any year since 1991. Despite low insect pressure, costs of insect control remained relatively high and were estimated to be $84 per acre in the Hill Region and $99 per acre in the Delta, giving a weighted average cost for the state of approximately $94 per acre. These continued high costs, despite low insect pressure are attributed to the fixed costs of insect management inputs such as: boll weevil eradication fees, Bt-cotton technology use fees, at planting insecticide costs, and scouting fees.

Missouri

In 1999, Missouri cotton growers planted .375,000 acres of cotton. Early-season planting weather was abnormally cool and wet. Weather-induced seedling mortality and delayed growth were above normal for Missouri. Several thousand acres of cotton required replanting or fields were converted to other crops. Thereafter, weather conditions were very favorable until early-July and high (>85%) fruit retention was observed in many fields. A drought episode started around the 4th of July holiday and continued until mid-September. Harvest conditions were excellent in 1999, and the Missouri crop matured .2 weeks earlier than normal. Due to the extended drought period, yields were .19% lower than the previous 5-year average for Missouri.

Overall, pest pressure in Missouri was moderate in 1999. Thrips populations were the highest on record, and persistent infestations frequently required one to two foliar insecticide applications. Weather was a major factor in slowing and prolonging seedling exposure to thrips feeding damage and decreasing the plants uptake of soil- and seed-applied insecticide treatments. Cutworm outbreaks were widely sporadic but intense in some areas. A combination of cool weather conditions and delayed destruction of winter cover vegetation increased seedling exposure to cutworm damage. Spring pheromone trap captures of overwintering boll weevils were down by .26% in 1999 compared to 1998. This was likely due to a combination of cold, wet weather during December and January that increased overwintering mortality, and delayed crop growth in the spring that intensified suicidal weevil emergence.

Aphid populations steadily increased until July when infections of the aphid fungus, *Neozygites* sp., rapidly reduced aphid infestations. Spider mite outbreaks were localized in several areas with some fields prematurely defoliated. Plant bug infestations were light in most areas. Bollworm infestations that required insecticide treatment(s) were largely limited to one generation. Late-season egg lays did not result in subsequent larval outbreaks. Tobacco budworms and beet armyworms were rarely collected in 1999. European corn borers became established once adjacent corn fields matured, but populations generally were sub-threshold.

In summary, cutworm and thrips infestations were high in 1999. Aphid, bollworm, boll weevil, and spider mite infestations were moderate with localized hot spots. Armyworm, plant bug, European corn borer, and tobacco budworm infestations were light to absent in Missouri.

New Mexico

The most significant news for 1999 was related to boll weevil and the status of eradication programs. Passage of boll weevil eradication programs has been difficult in New Mexico since those with 67% of the total acreage must vote in favor of the program. Effectively, both a high rate of returns and over 80% votes in favor are necessary for passage. Although most votes have had a majority in favor, the lack of sufficient acreage has resulted in a number of referenda failures in the past few years. This year a referendum was requested by the Pecos Valley Farmers and failed. A referendum in Lea County, the second in 2 years, also failed in early 1999. However, a second referendum requested by Pecos Valley Farmers in late 1999 passed with 95% of those voting in favor of a control district. Many farmers in Lea County (borders Texas) voluntarily joined the Texas boll weevil eradication program. The Mesilla Valley in south-central New Mexico and Luna County completed their second year of eradication programs. In December, Curry and Roosevelt Counties growers called meetings to discuss possible referendums for control districts in those counties.

Boll weevil caused significant economic losses in the eastern half of the state, which did not have eradication programs in place. For example, in 1998 the Pecos Valley Farmers were able to suppress boll weevil populations with a voluntary program. However, there was little control in the fall of 1998. In 1999, damage by boll weevil in south Eddy County in the Pecos Valley was extreme. Producers made 4-8 applications for boll weevil alone and still had approximately 20% yield losses. Yields in south Eddy County averaged 1.4 bales/A. Those who did not protect the crop from boll weevil picked 0-0.75 bales/A. In the adjacent county where boll weevil populations were lower, average yields were 1.8 bales/A.

Overall growing conditions in 1999 were at least average in most locations. Some early hail losses, particularly in the Pecos Valley, were reported. Rainfall in April, May and June was much higher than average, particularly in the desert valleys which only average 10-12 inches per year.

Apart from boll weevil, insect pressure was extremely light. Bollworm is the most consistent pest in New Mexico, but pressure was very light. There were no reports of beet armyworm, and pink bollworm pressure was much lighter than usual. There was only one report of stinkbugs. In eradication zones there were some infestations of aphids and whiteflies after multiple applications but little economic impact.

Acreage of Bt cotton increased in 1999. Approximately 50% of the upland cotton in the desert valleys were Bt varieties despite the lack of a Bt variety with the locally adapted Acala 1517 germplasm.

Acreage in southern New Mexico was down with only 31,000 acres in the Mesilla and Pecos Valleys. However, as in Texas, the range of the Cotton Belt in New Mexico is moving north with increased acreage in Roosevelt, Curry and Quay Counties. Boll weevil has been detected in those counties and growers are presently organizing to request a referendum for an eradication program.

North Carolina

Cotton was planted on just over 860,000 acres in 1999. Perhaps as much as 80,000 acres could not be harvested, primarily due to the effects of three hurricanes, Dennis, Floyd and Irene, which visited the Coastal Plain and the tidewater/blacklands sections of the state. Some farms were subjected to 30 to 40 inches of rainfall within 30 days, with numerous cotton fields within the flood plains of rivers (and some outside of this area) flooded, some for over a week. Recent crop estimates put the statewide cotton yield loss at approximately 40% of the late-August estimates. Due to the above conditions, this year's cotton crop will be harvested very late on average. In a modest expansion, approximately 20,000 acres of ultra narrow row cotton were planted.

Thrips levels were high throughout most of the state, up from last year, with western flower thrips accounting for control difficulties at a few locations. Approximately 90% of NC cotton growers used an at-planting insecticide (including seed treatments) in 1999. Foliar treatments for thrips were applied to just under 60% of our cotton acreage, up from 22% in 1998 and also up from our long-term average of 25-30% treated acreage.

Second generation tobacco budworms were very low throughout the state. However, the subsequent generation managed to surface in a few instances along with bollworms in the late-July to early-August time period, complicating bollworm control. Approximately 0.86% of the state's cotton acreage was treated for these early budworms, significantly down from the 8.25% treated in 1998, but similar to the 0.5% in 1997. North Carolina cotton producers have averaged treating just less than 5% for early budworms for the past 6 years.

Aphids were again a widespread and persistent problem in 1999, as in 1998, although most populations were still essentially wiped out or reduced to low levels by natural causes, primarily by lady bird beetles, the mummifying wasp parasites, and the fungus. In 1999, 1.4% of the cotton acreage was treated for aphids, similar to 1998. Biocontrol remains the major means of consistently reducing or eliminating local populations of cotton aphids in North Carolina although a few fields were treated with foliar imidacloprid.

Plant bug levels were down sharply from the past two years, both in the early part of the season (pre-bloom) and later on Bollgard. Only 1.0% of the state's acreage was treated for pre-bloom plant bugs this past year, similar to our longer-term average of about 1.5%, but significantly down from 6.6% treated acres in 1998. Approximately 0.1% or our cotton producers reported treating their Bollgard cotton specifically for plant bugs.

Our major mid-July to early-August bollworm moth flight generation averaged about 1 week behind schedule, and flight intensity and egg deposition was significantly down from 1998. However, egg deposition down in the plants was very common, especially on stems and on dried blooms. Statewide damage to bolls by bollworms on conventional cotton, at 4.2%, was just over our 14-year average of 3.9%, despite the lower moth and egg pressure. The average number of treatments required for bollworms and other occasional late-season pests was 2.07, less than our 14-year average of 2.8 applications. Although budworms typically constituted 5% or less of the bollworm/budworm populations taken from various check plots, this species made up a significant proportion of the surviving post-treatment population in some areas. Bollworm establishment under bloom tags now appears an annual problem in both conventional and Bollgard cotton. Adult vial tests for bollworm resistance/tolerance to pyrethroids again revealed that some of these populations appear to be developing tolerance to pyrethroids, although survival at both 5 and 10 microgram levels on the average was lower than in 1998 (not unexpected with the lower treatment levels). However, one August eastern population had a corrected survival level of 33% at 5 micrograms, while a second September northeastern population had survival levels of 14%. These are the highest bollworm adult moth survivals to date in North Carolina.

Bollgard cotton was planted on approx. 20% of NC's cotton acreage in 1999, up from 13% the prior year. Bollgard cotton was treated an average of 0.69 times, a decrease from 1998 (1.24 times), but similar to 1996 and 1997. Mean boll damage to Bollgard cotton from bollworms was about half that found in conventional cotton (1.39% vs. 3.2%), although overall boll damage to Bollgard cotton, primarily due to stink bugs (3.18% in Bollgard vs. 0.69% in conventional cotton), was slightly higher this year (4.63% vs. 4.24%).

Fall armyworms did not account for much overall damage this year; European corn borers were very light across most of the state, continuing a trend begun in 1990.

A Section 18 Specific Exemption, granted for Pirate insecticide use on beet armyworms, was used on 6 cotton fields in 1999. Only 3 of those fields were treated with Pirate. A handful of other cotton fields were treated with Tracer for combinations of bollworms and beet armyworms. This marks the fourth time in 22 years (1977, 1995, 1998 and in 1999), though 3 in the past 5 years, in which beet armyworms have migrated into North Carolina and become established at damaging levels on cotton.

NC cotton acreage for 1999 was 860,982.21, and was grown in 57 counties. 181,959 pheromone traps were installed on 74,369 cotton fields. Trap installation began July 19, and trap removal was completed by November 28. The last trap checking cycle was delayed due to warm weather, late cotton harvest and contractors behind schedule due to hurricanes. Seventeen temporary employees were hired to assist with quality control and trapping. Six additional 4-wheel ATV's were purchased to help with trapping in infested acres.

Boll weevil captures: Edgecombe County -- 1 boll weevil 2/2/99; 1 boll weevil 7/19/99 from a soybean field; 1 boll weevil 7/21/99 from a different soybean field; 1 boll weevil 9/9/99. All weevils captured were from different fields. No fields were treated because no reproduction was evident. These fields had been trapped all winter, due to the previous year's infestation of approximately 2,300 weevils in this area. These traps were finally pulled in October. Contractor traps (around all cotton fields in the county) were left on fields through November. This area was completely destroyed by flooding, and 90% of the cotton was dead. All trapping was on borders only. NCDA & CS had approximately 2,640 traps on 121 fields; 2,006 acres were trapped.

Pitt County -- No boll weevils. These traps were pulled in October also. All traps were on borders only. NCDA & CS had approximately 285 traps on 17 fields; 114 acres trapped.

Union County (Morrisville) -- B 1 boll weevil 8/27/99. Two fields, totaling 200 acres were trapped. Approximately 700 traps were set, both in-field and border traps. Four-wheelers were used to check these traps. We will buy this cotton as soon as yield information comes from the cotton grower. In-field traps were pulled in November with border traps left. These two fields will be trapped all winter and spring.

One boll weevil was trapped 11/19/99 between Albemerle and Monroe. Nineteen fields, totaling approximately 400 acres were trapped. Approximately 330 traps were placed around field borders. Cotton in this area has been harvested with small grain planted subsequently in most of these fields. These fields will be trapped all winter and spring. **(North Carolina Department of Agriculture and Consumer Services)**

Oklahoma

A total of 225,000 acres were planted, but stormy weather and drought conditions reduced harvested acres to 165,000. Southwest Oklahoma producers continue to abandon cotton in favor of a less risky crop, e.g. sorghum and corn. Below average temperatures and cloudy weather in early July delayed square initiation, especially in June-planted fields in Northern Oklahoma. A normal weather pattern returned by late-July. A total of 2,563 heat units accumulated between May 10 and October 1, which is slightly less than the 40-year average but still sufficient to produce an above average crop. The state production average is projected at 475 lbs lint/acre.

Widespread use of at-planting insecticides and over-the-top sprays limited thrips infestations and damage. Cotton fleahoppers were the target of insecticide applications applied before bloom. OBWEO insecticide applications limited the establishment by overwintering weevils thereby preventing economically damaging populations across most of the state. Economically damaging infestations were limited to Harmon County in the extreme southwest corner of Oklahoma.

Light bollworm populations, coupled with the large increase in acres planted to Bollgard cotton, limited spraying in 1999. Conventional cotton received between 1 and 3 insecticide applications to prevent damage. June rains delayed beet armyworm infestations. Unlike 1998, no damaging beet armyworm infestations were reported in Oklahoma this year.

Cotton aphid infestations flared during July. By July 22, the entire state had been cleared for Furadan use to control resistant aphids. Heaviest infestations occurred in cotton intensely managed. Most of the spraying occurred in Harmon, Jackson, and Greer Counties in Southwest Oklahoma. Severe yield loss would have occurred if Furadan had not been available for use. This aphid buildup was short lived and did not reoccur in September with the startup of the OBWEO fall diapause program.

South Carolina

Cotton farmers planted about 340,000 acres of cotton in 1999, an increase of 17% over 1998. Early yield estimates were about 650 lbs, before farmers began to pick their crops. Yield expectations kept going down, as a result of a late season drought and high temperatures. Farmers generally found estimates based upon boll numbers were too optimistic. Many fields yielded 200-300 lbs less lint/acre than expected. When all cotton is harvested, the state average yield will probably be less than 500 lb/acre.

The drought in July and August appeared to affect the size of the bolls, as they appeared to be much smaller than usual. There was also a problem with seed rot within unopened bolls that could not be correlated with insect damage. When the affected bolls opened, most were tightlocked and could not be picked. Seed rot seemed to be more prevalent at the lower nodal positions; and at positions closest to the main stems. It appears that yield losses may exceed 200 lbs lint/acre in some of the worst fields. Research is currently underway to try and determine if one or more disease organisms were involved in the seed rot phenomenon.

Thrips numbers were generally moderate to high. There were reports of some problems with control by soil insecticides applied at planting which may have triggered applications of more foliar sprays for thrips control than usual. Tobacco thrips appeared to be the most prevalent species attacking cotton in the Pee Dee area of the state.

False chinch bug numbers were unusually high on seedling cotton in some minimum tillage fields. There were even a few fields sprayed, or at least spot-sprayed, for false chinch bugs when 50 or more were found per plant. Some seedling cotton plants were killed, but in most cases the damage did not affect yields. False chinch bugs were also found in large numbers in squaring cotton, but this is not uncommon and has never been considered an economic problem.

In June 1998 tobacco budworm infestations were the highest observed in South Carolina in over 15 years. In 1999, however, budworm populations were extremely low in most areas. The use of pyrethroids for early-season worm control was discouraged, and with the low budworm populations and shortages of conventional cotton in most areas, there were hardly any applications made to cotton in June. There was one control failure with pyrethroids in July in Sumter County, where 95% of the larvae collected in the field proved to be tobacco budworms. We were unable to rear out sufficient numbers of moths to test for resistance, but the field was close to a farm where pyrethroid-resistant budworms were found in 1998.

Bollworms infestations were quite slow in developing, and numbers were light to moderate for the most part. In the Florence area, it was near the end of July before any damaging infestations developed. Most Bt-cotton fields were not sprayed for bollworms, and it was not unusual to see conventional cotton fields that were never sprayed for bollworm control. Given the number of control failures with pyrethroids against bollworms that were observed in 1998, we were somewhat surprised by the scarcity of problems in 1999.

Both fall armyworm and beet armyworm infestations were minimal to nonexistent. Very few of these insects were observed in cotton. Aphid infestations were high in a few areas of the state, but light to moderate elsewhere. A few fields were sprayed for aphids, but most growers waited for the fungus and parasitic wasps to take care of their aphid problems. They were not disappointed, as the fungus arrived somewhat early on the scene, and aphid populations were quickly reduced in late-July and early-August. Tarnished plant bug numbers were present at higher levels than in previous years in the Savannah Valley. The practice of growing a large percentage of 96:4 Bt cotton in the area during the last few years has in effect provided a sizeable acreage of unsprayed refuge for plant bugs. Stink bugs were a statewide problem. There is little doubt that stink bug problems have been increasing as the acreage of Bt cotton has increased.

A survey of green bolls from most of the cotton producing counties showed that more damage had occurred than would have been predicted based upon observations of both stink bugs and damaged bolls in the field.

Three boll weevils were captured in Lexington County in August. Trap numbers were increased, but no further captures were made.

Tennessee

Tennessee planted 600,000 acres in 1999 which was a significant increase of 150,000 from 1998. Grain crop yields were short in 1998, so producers decided they would take their chances on cotton again. A relatively mild winter left little doubt that insects could be a problem and were. Lack of rain was not expected. Drought was the number one contributor to yield loss since there are very few acres under irrigation, especially cotton.

Ninety-eight percent of the acreage is planted in 19 West Tennessee counties. Conditions during late-April and early-May were normal for planting and resulted in the crop getting off to a good start. A few general rain showers in May and June followed by very isolated showers in some counties was the extent of the moisture supply. Rainfall at the West TN Exp. Station in Jackson (Madison County) was 5.95 inches below normal for late-July, August and September.

Thrips infestations were generally high across most of the state. The lack of standard Orthene seed treatment created problems for some producers. About 80% of the acreage received at-planting treatments with 20% relying on foliar sprays. Fourteen percent received a foliar spray in addition to the at-planting treatment. As many as three foliar sprays were reported on some acres.

The status of boll weevil in Tennessee falls into three categories: post, present, and pre-eradication. Seven middle Tennessee counties (14,800 acres) finished active eradication in 1998 and voted for a containment program to start in 1999. Twenty-two weevils were captured for the year around thirteen fields located in Lawrence and Giles Counties. These were all considered migratory or "hitch hiking" weevils. The seven, southern West Tennessee counties (150,000 acres - Zone 1) in the first full year of active eradication experienced minimal economic damage. Since Tennessee experienced a lack of winter mortality, overwintered weevil survival in the eradication area was comparable to other programs at this stage. Trap captures peaked twice: the first week of September at 2.7 and again the first week of October at 4.0 weevils/trap/week. Migration in early August, especially from outside the program area, contributed to the need for extra diapause sprays.

A total of 9.7 malathion applications were made for the season. Outside of eradication, weevil numbers were high. Peak emergence, based on pheromone traps, occurred the last week of May. The average number of weevils/trap/week was 74, with a range of 12 in Lake County to 147 in northern Haywood County. Multiple pinhead applications were recommended. Overwintered weevils were still being caught in early-July. Some producers reported square damage even after making three applications. Over all, pinhead applications were very effective in reducing the overwintered population. By late-July and early-August, economic infestations were wide spread. The remaining 12 counties which grow cotton in West Tennessee are scheduled to begin the eradication program starting in August of 2000.

Tarnished plant bugs were abundant on alternate hosts early. As adults moved into squaring cotton, pinhead square applications for boll weevil helped control plant bugs as well. Outside the eradication area, producers were advised to use recommended insecticides which were effective on both insects. Within the eradication area, some producers were depending totally on malathion sprays to control plant bugs. Two problems developed. First, plant bugs moved into some fields before eradication sprays started at match-head size squares. Second, migration of adults between eradication sprays created the need for some additional applications. Some producers made applications between eradication sprays while others did not.

Prebloom infestations of primarily tobacco budworm (TBW) were above normal and at treatable levels in the southern counties. Non-pyrethroid chemistry gave good control on conventional varieties while Bt varieties performed well. Boll weevil eradication, a history of TBW and continued pyrethroid resistance all contributed to the five most southern counties (Shelby, Fayette, Hardeman, McNairy, and Hardin) planting about 90% of the acreage to Bt varieties. Overall, Tennessee planted approximately 65% to Bt varieties. This was a significant increase from the 15% in 1998.

July produced a mixed population of bollworm/budworm. Again, southern counties experienced a higher ratio of TBW (60-80%) while northern counties saw higher bollworm numbers (75-90%) which was normal. Mixtures of non-pyrethroid materials gave mixed results primarily when targeted against larger larvae or in clean up situations.

August populations were 60-90% bollworm across all West Tennessee counties which caused concern with Bt acreage. Ninety-seven percent of the acreage was exposed to bollworm with approximately 24% receiving one application.

Bollworm pyrethroid resistance monitoring was started this season as part of the Beltwide program. Moths were tested using the standard glass vials treated with a 5ug and 10ug cypermethrin dose. Two locations in the northern counties of Gibson and Lake produced 0-14% and 3-14% survival respectively at the 5μg dose during August. Only 2% survived a 10μg dose in one sample in Lake county. The highest survival was from moths captured within 2-3 miles of a frequent pyrethroid spray schedule used in a commercial vegetable area. Since bollworm is the predominant species in this area, any indication of resistance is of concern.

Aphids exploded in late June and early-July. This was somewhat expected within the active eradication zone but also occurred outside the zone. Thrips sprays and multiple early overwintered weevil applications contributed to a lack of beneficial insects. Seventy percent of the acreage was infested with about 14% receiving treatments. The fungus, *Neozygites fresnii*, developed by mid-July and provided satisfactory control.

Spider mite infestations also developed inside as well as outside the eradication zone. Mites were found across entire fields in most cases rather than along borders or in spots. Egg numbers were very high. About 48% of the acreage was infested with 30% receiving treatments.

Stink bugs were numerous and infested approximately 90% of the acreage. Twelve percent was treated specifically for bugs with some subsequent control from other insecticide sprays such as malathion for boll weevil. Whiteflies (banded wing) developed late in the season with very few acres treated. Cabbage loopers and yellowstripped and fall armyworm were all reported at sub-threshold numbers. Beet armyworm was not reported.

In summary, 1999 was an average insect year but experienced less than ideal weather. Statewide average yield was estimated at 504 lbs. Yield losses to insects are estimated at 10-12%, comparable to the 15-year average of 10%. Weather losses are estimated at 30%. Boll weevil, BW/TBW on conventional varieties, and plant bugs will rank 1, 2 and 3 respectively for yield losses. Spider mites, aphids and stink bugs were all higher than normal and will contribute to yield losses.

Texas

The 1999 harvested acreage was up substantially from the approximately 3.3 million acres in 1998 with 5.2 million projected to be harvested. Most acreage lost was from the High Plains area due to hail, flooding rains and subsequent stand establishment problems. The Rolling Plains area acreage was also reduced by moisture shortages and high temperatures impacting the dryland crop. Yields were generally average to fair across the state with some exceptions occurring in irrigated western acreage where yields as high as 4 bales were reported. Moisture limitations and high mid-summer temperatures severely limited dryland yields in many areas of the state. Weather also impacted yields in the South Texas area where hurricane Bret reduced yields as much as 33%.

Good early moisture in many areas of the state resulted in above normal problems with fleahoppers. This was especially true in the west Texas area where the pest was elevated to the top of the list for the first time in many years. Plant bugs were also a problem in the High Plains area, providing additional significant yield reductions, control costs and loss of earliness for as much as one million acres. Roundup Ready cotton was planted on most farms in the state.

Weather damaged cotton and rainy, windy weather conditions delayed treatment of Roundup to much of the west Texas crop until after the optimal treatment window. This resulted in square loss in addition to that recorded for fleahoppers and plant bugs. Early moisture and a subsequent abundance of early season hosts resulted in above normal levels of seedling thrips. Heavy rains in May and June significantly reduced thrips numbers and limited their damage in many instances.

Caterpillar pest problems were almost nonexistent through much of Texas, with some exceptions. Both cabbage and soybean loopers were abundant in the Coastal Bend area and cotton leafperforator numbers were above normal in the Southern Rolling Plains and Coastal Bend areas. Bollworms were an early season problem for the LRGV and tobacco budworms a problem in the Northern Rolling Plains irrigated acreage. Otherwise, Heliothines were at their lowest levels in years. Beet armyworms were also low in numbers, and the Section 18 for Pirate was not triggered. Pink bollworms were again a pest in the Far West Texas area but did not pose much of a problem since much of the acreage was planted to Bollgard varieties. The planting of significant acreages of Bollgard cotton in other areas probably contributed to lower damage levels from caterpillar pests but was not responsible for the lower levels of caterpillar pest numbers observed early in the season.

Cotton aphid infestations appeared earlier than normal in much of the cotton acreage but posed little problem as biotic and abiotic factors kept them in check for most of the season. There were enough fields with damaging infestations to necessitate the release of Furadan 4F under a Section 18 for all growing regions in the state, although not all at the same time. While yield-reducing infestations of aphids were uncommon across the state, the warm open fall in west Texas did result in persistent infestations which did cause honeydew contamination in a significant acreage of the High and Rolling Plains. While rainfall was minimal during the open boll stage, it is hoped that there was sufficient rainfall to alleviate some of the contamination problems. There was a trend for more late aphid problem fields in the eradication zones than outside these areas.

Boll weevil numbers were generally up this year, especially late in the season. Properly conducted overwintered boll weevil spray programs delayed the appearance of damaging infestations until late in the season, often minimizing yield impacts. Unfortunately, low cotton prices discouraged some needed treatments, Existing boll weevil eradication programs in 1.35 million acres and the late season start up of an additional 2.4 million acres probably reduced the overall yield impact of boll weevil infestations since most damaging infestations did not appear until late in the season. There is still approximately 2.4 million acres left that have not approved the start of a boll weevil eradication program with 1.9 million of this in West Texas. The record numbers of boll weevils late in the year in some areas will act as an inducement to vote in favor of eradication. Unfortunately, low cotton prices and the absence of state funds to support any new program until at least the fall of 2001 will discourage many growers to support eradication in the near term. There is still no area in Texas that has been declared weevil free. The Southern Rolling Plains program is having problems from migration from the west and north, and the South Texas/Winter Garden program ran into significant weather delays resulting in a significant buildup of late season weevils. The 5 new western zones ran into considerable pressure from record levels of boll weevils and may have not achieved the targeted goal of a 90% reduction of overwintering boll weevil numbers.

Lower Rio Grande Valley (LRGV)

Many area cotton fields were treated for fleahoppers in 1999. A few fields were treated more than once, but the fleahopper infestations did not appear to remove many squares from area fields. A Section 18 emergency permit was granted for Furadan insecticide for control of aphids. Infestations of this pest were sporadic throughout most of the remainder of the season, except in a few fields which had to be treated late in the year to prevent honeydew deposits on open cotton bolls. Silverleaf whiteflies (SLWF) were observed in most area cotton fields but were treated in only a few situations. Near the end of the season in July, SLWF were noted to be much heavier in stressed cotton fields but did not appear to warrant insecticide applications in most cases. Boll weevil pheromone traps caught large numbers until mid-April, as was the situation in 1998. The highest numbers of weevils were caught during planting and early plant development. As usual, weevil numbers dropped to near zero as cotton went into fruiting. Very high levels of boll weevils were reported from many fields in 1999. Weevil damage increased rapidly in some fields, especially in the mid-Valley area. Punctured square counts began at levels of only 1 or 2 punctured squares per 100 plants in late-May and early-June but rapidly built to levels exceeding 30-50 punctured squares per 100 plants by mid to late June. Damage was extensive in a few fields and required shortened spray intervals to minimize weevil damage. Average punctured square counts in irrigated fields on June 1 was 7.7 punctures per 100 plants in irrigated cotton fields scouted in the TPMA/IPM program.

Bollworms were about the only lepidopteran pest of consequence in cotton in 1999. Early infestations occurred from mid-April until early-June, then declined to remain at low numbers throughout the balance of the production season. A large number of fields were treated in early season for bollworms in scattered locations across the LRGV. Despite large numbers of boll weevil sprays in some fields, bollworms did not flare nor become secondary pests due to insecticide treatments. Beet armyworms were generally at very low levels during the entire production season. A few fields in the mid-Valley area had enough worms to warrant the use of Section 18 Emergency Exemption materials for beet armyworm control. However, the beet armyworm infestations soon collapsed and did not provide a serious further threat to yields.

Rapid plant bugs (RPB), *Creontides* spp. were reported in many areas but most farmers did not spray for the pests. A few scattered fields and locations, particularly along the eastern part of Willacy County, appeared to have the highest levels of RPB.

Coastal Bend (CB)

Cotton insect pest abundance was generally low throughout the Texas Coastal Bend. Thrips damaged early-planted cotton with some treatment required. Aphids reached treatment threshold, and some Furadan was used under Section 18 rules. The aphid population did not persist for long, and economic damage probably did not occur. Fleahopper numbers did not reach damaging populations on the early-planted cotton, but later-planted cotton generally sustained damaging numbers requiring 1-2 insecticide treatments. Bollworm and tobacco budworm infestations were also low but there were exceptions, especially in later planted cotton; no control problems were experienced. Stink bug numbers appeared to be low, but stink-bug-like damage was observed (some severe) in the northern half of the Coastal Bend. In some fields the number of damaged bolls was high, but it was difficult to attribute all the damage to stink bugs. Boll weevil infestations were generally low during early season in counties outside the boll weevil eradication zone, but by mid-season they had increased enough to require treatment. Other pests noted during the season included substantial numbers of cabbage and soybean loopers, cotton leafperforators and saltmarsh caterpillars. Little economic damage was caused by these insect pests except in isolate fields. Yields ranged from 500-1500 lb/acre. Hurricane Bret reduced yields about 33% and resulted in major loss in fiber quality in late-planted cotton in the lower Coastal Bend counties of Nueces, Jim Wells and Kleberg.

The boll weevil eradication program completed the second full season (Upper Gulf Coast counties are not in the program). No economic damage by the boll weevil occurred in the crop, but boll weevil numbers did increase to numbers exceeding the dry years of 1997 and 1998. Following harvest and stalk destruction, pheromone trap catches remained high in some areas. In other areas, although numbers were low, they exceeded previous year counts.

Southern Blacklands (SB)

The Southern Blacklands region produced one of the best cotton crops in the past 15 years. Area producers had great weather for cotton harvest. Irrigated areas in the Brazos Valley averaged 2.1 bales per acre and dryland areas averaged 1.3 bales per acre. Fiber strength and color grades were excellent. Rainfall was adequate in the spring and early summer, but August was dry. A single irrigation was provided to about half of the irrigated cotton. A record yield of 1963 lbs lint/acre was harvested on a field at the Texas A&M University Plantation in Burleson County. The area did vote in the eradication program for boll weevil but did not approve the budget. The area will vote on a new budget in early 2000.

The boll weevil continues to require five to eight applications of insecticide. Yield losses are still significant with the treatment practices used by growers. Fleahopper and the bollworm complex required treatment in most areas. Bollgard cotton did well in the area. More and more acres will be planted to the new Bollgard varieties. Some producers treated Bollgard cotton once for bollworms. A few aphid and spider mite infestations developed in mid- and late-season. Only a few fields were treated with insecticides

Northern Blacklands(NB)

The 1999 season was unique in that bollworm/budworm infestations were extremely light to absent. Limited sampling in corn indicated corn earworm infestation in ears was also very light. Fleahopper infestations were quite severe and sustained infestations often defeated standard spray programs. Yields were above average due to favorable weather, few insect pests, and good harvest weather.

Northern Rolling Plains(NRP)

Hot, dry conditions in 1999 as in 1998 were the primary factors limiting cotton production. Rainfall was well below normal from April 1998 through April 1999. Average to above average rainfall was received in May 1999, and June was average in some areas and below average in others. Cool wet conditions delayed cotton planting and stand development. However, July was below average in most of the area and little to no rain was received in much of the area during August. The parts of the NRP that received more rain in July and August (northwest), had more insect activity and are expecting better yields. The estimated cotton acreage of 420,000 acres is lower than last year. The acreage reduction is due to the lower cotton price and wind and hail damage during the planting season. With below normal cotton temperatures and wet conditions during planting season, thrips continued to move from spring hosts to cotton which did not out grow earlier infestations until warmer temperatures occurred in June. The impact of these infestations was masked somewhat by the hot dry conditions later in the season when the plants dropped many of the squares and small bolls due to hot dry conditions.

Cotton fleahoppers were light early and increased as the season progressed. Applications for fleahopper control were confined to irrigated cotton and dryland fields where there were better yield prospects. Fleahoppers caused little damage in most dryland fields because spring hosts were limited by the dry winter, and by the time fleahoppers did increase hot, dry weather was the primary factor causing the fruit load reduction.

Boll weevil eradication is being conducted in the entire Rolling Plains Area. In the Rolling Plains Central Zone, boll weevils have been reduced to the point that square damage was not evident in most fields during the 1999 production season. In the Northern Rolling Plains the eradication program began this fall with insecticidal applications at about weekly intervals to suppress numbers of overwintered boll weevils that will emerge to infest the 2000 cotton crop. The hot dry conditions of 1998 suppressed boll weevil population development, but numbers increased late in the season and an average of 23 overwintered boll weevils (44/trap/week) were captured the week of June 2. With the dry conditions of July, August and September the highest average number of boll weevils (21/trap/week) was captured September 22; by then, three to four Fyfanon ULV applications had been applied.

Next year heaviest boll weevil infestations are expected to be in Hall, Collingsworth, Childress Donley and Hardeman Counties which had heavier infestations this year and where there is more irrigated cotton; these counties with the exception of Hardeman also had more rainfall in July and August.

Bollworm, budworm and beet armyworm infestations were very light in dryland cotton fields. However, tobacco budworms were a problem in some irrigated fields, especially in fields in Knox and Haskell Counties that were not planted to Bollgard7 varieties. More than 90% and 30% of the irrigated cotton in the Rolling Plains Central and the Northern Rolling Plains Eradication Zones, respectively, was planted in Bollgard cotton varieties. Bollworm moth numbers captured in the Northern Rolling Plains were well below average while budworm moth numbers were average. Beet armyworm moths were captured in higher numbers than bollworm or tobacco budworm moths, but damaging beet armyworm infestations did not develop in cotton fields. Beet armyworm larvae were even difficult to find on pigweed.

Aphid outbreaks occurred in irrigated fields in Know and Collingsworth Counties in July. The Texas Department of Agriculture approved the use of Furadan7 4F under a Section 18 label for cotton aphid control in Extension District 3 and 1 on July 27 and 28. Aphids were present in most fields in August, but major outbreaks did not occur until September and October. In some cases, aphid honeydew was so heavy on cotton leaves that it prevented Cyclone7 from contacting the leaves.

Many of the fields that were hardest hit by the drought conditions were shredded. Yields of the cotton that will be harvested will be above average or about 270 lbs lint/acre. Many of the irrigated fields will yield over two bales per acre. With all the cotton that was shredded, 1999 can only be considered a fair year, but with the price of cotton considered it is a very poor year for the Texas Rolling Plains.

Southern Rolling Plains (SRP)

This summary covers the 600,000 acres of cotton planted in Concho, Tom Green, Runnels, Schleicher, Iron, Mitchell, Nolan, Scrry, Fisher, Jones and Taylor counties. The area was entering the third year of below average moisture. Winter rains were below average, but late spring rains in April, May and early June made planting less of a risk in 1999. However, rain did not occur in adequate amounts in July and August, and the resulting crop reflected the lack of rain.

Rain in May and early-June produced an abundance of alternative sites for thirps and cotton fleahoppers, and numbers were high, especially in the Rolling Plains Central. Thrip caused minor problems in some fields, but most fields escaped significant damage. Some producers chose not to treat for cotton fleahoppers, and yields were impacted by as much as 20% in some areas. The early-June rains also caused some fields to be replanted and caused some herbicide damage from chemical splashing on the leaves. The rain also delayed glyphosate applications which resulted in two problems. Some producers chose to treat during the optimum window (before the 5th true leaf emerged) but when wind was high. This resulted in many grain sorghum and non-Round-up Ready cotton fields being damaged by drift. Others delayed application which resulted in some square loss at the first two or three positions on the plant.

The crop was delayed during June with the cooler temperatures and rainfall but rapidly made up time during the rest of the season. Bollworm/tobacco budworm pressure was light, and less than 5% of the non-Bt acreage was treated. None of the Bt cotton was treated. Cotton aphids flared after early-season insecticide use on cotton fleahoppers. Although no control problems were experienced, populations rebounded quickly and the Section 18 for Furadan7 was requested for the area. Aphid populations were the lowest in four years. Some late season defoliation occurred from cotton leaf perforator especially in the Rolling Plains Central zone. The leaf perforators did not cause any yield reductions.

The boll weevil eradication program continues to make good progress in both zones. Early-season trap catches were low in both zones with 80% of the fields in the Southern Rolling Plains not recording any trapped weevils (as of July 4th). Some isolated areas still received multiple applications, but overall trap catches were low. Migration was a factor late in the season in the Southern Rolling Plains. Insecticide use in the Rolling Plains Central averaged 0.6 applications/field in the spring and rose to an average of 2.1 applications/field during the diapause phase. Cumulative applications in the Southern Rolling Plains was 0.4 applications/field with most of that on the western edge of the zone to handle migration from the north and west.

High Plains (HP)

The 1999 season began with excellent deep soil moisture just like in 1998, and both irrigated and dryland acreage was initially planted in a timely manner. Approximately 3.6 million acres were planted. Major weather events in May and June resulted in acreage losses of 200,000 and 635,000, respectively. Most of the acreage lost in May was replanted to cotton. Except from some fields south of Lubbock, most June losses were replanted to alternative crops. These weather events included hail, flooding rains, wind-borne sand, and cooler temperatures. These cool temperatures resulted in further acreage losses due to either physiological stress or diseases of unknown origin. The final standing acreage taken to harvest amounted to about 2.9 million, 530,000 acres to the north, was weather damaged and slow to respond to the return of favorable growing conditions. Yields are estimated to average 630,000 bales from the northern acreage and 2.13 million bales from the southern acreage. The average yield per acre was down 22% in the northern High Plains and 20% in the southern High Plains compared to 1998 (a droughty year). Some of this yield reduction was due directly to weather events and some to insects.

Following the rains in June, there was no more significant rainfall until mid-September. By this time the over-committed dryland crop was stressed beyond redemption, with generally low yields a reflection of this. Heat unit (HU) accumulations were below normal for May, about equal for July and way above normal in August. Early September HUs were average but below average for the latter part of the month. October HUs were at normal averages while

November was above normal. While the crop played catchup on HUs for the early-season deficit, by the end of August HU accumulations were on par with long term averages and ended up ahead for the season. The rapid progress of the crop resulted in much of the southern acreage ready for harvest aids by the 3rd week in September with over 2 million acres harvested before the freeze. The threat of an October freeze resulted in many northern acres of less than fully matures cotton receiving proactive applications of harvest aids. The use of boll openers on immature cotton prior to a plant killing freeze prevents most fiber stickiness problems associated with immature fiber caught by a freeze. The area-wide plant killing freeze occurred on November 24, 12-24 days later than usual, depending upon where the cotton acreage is located in the High Plains.

There were early extended thrips problems on seedling cotton, but May and June weather events significantly reduced thrips infestations. These same events produced soil-applied-systemic-insecticide-leaching rains which necessitated foliar applications on some surviving acreage. The result of all this was a thrips problem much less that usual.

Early season rains coupled with good soil moisture conditions resulted in a flush of wild weed hosts which appeared to increase the incidence of both fleahoppers and western tarnished plant bugs. Fleahopper numbers were at an all time high, eclipsed only by infestation levels observed only once the previous 22 years. Timely applications of insecticides by growers for this pest, as well as incidental control through numerous insecticide applications for emerging overwintered boll weevils, appeared to reduce yield losses below the 23% observed on the previous occasion. Even so, there were many producers that failed to recognize the problem in a timely manner and suffered significant yield losses. This was especially true of the western tarnished plant bug which infested acreage primarily to the west of Lubbock from south of Seminole to north of Hereford. The highest yield losses occurred in the northwestern acreage where inexperienced growers and consultants were caught off guard. The already late crop was delayed even further by as much as two more weeks where plant bugs were not properly addressed. Much of the acreage in this area was planted to PM2200, a variety that has an initial slow rate of squaring making it particularly vulnerable to plant bug damage. Less damage was observed on PM2326 and PM2145. The greater damage potential was apparently due to varietal characteristics and not due to transgenics.

There were virtually no widespread problems with caterpillar pests this year. Bollworm numbers were generally low with the exception of some fields in the northwest which had heavy infestations in late-September and October. Normally the crop is not vulnerable to damage this late in the season. Beet armyworm and looper activity was generally light with a few fields needing treatment. Section 18 insecticides, Confirm and Denim, were available. The Section 18 for Pirate was not triggered for this area.

Because of the numbers of boll weevils trapped late season in 1998, another mild winter with above average survival of weevils in the better overwintering sites (based on research conducted by Don Rummel, Lubbock Experiment Station Entomologist), and the numbers of boll weevils recovered in a 21 county overwintering site survey conducted in March, emerging overwintered boll weevil numbers were again predicted to be at all time highs. Producers were warned about the need for overwintered weevil applications and the problems associated with the predicted extended emergence profile. Even though rainfall events were rare after June, emerging boll weevil numbers were at record levels over much of the area. For the most part, producers did an excellent job with their overwintered weevil sprays and delayed the appearance of economically damaging infestations until September. Those growers that had succeeded with producing early maturing cotton escaped the late season weevil explosion. Those that elected not to spray overwintered weevils or did a poor job had to address problem fields as early as mid-August.

In spite of the significant delay in appearance of in-season damaging weevil infestations, most of the acreage saw very high levels of boll weevil activity as evidenced by catches in the 850 trap grid established by Extension and cooperation with Plains Cotton Growers, Inc. Boll weevil damage to the crop was estimated to be less than in 1998, due in part to the advanced maturity of some fields and the initiation of three eradication programs with fall diapause treatments beginning in September, encompassing approximately 1.8 million acres.

Any late-planted and irrigated fields outside of these eradication zones suffered extensive top crop losses unless treated with 1-5 applications of insecticides. Because of the warm open fall, many areas produced a late season supply of squares that were available for weevil feeding. This could mean that a larger percentage of weevils moving into overwintering sites late in the season could have sufficient at reserves to survive the winter host-free period. With the exception of the Western and Permian Basin eradication zones, late season boll weevil numbers were 1.5 to 1.9 times higher than in 1998.

Boll weevil eradication was approved for the Western (800,000 acres), Permian Basin (600,000 acres), and Northwest (550,000 acres) eradication zones, and diapause treatments were initiated in the two southern zones during August-first of September. The Northwest zone began spraying one week later. Twelve ounces of ULV malathion was applied on a weekly basis until the crop was harvested or a killing frost. All treatments were finished by the end of November. The program got off to a late start in an attempt to avoid cost overruns and secondary pest problems. The extended warm open fall prevented this objective from being met. The delay in program initiation may have cost the program some progress in reducing potential overwintered boll weevil numbers. An evaluation next year will tell the story. Accumulative treated acres exceeded 15 million. In spite of this, trapped boll weevil numbers were almost double that of last year in the Northwest zone but reduced by 74% in the Permian Basin zone and 8% in the Western zone. Because overall boll weevil numbers were higher this year than in 1998, the reductions in the last two eradication zones do represent a significant reduction.

The Texas Legislature provided $75 million as a cost share for active programs for the next two years. This allowed reduced assessments as low as $6.00 per acre on dryland and $12.00 per acre for irrigated acreage per year. Any program area not involved in active eradication will have to wait until the next legislative session to see if another $50 million request will be approved for the next two years.

Cotton aphids appeared earlier than usual in the growing season but were held in check for the most part by beneficial insects, primarily lade beetles. The greatly reduced numbers of caterpillar pests resulted in few pyrethroid applications and few field infestations reached economically damaging levels. A Section 18 for Furadan 4F was triggered and expired September 1. Because warm conditions extended well into October and November, regrowth was common in harvested fields and harvest aids often failed to kill terminal growth. This resulted in persistent aphid infestations well into the boll-opening period, sometimes at high levels. These infestations produced honeydew which contaminated lint in open bolls. Sometimes as few as 8 aphids per leaf over a four-day period was sufficient to cause a sticky lint problem. There were very few rainfall events in September-November to provide honeydew cleansing rains. Some producers sprayed these late infestations, and some others used their overhead sprinklers to wash the lint in the field. In spite of these efforts, it is feared that a significant portion of the High Plains crop is contaminated. There is some evidence that the stick cotton problem was more prevalent in the boll weevil eradication zones.

Far West Texas (FWT)

Cotton producers in the Trans-Pecos and El Pas production areas generally experienced average spring and early summer temperatures and rainfall in 1999. Temperatures were above normal and rainfall below normal during spring for the St. Lawrence production area. Unfortunately, this is the region where all of the dryland cotton production occurs. Unless pre-watered, rainfall amounts generally were not high enough for producers to plant dryland cotton during the late-April to mid-May planting period. Warm spring temperatures, however, ensured fast growth of seedling cotton where adequate soil moisture was not a limiting factor. Many dryland producers did not start planting until mid-June when adequate rainfall provided good soil moisture. Rainfall amounts exceeded 5 inches in some areas, causing local flooding and reduced cotton stands. Summer temperatures were good for highly variable yield potentials for the dryland production area. Most dryland cotton cutout by late-August and harvesting be by mid-September. Overall dryland and irrigated yields were average for the area.

Insect pest populations across the Far West Texas region were sporadic and generally treated on a local basis. Most of the insect pest problems occurred in the irrigated cotton production (Trans-Peco and El Paso) region. Insect pests were generally not a problem for dryland cotton producers. Cotton fleahopper was the only widespread pest that received pesticide treatments. Greater than half the planted cotton acres received pesticide treatments for bollworm, pink bollworm, and cotton aphid in the Trans-Pecos and El Paso production areas. Stink bugs continued to cause economic damage in the Trans-Peco area with greater that 75% of the acres treated to control this pest. Bt cotton more than doubled in planted acres over 1998. This occurred primarily because of technology fee price restructuring and its effectiveness against various lepidopterous pests. Boll weevil eradication was approved for the Permian basin region and the El Paso-Trans Pecos region this year. A diapause program was initiated this fall for both regions with the first full season of eradication beginning in 2000. The St. Lawrence region did not approve the boll weevil eradication program but will continue with a producer funded boll weevil diapause program that has been in place for approximately 30 years.

Virginia

Almost 110,000 acres were planted to cotton in 1999, an increase over the 91,000 acres planted in 1998. Although the overall weather conditions were dry, early estimates of yield potential were very high, ranging from 800-950 lb/acre. That was before a series of three Hurricanes, (Dennis, Floyd, then Irene), raked eastern Virginia during the period from mid-September through mid-October causing significant crop damage. Although Floyd dropped more rainfall causing flooding of some fields in some counties, the stalling of Dennis for a 10-day period the week prior to Floyd may have caused greater overall crop loss. The long period of wet, overcast, cooler conditions caused widespread plant lodging, boll rot on lower branches and locking of bolls, even after application of defoliants and boll openers. Further, because of soaked soils, some fields may be abandoned altogether by growers unable to drive heavy pickers into those fields, or yields and lint quality could be further reduced by the unusually late harvest. An estimated 10% overall crop loss is expected, although losses could easily exceed that depending on late-October and November weather patterns. Currently, optimistic estimates are for lint yield averages to be in the 700-750 lb/acre range.

Use of Bt cotton varieties is still relatively low in Virginia. An estimated 7% of the total acreage was planted to Bt cotton varieties, but of that, less than 1% was selected for the insect resistant trait. Most was "stacked" with the Round-up Ready gene and varieties were selected by growers for the herbicide resistance trait. Some Bt cotton varieties were selected for an expected yield or growth habit advantage.

Thrips populations were higher than normal which, when combined with the early season dry weather, slow seedling growth, and the slow uptake of in-furrow insecticides, resulted in a severe threat to plant health. In research plots, some untreated plants were actually killed by this combination of factors. In addition to applying an insecticide in-furrow at planting, most producers also applied at least one over-the-top insecticide treatment to suppress thrips populations, some made two applications. These treatments were effective, for the most part, in preventing severe seedling damage. There were some reports of insecticide failures due to a suspected influx of new insecticide-resistance thrips species. However, collection and identification of adult thrips did not reveal any new species. The "perceived" insecticide failures were most likely due to the large thrips populations, prolonged pressure and slow early season plant growth.

Cutworms, predominantly granulate or black, were found early in the season in a few fields as evidenced by cut seedlings, stand loss and live larvae active in the soil next to seedlings. Infestations were not widespread, but some fields appeared to have sustained significant levels of stand loss.
In Virginia, aphid outbreaks typically occur at two times during the season, early in the season soon after thrips sprays have been applied, and later in the season after bollworm sprays have been applied. This trend was also apparent in 1999. Although aphids could be found in many fields, most outbreaks were not serious enough to warrant treatment. When left untreated, beneficial populations of lady beetles, aphid-parasitic wasps and aphid disease eventually reduced populations to almost undetectable levels.

Plant bugs or stink bugs were a problem in Virginia in 1999. Populations were lower than in the previous year, and paralleling that, less square damage or loss and less young boll damage was observed. No fields were treated specifically for bug problems. Heliothine populations were considered light, variable and longer lasting compared with most years. This created a frustrating treatment decision-making environment with some fields being treated too early, before egg and boll damage thresholds were fully met. Those fields usually ended up having to be treated two more times, one more than the average for a typical season. Fields in eastern counties generally experienced larger bollworm populations, with more fields requiring three treatments. Fields in central and western counties experienced less pest pressure and treatment number averaged one to two. The overall state average was two treatments for control of the Heliothine complex.

The Virginia Department of Agriculture and Consumer Services - Office of Plant and Pest Services reported that Virginia was again boll weevil free in 1999. Because of lower program costs, cost to the producer ($3.25/acre) was at its lowest rate. An estimated 22,000 traps were monitored (one trap every 5 acres) from July 15 through November 12. According to VDACS, support for the program has been good as evidenced by producer cooperation.

Although evidence of possible bollworm resistance was reported from North Carolina, no problems were observed or reported in Virginia. No "spray failures" were reported and spot checking after producer treatments revealed excellent control with several standard pyrethroids. Excellent bollworm control was also documented in both large and small plot research experiments, as has been reported in previous years. However, with reported resistance so close to our border, we are considering beginning permethrin/vial testing of adults to establish a base line, and to alert us to any future change in this situation.

Research Progress and Accomplishments

Alabama

Due to the lack of insect pressure, limited insect field trials were undertaken. Opportunities did occur to look at the new materials (Pirate, Intrepid, Steward. strategy and Tracer) on soybean loopers. S-1812 was evaluated against a moderate population of bollworms, budworms and soybean loopers. In addition, several compounds were evaluated against both adult and immature tarnished plant bugs. Adage was compared to Temik on early season insects.

Twenty-two different treatments comprised of different insecticides and rates as either in-furrow or foliar applications were tested against cotton thrips in three field trials. All treatments resulted in lint increases over untreated controls, and most were significantly higher. Over all 22 treatments, lint increase ranged from 206 to 478 lbs/acre, with an average increase of 332 lbs lint/acre. This represented an average of 30% lint yield loss when plants were not protected from thrips damage. In general, lint yields were higher with in-furrow versus foliar applications. Additional foliar applications of Orthene 97 (3.1 oz/acre - applied in a 14-inch band over the row) increased yields of in-furrow applications of Thimet 20G (3.75 lb/acre), Di-Syston 15G (5 lb/acre), Temik 15G (3.5 and 5 lb/acre) and a seed treatment with

Gaucho 480 (8 oz/cwt seed), compared with in-furrow and seed applications, alone. Identification of a sub-sample of adults showed that 75% were *Frankliniella fusca* and 25% were *Thrips tabaci.*

Forty-two different treatments comprised of different insecticides and rates, applied using different spray schedules, were tested against the bollworm/budworm complex in six field trials. One test focused on evaluating different spray tactics (insecticide + rate + application schedule = spray tactic). Three tactics provided the highest lint yield increases: 1) a standard rate of lambda-cyhalothrin (0.025 lb ai/acre) applied at egg threshold, followed by a high rate (0.04 lb ai/acre) applied in 5 days; 2) a high rate at egg threshold, followed by a second high rate in 5 days; and 3) three standard rate sprays, one at egg threshold followed by additional sprays at 5 then 10 days. In a 9-treatment test comparing product efficacy and yield advantage, all treatments resulted in lint yields that were numerically higher than the untreated control. The following 6 treatments had significantly higher yields: Steward 1.25 at 11.3 oz/acre + Dynamic at 5% spray volume, Pirate 3SC at 8.5 oz/acre, Ammo 2.5EC at 3.0 oz/acre, Fury 1.5EC at 2.8 oz/acre, and Karate Z at 1.6 oz/acre - all applied twice, once at egg threshold and again in 5 days, and Ammo 2.5EC at 3.0 oz/acre at egg threshold then Capture 2EC at 3.2 oz/acre in 5 days. The lint yield advantages over the untreated control ranged from 94 to 149 lbs/acre, with a 592 lbs lint/acre yield in the untreated control. In a rate-response test, three rates of Decis 1.5EC (at 1.6, 1.9, and 2.56 oz/acre), Baythroid 2EC (at 1.8, 2.1, and 3.2 oz/acre) and Karate Z (at 1.6, 1.9, and 2.56 oz/acre) were compared for efficacy and yield advantage. Each was applied once at egg threshold and again in 5 days. All treatments, except Baythroid at the 1.8 oz rate, resulted in lint yields that were numerically higher than the untreated control. Only Baythroid and Karate at the high rates resulted in yields that were significantly higher than the control, 173 and 120 lb lint/acre higher, respectively, with a 698 lb lint/acre yield in the control. **(Department of Entomology Plant Pathology, Auburn University, Auburn, AL)**

Arizona

Sorbitol accumulation in silverleaf whiteflies (SLW) in conjunction with the expression of heat shock proteins, prevented the denaturation of whitefly enzymes, thus conferring thermal stability. Inhibiting the enzyme that regulates sorbitol accumulation has the potential to provide a novel means to control whiteflies. Analysis of whitefly salivary glands showed that the enzyme alkaline phosphatase is present and is secreted in SLW saliva. The role of alkaline phosphatase has not been established, but it could function in formation of the SLW stylet sheath, metabolism of a plant phloem sap component, or detoxification of plant compounds. Pathways for SLW carbohydrate metabolism were studied to locate potential inhibitors of trehalulose synthase and sucrase, enzymes involved in honeydew production, and ketose reductase, an enzyme in SLW and aphids that synthesizes a class of thermoprotective compounds called polyols. Fluordeoxyglucose and bromoconduritol were identified as possible inhibitors of trehalulose synthase and sucrase. Also, strong evidence was developed that shows that accumulation of polyols in SLW decreases high temperature-induced mortality by protecting proteins from thermal denaturation.

A novel trisaccharide [alpha-D-Glucose (1,6)-alpha-D-Glucose (1,1)-D-Glucose] was isolated from SLW bodies. It appears to be a component of sugar metabolism. Its structure is very similar to a honeydew sugar that was isolated earlier [alpha-D-Glucose(1,6)-alpha-D-Glucose(l,l)-D-Glucose] and named bemisiose for the SLW genus (*Bemisia*). The new trisaccharide was named isobemisiose.

Cotton lint stickiness caused by SLW and aphid honeydew remains a major issue in the cotton industry. Comparison of lint samples assayed on a new high-speed sticky cotton thermodetector (H2SD) and the standard manual thermodetector (SCT) confirmed earlier observations that lint stickiness is randomly distributed within cotton fields. Results also identified a potential problem with the H2SD system. In general, it appeared that use of the automated system resulted in greater between-assay variability compared with the manual system. Further testing and refinement of the H2SD system are underway.

Multivariate statistics were applied to a data set to determine biological and life history trait relationships of SLW to the changing amino acid content of phloem samples taken over a 12-week growing period. The use of multivariate statistics resulted in a reduced number of amino acid groupings, which will be used to generate hypotheses that can be tested experimentally once a holidic diet has been developed. SLW were shown to create nutrient sinks that result in elevated levels in 10 of the 20 common amino acids, at least when melon plants are vegetative. During reproductive growth differences due to SLW feeding were not observed, suggesting that shunting of amino acids to plant reproductive structures overrides the effect of aggregative SLW feeding. Changes in sink-source allocation during reproductive growth resulted in a 10% increase in development time in SLW nymphs, and a 6-10% decrease in adult weights.

A polycarbonate chamber, equipped with a Teflon membrane, was used to test a series of whitefly diets that evaluated the effect of sucrose concentration (10-30%), diet pH (6.5-8.0), the ideal number of eggs/chamber (< 50 to > 600) and the optimal egg age (3-9 d) on hatchability, development and emergence rates of SLW. Hatch rates and survivorship were significantly higher for diets with sucrose concentrations of

15-20%, when compared to diets containing 10 and 30% sucrose. Response to diet pH was variable. Survivorship was initially higher on diets with a pH of 6.5-7.0 than on diets with a pH of 7.5-8.0, but by Day 10 this difference was negligible. Five- to six-day-old eggs had a significantly higher hatch rate, and nymphs survived better than in all other age groups. There was a strong negative association between the number of eggs placed on the membranes and both hatch rate and survivorship. The ideal number of eggs was less than 200.

Mark-release-recapture studies have been designed and conducted to measure the dispersal pattern of the SLW parasitoid, *Eretmocerus emiratus* in cotton and melon fields. The markers used are purified vertebrate proteins. Marked individuals can then be assayed using a sandwich enzyme-linked immunosorbent assay (ELISA) for the presence of the protein marker using an antibody specific to rabbit IgG.

Results of studies showed that insect growth regulators (buprofezin and pyriproxyfen), in general, do not significantly affect SLW predators in cotton. In contrast, broad-spectrum insecticides are detrimental to the natural enemy complex. Detailed, cohort-based life table studies revealed that predation and weather were major mortality factors affecting whitefly eggs and nymphs. Parasitism was a very minor mortality force. Levels of natural enemy mortality in fields treated with insect growth regulators were more similar to untreated fields than to fields treated with conventional insecticides. An undefined mortality agent caused large-scale death of 4th instar whiteflies in early August, a pattern first observed in 1998. Ongoing research is attempting to identify the cause of death. *Bemisia* predator/parasitoid interactions studies suggest that several common predators of whitefly may preferentially prey on parasitized whitefly when given a choice of parasitized and unparasitized prey. These findings have implications for the estimation of mortality rates from life table studies and biological control of whitefly in general.

Three-week control of SLW was achieved with one application of Applaud and 5-week control with Knack. Minimum typical one-application results have been 2-week control with Applaud and 3-week control with Knack. Cantaloupes appear to have potential as a trap crop for managing SLW. Three entomopathogenic fungi were also shown promising for SLW control in integrated programs.

SLW outbreaks, in many cases, have been suggested to be caused by the misuse of insecticides either directly, through resistance and/or fertility stimulation, or indirectly through depletion of natural enemies. A review of the available evidence suggests that outbreaks correspond better to substantial increases in cropping areas and diversity than to the historical pattern of insecticide use. Outbreaks appear to be caused by a complex set of factors, but undue emphasis has been placed on insecticides as the reason for outbreaks and masked a clearer understanding that could help to avoid future outbreaks.

Okra-leaf, nectariless Pima cotton germplasm lines were released to the public. The okra-leaf trait has been demonstrated to be a non-preference trait for SLW and the nectariless trait confers a degree of pink bollworm (PBW) resistance.

An egg-larval parasitoid, *Chelonus* sp. near *curvimaculatus*, of the PBW has been maintained in culture in the laboratory. The cabbage looper is also a host of this parasitoid. Parasitoids cultured on this alternate host are significantly larger than those obtained on PBW. Additionally, PBW has a facultative prepupal diapause. Since these parasitoids interrupt host development in the prepupal stage, this host/parasitoid relationship is an excellent model for stockpiling large numbers of parasitoids for augmentative releases. Small-scale stockpiling of parasitoids in a state of diapause has been accomplished. To date, diapause has been induced using a 9L,20 deg C:15D, 18 deg C rearing regimen. Diapausing larvae are produced when hosts are placed into this diapause-inducing environment by at least 8 days post-hatching. If diapause induction is postponed to 10 days all parasitoids continue development and do not diapause. No doubt, lower nighttime temperatures may increase this window of diapause opportunity; however, such changes may not accurately mimic Arizona weather patterns.

The integration of *Lygus* control into a whitefly pest management system was evaluated in a third year of field studies. Results suggest that treatment for Lygus with broad-spectrum insecticides may lead to resurgence of whitefly populations, but also significantly enhance yields. *Lygus hesperus* and *Lygus lineolaris* were found to be predaceous on whitefly eggs and nymphs. All 5 instars of each *Lygus* species, as well as the adults, fed on whiteflies when offered on cotton leaves. **(USDA-ARS-Western Cotton Research Lab, Phoenix, AZ)**

Arkansas

COTMAN was the focus for further research in 1999. Work on insecticide termination, irrigation scheduling and termination, pest economic threshold refinement, and use of the program in both research and on farms continued and increased.

The regional program for monitoring for the aphid fungus, *Neozygites fresenii*, is out of the research mode and into full implementation and use.
It is being widely used in Arkansas and surrounding states to avoid unnecessary and costly insecticide applications against crashing aphid populations.

Research aimed at improving boll weevil eradication continued. Alternative methods for boll weevil eradication continue to be investigated. Work on the new Plato boll weevil traps was conducted this fall and showed poorer performance than Foundation trap. The Plato design was easy to service, however.

Work on transgenic cotton varieties continued. Investigations of Bollgard II were conducted in several locations in the state, and it showed good results against tobacco budworm, beet armyworm and loopers. Systems research on transgenic cotton varieties is continuing. Economic comparisons between Bollgard and non-Bollgard cottons have come down to the yield potential of the variety more than one other single factor. Because of this, the best non-Bt varieties have generally been more profitable in studies over the last 2 years.

Work on natural enemies continued this year o n predators in Northeast Arkansas. Tracer has been shown to produce relatively low mortality (<20%) of minute pirate bug populations, while Provado and Steward produced mortalities in the 60% range and Regent and Karate produced 100% mortality. Provado caused feeding to stop, and it never resumed.

Resistance monitoring for Tracer, pyrethroids and curacron continued in 1999. Budworm resistance levels to pyrethroids are high in most of the state and fluctuate at high levels season long. Curacron resistance started fairly low in the early part of the season but increased strongly in July. We saw movement of resistance in the vial test to Tracer in late July and early August. Thirty to 40% survival was seen in Southeast Arkansas.

Product testing again showed plots treated with Steward .11 lb ai/A produced consistently high yields. This year in a tobacco budworm test, Steward produced significantly more cotton than any other treatment in the test. We have seen this trend in 5 or more tests in our state. Denim and S-1812 gave good tobacco budworm control in 1999 tests.

In Bollgard II test plots, good results were seen on beet armyworm, tobacco budworm and cabbage and soybean looper. We do not have a strong data set on bollworm, however, because none of the tests in Arkansas had enough bollworm pressure. Adage and Gaucho seed treatments, and Admire in-furrow performed well in tests against standard treatments against thrips. Actara provided good control of tarnished plant bugs in 1999 studies. **(Arkansas Cooperative Extension Service, University of Arkansas and Arkansas Agricultural Experiment Station, Little Rock and Fayetteville, AR)**

California

Trials were initiated in the San Joaqun Valley to evaluate insect pest susceptibility of varieties new to California. Fourteen existing replicated variety trials were sampled weekly for arthropods including Acala, Upland, and Pima cottons. Large-scale trials continued to refine *Lygus* management tactics on an area-wide basis. Alfalfa was successfully managed in two sites to limit the *Lygus* migration through preservation of habitat in alfalfa. Caged releases of the imported *Lygus* parasitoid, *Peristenus digoneutis*, continued in the San Joaquin Valley. Results from research with aphids indicate important interactions between nitrogen levels in cotton, aphid population dynamics, and insecticide susceptibility. Area-wide management of silverleaf whitefly continued with good success in limiting populations buildup and maintaining insecticide susceptibility. Bollgard II cotton was evaluated in one trail and found to be very effective against beet armyworm. **(Cooperative Extension Service, Kern Co., Tulare Co., Kings Co., Kearney Agricultural Center, Parlier; UC, Davis; and UC, Riverside)**

Louisiana

In 1999, pyrethroid resistance was again documented in tobacco budworm, *Heliothis virescens* (F.), populations across Louisiana. Slightly over 500 tobacco budworm moths were assayed for pyrethroid resistance from May to August 1999 using a discriminating concentration of 10 μg in the adult vial assay. Percent survival in May, June, July and August was 46%, 64%, 53% and 58%, respectively. The high incidence of survival observed in May and Jun indicates that a large percentage of the tobacco budworm population was resistant to pyrethroids before growers began to use pyrethroids. These data suggests that pyrethroids may no longer provide effective control of tobacco budworm populations. Over 800 male bollworm, *Helicoverpa zea* (Boddie), moths were assayed against a 5 μg/vial concentration of cypermethrin. Percent survival for May, June, July, and August was 18%, 13%, 15%, and 16%, respectively. No bollworm control failures with pyrethroids were documented in Louisiana in 1999.

Several tests evaluated insecticide efficacy against thrips, *Frankliniella* spp.; cotton aphids, *Aphis gossypii* Glover; tarnished plant bug, *Lygus lineolaris* Palisot de Beauvois; and soybean looper, *Pseudoplusia includens* (Walker), in 1999. Adage 5FS and Gaucho 480S used as seed treatments provided similar levels of thrips control on seedling cotton, but generally did not reduce thrips numbers to the level in Temik 15G treated plots. In a foliar insecticide test, Orthene 90S, Actara 25WG, Regent 2.5EC, and dimethoate 4EC provided the most consistent control of thrips larvae on seedling cotton. Two pyrethroids, Capture 2EC and Karate-Z 2.09 SC, generally did not reduce thrips numbers as much as that observed in the non-pyrethroid treated plots. Provado 1.6SC, Calypso 4SC, Actara 25 WP, Fulfill 50WP, and

Furadan 4F provided the most consistent control of cotton aphids and significantly reduced the number of aphids compared to that in the untreated plots 2 days after treatment (DAT), 7 DAT and 14 DAT. Cotton plots treated with Actara 25WP, Regent 4SC, Curacron 8EC, Orthene 90S, and Steward 1.25SC had significantly fewer tarnished plant bug adults at 2 DAT and 5 DAT, and fewer nymphs at 2 DAT compared to that in the non-treated plots. Mortality of tarnished plant bugs caged on treated foliage ranged from 63.3 to 89.5% at 24 hours after infestation (HAI). Plants treated with Actara 25WG, Orthene 90SP, Regent 4SC, Curacron 8EC and Steward 1.25SC had significantly higher insect mortality levels compared to that on non-treated plants. The experimental insecticides, Denim 0.16EC, Steward 1.25SC, and Intrepid 80WP generally provided satisfactory control of soybean looper that was comparable to that of Tracer 4SC and Larvin 3.2F at 2 days after treatment and 5 DAT.

Tobacco budworm populations in Louisiana during 1999 were highly resistant to pyrethroids. In all tests that included a pyrethroid or pyrethroid as the primary component in a tank mix numbers of damaged fruiting forms and infestations of tobacco budworm larvae in those plots were not statistically different from those in the untreated controls when the tobacco budworm was the dominate Heliothine species. In those same tests, S-1812 4SC, Denim 0.16EC, and Steward 1.25SC, generally provided satisfactory control that was comparable to that of Tracer 4SC. Louisiana bollworm populations are still effectively controlled with pyrethroids. Tracer 4SC and none of these experimental insecticides demonstrated efficacy levels greater than that provided by the pyrethroids against bollworm, regardless of application timing and larval size. The commercial insecticides, Curacron 8EC and Larvin 3.2F are still effective against Louisiana bollworm populations.

Another field study evaluated the efficacy of spinosad (Tracer7 4SC) and thiodicarb (Larvin7 3.2F) against soybean looper in transgenic Bt cotton (cv. NuCOTN 33B), non-transgenic cotton (cv. DP 5415) and soybean (cv. Buckshot 66). Each crop received an application of spinosad at 0.012, 0.025, 0.0375 and 0.05 lb AI/acre, thiodicarb at 0.125, 0.25, 0.375 and 0.5 lb AI/acre and also included an untreated control. A subtending leaf at a first position cotton boll and a trifoliate leaf from the top one-third of a soybean plant was removed 1 hour after treatment. Three soybean looper larvae (3rd instar) and a leaf from a host plant were placed in a petri dish. Larval mortality was determined 72 HAI. The lowest rates of spinosad (0.012, 0.025 lb AI/acre) applied to Bt cotton resulted in significantly higher mortality, 71.1% and 75.5%, respectively, compared to corresponding rates applied to soybeans, which only gave 22.2% and 42.2% mortality, respectively. Similar results were reported for lower rates of thiodicarb (0.25, 0.375 lb AI/acre), which provided 95% and 93% mortality, respectively, in Bt cotton and only 66.6% and 65.5% mortality, respectively, in soybean. However, there was no significant differences in larval mortality between Bt cotton and soybean at the highest rates of spinosad (0.05 lb AI/acre) and thiodicarb (0.5 lb. AI/acre). Also, there were no significant differences in mortality comparing each rate of spinosad and thiodicarb between Bt and non-Bt cotton varieties. With the exception of spinosad (0.05 lb AI/acre) and thiodicarb (0.375 lb AI/acre), there was no significant difference in mortality between non-Bt cotton and soybeans. These results indicate that lower rates of spinosad and thiodicarb may be effective in controlling soybean looper in Bt cotton compared to rates required on soybean and non-Bt cotton.

Several transgenic *Bacillus thuringiensis var. kurstaki* Berliner (Bt) cotton cultivars and breeding lines (including those with the Bollgard II technology) were evaluated in field trials against native populations of tobacco budworm, bollworm, soybean looper, and beet armyworm, *Spodoptera exigua* (Hubner). Low infestation densities persisted during most of the 1999 season and few differences in insect control were observed among the Bt cotton lines. All Bt lines had significantly less injury to fruiting forms compared to that in the non-transgenic lines. Those lines containing the Bollgard II technology had significantly less foliage injury produced by the soybean looper compared to those containing only Cry1Ac protein. In addition, white flowers of 40 advanced Bt breeding lines and cultivars were infested with 1 to 2-day old bollworm larvae and evaluated at 72 HAI. Mortality of larvae and bollworm damaged bolls ranged from 20 to 79% and 10 to 89%, respectively.

In a laboratory, a field collection of bollworm larvae were fed bracts, squares, immature anthers (from squares), flower petals, and mature anthers (from flowers) dissected from flower buds (squares) and white flowers of cv. Deltapine 5415 and cv. NuCOTN 33B. Bollworm survival was highest on flower and square anthers at all rating periods. At 72 HAI, bollworm survival was significantly lower on all NuCOTN 33B reproductive structures compared with Deltapine 5415 reproductive structures. However, larval survival on flower and square anthers was not significantly different between the cultivars.

Whole plants of Bt cotton (cv. NuCOTN 33B), non-transgenic cotton (cv. DP 5415), and soybean (cv. Buckshot 66) were examined daily for the presence of soybean looper oviposition during 10 August to 1 September and 16 August to 6 September in 1998 and 1999, respectively. There were no significant differences in ovipositional preference among crop hosts. Soybean looper egg density peaked on 26 August and 29 August in 1998 and 1999, respectively in north Louisiana.

A thrips species survey on cotton seedlings was done at the Northeast Research Station, St. Joseph, LA; Macon Ridge Station, Winnsboro, LA; Red River Research Station, Bossier City, LA; and the Dean Lee Research Station, Alexandria, LA, during 1996 to 1998. Flower thrips, *Frankliniella tritici* (Fitch); tobacco thrips, *Frankliniella fusca* (Hinds); western flower thrips, *Frankliniella occidentalis* (Pergande); and soybean thrips, *Neohydatothrips variabalis* (Beach), accounted for >99% of the total thrips species collected at all locations from 1996-98. At the St. Joseph site, tobacco thrips accounted for 65%, 93%, and 96% of the total species during 1996, 1997, and 1998, respectively. Tobacco thrips were the most abundant species at the Winnsboro location (39%-1996, 64%-1997, and 84%-1998). Western flower thrips accounted for ca. 30% of the total in 1996, but were not collected in 1997 or 1998. At the Alexandria location, tobacco thrips accounted for 90%, 89%, and 98% of the thrips adults collected during 1996, 1997, and 1998, respectively. Tobacco thrips were the most abundant thrips species collected at the Bossier City location (68%-1996, 77%-1997, and 97%-1998). Western flower thrips represent 28% and 3% of the total in 1996 and 1997, respectively. Western flower thrips were not collected at the Bossier City location during 1998.

Field tests were continued during 1999 in North Louisiana to evaluate the effects of terminating insect control strategies at selected intervals during late season on seedcotton yields. Termination intervals based on cotton plant development used plant mainstem nodes above white flower (NAWF) and heat unit (HU) accumulation. The treatment termination intervals based on crop development rules included NAWF5 and NAWF5 + 350 HU. The termination intervals based on weather oriented rules used 17 August as a final cutout date in Louisiana. Insecticide treatments were terminated on ca. August 17 and August 17 + 350 HU. For two cultivars, cv. NuCOTN 33B and DP 5415, yields were significantly higher when insect control strategies were continued until August 17 + 350 HU compared to terminating insect control at NAWF5 + 350 HU.

Field tests were conducted in Northeast Louisiana during 1997 to 1998 to study the relationships among cotton boll abscission, seedcotton yields and boll injury. First position white flowers on individual cotton plants were tagged daily and the date of anthesis was recorded. Boll age was calculated based on heat unit accumulation (25 HU per day) from the date of anthesis to the date of infestation. First instar bollworm larvae were caged on bolls of non-transgenic (cv. Deltapine 5415) or transgenic Bt (cv. NuCOTN 33B) cotton from June 29 to August 11 during 1997 and 1998. Boll abscission was measured at 72 HAI, 7 days after infestation (DAI) and at the time of harvest. Seedcotton weights were recorded at the time of harvest. Deltapine 5415 bolls that accumulated 179 (7.2 d), 281 (11.2 d), and 253 (10.1 d) HU beyond anthesis were safe from bollworm induced abscission, respectively, at 72 HAI, 7 DAI, and at the time of harvest. NuCOTN 33B bolls that accumulated 157 (6.3 d), 185 (7.4 d), and 180 (7.2 d) HU beyond anthesis, respectively, were safe from bollworm induced abscission at 72 HAI, 7 DAI, and at the time of harvest. Bollworm larvae significantly reduced seedcotton weights of Deltapine 5415 bolls that accumulated between 58.5 (2.3 d) and 350.5 (14.0 d) HU beyond anthesis. Seedcotton weights of NuCOTN 33B bolls that accumulated between 0 and 281 (11.2 d) HU beyond anthesis were significantly reduced by bollworm injury. Deltapine 5415 and NuCOTN 33B bolls that accumulated 426.5 (17.1 d) and 299.5 (12.0 d) HU beyond anthesis, respectively, were not injured by first instar bollworm larvae.

One experiment was conducted at six locations during 1998 to 1999 to determine when cotton plants reaches physiological cut-out in Louisiana. A yellow snap-on-tag was placed at NAWF stages 6, 5, 4, and 3. All plants within each plot were harvested and yields separated into that above and below the tags. These data show that 18%, 13%, 7%, and 2% of the total crop was produced by cotton plants on fruiting branches above NAWF 6, NAWF 5, NAWF 4, and NAWF3, respectively. **(LSU Agricultural Center's Northeast Research Station, St Joseph and Winnsboro, LA; Louisiana Cooperative Extension Service, Winnsboro, LA; and Department of Entomology, Baton Rouge, LA)**

Mississippi

Use of egg identification kits and the Tracer/pyrethroid/tracer (or mixture) cycle for early, mid and late season cotton, respectively, in the Mississippi hills worked exceptionally well for ultra narrow row cotton (UNR) for the last two seasons. Serious drought conditions caused UNR cotton to mature later than conventionally planted cotton in neighboring fields. Research on evaluating options for thresholds for Heliothis management on UNR cotton is continuing. Research with insecticide placed deeply under the furrow for management of tarnished plant bug during pinhead square stage of cotton development has been initiated. Results indicate some potential for plant bug management that may delay foliar insecticide application beyond pinhead-square stage. A survey of thrips on seedling cotton has demonstrated that the dominant species is tobacco thrips (>90%), with soybean thrips, flower thrips, western flower thrips, and others making up the rest of the population. Research was initiated to identify benefits if any of several adjuvants when used with insecticides against common insect pests of cotton (aphids, heliothines, and tarnished plant bugs) in Mississippi.

Research to validate or improve tarnished plant bug treatment thresholds in blooming cotton was initiated. These studies included small-plot tests, where immature insects were released, and large-plot trials using naturally occurring infestations of plant bugs. Poor establishment of released insects and low naturally-occurring populations limited the value of this research. Research was also initiated to determine whether new Bt-transgenic cotton expressing two Bt toxins (i.e., Bollgard II) gave superior control of common lepidopteran pests than currently-available Bt cotton expressing one toxin. Laboratory and field studies indicated that Bollgard II cotton would have a greater and wider range of activity on common lepidopteran pests (e.g., fall and beet armyworm, soybean looper, bollworm) than Bt cotton expressing a single toxin. Other on-going research includes investigating the potential uses of remote sensing and other spatial technologies in the sampling and management of insect pests.

Three projects in the realm of insect pathology are ongoing: 1) Microbial control of *Lygus lineolaris;* 2) Use of *Nomuraea rileyi* against noctuid pests; 3) Mass-rearing of predators of cotton pests.

Insect physiological studies that may have impact on cotton insect pest management have been initiated with a neuropeptide gene with expression in baculovirus vectors.

Overwintering tobacco budworm (TBW) and cotton bollworm (CBW) pupae were samples in untilled cotton fields in northeast Mississippi January-April 1999. TBW averaged 86 ha^{-1} and 29 ha^{-1}. This was up from the previous two years for TBW and up from the previous three years for CBW. Spring tillage destroyed most of these populations. Spring emergence of adult TBW under covers placed over sites of fall wild host plants averaged 2,533 ha^{-1}. This was much higher than in the previous year. Pheromone trap catches of TBW populations emerging from overwintering in the spring were high. Sampling of wild host plants for TBW and CBW larvae during June-August in Sunflower (Delta) and Monroe (Hills) counties indicated low population densities compared to fall wild host plants. Some conventionally managed (non-Bt) cotton fields had high populations. Sampling of wild host plants of TBW and CBW continued through the end of November. **(Department of Entomology, Mississippi State University, Mississippi State, MS)**

A simple experiment was conducted to determine the impact cotton bollworms (*Helicoverpa zea*) damage has on potential yields of field corn. In early May, a population of *H. zea* was detected along the perimeter of a nearby cornfield. High numbers of natural enemies also were detected. These insects were feeding directly in the whorl of plants and had consequently stunted the plants. Thirty damaged plants were tagged and evaluated over the next 2 months. It was determined that the impact of *H. zea* feeding on whorl stage corn will not significantly affect yield, since the plant is able to compensate later in development. These data support the recommendations that early-season field corn does not have to be chemically treated for whorl feeding *H. zea* because: 1) natural enemies keep populations below the economic injury level, and 2) the plant is able to compensate. Because this insect pest does utilize corn early in the cotton-growing season and is a valuable source of insecticide-susceptible *H. zea*, indiscriminately treating *H. zea* with the same classes of insecticides will hasten insecticide-resistance in this pest. Thus, corn host-plant resistance and other integrated pest management practices should be continued for corn in this part of the Cotton Belt.

In June of 1999, unusual lepidopteran eggs were detected in delta cotton fields. Egg collections were made and larvae were allowed to develop on artificial diet. Adults were identified as the granulate cutworm (*Feltia subterranea*). These data serve to illustrate the importance of using an egg diagnostic kit to properly identify eggs before recommendations to chemically control are initiated.

Seventeen commercially available transgenic Bt cotton cultivars (12 DP&L, 5 Paymaster), were evaluated in small-scale field plots. The effect of soil type, plant parts, cultivar, and stacking with a herbicide-resistant gene on insect survivorship was examined for intrinsically tolerant Lepidoptera (i.e. the fall armyworm, *Spodoptera frugiperda*, and the cotton bollworm, *Helicoverpa zea*). Wild populations of high-quality insects were utilized. Seven commercially available conventional cotton cultivars also were examined as controls. Results indicate that there is significantly more variability among survivorship for *H. zea* fed transgenic Bt cotton than conventional cotton. Soil type, plant part, cultivar, and stacking with a herbicide resistant gene had a significant affect on insect survivorship. These data indicate that there are many factors that influence the effectiveness of the CryIA(c) Bt protein on insect survival and that these transgenic cultivars may not provide the same control for *H. zea*. Because of these complexities, resistance management of the intrinsically tolerant Lepidoptera may be compromised.

The amount of CryIA δ-endotoxin expressed among various plant parts and varieties of transgenic Bt cotton was determined. The amount of protein was measured (ELISA) and correlated with insect survival (*H. zea*) and development (*H. zea* and *S. frugiperda*). Two commercially available transgenic cotton cultivars [NuCOTN 33B (DPL; Bollgard®) and DP451B/RR(DPL; Bollgard® + RoundUp Ready®) were evaluated throughout the growing season. Results show that expression of the toxin decreases in cotton leaves as the plant matures. In addition, significant differences were detected among plant parts and between the two varieties. These data further complicate resistance management of these pests.

Fall armyworms were selected with transgenic Bt cotton leaves and diet treated with a discriminating dose of Bt protein (MVPII) to examine the mode of inheritance of tolerance. Insect survival and development were recorded. Results are similar to *H. zea* in showing that tolerance is heritable among larvae and more than one gene is probably involved.

Because the fall armyworm is comprised of two host-associated strains that widely differ in their susceptibility to insecticides, it is important to be able to routinely identify the strains. Since there is no method to morphologically identify one strain from another, molecular or DNA methods must be used. The strain status on cotton is questionable as well as the affect Bt corn has on one strain versus another. Collections were made from both Bt corn as well as Bt cotton to determine which strain is present. Development is underway for setting up a routine DNA assay to determine strains.

Recent advancements make it possible to determine what a moth species fed on as a larva. The implications of this type of technology are extraordinary for area-management of migratory pests such as *H. zea*; however, this technology is in its infancy. Before one can be sure of what a pest fed on as a larva, certain profiles must be developed for different hosts (i.e. wild hosts, corn, cotton, milo, etc.). Moth species were collected from pheromone traps as well as larvae were collected from corn and reared on that host until pupation. These individuals were then placed in ethanol and sent to North Carolina State University for analysis.

Production of insects for USDA-ARS research by the Stoneville Rearing Unit required maintenance of six insect species: *Heliothis virescens*, *Helicoverpa zea*, *Anticarsia gemmatalis*, *Spodoptera exigua*, *Cardiochiles nigriceps*, and *Microplitis croceipes*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; Weslaco, TX; College Station, TX; and Gainesville, FL required production of 156,000 *H. virescens* pupae, 150,950 *H. zea* pupae, 66,900 *A. gemmatalis* pupae, 143,800 *Spodoptera exigua* pupae, 69,538 *Cardiochiles nigriceps* cocoons, 76,152 *Microplitis croceipes* cocoons, 39,000,000 *H. virescens* eggs, 37,737,500 *H. zea* eggs, 9,840,000 *A. gemmatalis* eggs, and 431,400,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 27,210 30-ml cups and 3,849 multicellular trays with artificial diet. Total diet mixed and dispensed in 1999 was 4,380 gals. Several short courses in insect rearing techniques were given to employees of Dupont Agricultural Enterprises, Newark, DE. Approximately 150 researchers located in 37 states, England, Canada, Japan, and Mexico participated in the Insect Distribution Program.

Second-year results of a BWACT® (bait stick) study in a portion of the boll weevil eradication program near Collins, MS were inconclusive. In addition, first-year data of a similar study near Leland, MS were also erratic and inconclusive. Because the entire state of Mississippi is now involved in a boll weevil eradication program, bait stick evaluations will be discontinued.

We cooperated with scientists in the Application and Production Technology Research Unit at Stoneville in evaluating insect counts throughout the season in conventional and ultra-narrow-row (UNR) cotton (both dryland and irrigated). Insect numbers were extremely low in 1999; however, trends indicated that boll weevil and tarnished plant bug numbers may be higher in UNR but beet armyworms may be reduced. The speculated cause for these minor differences is that a denser canopy in the UNR cotton favors boll weevil and tarnished plant bug reproduction (protection from heat, poorer insecticide penetration) and deters beet armyworm because it prefers a spotty stand of cotton. More research is planned.

Moth trap records in 1999 collected at the same trap sites since 1995 showed that numbers of beet armyworms, bollworms, and tobacco budworms were the lowest on record. This supports the general observation of one of the lightest insect years in Mississippi cotton fields in recent memory. The cause of the low numbers is not known and is open to speculation.

Since 1991 (budworm) and 1996 (bollworm) we have made field collections of each generation (May through August) of both species for evaluation of response to five classes of insecticides in a spray chamber simulating field application conditions. As in previous years, all generations of budworms were not controlled with pyrethroids and susceptibility of generations 2-4 was reduced to all others tested except Tracer®. Bollworms continued to remain susceptible as in previous years to all classes of insecticides throughout the season. However, for the first time, control was less than 100% with pyrethroids and curacron.

Comparison of numbers of boll weevils captured from March–October for 1995-1999 indicated over 90% reduction in boll weevils from August-October in 1999 after diapause treatments began in the now state-wide boll weevil eradication program when compared to other years. Before boll weevil eradication (1995-1998), numbers captured in traps increased approximately 6-fold between spring and fall; in 1999 during boll weevil eradication numbers declined by 40%, during the same period or a 10-fold swing in numbers, or approximately a 90% decrease. Therefore, if the Mississippi Delta experiences an overdue severe winter in 1999-2000, boll weevil numbers will be severely reduced between the spring of 1999 and the growing season of 2000, which will be a major factor in the success of boll weevil eradication. Trap data and field observations suggested that increased numbers of boll weevils captured from mid-October to frost can be partially explained by release of boll weevils trapped in unopened bolls when stalks are cut. Other possible explanations include 1) a natural increase of boll weevils in fields affected by a combination of early picking, failure to cut stalks, and re-growth before frost and, 2) fields of late cotton producing boll weevils because of poor or delayed insecticide treatments, poor coverage, hard to reach areas (under powerlines, adjacent to trees, near populated areas, etc.) or a combination of these three factors.

In evaluation tests for control of cotton aphid, Bidrin, Furadan, Leverage and Provada significantly reduced aphid numbers when compared to Baythroid and an untreated control. Baythroid actually increased aphid numbers, and Furadan remained the most effective treatment.

Over 20 Bt and non-Bt varieties of cotton were evaluated in 1999 for variations in insect populations and yield. Because of generally low insect numbers in 1999, no conclusions were drawn as to effectiveness in insect suppression. Yield data are still being collected. Likewise, little or no meaningful data were collected in evaluations of Bollgard II (CryX, or double Bt gene) cottons because of low insect numbers.

The second of a three-year economic and biological study on Bt and non-Bt cotton has been completed. Fourteen farms that produced Bt and non-Bt cotton and which represented the different growing regions of the Mississippi Delta were included in the study. The project was a cooperative effort between ARS and Delta Research and Extension Center. Partial funding for the 3-year study began in 1998. In 1999 the average of fourteen farms Bt cotton yielded 18 pounds more lint than the non-Bt. The total specified insect cost per acre on Bt was nine dollars more than non-Bt. The difference included the technology fee. Yields of cotton on farms that planted 20-B were higher than those that planted 33-B. SureGrow 125 and BXM-47 were the highest yielding non-Bt varieties. Biological data collected during 1999 indicated that all insect populations in cotton were lower than in 1998.

Six different insecticides were evaluated for tarnished plant bug control in NuCotn 33B cotton in replicated small plots. New insecticides Regent, Actara, and Steward, were evaluated at two rates. Acetamiprid was applied at one rate. Orthene and Vydate were applied at one rate each and were used as the standard against the new insecticides and an untreated check. TPB populations were low at the beginning of the season and developed slowly, even in the untreated check. Insecticide treatments were actually started early anticipating boll weevil eradication sprays that began 1 August. At the end of July, populations in the untreated check were averaging over thirteen thousand/acre. Populations in all treatments were significantly lower than the check when sampled with drop cloth. Yields were eratic in non-irrigated cotton because of the hot, dry summer.

Regent and Actara were evaluated in large field plots (3-4 acres) under a EUP Permit for tarnished plant bug control. Both insecticide treatments were compared to the standard insecticides, Orthene, Vydate, and Leverage (mixture of Baythroid and Provado) and an untreated check. Populations of TPB were lower than anticipated throughout the season. Only three applications of each insecticide were made before boll weevil eradication treatments began on 1 August. By the end of July, all treatments had significantly lower TPB populations than the untreated check when sampled by drop cloth. There were no differences between the treatments and the untreated check when cotton was harvested.

A large field plot study in 3 locations was carried out to evaluate temik applied in-furrow and as a sidedress application. Treatments were temik at 0.50 and 0.75 lbs AI/acre applied in-furrow, temik 0.50 and 0.75 lbs AI/acre applied in-furrow followed by 0.75 lb AI/acre applied as a sidedress, and temik 0.50 lbs AI/acre in-furrow followed after emergence with foliar application of Vydate 0.25 lbs AI/acre. There was also an untreated check. Thrips and aphid infestations were high at all locations. Temik did an excellent job in controlling thrips and suppressing aphids below that of the check. Yield at all locations was higher in temik treatments applied both as an in-furrow and sidedress than applied as an in-furrow treatment.

Studies on several aspects of reproductive diapause in the tarnished plant bug begun in 1998 were continued in 1999. These studies showed that nymphs are sensitive to changing daylength, and that nymphs developing at a daylength of about 13.5 h or less begin producing adults in diapause. As the daylength continues to decrease, the number of adults produced in diapause increases. Nymphs collected on weeds in the last week of September and during all of October produced adult populations of which >90% of the males and females were in reproductive diapause. However, a few reproductive adults were also produced. This past winter reproductive diapause was terminated by mid- to late-December and viable eggs were found along with first instar nymphs on wild host plants in late-January in the Delta. These nymphs required about 40 days to become F_1 adults in March. The winter of 1998-99 was a mild one, and the study will be continued for another 1-2 years in hopes of studying the effects of a cold winter on reproductive diapause in plant bugs.

Tarnished plant bugs were collected from three locations in Washington County (Winterville, near Avon, and along the Old Leland Road) in the last week of July and their levels of tolerance to malathion was determined using a glass vial bioassay. In the first week of August, fall diapause applications with malathion to all cotton in the county were begun as part of Boll Weevil Eradication. Since August is a month in which a high percentage of the total plant bug population is in cotton (because of an absence of abundant wild hosts), the several applications of malathion could act as an intensive selection pressure for insecticide resistance. To test this hypothesis, plant bugs were collected in late-October (after all diapause applications) from the same 3 locations and their tolerance to malathion was again determined. The LC_{50} value for malathion for susceptible plant bugs from Crossett, AR is 4.1 micrograms per vial. The LC_{50} values for plant bugs from the 3 locations in Washington County in late July were 17.8, 3.4, and 3.7 micrograms per vial for Old Leland Road, Winterville, and Avon, respectively. Their LC_{50} values determined in late-October after diapause applications were 81.8, 72.2, and 24.2 micrograms per vial for Old Leland Road, Winterville, and Avon, respectively. Comparing October values to July values shows a 5 to 21 fold increase in resistance. The highest LC_{50} value of 81.8 is 20 times higher than the susceptible bugs from Crossett. Additional tests on the nature of the resistance and tolerance to other insecticides are being done using a laboratory colony established from the Old Leland Road collection site.

A survey conducted in 1998 to determine if plant bugs in the Delta have increased tolerance to orthene was repeated in October 1999. The same 20 collection locations used in 1998 were used in 1999 (4 in AR, 2 in LA, and 14 in MS). Plant bugs collected at each location were tested for resistance to Orthene using a glass-vial bioassay. LC_{50} values obtained for each location were compared to an LC_{50} value for orthene obtained from testing susceptible bugs from Crossett, AR. The highest amount of resistance found in 1998 was 3-fold and was found in bugs collected near Indianola, MS. In 1999, bugs from 3 locations in AR had 3.2- to 4.6-fold resistance to orthene. This level of resistance would probably decrease the effectiveness of orthene, but would probably not cause a control failure. The highest amount of resistance found in the 14 locations in MS was only 1.6-fold. Resistance in bugs from the 2 locations in LA was 3.3- and 3.5-fold. In 1998, all locations in AR and LA had less than a 2-fold resistance to orthene, and only two locations in MS had greater than a 2-fold resistance to orthene. So, orthene tolerance declined in 1999 in MS and increased in AR and LA.

Sticky traps baited with virgin males or females or synthetic baits were tested during the summer for their effectiveness in capturing plant bugs. In one test , one synthetic lure baited trap treatment captured 72% more plant bugs than were caught in the check, but only 15% of what was captured in the best treatment (traps baited with 10 virgin females). In a second test, two different treatments of traps baited with synthetic lures captured 3- and 2.6-fold more plant bugs than the check, but only 18 and 15% of what was captured in traps baited with 10 females. These results are encouraging in that the synthetic baits (from Jeff Aldrich) were more attractive than the check. A plant attractant formulated by Dick Dickens was not very effective in the traps.

A large experiment designed to evaluate control of tarnished plant bugs in cotton by reduction in numbers of wild hosts available for plant bug population buildups in the spring was conducted again in 1999. Four areas (3 in Washington and 1 in Sunflower Counties) each 3 X 3 miles in size, were used in both years. In 1999 two of the areas were checks (three areas in 1998) and received no treatment, while the other two areas (1 area in 1998) were treated in late-March and early-April with a broad leaf weed killer (Trimec) or mowing. The treated areas were near Dunleith and Tribbett; the check areas were at Hollandale and Kenlock. Treatments were applied in both years only to those marginal areas by roads, fields, or ditches, in which wild hosts were found. Prior to treatment in both years, wild hosts were sampled for plant bugs in all 4 areas. In addition, densities of the wild hosts were determined. These samples were repeated at the same locations 3-4 weeks after treatment. In June and July, cotton fields were sampled for plant bugs each week using a sweep net. The number of samples per field varied with field size and ranged from 10 to >50. Each sample was 25 sweeps taken back and forth over a single row as the sampler walked down the row. In most weeks 15 fields were sampled in each of the 4 experimental areas. Numbers of fields sampled were decreased in 2 weeks due to heavy rain or widespread application of Furadan for aphids. Since group IV and V soybeans and corn were found to be plant bug hosts in 1998, soybean fields were extensively sampled in 1999 (no corn fields were found in any of the 4 test areas). Soybean fields were sampled with a sweep net for adults and a drop cloth for nymphs. Four fields from each of the 4 experimental areas were sampled each week. In cotton fields bordered by soybeans extra samples were taken in the cotton field along its border with the soybeans. These samples were taken 100 ft or less from the border to determine if soybeans influenced numbers of plant bugs in cotton.

Plant bugs averaged 0.18 adults and nymphs per 25 sweep sample in the two check areas, and 0.06 per sample in the two treated areas over the 8-week sampling period. This was an average 3-fold reduction in numbers of bugs in the treated areas. Analyses of weekly data found significant differences in number of bugs during the third and fourth weeks of July. In the third week significantly more bugs were found in the check areas, a mean of 0.295/sample vs 0.038 in the treated areas. In the fourth week of July there were again significantly more bugs in the check areas, a mean of 0.434/sample vs 0.087 in the treated areas.

Tarnished plant bug populations in the soybeans averaged 1197 adults and nymphs per acre in the two treated areas, and

1219 per acre in the two check areas over the 8-week sampling period. In the 2nd week of June, soybean fields in the treated area at Dunleith had significantly lower numbers of bugs than in the other three test areas. This was the only week with significant differences in numbers of bugs in the soybeans. The highest population of 4580 per acre was found in the treated area at Tribbett during the first week of June. Soybeans influenced numbers of bugs found in cotton adjacent to them. Over the 8-week period plant bugs averaged 0.29 per sample in the extra samples taken in cotton less than 100 ft from its border with soybeans In samples taken in cotton >100 ft from an edge they averaged 0.117 per sample, while in samples in cotton <100 ft from an edge without soybeans they averaged 0.122 per sample. In the 3rd week of July plant bug numbers found in cotton >100 ft from an edge were significantly higher in the two check areas as compared to the two treated areas. Numbers found in the extra samples were also significantly higher in the check areas as compared to the treated areas. In the 4th week of July numbers of plant bugs in the check areas in the extra samples, the samples <100 ft from an edge, and the samples >100 ft from an edge, were all significantly higher than the corresponding numbers of bugs found in the treated areas.

The impact of a lower application rate of Gemstar™ with a virus enhancing agent, Blankophor BBH, was evaluated on the emergence of Heliothine adults from early season wild geranium in a small cage study. A virus preparation diluted in 0.5% Blankophor BBH and applied at a lower virus application rate was not as effective as the current recommended virus application rate in the area-wide virus program. These results indicate that using the virus enhancing agent with HzSNPV at a lower application rate would not provide any significant savings in the area-wide virus program.

A study was conducted to assess the effect of host plant on virus activity of the *Anagrapha falcifera* nucleopolyhedrovirus (AnfaNPV) on four host plants; white clover, *Trifolium repens;* velvetleaf, *Abutilon theophrasti;* soybean, *Glycine max;* and cotton, *Gossypium hirsutum*. Virus-infected insects survived longer on cotton than on the other plant genotypes evaluated in this study. Insects reared on the four host plants that succumbed to virus infection have been frozen and await examination to determine virus yield.

A laboratory and field study was conducted to evaluate the impact of lower rates of the *Helicoverpa zea* nucleopolyhedrovirus (HzSNPV) against *H. zea* on Bt cotton. In the laboratory study, virus-infected *H. zea* neonates reared on diet containing the Bt toxin more readily succumbed to virus infection and died. In the field study, lower virus application rates were shown to be more effective against cotton bollworms on Bt cotton.

A critical factor in the effectiveness of insect viruses as microbial control agents is their short persistence on leaf surfaces. Several additives to formulations of *Helicoverpa zea* nucleopolyhedrovirus (HzSNPV) were applied to cotton and sampled for nine days. None of the additives evaluated showed any increase in virus persistence on cotton.

Field populations of cotton bollworm and tobacco budworm were monitored for their tolerance to the Bt toxin Cry1Ac. Analyses of field-collected populations of the cotton bollworm found significant heritable tolerances to Cry1Ac. Evidence for a further shift in the tolerance of cotton bollworm from 1997 to 1998 was found in 1999 populations. No changes were observed in populations of the tobacco budworm.

The genetic architecture of resistance plays an important role in determining how and when an insect population evolves tolerance to an insecticide. The cotton bollworm, *Helicoverpa zea* (Boddie), is more intrinsically tolerant of Cry1Ac than another major pest of cotton, tobacco budworm, *Heliothis virescens* F. As a consequence, it has been speculated that the inheritance of tolerance to Cry1Ac may differ in these species. We used full-sib analysis to estimate the heritability of tolerance to Cry1Ac in a population of *H. zea*. Approximately 54% of the total phenotypic variation for tolerance of Cry1Ac was attributed to genetic variation. Follow-up tests using these same families found a significant linear relationship between the tolerance of parents and their offspring. The most tolerant families were an order of magnitude larger in size than the least tolerant families. Considerable heritable variation is therefore present in this population of *H. zea*, and unlike *H. virescens*, we concluded that a major gene is not affecting Cry1Ac tolerance.

Soybean looper larvae from the Mississippi Delta were collected from Bt and non-Bt cotton to determine the numbers of loopers in each variety and also to compare the rate of larval development on the two cotton varieties. There were significantly fewer larvae collected from Bt cotton than non-Bt cotton ($P < 0.01$) and the weights of these larvae were, on average, an order of magnitude smaller than larvae collected from non-Bt cotton ($P < 0.0001$). There was also an order of magnitude difference among the weights of larvae collected from Bt cotton, indicating considerable variability in the tolerance of the Bt toxin, Cry1Ac.

Studies were conducted to determine if beet armyworms, *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae), possess the genetic variation necessary to respond to selection for improved tolerance of the Bt toxin Cry1Ac. *S. exigua* individuals that were the fastest to reach pupation when fed Cry1Ac diet (ca. the first 20% to pupate) produced offspring that developed significantly faster on Cry1Ac diet than their parental-control strain. In addition, after two generations of selection, the selected population reached pupation 2 d faster than the control population. The selected group also developed significantly faster on transgenic-Bt cotton leaves (cv. NuCOTN 33B) than the control strain.

Effect of malathion applied in eradication on honeybee mortality was studied. A trailer containing a computer-based system for monitoring temperature, humidity, and honeybee activity at 10 different hives was received from Jerry Bromenshenk, University of Montana at Missoula. Monitoring began when trailer set-up was achieved in mid August. Problems with road construction and power outages hindered research, but significant progress was achieved. Because of drought conditions, cotton was cutting out, and little honeybee activity was observed in the cotton field even though all 10 hives were within 25 yards of the field. We estimated 1 bloom per foot of row when monitoring started. One serious kill of bees occurred after an application of Sevin to a neighboring soybean field, but no serious bee kills due to malathion application were observed. It appeared that maturing cotton was not very attractive to foraging honeybees. Data have been transmitted to Missoula and analysis will soon be underway.

Assuring that the bait sticks used in the boll weevil eradication program maintain high toxicity to boll weevils over the course of their use is important to the program. Toxicity of bait sticks has been measured by placing weevils on sticks for specified short time intervals (usually 30 sec.). Toxicity decreases with time in the field, but uncontrolled variables have resulted in erratic curves of toxicity versus time. We measured mortality of boll weevils placed on BWACTs and compared it to the amount of malathion washed from the surface of the BWACTs and total malathion in the tube. Toxicity over time was again erratic, but a highly significant correlation between mortality and malathion washed from the surface of bait sticks was established. We expect these data to form the basis for standards of quality for bait sticks purchased by the eradication program.

The effectiveness of an in-field attracticide, Last Call, produced by IPM Technologies (Portland, Oregon) was tested in field cages and pheromone traps. Measured blobs of the attracticide and control materials were placed on squaring and presquaring cotton plants in field cages. The attracticide was shown to cause significant mortality to weevils released in field cages. Tests conducted in Marianna, AR showed the attractiveness of Last Call to compare favorably to that of Hercon pheromone dispensers containing approximately 9.5 mg grandlure.

Laboratory and field studies were conducted to evaluate the effectiveness of an egg parasitoid, *Anaphes iole*, and three predators, *Orius insidiosus*, *Geocoris punctipes*, and *Chrysoperla refilabris*, on *Lygus lineolaris*. Results of these preliminary studies indicate that parasitism of *L. lineolaris* eggs by *A. iole* was <20%. Lab observation suggested that female wasps recognized *Lygus* eggs but had difficulty drilling through the plant tissue surrounding eggs. *Orius* did not prey on *Lygus* eggs, but had difficulty drilling through the plant tissue surrounding eggs. *Orius* did not prey on *Lygus* eggs but did prey on early instar nymphs. Early instar *G. punctipes* did not feed on *Lygus* eggs or early instar nymphs. *Chrysoperla* larvae consumed early instar *Lygus* nymphs.

Behavioral and pesticide bioassay methods were developed for minute parasitic Hymenoptera. The methods are relatively inexpensive, easy to setup, and require minimal space. The methods allow the use of living plant tissue and facilitate observation of wasps and assessment of sublethal as well as lethal effect of pesticides. Control mortality after 48 h exposure averaged ca. 5% for *A. iole*.

The methods developed above were used to assess the length of time that field-weathered residues of pesticides remained toxic to *A. iole*. Immediately after treatment, residues of all compounds (Orthene, Karate, Provado, and Vydate) resulted in nearly 100% mortality. Residual toxicity of Orthene and Karate declined relatively slowly; at 16 DAT wasp mortality was ca. 50%. Toxicity of Vydate and Provado residues declined more rapidly. At 6 DAT toxicity of Vydate residues was indistinguishable from control mortality. Provado residues 4 DAT resulted in 50% mortality which declined to ca. 22% 8 DAT.

The population dynamics of *L. lineolaris* and its natural enemies was studied in 4 alfalfa fields in Mississippi from April through October. *Lygus* egg densities and insect abundance were assessed weekly. Collection methods included sweeping, yellow bowl traps, yellow sticky traps, malaise traps, and vacuum sampling. Samples are still being sorted, but it is clear that densities of *Lygus* and beneficial insects varied greatly between sites.

A preliminary survey of nymphal parasitoids of *L. lineolaris* was conducted in the Midsouth. More than 100 parasitoids were reared from nymphs at several sites. Adult wasps have not yet emerged, but the cocoons appear to be those of Euphorine braconids.

A lab colony of *Peristenus howardi* was initiated. This wasp is a nymphal parasitoid of *L. Hesperus* in the western U.S. It is a newly-described native species that is multivoltine and has a female-biased sex ratio. Females readily sting early instar *L. lineolaris*; the F_1 generation increased 15-fold over the founding stock.

A field study was initiated on the flight dispersal of *L. lineolaris*. Objectives were to assess the impact of climatic and physiological factors on dispersal. Three trials were conducted using the mark-release-recapture approach. Preliminary results indicate that recovery rate of marked bugs varied from 2 to 9%. Wind speed and direction had considerable influence on flight. Wind speeds greater than ca. 6 mph led to mostly downwind flight. When winds were calm, *Lygus* dispersal appeared to be omnidirectional. Physiological factors (egg load, gender, age) of recaptured bugs have yet to be assessed.

Two varieties of Bollgard II®Monsanto) were evaluated for *H. zea* and *S. frugiperda* control. Laboratory results indicate improved efficacy against these pests.

E. I. Dupont de Nemours & Co. has several recombinant baculoviruses undergoing development that infect insect pest species of cotton. These recombinant viruses should provide better protection to cotton and offer another tactic to an integrated pest management program. Data were collected to evaluate field activity in large cage trials against *H. zea* and *H. virescens* on cotton. Results from this study were reported through a Cooperative Research and Development Agreement.

A laboratory study was conducted to assess the effect of dietary components in the insect medium on *in vivo* virus production. *Autographa californica* nucleopolyhedrovirus (AcMNPV) yield in *Heliothis virescens* was affected by modifications of the insect diet components. Results from this study were reported through a Cooperative Research and Development Agreement**. (USDA, ARS, Southern Insect Management Research Unit, Stoneville, MS)**

A computer monitoring system tracked activity of honeybees entering and leaving 10 small hives set up in mid-August within 25 yards of a cotton field. Mid-August through mid-October applications of malathion for boll weevil eradication in that field appeared to have no serious effect on mortality of honeybees in the hives. Bee activity was minimal in the neighboring field probably because of early cut-out of the crop caused by drought. One instance of high honeybee mortality was observed after an application of Sevin to a nearby soybean field.

Mortality of boll weevils placed on boll weevil bait sticks (Boll Weevil Attract and Control Tubes = BWACTs) was highly correlated with the amount malathion washed from the surface of BWACTs, but not with total malathion in the tube. We expect these data to form the basis for standards of quality for bait sticks purchased by the eradication program.

An in-field attracticide, Last Call, produced by IPM Technologies (Portland, Oregon) was tested in field cages and pheromone traps. The attracticide was shown to cause significant mortality to weevils released in twenty 6X6X6' field cages. Trapping studies conducted in Marianna, AK showed the attractiveness of Last Call to compare favorably to that of pheromone dispensers containing approximately 9.5 mg grandlure. **(USDA, Southern Insect Management Research Unit, Mississippi State, MS)**

We developed a new artificial diet for *Lygus* spp., which led to the application for a broad patent covering the diet for entomophages and for plant feeders that are facultative entomophages.

A new cage was developed for mass rearing of *Lygus* spp. to support *in vivo* rearing of *Anaphes iole*. A single new cage replaces seven or more of the old box type cages and requires less handling of the insects.

Anaphes iole females were found to frequently superparasitize *Lygus* spp. eggs in high density insect cultures, and that often several larvae will develop in a single host eggs. Superparasitization will have negative effects on the quality of adults of this parasitoid. Other findings of this study include the facts that female *A. iole* larvae often attack and kill other larvae in the egg, the larvae are sexually dimorphic, and that the larvae feed primarily on solid particulate matter found in the host egg. These findings are being applied to the development of an *in vitro* mass rearing system.

We designed and built a machine for producing 6X24 inch packages of Artificial Media for Rearing Entomophages (U.S. Patent #5,834,177) for use in rearing *Chrysoperla* spp. This machine, which is capable of packaging approximately 350 lbs. of diet per day, was developed under a CRADA. A Phase I SBIR Grant was recently awarded to the CRADA partner to support further evaluation and commercial development of this machine.

Two new strategies were developed for packaging of semi-solid artificial diets for presentation to predaceous insects. Both of these strategies lend themselves to automation.

We designed and built an improved lepidopterous egg harvesting/collection system, which consists of fewer moving parts and which is less subject to corrosion. This device was developed under a CRADA and is currently in use by the CRADA partner. In addition, a system was designed and built for more efficiently distributing *Chrysoperla* spp. eggs into Verticle larval rearing units. This automated system distributed 1-4 eggs in 78% of cells, which is significantly more efficient than manual systems.

A system was developed for mixing 30 kg batches of the Artificial Media for Rearing Entomophages, as opposed to the 0.5 kg batches in the original publication, which reduced labor costs associated with mixing from $32/kg to $0.52/kg.. **(USDA, ARS, Biological Control and Mass Rearing Research Unit, Mississippi State, MS)**

In cotton production, there are many factors than can reduce crop yield. One important cause is insects. Generally, the different species of insects affect yield by damage to either (1) leaves, stems, and roots, or (2) to the cotton fruit (e.g., squares, blooms, or immature bolls). Insects that cause loss to the fruit are frequently more destructive than those that damage leaves, stems and roots. This study describes an approach toward improving insect control practices directed against fruit feeding insects by integrating remote sensing imagery with on the ground sampling efforts by cotton scouts.

Generally, in this study, it has been determined that the use of multi-spectral, high resolution imagery maximizes the efficiency and value of sampling large cotton fields for insect pest that attack cotton squares (i.e., flower buds). Prior to the use of imagery, if a field were to be scouted for a pest with enough sample sites to detect a spatial pattern, considerable effort would have to be expended in obtaining enough samples from different sites across a cotton field. The time and number of persons required to map a large field with good precision would be too expensive to be affordable. However, with the use of imagery several advantages result that save time and labor. In essence, more acres of cotton can be effectively scouted with fewer samples and personnel. This improvement in scouting efficiency results chiefly through improved selection of sample sites before the field consultant even enters a field. By having in hand, a recent multi-spectral image of the crop, the consultant can quickly determine the spatial configuration of differences in crop growth. This task can be easily accomplished because the imagery measures, as different spectral classes, those portions of the cotton crop where density, plant canopy, and vigor of fruit initiation (i.e., squaring rate) are most favorable for attracting insect pests that use squares as their food and oviposition resource.

Once, differences in crop development have been captured on an image map, scouting the crop becomes considerably easier. The ecological premise at work is that just as the sensors used to acquire the image detect differences in crop status, so do many species of insects (e.g., plant bugs, boll weevils, and noctuid moths) have the sensory and behavioral capabilities to respond to differences in cotton phenological development. As a result, the first areas of a crop to be attacked by an insect pest are likely to be those areas where the crop vigor is best. Since the image can distinguish between different areas of crop vigor, the image once classified with the use of the normalized difference vegetation index (NDVI), defines the different sampling strata for the consultant to use in the selection of both his sample locations and how many samples to use in each strata. The different strata correspond to different ranges of values of the NDVI.

Whenever the combined effort of imagery and scouting indicate a pattern in the spatial distribution of a cotton pest and the spectral characteristics from different populations of cotton plants in a field it is possible to develop a spatially registered map prescribing which areas in a field are to be sprayed or unsprayed. The spatially variable insecticide (SVI) application map can be uploaded into a controller on a GPS equipped sprayer. The GPS-GIS capabilities of the equipment of the ground sprayer determine which areas of the field are sprayed or unsprayed for a particular cotton pest, such as the plant bug.

Ultimately, through the use of imagery for improving the scouting of cotton for major insect pests there will be a reduction in the amount, frequency and cost of insecticide applications. Whenever a spray application is needed, improvement in the timing of that application will also occur. By improving both the timing and the spatial application of insecticides it is expected to enhance the stewardship of the environment, reduce the cost of production to the producer, and maintain or even increase yield in cotton. (**USDA, ARS, Crop Simulation Research Unit, Mississippi State, MS**)

Missouri

Both experimental and registered cotton insecticides were evaluated in nine field trials. These tests included: at-planting and foliar thrips trials; plant bug/fleahopper control; and bollworm, boll weevil, and spider mite trials. Results from the foliar thrips, boll weevil, and bollworm trials were inconclusive. Bollworm infestations never developed to high levels, because field plots were non-irrigated and plants were drought stressed.

For the in-furrow thrips trial 29 days after planting at Portageville, plots treated with Admire (0.05 lbs AI/A), Admire (0.05 lbs AI/A) + Orthene 97G (0.5 lbs AI/A), and Gaucho (seed treatment) had significantly lower thrips populations than untreated ones. The top three treatments in yield (lbs seed cotton/A) were: Admire (0.05), Admire (0.05) + Orthene 97G (0.5), and Gaucho.

Both Portageville plant bug trials had low adult counts and nearly nonexistent nymphal populations; however, significant differences among treatments were observed with cotton fleahopper infestations. In trial one, the top three treatments with the lowest fleahopper counts were: Fulfill (0.28 lbs AI/A), Karate Z (0.033 lbs AI/A), and Vydate (0.033 lbs AI/A). In trial two, the top three treatments with the lowest fleahopper counts were: Regent (0.038, 0.05 lbs AI/A) and Actara (0.079 lbs AI/A).

In a Portageville spider mite trial, all treatments except [Lorsban (0.05 lbs AI/A)] had significantly lower spider mite counts than untreated plots 11 days after treatment. The top three treatments with the lowest spider mite counts were: Comite (1.6 lbs AI/A), Kelthane (1.5 lbs AI/A), and Capture (0.1 lbs AI/A). No significant differences in yield (lbs seed cotton/A) were observed among treatments, but the top three treatments were: Denim (0.01 lbs AI/A) and Kelthane (1.0 and 1.5 lbs AI/A).

In a state Cotton Incorporated-funded project looking at different infestation levels of boll weevils and their economic impact, yield data was inconclusive at Clarkton. No significant yield differences were observed at Portageville; however, the treated plots yielded .85 lbs more seed cotton per acre than untreated ones. A combination of lower boll weevil infestations and drought-stressed plants minimized feeding pressure in field plots.

A total of 501 cotton bollworm male moths were collected in pheromone-baited cone traps and tested for susceptibility to cypermethrin. These treated vial tests were held in conjunction with the Insecticide Resistance Actions Committee's *Helicoverpa zea* monitoring program. Corrected mean survival of moths at both the 5 and 10µg doses of cypermethrin was 4.2%. **(University of Missouri, Agricultural Experiment Station, Delta Research Center, Portageville, MO)**

New Mexico

A number of tests were conducted to evaluate various formulations and trap designs for boll weevil control. For example, field tests were continued to identify a microencapsulated malathion formulation with longer residual activity against boll weevil allowing eradication programs to make applications less frequently. This work was conducted with the USDA Methods Development Lab in Phoenix, AZ. Results of the first large-scale field trial are very encouraging and indicate that we may be able to reduce application intervals. Residual activity in the field against *Catolaccu grandis* was also evaluated. Tests in eastern New Mexico and the Pecos Valley to evaluate the effect of habitat on boll weevil overwintering were also continued.

Bt cotton variety trials were conducted in both the Mesilla and Pecos Valleys on commercial and experiment station farms. A third year of testing was also conducted to evaluate variation in resistant in Bt varieties. A second year of field tests were completed to determine crop value by time and boll position with 2 Bt cotton varieties, 1 locally adapted Acala 1517 variety, and one stripper variety (HS-26) commonly grown in eastern NM. For the third year samples were collected to determine the impact of Bt cotton on beneficial arthropods.

Tests were also conducted to evaluate the impact of row orientation and row spacing on crop microclimate and mortality of boll weevil and cotton bollworm. Rows oriented east west vs. north south were significantly warmer and drier and had higher boll weevil mortality in furrow. There were no significant differences in yield. Ultra-narrow row spacing (7") had significantly higher boll weevil survival than 28" and 40" rows.

Tests were conducted in Las Cruces and Artesia to evaluate the impact of natural predation on cotton bollworm mortality. **(Cooperative Extension Service and Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Artesia and Las Cruces, NM)**

North Carolina

The third of a multi-year test of the effectiveness several thrips control options in striper-harvested, Roundup Ready, Ultra Narrow Row (UNR) cotton (7.5-inch row spacing) was conducted in three replicated tests in the northcentral and central cotton growing regions of North Carolina. Due to the high cost of 'in-row' strategies (such as a granular at-planting insecticide such as Temik or a seed treatment such as Gaucho) the value (yield x $.7 minus chemical and application costs) of foliar treatment(s) appears to be somewhat higher than the former options, particularly with herbicide-tolerant cotton (which facilitates the `piggybacking' of a foliar thrips treatment along with the herbicide) virtually universal in UNR cotton.

Two early season tobacco budworm tests were carried out for the 6th year in southern North Carolina in an area of moderate second generation budworm pressure. Treatments in the first small plot, replicated test included various square and terminal removal plots, coinciding with the arrival of the second generation tobacco budworm generation flight. Removal of up to 50% squares and 50% terminals has resulted in no yields loss compared to the untreated check for the past 6 years, and very little delay in maturity.

A second test, which evaluated pyrethroid alternatives for control of second generation tobacco budworms, compared Tracer (0.045 lb. ai/acre), Larvin (0.6), a pyrethroid (Karate @ 0.025) Steward (0.09), Vydate (0.5), and an untreated check. No significant differences were noted between treatments in damaged terminals or squares, live budworms in terminals or squares, although numerical trends favored Steward and Tracer. No significant differences in yield were noted, although Vydate had the highest yield numerically, despite its higher insect damage (perhaps due to the product's activity against nematodes).

In a late-season insect (bollworms, European corn borers, fall armyworms and stink bugs) boll damage comparison of Bt (Bollgard) vs. conventional (pyrethroid-protected) fields under producer conditions, 51 Bollgard fields were compared with 51 conventionally treated paired fields, either managed by the same producer and/or in close proximity. This 'real world' evaluation of the efficacy of Bollgard cotton has now been undertaken for 4 years, 1996 through 1999 (712 total fields). The 51 producer-managed Bollgard fields sustained approximately one half as much damage from bollworms as did the conventional comparison fields: 1.39% vs. 3.20% in the conventional fields. Stink bug damage in the conventional cotton fields averaged 0.69% vs. 3.18% in the Bollgard fields. European corn borer (ECB) damage in the Bollgard fields was 0.0% vs. 0.08% in the conventional fields; fall armyworm boll damage was 0.06% in the Bollgard fields vs. 0.27% in the conventional fields. Overall damage for both protection systems in 1999, including stink bugs, was slightly lower in the conventional fields, 4.24% vs. 4.63%. A survey of North Carolina's licensed independent crop consultants working on cotton was conducted again 1999 to gather data on how second generation (June and early July) tobacco budworms, late-season bollworms, thrips, cotton aphids, and plant bugs and managed by these individuals in conventional and in Bollgard cotton (244,700 acres). Additional growers and selected county agents were contacted to make the survey more representative of the overall producer population. A very low 0.86% of the acres was treated for early budworms, (10% of the acreage treated in 1998). Supplemental foliar treatment(s) was used control for thrips on about 60% of the state's cotton acreage, which is very high for our cotton producers, who typically average 25 to 30% foliar-treated acreage. A very low 1.0% of cotton acres were treated for plant bugs, down from 3.3 and 6.1% in 1997 and 1998, respectively. Only 1.4% of our acreage was treated for cotton aphids (about average). Approximately 34% of the Bollgard cotton was not treated, while 65% and 1% received 1 and 2 applications, respectively, almost all for bollworms. Cotton producers average 0.69 treatments for their Bollgard cotton for late-season insects and 2.05 treatments on their conventional cotton, both down by approximately 50% from 1998. Only 0.05% of the Bollgard cotton was treated specifically for stink bugs in 1999, while 4.9% was treated specifically for plant bugs. Average plant heights for the Bollgard vs. the conventional cotton fields was 37.0 vs. 36.5 inches, respectively

Two Bollgard tests were undertaken in 1999 which addressed 1) bollworm thresholds, and 2) the relative susceptibility of various commercial Bollgard varieties to bollworms and stink bugs. Evaluations in Test 1 included various egg, larval and bollworm-damaged thresholds. Bollworm establishment, fruit damage levels, and yields losses continue to suggest that protective thresholds are needed for late-season insect damage under typical North Carolina conditions. In a test of 17 Bollgard and 3 conventional varieties, with the representatives of the two technologies within the same test but selectively hand-treated based on need, all of the Bollgard varieties (untreated) sustained bollworm damage to bolls of less than 8% except Sure Grow 125 BR, which showed 26% damaged bolls. Preliminary results showed that the harvested seed from these plots was not expressing the Bollgard gene, although a sample from the lot of the original planted seed was positive for the gene. Stink bug-damaged bolls in the Bollgard lines ranged from a low of 1% in Sure Grow 125 BG to a high of 20% in Deltapine 655 B/RR. Oddly, the relationship between stink bug damage and maturity was relatively weak. Deltapine 655, showing bollworm damage second to now-removed ST 4740 BG in 1998, sustained only moderate boll damage in 1999, although the number of live bollworms in DP 655 B/RR was second to Sure Grow 125 BR. All 3 conventional varieties (treated a single time) showed zero boll damage from stink bugs, confirming the efficacy of pyrethroids against southern green stink bugs (the predominant species observed at this location in 1999). No disruptive over-the-top sprays or irrigation were used in this study.

Limited adult vial testing for bollworm tolerance to pyrethroids revealed no survival of two August (southeastern and far-eastern) and a single September (northcentral) population at the 5 and 10 microgram cypermethrin level. More extensive evaluations of several northern and northeastern bollworm adult populations by Drs. Van Duyn and Bradley showed adult survival ranging from 1% to 33% for at 5 micrograms and from 0% to 5% at 10 micrograms in August populations. For September bollworm adults, survival varied from 0% to 10% survival at 5 micrograms to 0% to 14% survival at 10 micrograms. The above results suggest that bollworms, although generally very susceptible to pyrethroids in most fields in North Carolina, nevertheless are showing increased tolerance to pyrethroids in some populations

Three insecticide screening tests for bollworm control were conducted in 1999. In conventional cotton, all of the labeled pyrethroids tested showed numerically less boll damage than Tracer SC (0.63 lb ai/acre), while the 0.11 lb. ai/acre rate of Steward 1.25 SC performed better against bollworms than at the 0.09 rate. In Bollgard cotton, Karate, Tracer and Steward (same as rates above) all showed significantly less bollworm boll damage than the untreated check and were statistically similar to each other. Stink bugs were at low levels at this location. In ultra narrow row cotton, late-season insect pressure and establishment were nearly identical to that found in conventional cotton plots which were untreated or sprayed 1, 2, and 3 times. **(Cotton Extension IPM Project, Department of Entomology, NCSU.)**

Larvae were field collected from either Bt or non-Bt sweet corn. Larvae collected from a Bt host were transferred to artificial diet containing 0.1 µg/ml of CryIAc toxin. Selection experiments were performed to determine the rate of adaptation to varying levels of CryIAc. The selected colony developed ca. 50-fold resistance to CryIAc in only 6 generations and ca. 100-fold in 10 generations. Reciprocal crosses of control and selected individuals revealed high LC_{50} values for the progeny of these crosses which suggested that the resistance trait for Bt may be inherited as a dominant or incompletely dominant gene. Studies on cross-resistance to CryIIA toxin revealed low levels of cross-resistance as the selected strain was only 3X more resistant to CryIIA than the susceptible strain.

In three field studies Bollgard II lines (15813 and 15985) sustained significantly lower terminal, square, and boll damage compared to a commercial Bollgard variety (DP 50B) and a conventional cotton variety (DP 50). There were no significant differences between Bollgard II lines with respect to any of the data recorded.

The four genotypes were also evaluated in greenhouse environments for resistance to two bollworm populations; one population had been selected for thirteen generations for tolerance to the CryIAc toxin and the other population was field collected just prior to plant infestation. In the greenhouse Bollgard II lines significantly reduced penetration of cotton fruit for both the field and laboratory-selected strains of bollworm compared to DP 50B. However, larval survival and fruit damage by the laboratory-selected bollworm strain were significantly higher than that of the field-collected, non-selected strain.

A greenhouse study was performed to assess the damage and reproductive potentials of the two thrips species under environmental conditions simulating May 1-21 in North Carolina. Through measurements of plant biomass at the end of the study and visual plant damage ratings, the damage potential of tobacco thrips was found to be significantly less than that of the western flower thrips. There were no differences found in the reproductive potential of either species on either of two cotton varieties, DP 436RR and ST 474.

In test for efficacy against bollworm, Steward provided control equal to that of the standards, Tracer and various pyrethroids. S-1812, a compound with unknown chemistry, provided efficacy against bollworm equal to a medium rate of Tracer but less than that provided by a pyrethroid standard. Pyrethroids remain effective against bollworm in North Carolina, even though over the last two years we have recorded increased survival at the critical dose in adult vial tests. In tests of insecticides for efficacy against thrips species none of the insecticides evaluated provided a level of efficacy comparable to the Temik standard. Actara as a foliar spray applied either once or twice was inferior to foliar spray standards (e.g. Orthene). Also, the Adage seed treatments (3.2 and 4.0 oz ai/cwt) did not provide effective control of thrips. **(Department of Entomology, North Carolina State University, Raleigh, NC)**

Oklahoma

Several Bollgard trials were conducted in 1999 to further evaluate the value of this technology under Oklahoma conditions. Bollgard cotton provided sufficient bollworm control and produced increased yields to compensate for rental fees in all entries except one. Bollgard varieties increased profits for both dryland and irrigated production compared to conventional cotton varieties, regardless of management regimes. Greatest advantage was seen in irrigated (11/30/99, 960 lbs yields) compared to dryland cotton's $2.78 per acre gain (based on 190 lbs/A yields).

Overspraying Bollgard cotton when Heliothine pressure approached levels justifying insecticidal control in conventional cotton did increase yields. Tracer at .045 lb AI/acre yield gains did not offset control cost. Karate .025 lb AI/acre enhanced yield sufficiently to increase returns per acre.

This was the fourth year that Heliothine infestations failed to reach levels in economic threshold trials to activate insecticide applications. Heliothine pressure remained below 5 larvae (> 3/8 inch long) per 100 terminals. Insecticide protection was to be applied if infestations approached 10 larvae (> 3/8 inch long) per 100 terminals. Biweekly tagging of eggs and newly hatched larvae revealed no Heliothine survival at tagged sites. All newly hatched larvae died before any of the larvae reached ½ inch long.

Research continued in 1999 to determine the impact of planting date on boll weevil management grown under dryland conditions. Previous research during years with high boll weevil survival indicates planting date is critical, regardless of management scheme, to raise profitable cotton. Despite lower boll weevil numbers, 1999 results continue to emphasize importance of May-planted cotton. May-planted cotton outperformed June-planted cotton treated the same by at least 67.8 lbs lint/acre. Overwintering sprays of Vydate .125 lb AI/acre before bloom increased yields in 3 of the 4 treatments. Greatest lint gains (at least 23 lbs lint/acre) were seen in Paymaster HS 26 plots for both planting dates. Lint gains in Paymaster HS 26 plots offset insecticide inputs. Similar yield responses were not seen in Paymaster HS 183 plots. (**Oklahoma Cooperative Extension Service, Altus, OK)**

South Carolina

June applications of broad-spectrum insecticides again increased bollworm problems on both Bt and conventional cotton varieties. 1999 data confirm previous studies on the importance of preserving beneficial species as long as possible, particularly during June and early-July. Alternative chemistries, Tracer and Larvin, controlled this year's light bollworm infestations as adequately as the pyrethroids. The results of a 3-year study indicate that cotton bollworm can be controlled on Bt cotton with reduced rates; recommendations will be changed to reflect these studies.

Bollworm resistance to pyrethroids was only reported in one location. Subsequent tests indicated resistance was present in this population. Pheromone trapping indicated resistant individuals at both 5 and 10μg levels; numbers of resistant moths were not high enough to result in field failures.

Studies were also conducted with two cotton varieties containing the CryX gene for resistance to lepidoptera. These varieties were compared to a variety with the Cry1Ac and a conventional variety. In one study there were insufficient numbers of bollworms to make a valid comparison, while in the other study the varieties with the CryX gene performed well. **(Clemson University Pee Dee Research and Education Center, Florence, SC)**

Tennessee

Predominant thrips species on seedling cotton were determined at two locations to be the tobacco thrips, *Frankliniella fusca*, while the remainder were *F. truitici* and *Neohydatothrips variabilis*.

Thiamethoxam (Adage) as a seed treatment for protection of cotton from thrips injury reduced thrips damage ratings below those of Gaucho-treated plants and were comparable to those of Temik-treated plants. Total leaf area of Adage-treated plants was comparable to other insecticide treatments and all were superior to the untreated check. The number of blooms per ten row ft 64 DAP (days after planting) was significantly higher on plants with the proposed labeled rate compared to Gaucho- and Temik-treated plants, but did not differ from the two lower rates of Adage. Thrips larval numbers were reduced by all three insecticides up to 34 DAP and were lower than in the untreated control. First harvest lint yields were significantly higher in high Adage treatment compared to Temik and the untreated control. Total lint yields did not differ among insecticide treatments, and all were superior to the untreated control except the low Adage and low Temik treatments.

The effects of herbicides and herbicide-tolerant cotton varieties on early-season thrips management, plant growth, development and yield were evaluated at three locations. Use of conventional herbicides (Prowl + Cotoran) significantly affected yield at one location.

Early-season thrips control on ultra narrow row cotton was compared using seed treatments, foliar sprays and in-furrow granules. Thrips damage ratings differed among treatments, but yields were not affected in either of two locations/planting dates.

Bt cotton varieties were evaluated at three locations. Heavy tobacco budworm/bollworm (70:30) pressure occurred at the Ames Plantation. Main plot first harvest lint yields were greater in the sprayed plots. Significant yield differences were noted among varieties (subplots) with the best Bt variety PM 1218 BG/RR producing 390 lbs more lint than STV 474. Highest yields were produced at Jackson and Milan by PM 1218 BG/RR.

Two cotton lines containing two Bt genes (Insect Protected Cotton) were compares to DP 50B and DP 50 at two locations. At the Ames Plantation, yields from the Bt cottons did not differ from each other, but all were different from the conventional DP 50. At Jackson, the lines were evaluated under sprayed and unsprayed conditions. First harvest lint yields in the sprayed plots did not differ, but in the unsprayed plots, yields from the Bt cottons were different from the conventional variety. Yields from Bt cottons did not differ from each other in sprayed or unsprayed conditions. For total yield, the sprayed DP 50 did not differ from either group of Bt cottons, but the unsprayed DP 50 differed from all the Bt cottons.

Foliar sprays of acetamiprid provided the best control of cotton aphid three and six days after treatment (DAT), but did not differ from thiamethoxam 3 DAT or imidacloprid or thiamethoxam 6 DAT. Yields were not affected by treatment, even though aphid nymphal numbers exceeded 20/leaf in late-June.

Intrepid, Karate, Larvin, Pirate, Steward and Tracer and combinations of some of these were evaluated against a mixed population of tobacco budworm/bollworm (70:30). Four applications were made between July 1 and August 6. Highest yields were obtained with Larvin, and only Larvin and Tracer treatments differed from the untreated check. **(University of Tennessee, West Tennessee Experiment Station, Jackson, TN)**

Texas

Work continues on the use of irrigation to reduce aphid honeydew on cotton lint. 1999 tests involved overhead and in-canopy sprays at 0.25 and 0.50 inches per acre. One, two, and three applications were applied. Data from 1999 tests are not complete at this time. 1998 tests showed that as little as 0.25 inches per acre applied as an overhead or in-canopy spray significantly reduced the number of sticky spots on cotton lint compared to the untreated check. However, three applications were required to reduce the number of sticky spots below 3 per sample.

Burning of CRP grasses was shown to significantly reduce boll weevil overwintering in the Texas High Plains. Maximum fire temperatures measured in plant crowns during burning averaged in excess of 1100E F and ranged in duration from 75 to 450 seconds. No weevil survival was recorded in plots burned in February, while only 0.07% of the overwintering weevils survived burns conducted in mid-April. It is recommended that burning CRP fields be used as a cultural control practice in boll weevil eradication programs in the Texas High Plains. If conducted properly, this practice could significantly reduce the overwintered boll weevil population, thus reducing the requirement for insecticide treatment and lowering the cost of eradication. **(Texas Agricultural Experiment Station, Lubbock, TX)**

'Sphinx' cotton was planted April 28 to investigate the influence of irrigation treatment and insecticide treatment on cotton aphid buildup in late season. Cotton was grown dryland, irrigated with irrigation in mid-August, and irrigated with last irrigation in late August. Subplots included an untreated check, a Karate treatment only, a Karate treatment followed by Fulfill when aphids began to build, and Karate treatment followed by Actara when aphids began to build. Aphid populations remained below 5/leaf throughout the summer, but numbers began increasing in early September; peak numbers occurred on September 28 when numbers exceeded 300/leaf in some treatments. During September, numbers were highest in cotton with a final irrigation in late August, and the application of a pyrethroid, Karate, magnified aphid numbers in the dryland and both irrigation treatments in relation to numbers in the untreated checks. The aphicides, Fulfill and Actara, were more effective in limiting aphid buildup in dryland cotton and in cotton with irrigations terminated in early August, as compared to cotton with a final irrigation in late August. However, the benefits of Fulfill and Actara were lost by late September. By early October, aphid numbers were high and similar in all treatments.

'Sphinx' cotton was planted 29 April, 19 May, and 8 June. Row patterns within each planting date were solid 40" rows, and skip-row patterns of 2 x 1 (plant 2 rows and skip 1), and 2 x 2. Sampes were taken for cotton aphids, beet armyworms, bollworms, bandedwinged whiteflies, and cotton leafperforators. Cotton aphid numbers were low throughout the season, averaging < 6/leaf, and planting date did not affect cotton aphid populations. Aphid numbers were highest in the 2 x 2 skip-row plantings pattern (7.3/leaf), intermediate in the 2 x 1 skip-row pattern (5.6/leaf), and lowest in the solid planting (3.3/leaf). These results are comparable to those of the 1998 test. Very few beet armyworms and bollworms were detected during the summer. Apparently, the low numbers of these two pests was related to the reduction of ULV malathion applications for boll weevil eradication at Munday. Whteflies were not affected by plant date, but numbers were higher in solid plantings (10/leaf) than in the 2 x 2 plantings (4/leaf). Cotton leafperforators were not influenced by planting date or planting pattern (range 2-5/leaf). These two pests have not been a problem in the Rolling Plains, and they did not pose an economic threat in 1999.

Results with Knack for cotton aphid control
Average number of cotton aphids per leaf. Chillicothe, Texas. 1999.

Treatment	Rate	9/10 [a,b]	9/16	9/22	9/29	10/7
Untreated	B	6.1 a	19.5 a	45.4 a	51.7 a	61.6 a
Knack	24 gm AI/AC	3.4 a	8.7 ab	10.3 b	9.1 b	5.9 b
Knack	30 gm AI/AC	5.8 a	10.1 ab	15.8 b	9.3 b	4.1 b
Bidrin	0.5 lb AI/AC	5.0 a	7.0 b	11.9 b	16.9 b	15.3 b

[a/] Pretreatment counts.
[b/] Values within a sample date followed by a common letter are not significantly different. (LSD=0.05). **(Texas Agricultural Experiment Station, Vernon, TX)**

Insecticide efficacy trials were conducted against thrips, cotton fleahoppers, bollworms, beet armyworms, aphids, boll weevils, Lygus bugs. These insecticides are included in Table 3. Insecticides evaluated for fleahopper control in south Texas included Bidrin, Orthene, Provado, Vydate, Fulfill, Actara and Steward. Two treatments were applied at a 7-day interval beginning one day before bloom. All insecticides significantly reduced fleahopper and beneficial arthropod abundance. Yields were not significantly different, but all insecticide –treated plots produced more cotton (36-124 lbs/acre) than the untreated check. Adage, Gaucho and Temik were compared for thrips and aphid control in south Texas. All insecticides reduced insect numbers and all insecticide treatments, except Adage at the low rate (5.1 oz/cwt seed), produced significantly more cotton than the untreated check. Chemicals evaluated for aphid control included Provado, Calypso and EXP 4591 (Bayer Corporation), Fulfill (Novartis), Bidrin and Furadan. Aphid populations did not persist and no yield losses were sustained. Additional studies were initiated to evaluate potential insecticides for use on organically certified cotton. Bother commercial formulations of garlic and jalapeno pepper were ineffective.

Work was initiated on evaluating different sampling methods for cotton fleahoppers and *Lygus*. Visual, sweep net, drop cloth and KISS sampling techniques were compared. Validation of the COTMAN model continued in the South Texas and High Plains areas. This included evaluations of SQUAREMAN in IPM programs, and BOLLMAN as a tool to determine when to terminate insecticide applications for boll weevils and bollworms, as well as when to terminate the crop. Stripper Bt cottons were evaluated for economic Heliothine management under different cropping systems in the High Plains. Additional tests were conducted evaluating Bollgard II. Unfortunately there was very little pest pressure. We did get the opportunity to evaluate the response of PM 2200, PM 2145 and PM 2326 to fleahopper and Lygus bug attack in the High Plains area. It appeared that PM 2200 was more susceptible to damage perhaps because of its initial slow squaring rate. In addition we conducted a survey of boll weevil overwintering sites in 21 counties in the High Plains, evaluating relative importance of various habitats on attracting weevils and their survival. Dry conditions in the overwintering sites appeared to have a profound effect on boll weevil survival. A sticky cotton project continued into its 3rd year, investigating the relationship between plant and insect sugar levels, stickiness measurements and their correspondence to processing difficulties at the textile mills. This project is in cooperation with the Texas Tech University Textile Research Center. An additional sticky cotton project was initiated evaluating the ability of a commercial sprinkler system to reduce honeydew deposits down to an acceptable level. Preliminary data suggest that the amount of water necessary may depend upon the initial level of honeydew contamination. As much as 1 inch may be needed. **(Texas Agricultural Extension Service, Lubbock, San Angelo, Dallas, Corpus Christi, Weslaco, TX)**

Impacts of selected food characters and feeding regimes on the diapause response of boll weevils were examined in preliminary studies as possible sources of variation. Influence of square source (field versus greenhouse) was examined for weevils fed singly (1 square/weevil daily) and in groups (1 square/5 weevils daily). Field-collected squares tended to be smaller, paler in color, and to have more reddish coloration on the bracts than greenhouse grown squares. Influence of square size was examined by feeding squares with diameters either <7 mm or >7 mm to groups of weevils. Finally, diets of 1 square/5 weevils, 1 boll/10 weevils, or 2 squares plus 1 boll/20 weevils, each replenished 3 times weekly, were examined to identify practical feeding regimes that consistently elicit a high level of diapause. Occurrence of diapause in weevils fed field-collected squares was similar to that in weevils fed greenhouse grown squares. However, differences in square size may have masked the effects of square source because a diet of squares >7 mm resulted in a higher proportion of diapause than did a diet of <7 mm. There was no statistical difference in diapause response among diets of squares, bolls, or both. However, diets incorporating bolls tended to provide a numerically greater and more consistent diapause response than did diets of squares alone. These preliminary results suggest the need for stricter control over diets used in boll weevil diapause studies.

A technique was devised and evaluated to monitor pheromone production by individual boll weevils using an absorbent to collect pheromone from the air around the weevil (headspace). Pheromone recovery efficiency of the method was about 95%. Pheromone production indicated by frass extractions was similar to that in previous reports. However, measurements of pheromone from the headspace indicated that pheromone in the frass represents a small fraction of the total pheromone produced, and that the boll weevil can produce a much larger amount of pheromone than was previously recognized. In addition, use of our technique allowed detection of pheromone production at an earlier age than is typically reported. Our techniques appear uniquely suitable for monitoring boll weevil pheromone production and should prove invaluable to further efforts to investigate the ecology and management implications of boll weevil pheromone production.

The impact of food removal on larval survival and development was investigated to indirectly assess the role of food deterioration in natural mortality of boll weevils. Four hundred twenty-four third instars ranging in weight from 1.81 to 34.43 mg were removed from squares and held without food. No larvae weight <5 mg survived to the pupal stage while s high proportion of larvae weighing >5 mg survived to the pupal and adult stages (81% and 70%, respectively. When only larvae >5 mg were considered, the proportion of larvae surviving to subsequent stages was not related to larval weight. Our results question the status of food deterioration as a primary mechanism of natural mortality, and provide insight to future efforts to investigate this important phenomenon.

A field study was conducted near Caldwell, Texas to investigate the effect of prevailing wind direction on the distribution of daily capture of boll weevils. Pheromone traps were placed at 1, 2, 3, 4, and 5 miles within each of eight sectors (45-degree span of compass direction per sector)) radiating from a non-irrigated, 2-acre cotton plot (core field). Boll weevils were marked with paint, released at the core field, and recaptured to verify the distribution of insect flight displacements and their association with prevailing wind direction in 1998 and 1999. Daily recapture of marked boll weevils within the 1- to 5-mile range in the late-summer of 1998 and 1999 was generally too low for logistic regression. However, logistic regression established a significant positive relationship between the proportion of daily mean capture and the daily proportion of wind heading by sector for a five-day period following the shredding of the core field on 6 September 1999. The results of this study have direct implication to the development of strategies for monitoring the managing boll weevil populations that are moving from late-season cotton into overwintering habitats.

A study was conducted to compare a standard (12 oz.) ultra-low-volume (ULV) treatment with a 6 oz. Treatment of ULV malathion plus 6 oz. of cottonseed oil per acre. Cottonseed oil was added to the reduced rate of malathion so that the application parameters such as application rate, nozzles used, etc. would remain constant and not confound the results of the study. The efficacy of each treatment was measured by a leaf bioassay test conducted in the laboratory and by caging boll weevils on whole plants in the field. Evaluations were conducted at 0 and 2 days after treatment (DAT). The results from the leaf bioassay test and the cage study showed that the 12 oz. of ULV malathion/acre was superior to the reduced rate treatment. One exception was the 2 DAT measurement for the leaf bioassay; however, rain started during the collection of the samples for the leaf bioassay and may have influenced the results. The cage study, which allowed the weevils to move freely about the treated plants, had lower mortality readings than the leaf bioassay tests.

A study was conducted to evaluate three chemical protectants for their ability to decrease the rate of degradation of ULV malathion due to ultraviolet radiation. The chemicals that were tested as protectants were p-aminobenzoic acid (PABA), Congo Red, and Fluorescent Brightener 28. Each of the three protectants was added individually to ULV malathion, applied to cotton plants, and evaluated using leaf bioassays and chemical residue analyses. These treatments were compared to a ULV malathion only treatment and an untreated check. In the leaf bioassay, the three protectant treatements had numerically higher efficacy than the ULV malathion only treatment at 0, 1, 3, 6, and 10 days after treatment (DAT). The Congo Red treatment had significantly higher mortality than the malathion only treatment at 3 DAT, and all the protectant treatments were significantly higher from the malathion only treatment at 10 DAT. In the gas chromatograph residue analyses, the PABA treatment had the most rapid degradation out of 6 DAT measurements. All malathion treatments degraded by 60-75% at 10 DAT. A field evaluation is warranted to determine if the addition of Congo Red to ULV malathion extends the efficacy of ULV malathion.

Research ws initiated to evaluate insecticides that have potential for use in conjunction with feeding-based adult boll weevil control technology with emphasis on reproduction inhibition. Tests were conducted with female boll weevils captured in pheromone traps during the spring and fall of 1999. In initial studies, hexaflumuron at various concentrations (ppm ai wt:vol) mixed with 10% sucrose and 10% sucrose alone were fed once at the start of the tests to the females The volumes of test solutions ingested were measured. After feeding, the females were confined with males and squares in petri dishes to evaluate fecundity and laral hatch over about a 30-day period. Every 2 days, the squares were removed and new squares added. At the same time, the females were checked for mortality. Hexaflumuron significantly reduced fecundity and larval hatch at concentration between 50 to 100 ppm; however, at these concentrations there was also a significant amount of feeding deterrence. Based on these results, it appears that hexaflumuron has limited potential for use as a reproduction inhibitor in feeding-based adult control technology. This research did allow for the development of experimental techniques by which other insecticides can be evaluated for reproduction inhibition when ingested.

In continuing studies to develop adult bollworm/corn earworm control technology using feeding attractants and stimulants, hexaflumuron at various concentrations (ppm ai wt:vol) in 1.0 and 2.5 M sucrose solutions was also evaluated. Lethal concentrations to kill 90% of sex pheromone trap-captured males were 917 and 392 ppm for 24 and 48 hours, respectively. Results showed that hexaflumuron concentrations below 100 ppm were highly effective in preventing larval hatch from eggs oviposited by laboratory-reared females that were fed test solutions once on the day following emergence. There was also some feeding deterrence evident; however, the concentrations at which deterrence were evident did not overlap as much with those which reduced larval hatch. Feeding hexaflumuron to male laboratory-reared bollworms/corn earworms and pairing these with untreated females did not have a significant effect on reproduction by the females. In both tests, hexaflumuron did not have a significant effect on mating of both the treated and untreated females. In both tests, hexaflumuron did not have a significant effect on mating of both the treated and untreated females. Females fed hexflumuron mixed with 1.0 and 2.5 M sucrose ingested more of the 1.0 M solution than the 2.5 M solution. These results indicated that hexaflumuron has potential for use as a reproduction inhibitor in adult control technology using feeding attractants/stimulants. Field evaluations of backpack and aerial applications of a feeding stimulant mixed with carbaryl at 100 ppm indicated that it is feasible to kill large numbers of adults bollworm/corn earworm in maturing corn and cotton. Under the conditions of the evaluations, use of a feeding attractant in conjuntion with the feeding stimulant/toxicant mixture did not significantly increase the number of adult moths killed. **(USDA, ARS, Areawide Pest Management Research Unit, College Station, TX)**

A laboratory culture of *Catolaccus grandis*, an ectoparasitoid of the boll weevil, was exposed to lethal and sublethal doses of insecticides and an insect growth regulator (IGR) using a spray chamber bioassay. Materials tested were azinphos-methyl, endosulfan, fipronil, malathion, cyfluthrin, dimethoate, spinosad, methyl parathion, acephate, oxamyl, and tebufenozide. At full rates, spinosad was significantly less toxic to female *C. grandis* than other treatments except endosulfan. Fipronil, and malathion were significantly more toxic to females than other treatments. Most of the chemicals tested were highly toxic to male *C. grandis;* spinosad was numerically least toxic. At reduced rates, most of four selected chemicals tested were low in toxicity to *C. grandis*; however, a reduced rate of malathion was significantly more toxic to females than other treatments. No *C. grandis* pupae developed from parasitism during a 24-h treatment period with malathion or spinosad. The sex ratio of progeny from sprayed adults appeared to be unaffected by the treatments.

Adults of the big-eyed bug, *Geocoris punctipes*, from a laboratory culture, were exposed to selected insecticides and insect growth regulators (IGR's) using a spray chamber bioassay. Male and female *G. punctipes* were very tolerant of methozyfenozide, tebufenozide, and spinosad compared with chlorfenapyr. At high rates, tebufenozide and chlorfenapyr significantly reduced the fecundity of *G. punctipes* compared with a control. A high rate of chlorfenapyr significantly increased host egg consumption of *G. punctipes*, suggesting a possible compensation mechanism in response to toxicity. This study indicated the importance of observing both direct mortality and sublethal effects of insecticides on beneficial arthropods.

Females of the boll weevil parasitoid *Catolaccus grandis* were submitted to various pre-release conditioning treatments (i.e. with or without exposure of boll weevil larvae for pre-release oviposition and feeding) in the laboratory to study the effect on parasitism of boll weevil in cotton. During early season releases, there appeared to be little difference in parasitism by 3 day old females, either with or without conditioning, while 1 day old females without conditioning parasitized fewer boll weevils than either of the other treatments. Eliminating conditioning of females prior to release can significantly reduce production costs if field efficacy is maintained.

Cienfuegosia drummondii is a malvaceous plant commonly found in rangeland habitat in counties adjacent to the Gulf of Mexico in the Coastal Bend of Texas. New knowledge was generated on this alternate host of the boll weevil, including delineation of plant habitat, fruiting phenology, and occurrence and degree of infestation by boll weevil. In the laboratory, weevils were successfully reared for 4 generations when provided only buds and capsules of *C. drummondii*. Further study is needed to determine the significance of the plant on boll weevil population dynamics and eradication efforts.

A survey was recently initiated to identify the uncultivated host plants of two mirid pests (cotton fleahopper and *Creontiades* sp.) and their associated natural enemies in South Texas.

The pheromone trap is an indispensable component of boll weevil monitoring, management, and suppression programs, but environmentally induced fluctuations in trap captures make interpretation of trapping data difficult. We found that there is a strong negative relationship between wind speed and trap captures, and that on days warm enough for flight, wind speed alone accounted for 50% of day to day variation in weevil captures. However, brush lines modified this effect by slowing the wind around traps on the lee side, resulting in an average 3-fold increase in captures in traps protected from the wind compared with nearby traps exposed to the wind.

Cuticular hydrocarbon profiles have been compiled from boll weevils of known age as a tool for aging trap-captured weevils. Knowing the age structure of a population will permit improved interpretation of trap-capture data, which in turn will permit more efficient and effective application of management tactics. A hemolymph protein has been isolated that may be indicative of boll weevil diapause. This protein is being characterized developmentally and molecularly, and hormonal control of diapause and reproductive development is being investigated using this protein as a diagnostic marker. Methods were developed for amplifying a large fragment of boll weevil mitochondrial DNA using the polymerase chain reaction (PCR). Initial screening of restriction enzymes against this fragment amplified from weevils captured in the Lower Rio Grande Valley have so far revealed one polymorphism (for EcoR-I). Restriction fragment length polymorphism (RFLP) profiles will be obtained from other populations to estimate gene flow as a function of geographic distance. This information will be useful in determining the extent of boll weevil migration and dispersal relative to eradication zones.

A non-intrusive immunological method of mass-marking boll weevils in the field was tested. Weevils marked with rabbit immunoglobulin were released and recaptured over a two-week period in traps radiating out 5 miles from the release site. The procedures involved in performing the ELISA's (enzyme-linked immunosorbent assay) necessary to detect the mark have been scaled up so that 1800 samples can be processed per day. Weevils were immunomarked in the field using a backpack sprayer with 25-30% efficiency, a rate which we believe can be improved. This strategy promises to permit detailed study of weevil dispersal without altering normal weevil behavior during the marking process.

We began the effort to develop a late-season trap crop system to replace the current effective but inefficient method of diapause treatments for suppressing overwintering boll weevil populations. Preliminary mark-recapture studies demonstrated that late-fruiting rows of cotton spiked with synthetic pheromone are highly attractive to boll weevils forced from the adjacent main crop by defoliation or shredding.

Beet armyworm oviposition potential and behavior were investigated in the laboratory and in field cage tests. In cotton, 95% of beet armyworm eggs are found within the upper and inner 75% of the canopy, while in carelessweed (pigweed) 95% of the eggs are found within the upper 85% and inner 60% of the canopy. Most eggs are oviposited near the center of the plant, suggesting that the current method of scouting only the upper leaves in the cotton canopy is inappropriate. These results will contribute to improved sampling plans that will be necessary for extensive surveys within host communities to identify host use patterns and elucidate the roles of host-specific natural controls. **(USDA,**

ARS, Subtropical Agricultural Research Laboratory, Weslaco, TX)

Virginia

Twenty-two different treatments comprised of different insecticides and rates as either in-furrow or foliar applications, were tested against cotton thrips in three field trials. All treatments resulted in lint increases over untreated controls, and most were significantly higher. Over all 22 treatments, lint increase ranged from 206 to 478 lb/acre, with an average increase of 332 lbs lint/acre. This represented an average of 30% lint yield loss when plants were not protected from thrips damage. In general, lint yields were higher with in-furrow versus foliar applications. Additional foliar applications of Orthene 97 (3.1 oz/acre - applied in a 14-inch band over the row) increased yields of in-furrow applications of Thimet 20G (3.75 lb/acre), Di-Syston 15G (5 lb/acre), Temik 15G (3.5 and 5 lb/acre) and a seed treatment with Gaucho 480 (8 oz/cwt seed), compared with in-furrow and seed applications, alone. Identification of a sub-sample of adults showed that 75% were *Frankliniella fusca* and 25% were *Thrips tabaci.*

Forty-two different treatments comprised of different insecticides and rates, applied using different spray schedules, were tested against the bollworm/budworm complex in six field trials. One test focused on evaluating different spray tactics (insecticide + rate + application schedule = spray tactic). Three tactics provided the highest lint yield increases: 1) a standard rate of lambda-cyhalothrin (0.025 lb ai/acre) applied at egg threshold, followed by a high rate (0.04 lb ai/acre) applied in 5 days; 2) a high rate at egg threshold, followed by a second high rate in 5 days; and 3) three standard rate sprays, one at egg threshold followed by additional sprays at 5 then 10 days. In a 9-treatment test comparing product efficacy and yield advantage, all treatments resulted in lint yields that were numerically higher than the untreated control. The following 6 treatments had significantly higher yields: Steward 1.25 at 11.3 oz/acre + Dynamic at 5% spray volume, Pirate 3SC at 8.5 oz/acre, Ammo 2.5EC at 3.0 oz/acre, Fury 1.5EC at 2.8 oz/acre, and Karate Z at 1.6 oz/acre - all applied twice, once at egg threshold and again in 5 days, and Ammo 2.5EC at 3.0 oz/acre at egg threshold then Capture 2EC at 3.2 oz/acre in 5 days. The lint yield advantages over the untreated control ranged from 94 to 149 lb/acre, with a 592 lb lint/acre yield in the untreated control. In a rate-response test, three rates of Decis 1.5EC (at 1.6, 1.9, and 2.56 oz/acre), Baythroid 2EC (at 1.8, 2.1, and 3.2 oz/acre) and Karate Z (at 1.6, 1.9, and 2.56 oz/acre) were compared for efficacy and yield advantage. Each was applied once at egg threshold and again in 5 days. All treatments, except Baythroid at the 1.8 oz rate, resulted in lint yields that were numerically higher than the untreated control. Only Baythroid and Karate at the high rates produced yields that were significantly higher than the control, 173 and 120 lb lint/acre higher, respectively, with a 698 lb lint/acre yield in the control. **(Virginia Tech, Tidewater AREC, Suffolk, VA)**

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 1999 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 1999 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 1999.

State	Pesticide (lbs AI/A)	Target Pest
Alabama	None	
Arizona	None	
Arkansas	Leverage	Bollworm, tarnished plant bug, cotton aphid, boll weevil, whitefly suppression
	Confirm	Beet armyworms, soybean loopers, cabbage loopers
California	Savey™ Section 18	Spider mites
	Applaud™ Section 18	Silverleaf whitefly
	Success™ Section 2	Beet armyworm, other foliage-feeding worms
	Knack™ Section 3	Silverleaf whitefly
Georgia	None	
Florida	None	
Louisiana	Confirm 2F labeled in late 1999	
	Pirate, Confirm, Furadan and Denim Section 18	
Mississippi	No response	
Missouri	None	
New Mexico	None	
North Carolina	Pirate 3 EC (NC under Threshold Certification plant for Section 18 Specific Exemption for Pirate)	Beet armyworms
Oklahoma	None	
South Carolina	Confirm	Armyworms, loopers
Tennessee	Confirm	Beet armyworm
Texas	Confirm	Beet armyworm
	Denim (Section 18)	Beet armyworm
	Pirate (Section 18)	Beet armyworm
	Furadan 4F (Section 18)	Aphids
Virginia	Orthene 97	Thrips, plant bug
	Karate Z	Bollworm, cutworm, thrips, European corn borer
	Warrior T	Bollworm, cutworm, thrips, European corn borer

Table 2. Changes In reply to state recommendations for treatment for arthropod pests of cotton for 2000.

State	Pesticide	Target Pest
Alabama		
Addition	Leverage	Aphids/Tarnished plant bugs
Deletion	Guthion	Stink bug
Arizona	None	
Arkansas		
Additions	Confirm	Beet armyworm, fall armyworm
	Capture	Cutworms
	Thiodan	Overwintered boll weevils
	Phaser	Overwintered boll weevils
	Atrapa ULV	Overwintered boll weevils
	Fyfanon ULV	Overwintered boll weevils
	Decis	Boll weevils (July 1 – Aug. 15)
	Thiodan	Boll weevils (Aug. 15 – end of
	Phaser	season)
	Atrapa ULV	Boll weevils (Aug. 15 – end of
	Fyfanon ULV	season)
	Confirm	Boll weevils (Aug. 15 – end of
	Orthene 97	season)
		Boll weevils (Aug. 15 – end of
Deletions	Lorsban	season)
	Capture	Cabbage and soybean loopers
	Imidan	Thrips, cutworms, tobacco
	Imidan	budworm
	Imidan	(tank mix), plant bugs and
	Lannate LV	whitefly
	Lorsban	Aphids
	Ovasyn	Aphids
		Overwintered boll weevils
		Boll weevils (July 1-Aug. 15)
		Boll weevils (Aug. 15 – end of
		season)
		Cabbage and soybean loopers
		Spider mites
		Spider mites
California	Success™ early to mid season	Beet armyworm
		Silverleaf whitefly
	Knack™ during initial population buildup	
Georgia	Provado 1.6	
	3.75 oz/acre	Tarnished plant bug
	2.0-3.75 oz/acre	Aphids
	Leverage	
	3.0 oz/acre	Stink bugs
	3.75 oz/acre	Bollworm
Louisiana		
Additions	Karate 2.08SC replaces	Green and brown stink bugs in
	Karate 1EC	all recommendations
		All insect pests where Orthene
	Orthene 97	90S was previously used
		Whitefly
Deletions	Orthene 90	Whitefly
	Orthene 97	Whitefly
	Knack	Tobacco budworm, boll weevils
	Pyrethroids All recommendations for	
Missouri		
Additions	Confirm 2F	Beet armyworms
	Orthene 97G	Bollworms, plant bugs, thrips, tobacco budworms, whiteflies
Deletions	Lorsban 4E	Spider mites
	Bolstar 6E	Bollworms, tobacco budworms
New Mexico	None	

N. Carolina	Orthene 97S 0.24-0.97 lb ai/acre at planting 0.97 lb ai/acre and post emergence 0.15-0.18 lb ai/acre Gaucho 480 seed treatment 8.0 oz/100 wt	Thrips
Oklahoma	None	
S. Carolina		
Additions	Dannitol 2.4 (2E registration) Profado 1.6 Confirm	Spider mites Plant bugs, cotton aphids Beet armyworm, fall armyworm, loopers
Deletions	Orthene97 Nemacur 15 G	Same uses as Orthene 75S Thrips
Tennessee		
Texas		
Additions	Synthetic Pyrethroids (With precautionary footnotes pertaining to resistance issues and aphid flaring)	Lygus
	Provado (3.75 oz)	Lygus
Virginia		
Additions	Orthene 97 12.4-16.5 oz/acre in-furrow spray 1.5-3.1 oz/acre foliar band 8.2 oz/acre foliar spray	 Thrips Thrips Plant bug
	Karate Z 0.96-1.28 oz/acre 1.6-2.56 oz/acre 1.6 oz/acre	Thrips Bollworm European corn borer
	Warrior T 1.92-2.56 oz/acre 3.2-5.1 oz/acre	Thrips Bollworm European corn borer
New Section	3.2 oz/acre lambda-cyholothrin (Karate Z) 0.96 oz/acre thiodicarb (Larvin 3.2) 24 oz/acre cyfluthrin (Baythroid 2EC) 0.8-1.6 oz/acre esfenvalerate (Asana XL 0.66 EC) 5.8 oz/acre cypermethrin (Ammo 2.5EC) 1.3-5.0 oz/acre zeta-cypermethrin (Fury 1.5ED) 1.4-2.0 oz/acre bifenthrin (Capture 2EC) 2.6-6.4 oz/acre deltamethrin (Decis 1.5EC) 1.1-1.6 oz/acre tralomethrin (Scout X-Tra 0.9EC) 2.28-2.84 oz/acre fenpropathrin (Danitol 2.4 EC) 8.0-6.0 oz/acre	Cutworm

Table 3. Promising pesticides screened in 1999 for control of cotton arthropod pests.

State/Pesticide (lbs AI/A)	Target Pest(s)
Alabama	
S-1812 at 0.075 B 0.2	BW, TBW, Soybean looper
Denim at 0.01	Soybean looper, BW, TBW
Intrepid (RH-2485) at 0.1 B 0.15	Soybean looper, BW, TBW
Steward at 0.065, 0.9 and .11	TPB, BW, TBW, Soybean looper
	Soybean looper, TPB
Pirate at 0.2 B 3.5	TPB
Acetamiprid at 0.025 - .075	Soybean looper
Lepinox at 1 lb	Soybean looper
AC 814, 827 at 0.15	Thrips
Adage at 200, 250 and 30 oz	Thrips
Admire at S.T.	
Arkansas	
Actara	Aphids, tarnished plant bug
Adage	Thrips
Bollgard II	TBW, cabbage and soybean loopers, and beet armyworm
Denim	Bollworm, budworm, TPB
Fulfill	Aphids
Intrepid	Soybean and cabbage looper
Regent	Tarnished plant bug (TPB)
S-1812	TBW
Steward	TBW, TPB
Arizona	None
California	
Fulfill™ 50WP (0.09-0.11 lbs ai/A)	Aphids
Bollwhip™ (rate not reported)	Aphids
Agroneem™ (2 liters/A)	Aphids
Regent™ 80WDG, 2.5ED, 6.2ED 0.05 lbs/ai/A)	Lygus
Trilogy™ (1 at/A)	Spider mites
Organic solutions (250 ppm/A)	Spider mites
Alert™ 2SC (0.15 lb ai/A)	Spider mites
Savey™ 50WP (0.125 lbs ai/A)	Spider mites
Florida	None
Georgia	None
Louisiana	
Leverage 2.7SE	Bollworm, TBW, TPB, Thrips
	TPB, Thrips, Aphids
Capture 2EC	Bollworm, TBW, TPB, Thrips,
Karate-Z 2.09SC	Aphids
	Boll Weevil
Atrapa 96% L	TPB, Thrips, Aphids
Actara 25WG	Bollworm, TBW, TPB, Soybean
Steward 1.25SC	Looper
	TPB, Thrips, Aphids
Acetamiprid 70SC	Bollworm, TBW, TPB
Denim 0.16ED	Bollworm, TBW, Armyworms,
S-1812 4EC	Soybean looper
	Thrips, Aphids
Decis 1.5ED	Armyworms
Confirm 2F	TPB, Thrips, Boll weevil
Regent 2.5EC, 4F	Bollworm, TBW, Soybean looper
Pirate 3SC	Bollworm, TBW, Soybean looper
Intrepid 80WP	TPB, Aphids
	TPB, Aphids
Fulfill 50WP	
Calypso 4SC	
Mississippi	
Acetameprid 0.025	Cotton aphid
Acetameprid 0.038	Aphid

Acetameprid 0.105	Aphid
Actara 0.047	Aphid
Steward 1.25 SC 0.09	Tarnished plant bug
Steward 1.25 SC 0.11	Tarnished plant bug
Regent 4 SC 0.038	Tarnished plant bug
Regent 4 SC 0.03	Tarnished plant bug
Actara 25 WG 0.047	Heliothines
S1812 35 WP 0.05	Heliothines
S1812 35 WP 0.06	Heliothines
S1812 35 WP 0.075	Heliothines
S1812 4 EC 0.075	Heliothines
S1812 4 EC 0.1	Heliothines
S1812 4 EC 0.15	Heliothines
S1812 35 WP 0.15	Heliothines
Steward 1.25 SC	Heliothines
Missouri	
Actara 25WG at 0.036, 0.47, 0.62	Thrips, plant bugs
Denim 0.16E at 0.01, 0.02	Bollworms, spider mites
Fulfill 50WG at 0.089, 0.28	Plant bugs
Leverage 2.7SC at 0.08	Bollworms, boll weevils, plant bugs
Regent 2.5E at 0.025, 0.038, 0.05	Boll weevils, plant bugs, thrips
Steward 1.25SC at 0.065, 0.09, 0.11	Bollworms, plant bugs
New Mexico	None
North Carolina	None
Oklahoma	
Orthene Ag	Thrips
South Carolina	
Tracer and Steward	Cotton bollworm
Tennessee	
Thiamethoxam (0.2-0.3 lb ai/cwt)	ST thrips, aphids
Thiamethoxam (0.05-0.06 lb ai/ac)	Plant bugs
Acetamiprid (0.025-0.05 lb ai/ac)	Cotton aphid
Thiamethoxam (0.025-0.05 lb ai/ac)	Cotton
Texas	
Adage (4.8-5.1 oz/cwt seed)	Thrips
Agroneem (48 oz/A)	Aphids
Fulfill 50 WP (2.75 oz/A)	
Actara 25 WG (3.0 oz/A)	
Dibrom 8 (0.5)	
EXP 4591	
Calypso	
Bidrin 41 WP (0.33)	
Knack 0.86EC (24-30 gm ai/A)	
TADS 12253 0.82 EC (0.1)	Cotton felahopper
Actara	
Steward 1.25 EC (0.065-0.11)	
Orthene AG 97 SG (0.25)	
EXP 671486 A 70 WP (0.025-0.035)	
Regent 2.5EC (0.025-0.035)	
Fulfill 40WP (0.085)	Plant bug
Steward 1.25 SC (0.065-0.09)	
Regent 2.5 EC (0.025-0.05)	Bollworm
Steward 1.25 SC (0.065-0.11)	Beet armyworm
Pirate 3 SC (0.2)	
Steward 1.25 SC (0.065-0.11)	
Denim	
Intrepid 80WP ().05-0.2)	Boll weevil
Regent 2.5 EC (0.05)	
Atrapa	
Virginia	
CGA-293343 2G at 5.lb/acre	Thrips
Steward 1.25EC at 9.2 and 11.3 oz/acre	Bollworm
Pirate 3SC at 8.5 oz/acre	Bollworm
Leverage 2.7 at 3.0 and 3.2 oz/acre	Bollworm/aphid