49TH ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

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Foreword

In 1995, there were approximately 15,889,000 acres of cotton (Upland and Pima) harvested in the U.S. with an average yield of 1.15 bales per acre (480-lb bales) amounting to a 18,325,700 bale production (USDA--December 11, 1995 report). Harvested acreage increased 18.6% but total production decreased 6.8% compared to 1994, indicating a yield decrease of about 17%. Arthropod pests reduced overall yield by 11.08%, one of the highest ever, in spite of control measures which cost an average of $57.93 per acre. The bollworm/budworm complex was still the number one pest in the U.S. with a yield reduction of 3.97%. Eighty-two percent (82%) of the acreage was infested with bollworm/budworm in 1995, requiring 2.4 applications of insecticide per acre. Beet armyworms were second in 1995, reducing yields by 1.68%. Boll weevils were a close third at 1.66% reduction in 1995. These pests infested about 62% of the country's cotton crop and required about 2.0 applications of insecticide per acre. Aphids were the fourth most severe pest at 1.09%, and *Lygus* a severe pest in the far west in 1995, dropped to fifth place at 1.02% reduction. Spider mites, whiteflies, and thrips were also costly pests in 1995. Total cost of management and loss to insects to the 1995 crop exceeded $1.68 billion (see M. R. Williams, these proceedings).

Crop and Arthropod Pest Conditions

Alabama. Anticipating enhanced insect problems due to Boll Weevil Eradication efforts, North Alabama cotton producers strove for earliness via variety selection, planting dates, etc. Much of that effort was erased due to multiple sandstorms, tornado and other weather damage which required significant replanting. Thrip populations were somewhat higher than average and, in conjunction with poor seedling development, quite a few acres were treated foliarly for thrips control. A vast majority of fields received 2-4 applications of malathion in June. These treatments virtually eliminated the tarnished plant bug as a pest. Cotton aphid populations began to explode during mid-June and by late-June cotton was suffering under the effects of aphids. A considerable amount of money was spent trying to suppress the cotton aphid. The fungus, *Neozygites fresenii*, finally removed most of the aphids in early- and mid-July. Beet armyworms were present in most fields from June throughout the season, and it appeared that populations were ready to explode during July and early August. Widespread damage from the beet armyworm never occurred, but an abnormal number of fields did have treatable levels, and a great deal of money was spent on beet armyworm control.

The June generation of tobacco budworms was moderate but extended. The July generation began early, increased to historically high levels, and pretty much remained there for the duration of the season. Control failures were commonplace and damage by the budworm was extensive. The corn earworm was notably absent. Bandedwinged whitefly populations were above average. Two-spotted spider mites, Western flower thrips, yellow-striped armyworms, fall armyworms, salt marsh caterpillars, and loopers were common but caused little damage.

Cotton lint yields will average less than 400 lbs. per acre. Much of the loss can be attributed to budworm damage despite a 3-4 fold increase in control inputs.

Beet armyworms exploded areawide during the late July and mid-August generations in central Alabama and in individual fields in the southern parts of the state. Levels were reached that completely stripped remaining fruit and all vegetation from the plants. However, not much fruit was present to destroy due to two previous generations of tobacco budworms.

In the central and southern parts of the state, budworms occurred in historically high levels beginning with the first cotton generation at pinhead square. Levels of one to five larvae per plant continued through the second generation and into August. Basically no pyrethroids were used prior to bloom. However, alternatives, other than beneficial insects, were totally ineffective. During the July flight all currently registered products were used alone or in combination with very poor results (10-40% control).

With the numbers of budworms encountered in 1995 and their level of resistance to pyrethroids, carbamates, and phosphates, cotton growers do not have the tools available to grow cotton economically in Alabama at this time. Hopefully, Bollgard varieties and new chemistries will become available in time to save the industry.

Arkansas. The thrips population was very high during the spring in southeast Arkansas and untreated cotton sustained severe damage. In test plots, excellent thrips control was achieved using Payload, Temik, DiSyston, and in-furrow applications of Orthene. Gaucho seed treatment also gave excellent control and will be included in the

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recommendations for thrips control next year. The overall thrips population was classified as one of the highest in recent years and caused severe stunting and stand loss in untreated cotton. A few fields that were treated with in-furrow with systemic insecticides had to be treated with foliar sprays to prevent damage and delayed maturity.

The boll weevil population that survived the winter was extremely large this year and was the result of warmer than normal winter temperatures. Trap captures were much higher compared to 1994. The boll weevil overwintered sprays suppressed the population in most areas, but areas that had the heaviest pressure began spraying fields in early July. Boll weevil control tests showed that Karate and Baythroid gave superior control of the boll weevil. Fipronil also gave good control and performed better than the standards Guthion and Vydate.

The plant bug population was relatively light this year compared to previous years. Plant bug populations may have been overlooked in many situatuions because of the larger than normal aphid populations.

The aphid population level was extremely high early in the season. The high boll weevil population caused a higher percentage of the fields to be sprayed for overwintering suppression. The high incidence of spraying probably contributed to the higher aphid population this year by the destruction of predators and parasites associated with the spring aphid populations. The aphid population also started to build in fields much faster this year compared to previous years. Aphid control was difficult because of resistance to the insecticides currently in use. Provado was used in many cases and provided good control of the cotton aphid. The aphid fungus, *Neozygites freseni*, was late and did not spread as quickly as noted in previous years.

The bollworm occurred in high numbers in early July and to some degree in late August. The populations level was light to moderate. Excellent control was achieved using all insecticides. The tobacco budworm occurred during the latter part of June and early July in most of the state in relatively low numbers as determined by pheromone traps. The population was spread over a longer period of time this year compared to previous years when a more prominent peak was typical. The tobacco budworm occurred again in late July and early August. The population was significantly higher and caused a moderate number of eggs to be oviposited in fields. Resistance levels started relatively low in June with about 20 percent survival in the vial test at the 10 microgram rate. The percent survival in the adult moth resistance vial test increased rapidly during the late July flight to about 80 percent survival. Several control failures occurred as a result of the higher population level and high resistance level. A section 18 exemption was granted for the use of Pirate against infestations of the tobacco budworm, but it was available only in small quantities for Arkansas. The State Game and Fish Commission was responsible for field monitoring the effect of Pirate on wildlife in each area of use. A preliminary report found no significant effect on wildlife from field observations after applications. The resistance level of the tobacco budworm also increased to the organophosphate insecticides as the season progressed. Several county extension agents and consultants reported failures of the organophosphates in fields infested with tobacco budworms.

The fall armyworm infested cotton fields in central and northeast Arkansas during mid July and early August in conjunction with the bollworm moth flight. In many cases, the fall armyworm was identified as the bollworm. The fall armyworm was not controlled by the pyrethroid insecticides and several producers reported that the pyrethroids were not controlling the bollworm. Upon closer examination, the insects were identified as the fall armyworm. The insecticides Larvin, Curacron , Bolstar and Lannate controlled the fall armyworm population. The beet armyworm occurred in small numbers across most of Arkansas. A section 18 for Confirm and Pirate was requested for use against the beet armyworm. However, the exemption was only granted for Confirm. The beet armyworm was not a serious problem, but did reach treatment level in a few fields.

Spider mites were a problem in several fields across the state. The spider mite populations started early and built up quickly to treatment level. The currently recommended insecticides only gave fair control and most producers were not satisfied with the control.

The major problems in northeast Arkansas were thrips and aphids this year. Pressure from other insects was similar to proceeding years. Thrips numbers were extremely high and caused extensive damage in fields that were not protected with an in-furrow insecticide. Many fields were treated with several foliar applications for this insect in addition to the in-furrow applications that were made at planting. Numbers were as high as 15-20 thrips per plant in some fields.

Numbers of boll weevils emerging from overwintering quarters were higher than the year before. The majority of producers made two pin-head applications which helped keep numbers down until late in the season. Many growers did not treat again for boll weevil until mid to late August. However, there were some areas with heavier pressure earlier in the season.

Aphid pressure became quite heavy in some areas due to the number of early season applications required to control both thrips and boll weevils. Many growers delayed treatment waiting for the fungus to come through and control the aphids. However, aphid pressure was quite heavy early and some fields appeared to be hurt by the aphids by the time the fungus came through. Provado seemed to give the most consistent control compared to the other traditional aphid materials. With other insecticides, results varied from field to field.

Plant bugs were only a minor problem this year throughout most of the season.

Several applications were required for bollworm this year. Most of our acreage required, on average, two applications for this insect. Because the population was predominantly bollworm, the pyrethroids gave satisfactory control. There were a few problems with larvae being difficult to control because they were feeding under stuck blooms. There were also areas with heavy tobacco budworm pressure that were difficult to control with pyrethroids. Mixtures of different chemistries gave the best control, but this control was less than satisfactory. Many growers in these areas made several applications trying to control budworm but achieved at best 50-60% control.

Fall armyworm was a major problem in some areas. A major problem was identification of early instar larvae. Many fields were treated with a pyrethroid thinking the armyworms were bollworms. After the pyrethroids failed to give satisfactory control, it was discovered that the insects were fall armyworm instead of bollworm. Many growers used Lannate, Larvin or Curacron and cleaned up the remaining infestation. However, some yield was lost due to this insect before it was controlled. Beet armyworms were present in some fields this year. Numbers were low and infestations were scattered with very few fields being treated for this insect.

Spider mites were a problem in scattered areas which were hit hard and required 2-3 applications to obtain control. However, overall pressure from this pest was light.

Overall insect pressure was heavy this year. This is in part due to the fact that several insecticide applications were required early in the season for thrips and boll weevil. This decreased beneficial insect numbers and probably increased the number of applications necessary for other insects such as aphids and bollworm/budworms. Yields were lower this year than the previous year. Many dryland fields yielded around 350 to 500 lbs of lint/acre. Most irrigated fields yielded 500 to 700 lbs of lint/acre with a few yielding 1000 lbs.

California. Insect and mite pests were again a major production problem on San Joaquin Valley cotton in 1995. For the second consecutive year, growers had to contend with an assortment of insect and mite pests, and in many cases, budgets were stretched to the limit. As with other aspects of cotton production in 1995, the rainy, cool, early-season weather greatly influenced the insect pest levels. Weather impacted the crop by delaying planting, causing some replanting, and delaying growth and development. Over half the cotton yield reduction is attributed to weather, the other half to insects. Yields of 900-950 lbs/acre are estimated to be off by 20-25% compared to the 5-year average of 1,280 lbs/acre. Miticide/insecticide applications numbered from 2 to 8 depending on location, costing as much as $250/acre in extreme cases.

Thrips, primarily western flower thrips, *Frankliniella occidentalis*, were at very high levels in many cotton fields from emergence to late May. The infestation was concentrated in the southern San Joaquin Valley. Thrips infestations occur yearly, but generally the damage inflicted to cotton is minimal. However, the cool environmental conditions, which delayed plant growth and development, allowed extensive thrips damage in 1995. The loss of significant amounts of leaves and some terminals necessitated some control actions for thrips.

Cotton production in the San Joaquin Valley in 1995 was again hindered by the presence of cotton aphid, *Aphis gossypii*. Pre-squaring populations of this pest were generally low. Except for a few pockets, such as eastern Tulare county, high early-season populations of beneficial insects (lady beetles, syrphid fly larvae, lacewings, and parasites) prevented aphids from establishing. However, populations of cotton aphid were very high in many fields in July and August. These "mid-season" aphids have appeared in SJV cotton three of the last four years and have been particularly severe the last 2 years. Aphids during the middle part of the growing season compete with the developing bolls for the limited energy reserves, i.e., photosynthates; boll size can be reduced by aphid feeding. Control of these aphids with insecticides was difficult because of insecticide resistance and reinvasion of the fields within days. The density of winged adults was high during July and August. Populations decreased after August, but reinvasion continued to be a problem into September. Late season aphid during boll opening was not a major factor, and thus quality was not affected in 1995.

By all accounts, 1995 was the worst year for *Lygus* bugs since 1978. The frequent winter/spring rains produced a bumper crop of vegetation in the foothills. This allowed for high levels of *Lygus* bug survival and reproduction and accounted for a lengthy migration into the cotton fields. *Lygus* bugs began infesting cotton in most areas in June which coincided with the initiation of squaring in many fields; counts were not as high as in previous years, but the damage, as monitored with square retention, was severe. Fields with *Lygus* bug counts in the 3-4 range often had low retention. Two factors may account for this; first, the *Lygus* bugs in 1995 may have been more aggressive because of previous poor quality of hosts. Secondly, the poor growing conditions for cotton during squaring may have reduced the plant's physiological ability to retain squares. Control actions for *Lygus* bugs generally were successful but reinvasion was a problem. In addition, these insecticide applications undoubtedly contributed to aphid and mite outbreaks later in the season by reducing levels of natural enemies.

Mite populations were generally held down during May and June by the cool, wet weather and by the high levels of predators. However, with preventative and cleanup sprays in June, late season mites in the southern part of the San Joaquin Valley were severe and caused substanial crop reduction. The repeated use of broad spectrum insecticides early and mid-season reduced the level of natural enemies and probably was the cause of this late season problem.

Populations of silverleaf whitefly, *Bemisia argentifolii*, were generally lower in 1995 than in 1994. As in many other cases, the cool, rainy spring weather inhibited the buildup of this pest in the spring. The frequent rainfall events may have even killed many of the newly emerging whitefly adults in March, April, and May. The cool weather slowed the development of the nymphs. Finally, as an indirect result of the weather, the planting of many spring melon fields was delayed or prevented; these melon fields act as a site for whitefly buildup in the spring for later invasion into cotton fields. Overall, whitefly densities in 1995 were at levels similar to those seen in 1993.

Beet armyworm and cabbage looper outbreaks occurred in some fields, mainly in the southern San Joaquin Valley. The outbreak was a result of both weather and use of broad spectrum insecticides. Usually these insect populations remain below economic levels due natural enemy predation and parasitism.

Georgia. The 1995 season has been an interesting one with confirmed resistance to pyrethroids in tobacco budworm, two emergency exemptions for new insecticides, a new armyworm species feeding on cotton and lots of our old favorite pests. Preliminary indications are that our average number of sprays will be up compared to the last three seasons -- perhaps as high as 5 or 6.

The 1995 season started dry -- like 1994, but we did manage to get a lot of our April and early May cotton up. Rain in early June brought the rest of the May plantings to a stand, and some cotton was planted into July. Drought returned by late June and continued through the summer in many areas. Eastern counties got some much needed late season rain from several tropical storms that brushed the coast. Record high temperatures through July and another spell in August were tough on non-irrigated acreage.

The first tobacco budworm moth flight was light to moderate, and control was relatively easy. The second flight over the Fourth of July proved to be much heavier and more difficult to control. Testing in the laboratory indicated the possibility that we may have isolated pockets of resistance to the pyrethroids. Many factors can contribute to the control problems we experienced, but a number of facts point to resistance and spotty, heavy infestations as major players. In some areas the bollworm/budworm pressure remained at high levels through July and well into August.

Beet armyworms were found in cotton in May, but infestations did not develop into damaging numbers until July, and then only in limited areas. Where they did get bad, they got really bad, and caused a few growers to abandon fields. Confirm - used under an emergency exemption - did a good job. Where intensive spraying was not needed for other pests, the parasite, *Cotesia*, kept beets in check through the year. Fall armyworm outbreaks were reported in many areas, but east Georgia was hardest hit. Soybean loopers were worse in '95 than in recent years. Two late season generations defoliated a lot of cotton because we do not have any effective insecticides against this pest. Yellowstriped armyworms also were more numerous this season and remained in cotton through July. The southern armyworm apperared in June as 1995's "new" pest.

A statewide aphid outbreak in June continued into July before the fungus disease wiped it out. Unfortunately, many fields were sprayed for aphids which may have contributed to some of our armyworm problems. Whiteflies developed late in the year, as did limited spider mite problems. Stink bugs are just getting started good.

The Boll Weevil Eradication Program continued to make progress toward getting the last boll weevil in Georgia. Northwest Georgia appears to be nearing eradication and the Elbert County outbreak of 1994 has been cleaned up. The BWEP reacted quickly and effectively to the Brooks County problem, trapping and spraying intensively to prevent its spread.

The tremendous acreage increase caused a number of problems that will be corrected in time. Shortages of experienced scouts, chemicals, and rain, and an abundance of insects and high temperatures all combined to make 1995 a tough year to begin growing cotton.

Florida. In the western panhandle, most fields were planted and emerged in late April-early May. In the eastern panhandle, planting was somewhat later due to insufficient soil moisture in early May. Heavy rainfall in the west on May 10 and sandblasting of cotton caused by high winds throughout the panhandle on May 19 caused several fields to be replanted. During the latter part of June and most of July, rainfall was below normal causing severe crop stress. Wind and rain from hurricanes (Erin on August 3 and Opal on October 4) severely damaged the crop throughout the panhandle. The average yield in the western panhandle is expected to be below 500 pounds of lint per acre. Although yields were somewhat better in the eastern panhandle and considerably better in the newer cotton production areas further to the east, the state yield is expected to be about 580 pounds of lint per acre.

Thrips populations were near normal and granular insecticides, used on nearly all of the fields, provided adequate control. Tarnished plant bug populations were generally high, although some fields experienced only minimal pressure. In other fields, populations appeared to be low based on monitoring for adults; however, early square retention dropped as low as 65% with the loss attributed to plant bug feeding. Aphid populations increased early to very high levels in most fields. The fungus disease became established in early July, approximately 2-3 weeks earlier than normal and quickly brought the populations of aphids under control. Very few fields were treated for aphids.

The bollworm/tobacco budworm was the most common pest in cotton in 1995. Heavy infestations began in mid-June and continued through August in many fields. However, some fields in north Florida saw minimal populations and were not treated for the bollworm/budworm for the entire season. In the western panhandle and in northeast Jackson County, 8 to 10 insecticide applications were not uncommon. In many instances, pyrethroids did not provide adequate control, and tank mixes with organophosphate or carbamate insecticides were applied to suppress the population. Vial tests indicated up to 50% survival at to 10 ug dose. Spinosad, used under an EUP, provided superior season-long control when compared with a pyrethroid standard program in replicated tests.

The beet armyworm caused extensive damage in several areas of the panhandle. Damage was most notable in the Walnut Hill area of Escambia County, the Allentown and Chumuckla areas of Santa Rosa County, northern Okaloosa County and northeast Jackson County. Treatments began during the first week of July in many fields and by early August many fields had severe fruit damage despite multiple applications of labeled insecticides. Confirm 2F was used beginning August 14 under a Section 18 (crisis exemption). However, control was estimated at only 50-60% after 7 days and was insufficient for pretreatment populations in excess of 80 larvae per 3 feet of row. On September 1, the EPA granted a Section 18 (specific exemption) for Pirate 3SC. The product gave effective control of the beet armyworm within 48 hours of application; however, insufficient supplies of the product and extensive damage prior to the emergency label resulted in considerable loss of yield.

Fall armyworms, banded winged whiteflies and soybean loopers showed up mid- to late season on schedule. Populations in nearly all fields failed to develop to threshold levels. The silverleaf whitefly was common over approximately 8,000 acres in the newer production areas in the east. Multiple insecticide applications were required in many fields, particularly those planted after mid-May. Some fields planted late and not treated were defoliated by the whitefly.

Stink bugs were common in many fields beginning during the latter part of July. Numbers increased in September through migration, and reproduction causing scattered damage. In many cases, populations and/or damage were not recognized and yield loss occurred.

Louisiana. The vast majority of the 1994 cotton crop was planted between late April and early May. Heavy rainfall and cool temperature during mid April resulted in significant stand loss and increased incidence of seedling disease in fields planted in early April. Most of the state experienced dry growing conditions and high temperatures during June, July, and August. In Northeast Louisiana the only significant rainfall to occur during this time period occurred on 5 July. Greater than 90% fruit set was observed on most of the cotton prior to bloom. Most of the cotton acreage was cutout by late August, and most of the state experienced favorable harvest conditions through October. Louisiana cotton yield are estimated to be approximately 638 pounds of lint per acre on 1.06 million acres. In 1995, yield reductions were attributed to the following: weather 66%, insects 25%, chemical 5%, other pests 1.6%, and various agronomic influences 1.4%.

Early-season insect pest pressure was light. Thrips populations were light over most of the state. Cutworm pressure was light with most high risk fields receiving a prophylactic treatment for cutworm control. Yellow striped armyworms and saltmarsh caterpillars were present in many fields, but most did not require treatment. Overwintered boll weevil populations were extremely high with most fields receiving at least one pinhead square treatment. After pinhead square, boll weevil populations were almost non-existent until late July. From late July to harvest boll weevils were present in most of the state's cotton fields. Tarnished plant bug populations were extremely low in 1995. Most fields either did not require treatment or only a single treatment was applied for their control prior to bloom. Tarnished plant bug populations were slightly higher in late July and August; however, most did not require control. Cotton aphid populations were high during June and early July, with almost all fields having an aphid infestation. Many fields were treated for aphids during late June and early July. The pathogenic fungus appeared in late June in the areas where aphids were initially detected. Areas where aphids were first observed were where the epizootic occurred first, and the last areas to observe heavy aphid infestations were the last to observe the epizootic. Bollworm/tobacco budworm populations were generally light during 1995, although heavy infestations (one to three larvae per plant) did develop in scattered fields. Pyrethroid resistance levels in tobacco budworm populations were similar to that of 1994. North of Interstate 20, bollworm was the predominant Heliothine species. South of Interstate 20, tobacco budworm was the predominant species observed in cotton. Beet armyworms were found in most cotton fields in 1995. Populations were initially observed in June in southern

Louisiana. In mid July beet armyworms were observed in many areas of the state. Several fields in the Red River Valley and Northeast Louisiana were treated for beet armyworms in July. During August, heavy infestations of beet armyworms were observed in the southern delta area of Northeast Louisiana. About 60% of the cotton fields in this area required treatment for beet armyworm populations. Secondary pests such as spider mites, whiteflies and western flower trips were present in many fields. Spider mite populations were high in late June and early July. Several fields in the Red River Valley required treatment for spider mites. Populations of whiteflies and western flower thrips did not generally reach treatment threshold.

Mississippi. The 1995 crop exceeded 1.5 million acres at planting but localized flooding reduced this acreage to approximately 1.45 million. Early planting and growing conditions were generally favorable but considerable acreage was replanted due to heavy, late April rainfall.

The winter of 1994-95 was exceptionally mild. Consequently overwintered boll weevil numbers were high throughout the state and most acreage required one or more treatments for their control. Approximately 100,000 acres of cotton along the Eastern edge of the state initiated a Boll Weevil Eradication Program in the fall of 1994. Overwintered boll weevil populations were much lower in this area, but most acreage still required early season treatments. Tarnished plant bug populations, on the other hand, were quite low and only a relatively small percent of acreage required treatment for threshold populations of plant bugs prior to bloom.

Cotton aphid populations were unusually heavy and appeared earlier than normal throughout the state. High populations appeared on pre-blooming cotton and continued to build for several weeks. Many fields suffered infestations of several hundred aphids per leaf during this time. Treatments were applied to much more acreage than usual, but lasting control was difficult to achieve due to widespread resistance. Of currently available materials, Bidrin (dicrotophos) and Provado (imidacloprid) performed best and usually provided effective short-term control when adequate coverage was obtained. Furadan (carbofuran) was used under Section 18 Emergency Exemption on approximately 200,000 acres. However, effects of these Furadan treatments generally were masked by a widespread epizootic of the *Neozygites* fungus that began approximately July 6 and ultimately controlled the aphid outbreak throughout the state.

Budworm/bollworm populations were unusually low throughout much of the Delta portion of the state, resulting in little treatment for these pests prior to late July. However, in the hill portion of the state, June tobacco budworm infestations were more common than usual and occurred over a longer period of time than usual. In most cases these June infestations were light to moderate. However, several localized areas scattered throughout the hills experienced very heavy June infestations and sustained severe square loss despite intensive control efforts. Surprisingly, these June infestations seemed to be more common and more severe in that portion of the hills which was not involved in boll weevil eradication.

Despite these localized problems, most of the crop entered July with high levels of fruit retention, and mid-July yield potential of both the hill and delta cotton crop was excellent. This changed drastically in the hill portion of the state with the arrival of second generation tobacco budworms. Beginning the third week of July, extremely heavy budworm egg lay was encountered over much of the hills (approximately 500,000 acres). Infestation levels varied considerably within this area, but in the most heavily infested areas initial population levels ranged from 50 to 100 percent infested plants, with multiple eggs per plant. This level of pressure persisted for two to three weeks before declining to infestation levels of 20 to 50%. It is noteworthy these severe infestations occurred in hill cotton both inside and outside of the active boll weevil eradication area.

The combination of high, sustained infestations and high levels of insecticide resistance made it impossible for producers in the most heavily infested areas to achieve control. Despite timely, frequent application of costly treatment combinations, many hill fields experienced severe damage. Populations as high as 3 to 6 large larvae per plant were frequently observed following 3 to 4 insecticide applications. High levels of resistance existed to all classes of insecticide chemistry, but pyrethroids were particularly ineffective, especially in areas where they had been used against first generation budworms. By the first week of August the most heavily infested fields had sustained 50 to 90% damaged bolls with many large larvae still present, and many fields were being abandoned.

August budworm infestations were even higher, with counts of 10 to 30 eggs per plant being common in much of the hill cotton. Shortages of insecticides also contributed to the overall problem. Fortunately, this third generation was considerably easier to control than the July generation, presumably because of increased mortality from parasitism and disease, and many hill producers were able to salvage a partial crop, albeit at greatly inflated control costs. The insecticide Pirate received Section 18 emergency exemption for use against tobacco budworm late in the 1995 season, but product availability was extremely limited. Late season pressure intensified in the delta also, but most of the delta crop matured in time to escape severe damage.

Although no statewide beet armyworm (BAW) outbreak occurred in 1995, there were isolated areas within the state where heavy populations did develop, and some fields sustained severe yield loss as a result of these infestations.

Cotton in the vicinity of Jackson, Canton and Yazoo City was most heavily infested with many fields in this area receiving 2 to 3 treatments specifically for BAW. This area has experienced BAW problems for several years, and BAW larvae were detected on seedling cotton in this area in 1995. During July it appeared that BAW populations were beginning to build to threatening numbers in the southern delta. Conditions were generally favorable to development of a severe outbreak, but this problem did not develop. Presumably, the relatively low amount of treatment required for other pests allowed beneficial insects to aid in suppressing BAW. In the hills, problems with BAW were generally overshadowed by the tobacco budworm outbreak. Two products, Pirate and Confirm received Section 18 emergency exemptions for use against BAW in 1995.

Several minor caterpillar pests were much more numerous than usual in 1995. These included: cabbage looper which appeared in high numbers on seedling cotton; salt-marsh caterpillar, which required treatment on a few isolated fields; and yellowstriped armyworm, which was much more common than normal throughout the state and even required treatment in a few cases. Apparently the same environmental factors that were responsible for high populations of tobacco budworm also contributed to the survival of these minor caterpillar pests. Low level fall armyworm infestations were observed throughout the state in early July, but few fields required treatment specifically for this pest in either July or August.

In summary, 1995 was a disastrous insect year for Mississippi's hill producers due to the severe outbreak of resistant tobacco budworm. Many thousands of acres of hill cotton were totally destroyed by this pest, and many counties suffered overall yield losses of 50% or more, despite extremely high control cost. This combination of high control costs and low yields meant economic disaster for many producers, and economic factors coupled with concerns over the potential for similar problems to occur in 1996 will cause hill cotton acreage to decline substantially in 1996. However, it is important to recognize that the potential for this type problem to recur is not confined to any single part of the state.

Yields were also down considerably in the delta, despite generally low insect pressure. Most delta producers entered late season with high boll counts and expectations of average to above average yields. However, much of the delta experienced unusually hot, dry conditions during mid to late season. Consequently many areas of the delta harvested yields that were 10 to 20% lower than normal due to small boll size and light lint. Mississippi's 1995 cotton crop averaged approximately 600 lbs of lint per acre, which is aboutlbs less than the five-year average yield. Insect control costs, excluding application costs, were estimated at $76.32 per acre for the Delta and $118.51 per acre for the hills. This is the first time since beltwide cotton losses were first recorded that hill control costs have exceeded those for the delta.

Missouri. The 1995 growing season was marked by difficult weather and the most severe insect pressure on record. The winter of 1994-95 was very mild; no air temperatures below 12°F or temperatures under leaf litter below 18°F were recorded for the winter. Precipitation was also somewhat below normal. March and the first 20 days of April were exceptionally warm and dry; this facilitated field work but also encouraged some premature planting. These conditions may have also allowed thrips and aphids to pass through an additional early Spring generation on alternate hosts. Many areas in southeast Missouri saw cool weather and significant precipitation in late April and early May; these conditions severely stressed cotton that had already been planted. Persistent high winds from the Southwest caused substantial seedling mortality through sand-blasting in some areas throughout this period.

Tremendous thrips pressure was evident as soon as cotton began emerging; the pressure remained intense through mid-June in most areas. Severe damage and plant mortality were observed in cotton unprotected by insecticides; even cotton planted with standard at-planting insecticides showed significant damage before seedling root systems grew enough to take up insecticide. Foliar applications for thrips were made on a substantial portion of the acreage. Cotton aphids and yellow-striped armyworms were also present in much higher than typical numbers at seedling emergence, and pockets of heavy cutworm pressure were present (although cutworm activity was not as severe as in 1994).

Rainfall was abundant from the latter half of May through July (approximately 16 inches for the period), and cotton that was not hampered by early season stress made good vegetative growth. However, there was a total of about 54 cloudy or mostly cloudy days during this period, and this apparently hindered fruit development. The rainy weather was also accompanied by several episodes of widespread, heavy hail, particularly in early June. A substantial portion of the acreage was replanted due to hail damage, sand-blasting, and heavy early insect pressure.

Overwintered boll weevil numbers were the highest on record; peak captures were approximately twice as great as those observed in the spring of 1993 (the previous high year). While numbers were very high, the bulk of the population appeared to emerge fairly early, and accurately timed pinhead applications proved very effective for many growers. Boll weevil pressure resurged by early August and necessitated in-season applications on about 20% of the acreage.

Heavy aphid pressure was pervasive and about two weeks early. A significant proportion of acreage received from one to three insecticide applications for aphids; poor control with traditional materials was noted in several cases, and many treatments went out just before fungal epizootics occurred. *Neozygites fresenii* wiped out virtually all infestations by about July 21. Spider mite infestations were spotty but unexpectedly heavy given the high rainfall and humid weather.

Fall armyworms began showing up in economically significant numbers about July 6, and bollworms reached economic levels in some fields about a week later. While bollworm numbers fluctuated, and did not become severe in most fields until August, fall armyworm pressure remained fairly constant through most of the rest of the season. Tobacco budworms appeared in economically significant numbers in late July, although in most years, budworms are very rare throughout the season. In early August, beet armyworms appeared in the area, and a handful of fields developed economically significant infestations of defoliating larvae by mid-month (beet armyworms did very little boll damage in any of these infestations).

No precipitation fell from August 10 through September 15; cotton fruit maturation apparently was hindered by the lack of moisture. Very large numbers of boll weevils were produced during the post cut-out period throughout the region, and diapausing populations are probably currently at a new all time high.

Yields for the Missouri crop at the time of this writing (November 1) are expected to be down about 100 pounds from the five year average. The average number of insecticide applications is more than 2X normal, and insect control costs are about 2X normal.

New Mexico. There are four production areas in New Mexico and each area was faced with varying conditions in 1995. In general, insect populations were higher than in 1992-94. The High Plains area on the east side of the state was similar to those for the West Texas High Plains. As in 1989-94, planting was late or was prevented in some cases due to lack of moisture or excess moisture, and then hail storms and seedling diseases took out some plantings. As usual, bollworm problems were spotted but were heaviest in the southern counties. A majority of fields in the Clovis area were still treated for bollworms. Plant bug and stink bug populations were light again this year, with only 650 acres being treated. Early thrips populations were much lower in 1995 as they were in the Texas High Plains. Some boll weevils were captured in pheromone traps late in the 1989, 1992, 1993, and 1994 seasons. The 1995 season will be long remembered as overwintering weevil populations were detected in both Lea and Roosevelt Counties. Over 1,700 weevils were eventually collected in Roosevelt County and 30,852 in Lea County (see special report below). Weevils were even detected in Quay County in November. Yields are estimated to be in the 700-900 lbs. of lint/acre range.

In the Pecos Valley, the 1995 growing season again can best be described as one of extremes. April temperatures were unseasonably cool, and many producers delayed planting as a result. The average minimum air temperatures were 3.4 degrees Fahrenheit below normal and averaged only 38.43 degrees. Maximum temperatures averaged 76.40 degrees and were 2.13 degrees below normal. Heat units for April totaled 73 compared to 157 average. Temperatures in May improved with maximums near normal and minimums above normal, resulting in slightly above normal heat units. Overall cotton was very slow in initial growth stages and was 2-3 weeks later than normal at first bloom. The crop was further reduced by hail damage and insect infestations. Bollworms required control in some fields in mid-season and pink bollworms in the latter part of the year. In both cases the reduction in beneficial insects resulted in dramatic increases in aphid populations that required control measures. In some cases, producers chose to ignore the aphid invasion and yields of cotton suffered. An intense build-up of beet armyworms in August resulted in serious defoliation and loss of young bolls, resulting in further yield reductions. Perhaps the lone bright spot in an otherwise dismal cotton season was favorable temperatures in September, coupled with a dry harvest season in October and November. As we look ahead to 1996 and beyond, the buildup of the cotton boll weevil in this area (see boll weevil section below) should be noted. Reproducing populations have been documented in 1995, and some limited diapause control measures have been initiated. Our effectiveness in dealing with this pest may well determine the future sustainability of cotton as a viable crop in New Mexico.

Pink bollworm infestations have been prevalent in the southern portion of Eddy County and were present to a lesser extent in the northern part of the county in 1993-94. The pink bollworm problem reached proportions sufficient to merit a mandatory plowdown regulation in 1994-95 and will be continued in 1995-96. About 6,000 acres were still treated 3-5 times for the pink bollworm in 1995. Without complete grower compliance with the mandatory plowdown, this pest may also cause serious losses to growers, even in southern Chaves County, in 1996. The quality of the crop has been excellent to date with harvest nearing completion at this time (mid-November). Yields have generally been in the 700-850 pound range.

Thrips were only a spotted early season problem in the Pecos Valley with only about 50% of the acres being treated with systemics at planting or with foliar sprays after emergence. Fleahoppers, lygus, and other mirids were present, but generally at low populations levels, and only about 20% of the acreage was treated for these pests. Bollworms, primarily the cotton bollworm, were present in moderate numbers in about 70% of the fields; however, some infested fields were treated three to four times during the season. Armyworms, primarily the beet armyworm, were a general pest, and about 60% of the area was treated up to four times for this pest. Spider mites were present, but populations never flared in most fields.

Aphids were again of primary concern in late August, but proved to be fairly easy to control. Due to low beneficial arthropod populations, many untreated fields did not experience the drastic aphid population reductions observed in previous years and suffered some yield losses this season. Most fields treated for bollworms and beet armyworms included an aphicide to reduce the chance of flaring aphids. Populations failed to rebound after the cotton began to open, thus preventing a sticky lint problem.

Weather was a major factor throughout the 1995 growing season in the lower Rio Grande Valley. Problems from cold temperatures in April, hail, flooding, and wind created erratic stands, crop damage, and a late crop. These factors coupled with insect problems in some areas resulted in yield reductions.

The weather was quite favorable the latter part of March and the first ten days of April. The weather turned cold and did not warm up until the last week of April. Cotton planted before the cold weather generally did fairly well. Any planted during the middle of April had serious stand problems from poor germination and seedling disease.

Seedling diseases were associated with the 1995 cotton crop in New Mexico. Prolonged cool temperatures in the spring caused significant stand losses from plants diseased by Rhizoctonia (seed decay, damping off, and root rot) and Fusarium wilt. Plant losses in some fields was substantial enough to replant. Plant damage associated with root-knot nematode and Verticillium wilt was sporadic and in most fields did not cause significant losses.

Late April and May planted cotton resulted in good stands but the crop was late. A good August and an open fall allowed this cotton to provide some good yields. Several farmers in the lower Rio Grande Valley picked in excess of two bales and some up to three bales per acre.

Insect populations were low in the Rio Grande Valley throughout the 1995 season. Only a few fields were treated for thrips or *Lygus* bugs and other mirids. Bollworm treatments were made on less than 8% of the area. The pink bollworm expanded its range in 1994 and 1995, but less than 5% of the acres were reported to be treated. Aphids and whiteflies were present, but were not a problem in this production area. Harvesting was in progress at the time of this writing (November 23), but reports indicate average yields in the range of 700-800 lbs. of lint/acre for upland and 600-700 lbs. for pima.

Similar weather conditions were encountered on the west side of the state, but thrips and *Lygus* and other mirids were reported to be a problem in several fields in that area. Late season aphid infestations were reportedly not treated. Beet armyworms and pink bollworms were noted in most fields, but no fields were treated. However, 250 acres were treated for pink bollworms in Luna County in 1995. No boll weevils were trapped in Hidalgo or Luna counties in 1992-1995, and no field infestations were found in this area either. Due to these insect and weather conditions, average yields are expected to be in the 800 lbs./acre range. Lint quality in these counties is also expected to be quite good.

As in 1989-1994, very few of the areas had grasshopper problems. High rain conditions that occurred before and after initial grasshopper hatch has been attributed with reducing this problem. Beet armyworms were also cited as minor problems in some areas with major problems in the Pecos Valley. The fall armyworm was reported as a minor problem on the east side again this year. However, the fall armyworm was controlled in routine spraying for bollworms and beet armyworms, and no special treatments were made in most cases.

The cotton boll weevil dominated the cotton insect concerns in New Mexico in 1995. Until 1995, the boll weevil was not considered an established pest in New Mexico cotton fields. Sporadic interceptions of this key pest in prior years were interpreted as evidence of long range dispersal of late-season adults from established populations in neighboring states; no evidence of current year square or boll damage due to boll weevil infestations was ever linked with these New Mexico interceptions. Also, interceptions were almost exclusively made late in the season when dispersal was most likely; the lack of adult weevil captures the following spring in these same areas suggested a failure of the pest to overwinter or to become established. Nevertheless, noticeable increases in interceptions, primarily in southeastern New Mexico over the last 3-5 years (especially 1994) strongly suggested situations were changing and the pest was gaining a foothold.

In 1995, several agencies established lines of Leggett boll weevil traps using standard USDA installation and servicing protocols in the key cotton production areas of New Mexico as follows:

Table 1. Location, agency reponsible, and number of boll weevil traps in New Mexico in 1995.

County	Agencies Responsible	Approx. No. Traps
Lea Co.	USDA-APHIS-PPQ	164
Roosevelt Co.	USDA-APHIS-PPQ	44
Quay Co.	USDA-APHIS-PPQ	26
Eddy Co.*	Coop. Extension Serv.	262
Chaves Co.*	Coop. Extension Ser.	183
Dona Ana Co.**	NMDA	587-764
Luna Co.	USDA-APHIS-PPQ	10
Hidalgo Co.	USDA-APHIS-PPQ	15

*These two counties comprise the "Pecos" area in the table. Both are on the Pecos River drainage.

**NMDA set 587 traps in the original trapping grid. In response to multiple captures in the original traps, additional traps were placed in Dona Ana County beginning in July and continuing sporadically until October 4.

USDA-APHIS-PPQ officers and staff from El Paso, TX also established and maintained a trap line of an additional 194 traps on the TX-NM border where the agricultural area of extreme NW El Paso, TX blends into the agricultural area of south-central Dona Ana County. Other listings for USDA-APHIS-PPQ pertain to officers and staff stationed in New Mexico.

Most of the Dona Ana County traps were established by late April and the other trap lines by mid-May. Traps were serviced weekly from establishment through early July in Dona Ana County and every other week in other areas. Traps in Dona Ana, Chaves, and Eddy Counties were serviced every other week from early July through mid-August, while traps serviced by USDA-APHIS-PPQ were left in place but not serviced during the summer. The original schedules of trap checks were resumed in all areas in mid-August and were continued through the middle or end of November when the traps were removed.

To date, no boll weevils have been recovered from any traps located in Hidalgo and Luna Counties. A single boll weevil was found in a trap near a gin in Quay County on October 31, the first and only recovery this year. In the other counties, boll weevils were collected sporadically in some areas and ever increasing numbers in the remainder. After the summer hiatus, tremendous numbers of boll weevils were recorded almost routinely in Lea County. An apparently localized boll weevil infestation in Dona Ana, Eddy, and Chaves Counties provided impetus for organization of numerous local cotton growers into cotton pest management cooperatives directing local funds into a concentrated treatment effort against boll weevils that continued from late summer through harvest.

Table 2. Monthly summary of boll weevil trap catches by area (running totals are in parentheses for each area).

Month	Dona Ana*	Pecos**	Roosevelt	Lea
May	4 (4)	0 (0)	0 (0)	21 (21)
June	3 (7)	3 (3)	3 (3)	13 (34)
July	7 (14)	2 (5)	9 (12)	27 (61)
Aug	81 (95)	8 (13)	21 (33)	266 (427)
Sept	203 (298)	51 (64)	340 (373)	1955 (2382)
Oct	1566(1864)	301 (365)	1224(1597)	21483(23865)
Nov	2897(4761)	7151(7516)	679 (2276)	18345(42210)

*Does not include 57 boll weevils (as of November 21, 1995) from the USDA trapline on the TX-NM line.
**Pecos includes Eddy and Chaves Counties.

North Carolina. North Carolina's two major insect pests, the bollworm and the European corn borer, were on the light side in 1995, particularly the latter species, with thrips pressure about average and tobacco budworms, cotton aphids, beet armyworms and soybean loopers present in unusually high, but most often sub-economic, levels for this area.

With moderate, but extended, thrips pressure in several areas of the state, a moderate number of producers had to supplement their at-planting insecticide with a foliar application for thrips, particularly in April-planted cotton.

Plant bug populations remained low throughout most of the state, in keeping with our history of *Lygus* being a very minor problem here. A state-wide survey of our independent crop consultants confirmed these findings, with both high square retention (often in the mid-90's) and low sweep numbers of adults the rule. Little reproduction, as indicated by the presence of nymphs, was observed. However, some fields did reach threshold levels, as noted by several consultants in a few of our northeastern counties. Out of a total of 270,000 consulted acres, 600 acres, or 0.25%, of the fields were treated in 1995 for plant bugs. Several thousand acres not managed by consultants were again treated for essentially non-existent plant bug problems. In total, approximately 1% of our state's cotton acreage was treated for plant bugs in 1995.

Tobacco budworm levels were very low in cotton in the June (second) generation. Approximately, 3.7% of this generation was treated on 'consulted acreage', a figure which probably mirrors the state as a whole. However, atypically high tobacco budworm populations were present just prior to and as a component of our major late-July to early August bollworm (third) generation. As a result of tobacco budworms occupying a significant proportion of the bollworm/budworm complex and extended hot, dry weather, a number of 'control failures' were reported. Follow up treatments by producers under better conditions and two insecticide screening tests in one of the 'problem' areas suggested that pyrethroid resistance was not the culprit. In the above follow-up tests, although Spinosad and Larvin performed well, the candidate pyrethriod(s) numerically reduced boll damage to lower levels. The potential elevation of the tobacco budworm to a more significant pest of cotton in North Carolina in the wake of greatly expanded cotton acreage is presently a matter of speculation but merits close monitoring.

Bollworm populations and their resulting damage to cotton was on the light side (2.58% year-end damaged bolls across the state compared with a ten-year average of 3.97%). For the first time in more than 30 years, cotton acreage exceeded corn in North Carolina this past year. In 1978, the ratio of planted corn acreage to that of cotton was approximately 43:1. Because untreated field corn serves as the major nursery for both corn earworms (bollworms) and European corn borers, acreage shifts to cotton at the expense of corn in many areas of the state may be significantly lowering the populations of corn earworm adults available to cotton. A number of cotton fields in North Carolina were again untreated with foliar insecticides in 1995.

Perhaps partially due to the reason stated above for corn earworms on North Carolina's diminishing corn acreage, European corn borers were present at astonishing low levels this past year, as evidenced by a statewide damaged boll level of just 0.09%, compared with a 10-year mean of 1.69%, the lowest since the initiation of the 1885 survey.

Stink bugs were also present at relatively low levels this past year, even in untreated producer fields and in untreated transgenic *B.t.* cotton tests. Of great interest will be the status of this pest in 1996 and beyond with the advent of cotton essentially untreated for budworms and, in most cases, bollworms.

Several insect species, although not responsible for widespread damage to cotton in 1995, reached relatively high levels by North Carolina standards. The cotton aphid persisted at easily detectable levels in a large number of cotton fields throughout much of the growing season, even into opening cotton in some cases. The mummifying braconid wasp parasites (primarily two species) did a good to fair job of holding cotton aphids at "sub-concern" levels during the mid-season. Our common entomophtherian parasite, *N. fresenii*, appeared to reduce aphid populations less dramatically than in recent years, although this fungus was both geographically widespread and effective once significant cotton opening was underway. NCSU entomologists continued to advise cotton producers not to treat for *Aphis gossypii*, primarily due to parasites, fungi and the presence of multiple insecticide resistance in some of the populations.

Migratory beet armyworms are little more than occasional visitors to this state's cotton fields in most years. Beet armyworms were found at some level in virtually all of our cotton-producing counties. Although in most cases this pest was an unusual curiosity, several counties, especially Harnett and Sampson in the central cotton-producing area of the state, experienced very high levels of larvae in some fields. These high larval populations completely defied control by conventional insecticides such as high rates of Lannate, Larvin and Curacron. A Section 18 Crisis Exemption was issued on 30 September for Confirm and the product provided moderate to good control in several of the treated fields. The last year "beets" were present in anything approaching these levels in North Carolina was in 1977 under similar weather conditions. All in all, beets likely caused economic damage in less than 0.25% of the state's cotton fields. However, a handful of the infested fields were almost completely devastated by this thankfully more typically southern cotton pest.

Fall armyworms were present in a number of our state's cotton-growing areas, although at less than alarming numbers, with little treatment required. Only 0.27% fall armyworm-damaged bolls were uncovered across the state in this year's survey compared with a long-term average of 0.47%.

Soybean looper also was present in a number of geographically-widespread cotton fields in 1995. In a few cases where treatment for moderate to high levels was attempted with conventionally-labeled insecticides, virtually no control was achieved. Overall, soybean looper larval populations showed up late enough in the season to cause minimal defoliation damage.

As of this writing (early-December), 19 boll weevils have been found in North Carolina in 1995, an encouraging decline after last year's total of 32. However, both our Virginia neighbors and our more southern (South Carolina, Georgia, Florida and Alabama) producers have witnessed significant breaches in their monitoring and detection programs. We are hopeful that our neighbors recognize and appreciate the vital importance of successful containment programs to the long term stability and profitability of cotton in their respective areas, and that 1995 serves as a wakeup call.

With one of the wettest Junes on record over a significant portion of the state's cotton acreage (20 to 30 inches in places), followed by an exceptionally dry July and August and topped off by a miserable, wet harvest season, projected yields are presently December) in the 520 to 580 pounds of lint per acre range. Out of a total of 810,000 planted acres, approximately 25,000 acres may have been abandoned, some following very difficult weed management in June, somewhat less following the very dry weather, and a significant portion abandoned as a result of poor harvest conditions or an accumulation of all three.

Oklahoma. Stormy weather delayed planting of this year's cotton crop, and June-planted cotton in Oklahoma spells trouble. A total of 380,000 acres was planted, but weather and insect damage reduced the number of acres harvested to less than 320,000 acres. Heat unit accumulations (2560 hu) lagged behind the 40 yr. average. Besides being short on heat units, a cool September stopped fiber development, reducing lint weight and lowering grades. The state production average will likely be less than 300 lbs. of lint per acre.

Thrips infestations caused isolated damage because of good growing conditions in June and widespread use of at-planting insecticides. Cotton fleahoppers and boll weevils were targets of many insecticide applications applied before bloom. A mild winter allowed the boll weevil to survive across most of the cotton producing area of Oklahoma. Boll weevils inflicted economic loss across all of southwest Oklahoma. Irrigated cotton averaged 4 insecticide applications to prevent economic loss and dryland cotton 2 insecticide applications.

Widespread rainfall in early August increased the attractiveness of cotton for bollworm oviposition. Dryland cotton received 1 to 2 insecticide applications while irrigated fields were sprayed 3 times to prevent economic loss.

Cotton aphid infestations exceeded the economic threshold across the state. Heaviest infestations occurred in cotton under intense management. Most of the spraying occurred in Harmon, Jackson, and Tillman Counties in southwest Oklahoma. Fields averaged two insecticide applications to control aphids. Furadan was the product of choice once counties met the criteria for emergency use under the Section 18 label.

Beet armyworm infestations reached damaging levels in September. Economic damage occurred across southwest Oklahoma. Two control strategies were employed: 1) use of Dimilin when egg masses were first detected; or 2) delaying treatment (Larvin, Lorsban, and Lannate) until economically damaging populations existed.

South Carolina. Growers who planted early in 1995 had good growing conditions and excellent stands for the most part. Cotton planted after the first week in May was often "dusted in" as moisture became the limiting factor. Consequently, herbicides did not perform well and weeds (primarily pigweed species) were poorly controlled in many of these fields. Where growers were able to control the weeds, however, some excellent yields were obtained in late planted cotton fields.

The Crop Reporting Service expects that 335,000 acres will be harvested in South Carolina. This will be 112,000 more acres than were harvested in 1994. The average yield is projected at 635 lbs lint per acre--211 lbs. less than last year.

Thrips damage was evident in many fields where dry soils may have hindered the uptake of soil insecticides. But the slow growth of cotton seedlings due to cool temperatures and lack of moisture may have been more responsible. Surprisingly good thrips control was achieved in a number of fields that had scarcely a drop of rain for 3-4 weeks after planting. As usual, plants were badly damaged by thrips in test fields where no soil insecticides were used. More than 90% of the cotton acreage was treated with soil insecticides at planting.

The first two generations of cotton bollworm and tobacco budworm were reported infesting cotton several days ahead of schedule as a result of unusually warm temperatures. Early egg counts were sometimes high, but generally, budworm infestations in June were extremely light. During most of the past 15 years farmers treated about 25% of their cotton acreage in June to control budworms, which is the predominant early-season species in SC. In 1995, probably less than 5% of the cotton was treated for budworms in June. By 8 July bollworms were infesting cotton in economically damaging numbers. This occurrence was about a week earlier than expected, but quite similar to bollworm activities in 1994. Infestations were not extremely high, although many farmers were forced to continue treating the same fields with pyrethroids for 3-4 weeks without a break in the action. We also saw this in 1994 following a very mild winter.

Since budworm numbers were light in cotton, there were few control problems. Vial tests were conducted on budworm moths to measure their susceptibility to pyrethroids. In 1994 we did not obtain enough moths to run any meaningful tests, but this year we tested several hundred moths from seven different locations and noticed some increased survival of moths at the 5 µg/vial dose of cypermethrin in July and August. Later in August we began testing moths with 10µg treated vials. Two groups of moths collected from six different locations bioassayed on 22 August and 24 August had survival rates of 94% and 81% respectively at the 10 µg dose. These were the highest survival rates of budworm moths that have been observed in South Carolina.

Fall armyworms were present in a large number of fields at generally low infestation levels. We began catching fairly high numbers of beet armyworm moths in traps in several areas of the state in late August and numbers increased for the next few weeks. Damaging infestations in cotton showed up in Hampton County in early September. By the end of September, several thousand acres of cotton in several counties had received some economic damage. This was probably the most severe infestation experienced in SC since 1978. Soybean loopers infested several thousand acres of late cotton in mid September producing some moderate yield losses.

European corn borer damage was light to moderate in Dillon, Marlboro and Darlington Counties. Stink bug infestations were high in parts of the lower state and in various locations in the Pee Dee area. Late-planted cotton generally suffered the most severe damage, with 30 to 40% damaged bolls in some fields. Aphid infestations were light for the most part with few attempts made by growers toward insecticidal controls. Plant bug infestations were also generally light.

In 1994, 286 boll weevils were caught in traps in a six-county area. The highest numbers were in Greenwood and Anderson Counties. Although reproduction occurred in a number of fields, the initial infestations are thought to have resulted from weevils moving in from Elbert County Georgia where an outbreak was first detected in August. The infestation appeared to be cleaned up since only nine boll weevils were captured in the spring of 1995 in the six-county area and none were captured after mid June. In August the first boll weevil was captured in Orangeburg County. A week late another weevil was caught there. During the first week in October, 30 boll weevils were caught. Numbers continued to escalate as more and more acres were being monitored at one trap per acre. By the first killing frost in mid November, over 16,000 boll weevils had been captured in Orangeburg and a few surrounding counties. More than 85,000 acres were treated with malathion. The total land area involved (fields with one or more weevils captured) was over 16,000 acres.

Tennessee. The 1995 crop was very promising at the end of July. Based on crop conditions as of August 1, yields were projected at 664 lbs. lint per acre. However, excessive rainfall in early August, unusually heavy insect infestations, and a late season drought reduced yields. Producers will harvest an average but expensive crop in 1995. Although 700,000 acres of cotton were planted, only 660,000 acres will be harvested and an average yield of 575 lbs. lint per acre.

Thrips pressure was heavy across most production areas. A significant amount of the acreage had to be oversprayed for thrips control regardless of at planting treatment. Problems with cutworms did not develop.

Very high populations of boll weevils were present in the fall of 1994. Coupled with the mild winter, high populations of overwintered boll weevils were present in June. Overwintered boll weevil sprays were used to suppress weevils and held populations below threshold levels until early to mid-August. Fortunately, a large percentage of the population emerged by late June. Overall boll weevil damage was less than expected.

Plant bug populations were lower than normal and may have contributed to the high early season square retention. Aphid numbers built rapidly in late June and were beginning to be a problem. However, the pathogenic fungus caused aphid populations to crash in the second week of July, which is earlier than normal.

Tobacco budworm pressure was intense over the southern half of the state. Bollworm moths and larvae were practically non-existent in cotton fields. In late June, tobacco budworm populations were heavier than normal in the southern tier counties. The second field generation was very heavy in late July and early August. Excessive rainfall during this period hampered control efforts, and significant damage occurred in the southern counties. Acceptable control was only achieved when larvae less than 1/4 inch long were targeted. This flight (second field generation) appeared to be extended compared to previous years. Adult vial tests were conducted on the second generation on four occasions, and pyrethroid resistance levels were in the 25 percent range. The third field generation was even heavier, and resistance to pyrethroids was more apparent. Shortage of insecticides forced many growers to continue the use of pyrethroids late into the season. Overall, control of tobacco budworm was acceptable at best.

Beet armyworms were not an economic concern in most areas. However, late in the season they could be found at low levels in most fields. Fall armyworms were present at low levels in late July in some areas. Loopers caused problems in a few fields but were not widespread.

Texas. Producers had high expectations for the 1995 cotton crop because of high prices and exceptional yields in 1994 and increased their planted acreage. Problems with weather and insect pests soon turned the 1995 crop year into a disappointment for many growers because of high input costs and an unexpected 20% reduction in yields from predictions based on late season boll counts. Texas' producers still harvested close to 5 million bales from 5.7 million harvested acres.

The 1994-1995 winter was the 5th consecutive mild winter in a row. Prior to this series of mild winters there has never been more than two consecutive mild winters since weather information has been recorded. This string of mild winters is strongly implicated as a major contributing factor to the latest spread of boll weevils into the High Plains area, the early appearance of aphids on seedling cotton in all areas of the state, and the wide spread severity of beet armyworm infestations in 1995.

Boll weevil eradication programs were conducted in three areas, the Lower Rio Grande Valley (LRGV)-360,000 acres, Southern Rolling Plains (SRP)-225,000 acres, and the High Plains (HP)-over 2 million acres. The LRGV began its eradication effort in the fall of 1994 with an aggressive stalk destruction program in lieu of a fall diapause program. This was followed by a traditional eradication program consisting of overwintered weevil applications, in-season insecticide applications and a fall diapause program. 1995 program activities had a rocky start because of some environmental concerns and legal problems. The success of the first year of eradication is still being evaluated and debated because of the unprecedented yield losses accompanying severe beet armyworm outbreaks thought to be associated with the increased number of insecticide applications of the eradication zone. The SRP eradication program was clearly a success with a 98% reduction in trap catches documented in the fall of 1995 as compared to the same time period in 1994. While the SRP program area also suffered through severe beet armyworm problems, these infestations were thought to be the result of a massive influx of moths on a hurricane front that stalled out over the San Angelo area in early August. The HP eradication program actually is not due to start until the spring of 1998. However the recently passed referendum provided additional funds to enhance the existing diapause program to address the alarming spread of boll weevils across the area's cotton. Over 5 million acre-applications were made on approximately 2 million acres at a cost of $12.2 million dollars. Hopefully the enhanced diapause program will limit the spread of the boll weevil so that the 1998 eradication program will not have to encompass the entire 5.2 million acre eradication zone.

Much of the cotton acreage was either planted late (replanted in some cases) or early plant development was retarded significantly by unusually cool, wet conditions. Hot, dry conditions soon followed, providing cotton with adequate moisture an opportunity to recapture lost heat units. Dry conditions severely limited dryland yields in many areas and heavily taxed the ability of irrigated growers to keep up with crop water demands. These same hot and dry conditions did cause high boll weevil mortality but also provided conditions associated with beet armyworm outbreak years. Late summer rains drenched some areas of the state but missed other areas entirely. Heavy rainfall occurred even in the Rolling Plains area, resulting in lush cotton growth and unusually heavy bollworm infestations. While early season thrips and cotton fleahopper infestations were generally lighter than usual, seedling aphid infestations were heavier. Texas did receive a section 18 for use of Furadan 4F for aphid control with county-by-county declarations required. Much of the Texas production region did meet the criteria for use of Furadan 4F (less than 80% control with an accepted aphicide followed by resurgence of aphid numbers to 1100 or more per leaf). Furadan 4F performed very well with no environmental problems documented. Boll weevils were more of a problem in west Texas but lighter elsewhere. Bollworm infestations were more intense in the Rolling Plains and Central Texas areas but less intense in the remainder of the state. There were no significant problems with insecticide-resistant tobacco budworms. Beet armyworms infested most of the state in higher than usual levels with the exception of central and eastern Texas areas. Damage was most severe in the two eradication areas, LRGV and SRP. While yield losses were minimized, control costs for beet armyworms were high in the Northern Rolling Plains, HP, and Far West Texas (FWT) areas.

Weather was a key factor in both the direct loss of yield and to aggravating insect problems in cotton in the LRGV. Very hot and dry weather conditions existed starting in early April and continuing until late May, putting plants in very stressed conditions. No rain fell from April 5 to May 27 at the Weslaco Experiment Station. Similar trends were noted in all other areas of the LRGV in 1995. The cotton crop, especially the dryland fields, had been at or near complete cutout by the middle of May. Some irrigated fields had blooms at one to three nodes from the top of the plants by mid-May also, indicating the plants were nearing fruit "cutout", prematurely. Despite all of the weather related problems, the cotton crop appeared to have the possibility of producing some lint even though it probably would have been below average. Insects, beginning with cotton aphids and following through with beet armyworms and whiteflies prevented or damaged much of the fruit that was on the plants in most fields by the end of the season.

The general insect situation in cotton in the LRGV in 1995 was for pests to be higher than normal and natural enemies to be lower than normal. The usual pests of fleahoppers, boll weevils, bollworms/tobacco budworms, aphids and whiteflies were all present in varying numbers in 1995. However, aphids, beet armyworms and whiteflies contributed to damage to cotton yields in the LRGV in 1995. Pesticide usage, particularly on irrigated farms was higher than normal. Fields across the Valley had aphid infestations recorded as light by mid April, which is not uncommon. However, by early May, aphid infestations in most fields had grown to medium or heavy levels and remained heavy until the heavy rains in late May and early June. Even then, many fields kept high levels of aphids. Lady beetles particularly and aphid parasites generally, increased to very high levels in many fields by the end of May and early June. The natural enemies began to have an effect in some fields by controlling the very high aphid infestations. Most growers had already treated at least once for aphids, and in many cases twice, due to the very high numbers of aphids and lack of beneficials.

Very light beet armyworm populations were first detected in a few fields by mid-April. Heavy levels of beet armyworms were detected in most fields across the LRGV during the week of May 22, following the aphid infestations. Field counts of beet armyworms showed populations as high as 60-80 larvae per foot of row. Populations declined to very low levels by the week of June 12. The week of June 19 saw another major cycle of beet armyworms appear in cotton. Infestations were large during the second cycle, but were not as much of a threat to the Valley as a whole due to the availability of a new insecticide, Confirm. Worm numbers declined to low levels by the end of June. The next cycle of worms occurred in cotton by the week of July 17. However, the population was much lower than the previous two cycles. Beet armyworm moth trap records from a combined trapping effort near McAllen and Weslaco showed that the moths were in very high numbers by late May and declined thereafter until late July, when another cycle began. Moth trap capture records showed that there was a major peak of activity until tropical storm Gabrielle hit on August 9. Thereafter, beet armyworm moths were at very low levels.

Cabbage loopers were also of much concern to producers in cotton. Very large numbers of moths and larvae of all sizes appeared in cotton in early May, coinciding with the beet armyworm cycles. Looper larvae stripped much of the foliage off of plants not already attacked by beet armyworms. The loopers eventually cycled out of the pattern established by the beet armyworms. While only leaves and bracts of fruit were destroyed by the loopers, so many loopers appeared in fields that considerable leaf loss along with leaf loss by beet armyworms no doubt added to the yield potential reduction in many fields across the LRGV. Whiteflies began to appear in cotton in large numbers by early June. By the second week of June, many fields were being treated for increasingly heavy infestations of whiteflies. Counts of adult whiteflies ranged from 0 to 8 per leaf by mid-June. The heaviest infestations which caused plant death and yield losses occurred by late June and early July. Boll weevils were at low levels until about mid-June when punctured square counts began to increase. Punctured square counts ranged from 0 to 3 per 100 plants by mid-May and increased to a range from 0 to 16 by mid-June. Thereafter, punctured square counts ranged from 0 to 50 per 100 plants in some fields. Bollworm and tobacco budworm infestations remained lighter than expected throughout much of the season. Bollworm numbers remained near 0 early in the season. Most area fields did not have high numbers of bollworm/budworm until near the middle of July when worms were reportedly escaping close interval applications of pyrethroids in the La Feria area. Overall bollworms and budworms were considered to be light for the season.

Cotton in the CB was planted late along the southern and early along the northern Gulf Coast. Generally, dry conditions prevailed for nearly 60 days. During this period fleahopper numbers were high but control was successful. Aphids and cabbage loopers were heavy very early in the season especially in the lower CB. Cabbage looper infestations continued until early bloom. Leafminers were so heavy in some fields that defoliation occurred. Beet armyworm numbers increased to alarming numbers in the drier areas by late May. Expensive insecticide applications were made in many fields, some justified and some not justified. Later, large numbers of beet armyworm egg masses were observed but heavy infestations did not develop. Some of the egg masses turned out to be fall armyworm. These infestations were widespread but generally heavy damage did not occur. Boll weevils numbers were generally not heavy until the 2nd or 3rd generation. Aphids again increased in the drier areas and did cause economic damage. Insect parasites and a fungus disease finally reduced aphid numbers. Fruit loads by late season ranged from poor to very good depending on the amount and timing of rain received; the amount of insect damage from loopers, leafminers and beet armyworms; and to some extent; on the planting date of each field. Final yields in the south were 300-600 lb/acre and in the north 750-1500 lb/acre.

The Southern Blacklands (SB) suffered through cool planting conditions that caused some replanting and delayed the crop for three weeks before the crop recovered. Early season insect pressure was light overall, although some areas reported having to apply foliar insecticides for thrips due to damaged root systems not picking up the soil insecticides. Most consultants feel the poor uptake was due to herbicide damage. Fleahopper pressure was light for the season and overall boll weevil pressure was also light. Moisture in the SB and Brazos River bottom was adequate although yield differences could be found in the area where late season rains occurred. The northern part of the SB had adequate moisture throughout the season except for two weeks in July. Yields were average in the SB and close to twenty percent below average in the Brazos River bottom. Most producers in the river bottoms are blaming insect pressure for lower yields. However, the area experienced record high night time temperatures and record high humidities that probably contributed to lower than expected yields. First generation bollworm pressure was much higher than expected and contributed to yield losses. Aphid pressure was also higher than previously experienced and also contributed to some yield losses. Beet armyworms were not a problem.

Crops were planted late in many cases in the Northern Blacklands (NB). Cotton aphid infestations were present earlier and in higher numbers than usual. Infestations persisted throughout much of the season; densities of several hundred per leaf were typical. Fungus helped in many cases but plants had often suffered several weeks of injury before aphid infestations crashed. Bollworm infestations were widespread and difficult to detect with aphid infestations. Spider mites were a late season problem and may have resulted from intensive insecticide use for aphids and bollworms. There were no beet armyworm infestations in fields although moths were captured in pheromone traps. Overall yields were slightly lower than expected. This was an expensive crop because of the heavy investment in insecticides.

Weather and insect problems dominated cotton production in the SRP in 1995. Severe spring storms including tornadoes, hail and windstorms caused lots of acres to be replanted and cotton to be very late. Much of the acreage was in the first full year of the Boll Weevil Eradication Program after a fall diapause program in 1994. The winter was the second mildest on record and many insect species apparently survived in relatively large numbers. While pheromone trap data and habitat sampling date indicated that approximately 75% of the fall boll weevil population was killed off by diapause treatments, percent survival of the remaining population was very high and more than anticipated spring insecticide applications had to be made for overwintered boll weevils. Aphids, beet armyworms and cabbage loopers infested seedling cotton by mid-June. Extremely high populations of beet armyworms, aphids and bollworms followed by late July and early August. Populations of beet armyworms reached 50-60 per row foot in some fields. Approximately 50,000-75,000 acres of cotton were abandoned in terms of continued attempts to control the complex of pests. Yields suffered tremendously. Tobacco budworms occurred in a number of fields where control attempts at other pests continued. Both Pirate and Confirm received Section 18's for beet armyworm control in this area late in the season.

Heavy rain and high winds June 3 and 4 damaged most of the cotton planted prior to that time in the Northern Rolling Plains (NRP). Most of the mid-May planted fields were lost due to seedling disease, wet weather blight, and physical damage due to blowing sand and excessive wind-driven rain. Most of the cotton was planted or replanted after June 15. Planting seed of the more determinate cotton varieites was in short supply. Thrips infestations were light, with cotton planted in mid-May showing some thrips injury. Cotton aphids moved to cotton fields as soon as they emerged. Winged aphids could be found in most fields. In part of the area, cotton in the one to two-leaf state was heavily infested with aphids. Most producers did not treat for these early aphids; and by the end of June, lady beetles, lacewings, spiders, and nabids were beginning to control aphids. In some fields, lady beetle larvae and adults built to 3.8 to 6.6 per row foot, and lady beetle egg masses could be easily found. By mid-July, aphids were being controlled by lady beetles, lacewings, and other predators; parasitic wasp activity was light, but increasing. While cotton planting was late due to sprng weather in the SRP, boll weevil emergence was also late. Boll weevils captured in phermone traps in two traplines in Wilbarger and Foard Counties and in Knox County averaged 157 and 84 boll weevils per trap week in June and 25 and 31 per trap week during the first two weeks of July. The boll weevils migrated to the earlier planted fields, and three or four early-season insecticidal applications at five-day intervals were required in some fields where producers attempted to control overwintered boll weevils. By July 21, boll weevil movement to pheromone traps had dropped to less than ten per trap. Aphid infestations increased in some fields following the early-season boll weevil control applications.

Fleahopper populations in parts of the SRP area were nearing the economic threshold in early July. However, early square loss was due to the combined effects of weather conditions and fleahopper, boll weevil, and aphid infestations. Heavy rain occurred across the area August 1-2 due to the remnants of Tropical Storm Dean. Some parts of Wilbarger, Foard, and Hardeman Counties received between 14 and 15 inches of rainfall. The cotton in the area was growing rapidly when bollworms increased during the second and third weeks of August. Heavy damage occurred in many fields, and in some fields, bollworms stripped most of the squares and small bolls from the plants. Loss of half the fruit on the plants was not uncommon. Beet armyworms were reported in Jones and Baylor Counties by June 30. By July 13, beet armyworm feeding damage could be found scattered through most of the area. Beet armyworm moth numbers increased to 11.2 per night August 9, but infestations were light in most of the area. The week preceding August 24, two beet armyworm hatching egg masses per 100 row feet were being found as far north as Wilbarger and Wichita Counties. The following week, up to one egg mass was found per 15 feet of row. Beneficials, primarily predators, were feeding heavily on the egg masses. Because other materials were unavailable, Dimilin was the primary material used for beet armyworm control. Beet armyworms continued to be a threat to the cotton crop through mid-September, especially in fields where beneficial populations had been destroyed.

During the first week of August, aphids increased in SRP fields where insecticidal applications were made for other cotton pests. Populations grew quickly where there were few predators to hold populations down. Furadan 4F was being used by mdi-August under a Section 18 on a county-by-county basis. The aphid fungus, *Neozygites fresenii*, was observed in Wilbarger County by August 24, but did not become widespread. The dry conditions of August and September, along with lady beetles and lacewings, limited aphid population development; but moderate to heavy infestations persisted in irrigated fields. Late-season movement of boll weevils began to increase August 20 and continued to increase through October 13, when peak late-season boll weevil numbers were captured in pheromone traps. These late season weevils caused heavy damage to squares and bolls in the top of plants from late August through the remainder of the production season. Dry conditions prevailed from August 3 through September 13. Rainfall in mid-September was too late to have much effect on the 1995 cotton crop. Cotton yields were generally disappointing. The bolls were small, and yields were generally well below expectations. Many fields that suffered heavy bollworm infestations during the first and second weeks of August followed by heavy, late-season boll weevil infestations were not harvested.

The 1995 cotton crop in the Far West Texas (FWT) region started out late. Cold soils, high winds, heavy rains and hail storms combined to delay the crop. The rest of the season could be characterized as hot and dry. Dryland fields received far too little rain to produce normal yields. On irrigated farms, most growers were unable to supply enough water or to irrigate soon enough. Because of the harsh conditions and problems with insects, yields were below average.

The insect pest situation in the FWT region was more severe than normal. Five mild winters in a row have allowed pests such as boll weevil and pink bollworm to increase and spread to previously uninfested areas. Some $7 million were spent on boll weevil control and weevils still destroyed about 7% of the crop. Bollworm and tobacco budworm populations were moderate, but budworms were difficult to control. Stink bugs were a major concern. They began attacking the crop in July and continued through September. Stink bug control costs were an estimated $1.1 million in 1995. Some 3.5% of the crop was lost to stink bug damage. Pink bollworm more than doubled the acreage of cotton it infests in Texas. Infested acreage went from about 70,000 acres to 170,000 acres (with another 90,000 acres newly infested in adjacent cotton production in New Mexico). Over $1.5 million were spent to control pink bollworms. Aphids and cotton fleahoppers were not a major problem on most Far West Texas cotton this year. Acreage treated for these pests was estimated by 100,000 and 20,000, respectively (of a total of about 435,500 acres). Beet armyworms occurred and were a problem on seedling cotton and late planted fields in August-September. Some

$1.6 million was spent controlling them on about 80,000 treated acres. Control using Confirm was coverage sensitive. Fields treated using high gallonage normally got good results. Lower gallonage and any other factors causing less than complete plant coverage produced less effective control.

The High Plains (HP) area of Texas got off to a late start because of early moisture shortage problems and weather related replanting. Cool conditions also slowed development of seedling cotton. These delays resulted in a 2-4 week heat unit deficit. The dryland crop never did receive sufficient moisture to make a respectable crop in most areas and also did not provide conditions conducive to insect pest infestation development. Growers with irrigation capability ran their systems almost continually in an attempt to stay up with the crop's needs during the hot and dry mid summer period. While moisture was limiting, high temperatures did allow the crop to catch up on missing heat units. The earlier hurricanes failed to deliver needed rains to the area, but a September cool down did effectively terminate the crop early.

Thrips and cotton fleahoppers were not much of a problem this year. Aphids did infest seedling cotton upon emergence. This was the earliest widespread aphid infestation on record. Early aphids did increase to levels approaching 50-60 per leaf in many fields by June but were controlled by predators and high temperatures when left alone. Some producers opted to control these June infestations. The result was rapid resurgence of aphid numbers following these early applications. Because of these early control problems, the use of Furadan 4F was authorized. The 1994 Diapause Boll Weevil Control Program reduced weevil numbers by 75% in areas that received treatments. Unfortunately, high overwintering survival (62%) resulted in significant numbers of boll weevils to emergence and infest area cotton. A grid trapping program documented that weevils had successfully overwintered in all counties in the HP area. Because of the mild winter, boll weevils continued to emerge well into July, making weevil management using planting dates a difficult task. The heaviest early season weevil infestations were in the southern and eastern counties, although some Lubbock County fields did receive overwintered weevil applications. Where overwintered boll weevil applications were made, the use of ULV malathion, methyl parathion and Guthion appeared to flare aphids, especially after the second application. Aphid flareups did not generally appear following applications of Vydate or Thiodan/Phaser.

Because of the increased weevil problem, the HP area held a referendum in the Spring to collect funds to enhance the diapause program prior to full scale eradication in 1998. The referendum passed with an 82% approval. In addition to the diapause program, Extension provided management guidelines which included managing for earliness, use of the trap index for overwintered boll weevil control, three in-season treatment thresholds depending upon crop phenology, suggestions on crop termination and the addition of an insecticide to the harvest aid. Also, since 1994 studies had indicated that Conservation Reserve Program (CRP) grass was strongly implicated in providing additional overwintering sites, a pilot burning program was initiated. Evaluation in 1995 indicated that there was a 115-fold decrease in weevil numbers entering fields with adjacent burned CRP grass versus those surrounded by unburned CRP grass. Widespread boll weevil migration began in late August with very heavy numbers caught in pheromone traps beginning in early September. The enhanced diapause program initiated treatments on September 23rd and finished after 3 applications by the end of October, after the entire world's supply of malathion was depleted. Program applications were successful in reducing weevil numbers by 82% where multiple treatments were applied. Fund limitations prevented spraying of all infested acreage, especially north of Lubbock. The 1995-1996 winter has been harsher so far than last winter, but has not been sufficiently cold thus far to significantly impact on the large numbers of boll weevils that are presently in overwintering sites.

Bollworm infestations were about average to slightly below average this year. Beet armyworms and fall armyworm numbers were considerably higher than normal, especially following the movement of moths on a hurricane in early August. Predators were particularly effective in eliminating potentially damaging infestations of eggs and small worms where insecticides had not been used. The horror stories emanating from the LRGV and SRP areas resulted in many questionable applications made in this area. Confirm was effective in controlling beet armyworms, but its expense and narrow pest target range removed it as a viable tool once multiple pest situations developed. Over 28 armyworm egg masses per 100 foot of row were documented. Some of these failed to develop economic infestations. Lannate and Lorsban and combinations of Lorsban with methyl parathion or Dimilin were popular. The fact that these insecticides were effective when beet armyworm tests from other areas indicated otherwise, appeared to lend credence that some of these infestations were mainly fall armyworms. A lot of money was spent on armyworm control with little yield loss documented in most cases. The southwestern area of the HP did suffer through almost continuous multiple pest problems from stand emergence to termination. Up to $250.00 per acre was spent on insect control in this area, mostly due to boll weevils, followed by beet armyworms. The boll weevil became the number one pest of cotton for the HP for the first time, accounting for over $71 million dollars in control costs and yield losses. If the boll weevil is not eliminated as an economic pest from the HP, cotton will no longer be a viable economic enterprise.

In summary, weather again dominated cotton production prospects either directly or indirectly by influencing the severity of insect problems. Beet armyworms were especially damaging in the LRGV and SRP areas but also represented a considerable control cost in the west Texas areas. Beet armyworms were strangely absent from central Texas. Aphids infested cotton early in most areas. Early applications for other pests, notably the boll weevil, resulted in infestation flareups requiring considerable insecticide use. Otherwise, beneficial insects kept aphids in check. Boll weevils were the number one pest in all areas of the state except the two eradication zones. Consecutive mild winters appear to be the main contributing factor. Yields were generally a disappointment in most areas except the CB. Based on boll counts, yields were on average 20% below predictions. The 1995 crop was a very expensive crop to manage.

Research Progress and Accomplishments

Arizona. Pest insect infestations and natural enemies in seven lines of transgenic cottons were compared to the parent Coker 312 and DP50, a locally adapted cultivar in Arizona. There were no significant reductions in any of the observed beneficial insects in the transgenic lines. Leaf feeding Lepidoptera such as the cotton leafperforator, beet armyworm and saltmarsh caterpillar were unable to complete development on the transgenic lines. The lines were fully susceptible to the sweetpotato whitefly. Pink bollworm infestations were reduced greater than 95% compared to Coker 312. The two control cultivars, Coker 312 and DP50, had measurably greater damage. The cotton leafperforator was the most common leaf feeder observed and the cause of most of the damage. There was no effect on the numbers of *Lygus* bugs taken in the samples. Only one transgenic line (T531) had significantly greater yield of seedcotton than Coker 312 and this line produced an equivalent percentage of lint. Three lines produced less seedcotton (T1076, T1626, T18880) and three the same amount (T757, T1849, T2020) as Coker 312. Those producing less seedcotton also produced lower percentages of lint.

Overwintering pink bollworm (PBW) larval susceptibility to *Steinernema carpocapsae* (Weiser) and *S. riobravis* Cabanillas, Poinar and Raulston nematodes was evaluated under field conditions at Phoenix, AZ in March and April by monitoring PBW adult emergence and nematode persistence in nematode-treated and untreated plots. The March test results (200 million nematodes/acre equivalent) indicated no difference in adult emergence in nematode treated and untreated plots. Adult emergence decreased dramatically at the end of April in all plots. However, nematodes persisted, as measured by laboratory bioassays, in the soil for 90 and 14 days for *S. riobravis* and *S. carpocapsae*, respectively. The April test results (1 billion nematodes/acre equivalent) indicated a trend toward reduced PBW adult emergence in nematode-treated as compared to untreated plots. *Steinernema riobravis* and *S. carpocapsae* persisted in the soil for 63 and 6 days, respectively. Persistence of *S. riobravis* in the field may offer the potential for introduction and permanent establishment of this nematode for PBW control in southwestern cotton growing areas.

Field-grown Upland cotton plants (*Gossypium hirsutum*) irrigated weekly had 32% more PBW larvae in bolls at the end of the growing season than plants irrigated biweekly.

The gut contents of over 10,000 individual predators collected from Arizona cotton fields were examined for the presence of whitefly and PBW egg antigens using ELISA. Of the nine predator species examined, *Collops vittatus* (55%), *Geocoris* spp. nymphs (39%), *Orius tristicolor* (38%), and *Hippodamia convergens* (33%) were the most frequent whitefly predators. The most frequent PBW predator was *Lygus hesperus* (adults 30%, nymphs 20%)/ *Lygus hesperus* was also the predator species with the highest frequency of individuals preying on both pest species (12%). We compared the efficacy of commercially-reared *Orius insidiosus* against native populations of *O. tristicolor*. Commercially-reared predators were released into field cages and then recaptured 36h later for analysis by ELISA. Results showed that 4% of *0. insidiosus* and 26% of *O. tristicolor* were positive for whitefly antigens and that 8% of *O. insidiosus* and 5% of *O. tristicolor* were positive for PBW antigens. We have also been studying the functional response of various predators feeding on PBW eggs in plant arenas in the greenhouse. In conjunction with field data, results suggest that predators are responsible for removing 15-20% of all PBW eggs over a growing season.

Between 1990 and the present, the silverleaf whitefly has become the most serious insect pest of cotton in the arid regions of the southwestern United States. Better control was achieved in several areas in 1993 than in previous years. These results may have been obtained by early planting of smooth-leaf cultivars, managing for early crop termination, improved sanitation of other host crops, and in part by timely chemical treatments. Several U.S. researchers hypothesized that early treatment, when whiteflies first appear or when populations just begin to increase, would lead to more efficient control with fewer insecticide applications than would initiation of treatment when populations were higher. A regional project has been established to develop quantitative action thresholds for whitefly control. Field experiments are being conducted at Weslaco, TX, Yuma and Maricopa in AZ, and Bakersfield and Brawley in CA. Standard treatments of fenpropathrin + acephate were applied when thresholds reached 2.5, 5, 10 and 20 adults per leaf. Untreated plots serve as a reference. Insect counts on all plots were taken weekly, commencing 30 days after planting, from the fifth uppermost full expanded leaf. The experimental design is a Latin square with five replications. Data include numbers of eggs, nymphs, and adults, crop phenology, lint yields, and stickiness as determined by a thermodetector.

The effect of plant water stress on *Bemisia tabaci* population development was studied in replicated 0.1 ha field plots. In comparison with biweekly irrigation, weekly irrigation consistently reduced plant water stress which in turn reduced densities of this pest 22-47% depending on cultivar and year. In comparison with ST-506, DPL-50 had lower whitefly infestations and in comparison with DPL-50, Pima S-7 had lower infestations. Yields were generally higher in weekly irrigated cotton, due to a combination of lower pest damage and the greater amount of water applied to weekly plots. Weekly irrigation permitted one less application of insecticide regardless of the action threshold employed for treatment initiation. Concurrent with experimental studies, various adult and immature sampling methods were evaluated, developed and refined. Efficient sampling plans, based on numerical and binomial count models, were finalized for all life stages of *B. tabaci*. These sampling plans were field tested in a 3200 ha commercial production area. Fixed-precision sequential sampling plans for immatures and adults performed adequately, and a binomial sampling plan for adult whitefly performed exceptionally well in terms of allowing the proper decision to be made regarding the need for pest control action. Significant progress was also made in the development of a population dynamics model for *B. tabaci*.

Techniques developed to determine the chemical composition of honeydews found on cotton fiber have been employed in an investigation to develop enzymatic methods of diminishing the sticky nature of such lint. Hot water was used to quantitatively remove honeydew from contaminated lint. Sugars so extracted were quantified as anions, by gradient ion-exchange HPLC. Honeydews extracted from cotton fibers were found to be complex mixtures of sugars ranging in size from monosaccharides to polymers approximately twelve monosaccharide units in size. These complex mixtures are created from sucrose in the phloem sap of the cotton plant by transglycosylation reactions within various homopteran insects. A series of enzymes were sprayed on honeydew-contaminated cotton during harvest to determine whether their stickiness could be reduced in this manner. One of the enzyme preparations investigated in this manner produced cotton with diminished reducing sugar content and minicard ratings. However, some of this reduction was determined to be due to activation of microbes on the fiber by the applied enzyme solution.

Cotton acceptance by silverleaf whitefly (SLW) was influenced by phosphorous nutrition and position of vascular bundles. SLW have starch-digesting enzymes that indicate non-vascular tissue feeding. Lint stickiness was correlated with % sugars. Spraying 5 edge cotton rows reduced SLW numbers as effectively as spraying 10 or 15 rows. Treatment effects did not extend beyond treated areas. After 5 applications, 96 and 95% SLW reduction occurred from buprofezin and *Nicotiana* sugar esters and 89% reduction with bifenthrin + fenoxycarb. A trap line between Nogales and Phoenix indicated that cotton leafperforator populations developed in the Phoenix area independent of migration from Mexico. A strain of pink bollworm which is highly resistant to transgenic Bt cotton cultivars T81 and T65 was tested against 7 new Bt cultivars. Two of the new cultivars were highly toxic to the PBW Bt resistant strain. Whitefly DNA studies have been expanded to new geographic areas. **(USDA, ARS, Western Cotton Research Laboratory, Phoenix, AZ)**

California. The efficacy of Temik at planting, Gaucho seed treatment, and Orthene seed treatment on early-season insects was compared. Temik and Gaucho provided about 6 week aphid control, whereas the Orthene performed for ~3 weeks. Temik was stronger than Gaucho on thrips (slight control with Gaucho) and spider mites (no control with Gaucho). Side-dressed Admire and Temik were added as treatments at layby. Yields were evaluated from these replicated treatments. The efficacy of 20 different insecticide treatments was tested on a June infestation of cotton aphids; several products provided 70-90% control at 3 and 7 days after treatment. At 14 days after treatment, only a few products were still showing activity. No efficacy was seen at 21 days after treatment with any treatment and, in fact, the aphid density was greater in all treatments than in the untreated (up to 4 times greater). Several soap/oil products were also tested for their effect on aphid population density. The best of these products reduced aphid densities by ~60% for 1-2 weeks. The effects of pre-squaring cotton aphids on cotton yield were evaluated in replicated large plots. As in past years, aphids (up to 600 aphids/leaf) during this part of the growing season had no effects on cotton yield. Conversely, aphid infestations of up to 900 per leaf during July reduced lint yield by 36.7%. Research is continuing on quantifying the influence of mid-season (squaring to boll crack) aphid infestations on cotton development and yield. Replicated field plots were established with various levels of cotton aphids and with aphid infestations for various lengths of time. Aphid infestation in the plots began ~10 July. The incidence of aphid resistance to insecticides was studied in southern San Joaquin Valley cotton fields. Based on samples from 26 fields, resistance to Capture, Thiodan, and Lorsban was recorded in 77, 12, and 0% of the fields, respectively.

The efficacy of 11 registered insecticides was evaluated against *Lygus* bugs. The pyrethroid products provided good control through 7 days after treatment, except for Baythroid which provided 100% through 14 days after treatment. The organophosphate products gave good control at 4 days after treatment and moderate control at 7 days.

Spider mite control with 4 registered materials and 2 experimental compounds was evaluated against a high, rapidly growing population. Zephyr provided the best control with ~80% reduction at 21 days after treatment. Comite, Kelthane, and Ovasyn provided significant control, but less than that with Zephyr. Alert (Pirate) and

CM-006 were also tested; efficacy with Alert was less than with Zephyr, but better than the other registered compounds. CM-006 provided moderate control at the highest rates only. Seed cotton yield was only ~250 lb./A in the untreated compared with ~2200 lb./A for the best treatments.

Seasonal dynamics of silverleaf whitefly were studied for the third year in the San Joaquin Valley. Whitefly densities were lower and about 3-4 weeks later in 1995 than in the same areas in 1994. The cool, wet spring conditions and delayed planting of favorable early- season crops probably accounted for this delay. In general, population dynamics in 1995 were more similar to those recorded during the 1993 season than during the 1994 season.

Fourteen fields were sampled weekly throughout the San Joaquin Valey in 1995. Insects, mites, and plant development were monitored with sweep net, presence/absence inspection, and plant monitoring. Agronomic and pesticide use records were collected from each site. Aphids and mites were collected for pesticide bioassays. Natural enemy populations were adversely affected by broad spectrum insecticide applied for *Lygus* and aphids. Late season mites were at higher populations the further south they were located. Spider mite susceptibility to common acaracides remained adequate through the season. Aphid populations were not susceptible to bifenthrin, but most populations were susceptible to organophosphates and organochlorines. **(Cooperative Extension Service, Kearney Agricultural Center, Parlier, CA; UC, Davis; UC, Riverside)**

Louisiana. Diagnostic dose bioassays on both tobacco budworm larvae and moths indicated resistance was still present in this species to carbamates, organophosphates, and pyrethroid insecticides during 1995. The mean survival of 2,131 moths tested during 1995 for pyrethriod resistance at the 10 µg/vial diagnostic dose was 39% which was the same as observed during 1994. Pyrethriod resistance (percent survival) during the non-pyrethriod use period of May and June was 18 and 20%, respectively. However, survival increased to 37% during July when pyrethroids were used widely. Survival during both August and September was 49%. Survival of moths to doses of 10 or 20 µg of profenofos/vial during 1995 was 6 and 3%, respectively. Survival at these doses in 1994 was 13 and 7%. Thus resistance to both organophosphates and pyrethroids appears to have stabilized or decreased during 1995 compared to 1994.

Tarnished plant bugs exhibited a seasonal pattern of resistance to pyrethroids (13X), organophosphates (6X) and carbamates (8X) based on results of bioassays with representative chemicals in 20 ml glass vials. In field tests, several insecticides (fipronil, imidacloprid, lambda-cyhalothrin, and acephate) gave good initial control for tarnished plant bugs, but residual activity was poor. Also considerable variation was observed in the amount of damage caused by tarnished plant bugs in various cotton cultivars.

Beet armyworms exhibited resistance to organophosphate and carbamate insecticides in laboratory bioassays using insecticide-dosed artificial diet. There was no clear evidence of cross-resistance to Confirm, Pirate or Spinosad.

Evaluation of the Bollgard™ technology during 1995 again demonstrated that this Bt technology is very effective in controlling bollworms and tobacco budworms. **(Louisiana State University, Agricultural Center, Louisiana Cooperative Extension Service, Winnsboro, LA)**

Mississippi. Heliothine research in the insect genetics lab concentrated on measuring gene flow among local populations to estimate gene flow rates for each generation, and on marking studies to determine mating and egg-lay patterns of *Heliothis virescens*. A graduate student collected tobacco budworm and bollworm samples from 8 different sites in LeFlore Co. throughout the summer. These will be analyzed by electrophoresis and RAPD-PCR to determine if F_{ST} (a measure of genetic differentiation between populations) varies by generation, indicating that gene flow rates also vary by generation. The trapped moths have been frozen in ultra-cold freezers and are awaiting analysis. We also released approximately 6000 marked moths this summer in an attempt to determine patterns of mating between males and females and the distribution of eggs laid by females released from a point source. The 1000 eggs that were sampled will be analyzed for the presence of the markers.

Laboratory, spray chamber, and field studies were initiated to compare the relative potency of different commercial formulations of *B. thuringiensis* for control of *H. virescens* on cotton. Large-plot field studies were initiated to measure the value of *B. thuringiensis* for cotton insect control.

Base-line data were collected on the susceptibility of *Helicoverpa zea, Heliothis virescens*, and *Spodoptera exigua* to endotoxin proteins expressed in transgenic cotton. Some variation was measured in the response of different colonies to purified endotoxin proteins CryIa(b), CryIa(c), and several commercial *Bacillus thuringiensis* products in a diet incorporation assay, but field colonies were generally as susceptible as laboratory colonies. In a laboratory study, lepidopteran larvae demonstrated behavioral avoidance to artificial diet containing endotoxin proteins.

The Mississippi Agricultural and Forestry Experiment Station project to evaluate strategies to reduce insecticide costs for cotton producers in Mississippi was initiated in

1995. Field size units with a minimum of 25 acres per treatment were established in Lee, Madison, Tallahatchie and Yazoo Counties with each site serving as a replicate for the experimental treatments. All treatments were also replicated in field size units in Leflore Co. Small plot strategy research was also initiated in a delta and hill location to help develop techniques to be advanced to the large plot trials and hence to growers. Of interest were the large plot results of NuCotn33 (transgenic cotton) receiving no chemical control for Heliothines as compared with DPL5415, and 'grower variety' that received season long control as directed by the current Mississippi Insect Control Guide. Average lint yield and insecticide input cost (insecticide only) results for all sites for the NuCotn33, DPL 5415, and 'grower variety' treatments, respectively, are: 840 lbs, $35.37; 668 lbs, $96.65; 717 lbs, $93.78.

In other field research, work has been initiated to evaluate the entomological interface between corn, cotton, and other crops in neighboring fields. Tarnished plant bugs were found in very low numbers in corn in 1995, but attempts to establish plant bugs in corn of different ages failed, indicating that corn at any stage may not be a good reproductive host for tarnished plant bug. Additional work will explore the probability that weeds are the primary source of tarnished plant bug in corn. Other detrimental or beneficial insects developing or aggregating in corn that may move into cotton will be monitored in the coming 2 years to provide input for decisions concerning cropping strategies.

An electronic, programmable controller has been developed to automate the spray system of a high clearance spray tractor modified for small plot insecticide evaluation. The controller will prepare the system for each compound, and automatically spray and rinse the system including the spray bottle. It eliminates the need for hand rinsing of containers following a test application, and insures a precise rinsing following each chemcial. In addition, insecticide mixtures remaining in the boom after a plot is sprayed or rinsate resulting from flushing the system can be channeled into a central collection system for disposal. The device also provides emergency and manual override of the automated system for safety or specialized applications that may develop in the future.

Numerous small plot or laboratory insecticide efficacy trials were completed to provide background information for control recommendations. Spinosad, the new non-registered product from DowElanco Company, essentially doubled yield as compared with current registered compounds from ca. 2,100 lb of seed cotton per acre to nearly 4,000 lb in a trial with exceptionally heavy lepidoptera larva densities. No benefit was gained by increasing rates of this compound above 0.067 lb (AI)/acre. Foliar applications of all systemic insecticides were as effective in controlling a high population of *Frankliniella fusca* thrips; however, there was an indication of slight delay of fruiting in foliar applications as compared with in-furrow treatments, suggesting that foliar applications need to be applied just prior to infestation of adult thrips for optimum benefit.

In intact-animal physiological studies, 2-day-old females of *Helicoverpa zea* injected with 2 pmol synthetic *H. zea*-pheromone biosynthesis activating neuropeptide (HezPBAN) exhibited significant stimulation of pheromone production. In contrast, octopamine did not stimulate pheromone production when injected 30 minutes before lights off. Additionally, females injected with PBAN and mianserin (an octopamine antagonist) or reserpine, produced significant amounts of pheromone. These results suggest that octopamine may not be involved in regulation of pheromone production in *H. zea*. In abdomen incubation assays, Hez-PBAN stimulated phromone production at doses as low as 10 fmol. Additionally, 1 female equivalent of hemolymph or serum from scotophase females exhibited pheromonotropic activity that was comparable to activity elicited by 10 fmol synthetic Hez-PBAN. Using an abdomen bioassay and an enzyme-linked immunosorbent assay, an estimated range of 5-10 fmol PBAN-like activity was detected in the hemolymph. High pressure liquid chromatographic (HPLC) fractionation of scotophase *H. zea* hemolymph serum filtrates, obtained after filtration through molecular weight filters, suggested that the pheromonotropic fraction had a molecular weight of less than 3,000. Additionally, activity with the *H. zea* serum filtrate was obtained at an earlier elution time in HPLC fractions than that with synthetic Hez-PBAN. These results suggest that the hemolymph pheromonotropic factor may be a molecule that is smaller than the 3,900 MW Hez-PBAN.

The mechanism involved in bringing about post-coital suppression of pheromone production, pheromonostasis, was studied in *Heliothis virescens*. Mating results in a transient suppression in pheromone production, the signal for which appears to originate in the testes and other components of the male's reproductive system. The mating-induced pheromonostatis is due to an ascending signal via the central nervous system that appears to inhibit the release of the pheromonotropin, PBAN, or other potential pheromonotropic substances, and is not due to a refractoriness in response of the sex pheromone glands to BPAN in the female. A similar mechanism is operative in several species of moths where post-coital pheromonostasis has been observed. Sperm quality is not important for pheromonostasis in *H. virescens*, because males with apyrene or eupyrene sperm elicit similar pheromonostatic responses. The pheromonostatic activity of the ecdysteroid, 20-OH-ecdysone, appears to be the result of a direct effect on the sex pheromone glands.

Insect pathology studies included work with parasitoids of tobacco budworm. Four combinations of healthy (H) and infected (I) with nonoccluded *Microplitis croceipes* baculovirus (Mc-NOBV) adult *Microplitis croceipes* (Creeson) were paired and mated as follows: group I = (I) male + (I) female; group II = (H) male + (I) female; group III = (I) male + (H) female; and group IV (control) = (H) male + (H) female. Females were allowed to parasitize 3rd instar larvae of tobacco budworms, *H. virescens* (F.). The percent parasitization by group IV females was significantly higher than that of any other group. Parasitization by groups I, II, and III were lower than group IV by 25.7; 13.8; and 10.4%, respectively. The number of offspring from group IV was also significantly higher than from the other groups. Groups I, II, and III averaged 95.4; 79.8; and 47.6% fewer offspring, respectively, than group IV. Developmental times from oviposition to larval emergence, larva to cocoon, and cocoon to adult, were longer in groups I, II, and III than in group IV. The percent mortality from all immature stages up to adult was significantly higher in groups I, II, and III than group IV. Adult longevity in both sexes in groups I, II, and III was shorter than in group IV. Most of the adults that originated from healthy parents lived longer than 1 wk while those from infected parents lived less than 1 week.

Transmission of *Microplitis croceipes* (Creeson) nonoccluded baculovirus within and among individual *Microplitis croceipes* wasps was studied by light microscopy and transmission electron microscopy. Systemic transmission by way of hemolymph may represent the major route of transmission of this virus in a host. Both sexes contributed to vertical transmission of virus-infected F1 progeny from 4 combinations of healthy and infected parents. Virions were detected in the thin sections of 4 male and 7 female reproductive systems out of 10 that were examined. The percentage of horizontal transmission by female parasitization on virus injected tobacco budworms, *Heliothis virescens (F.),* 4 days after parasitization was 88.0%, whereas the percentage of viral infected males by feeding on 50% honey water contaminated with 1 μg/ml of virus 4 after exposure was 92.0%. **(Department of Entomology, Mississippi State University, Mississippi State, MS)**

Evaluation of the 1994 Bait Stick test was accomplished during the spring of 1995 by comparing eradication program trap captures in Noxubee County with those from adjoining and nearby counties, where the scheduled seven applications of malathion were applied. As of July 6, the average numbers of weevils per acre per two week cycle were 8.6 for Noxubee County. For the adjoining counties of Lowndes and Winston, the averages were 13.4 and 34.4, respectively. The average for Monroe County, not adjoining but separated by about 50 miles, was 10.4. Bait Stick use in the spring and fall plus one application of malathion was at least as effective as seven applications of malathion, based on the spring 1995 catches. In comparison tests using equivalent Grandlure dosages in traps and Bait Sticks, Bait Sticks coated with Stickum captured about three times as many weevils as traps.

Eight, twelve, and sixteen ounces of malathion were compared in a field test. Average mortalities for 48 hours were 93, 98, and 99 percent for the three dosages, respectively. We concluded that 12 ounces of malathion as used in the Southeastern Boll Weevil Eradication Program is as effective as 16.

In San Angelo, Texas, 57 female *Cotesia marginiventris* adults were released into small cotton plots containing second instar beet armyworms. These plots, except for the checks, were sprayed aerially with a beet armyworm virus. Mean percent mortality for parasitoid/virus plots, virus alone plots and check plots was 76.5, 56.5, and 6.6%, respectively. This parasitoid and virus worked well together.

For the fourth year, monitoring of boll weevil infestation levels was accomplished with the GIS system. Survey data were displayed at the section level. Other insects included were tobacco budworms, beet armyworms, and bollworms. We also began satellite imaging work. Several satellite maps were obtained, along with software. A protocol is being developed to use these images in the GIS. **(USDA, ARS, Integrated Pest Management Research Unit, Mississippi State, MS)**

A study was began to evaluate the effects of parasitization on lectin and catecholamne levels in corn earworm larvae, *Helicoverpa zea*. The CEW larvae were parasitized using *Microplitis croceipes*.

As in 1994, over 8 million cotton bollworm larvae were grown and used to produce enough of an EPA-labeled insect virus to treat 215,000 acres to evaluate the effect of treating early season hosts of the tobacco budworm as an area-wide pest management procedure. The virus was applied under a contract using private aircraft with global position systems for guidance to treat the same 311 square mile area with the virus as was treated in the 1994 test. This year, the virus was applied from 5 May through 10 May 1995, approximately one week later than in 1994 when it was applied between 28 April and 3 May. Our data did not show any differences in the numbers of larvae or eggs on the cotton, but we did see positive indications of this year's effect that may be compared to 1994. First, when larvae were collected from early season weeds in 1994 (tobacco budworm and bollworm), 85% of those collected died from virus infection. Those larvae were collected from only 2 locations for a total of only 57 larvae, and they were collected at 3 days after treatment. In comparison, a total of 398 tobacco budworm larvae were collected from weed hosts in 1995, and they were sampled from 21 different spray areas (8,000 acres per area) and at various times. The mortality of these larvae averaged 54% due to virus infection, and 100% of those collected immediately after the application were diseased. By the next week, the percentage infected larvae decreased - but by that time, many of the infected larvae would have been dead and therefore would not have been collected. The persistence of virus infection for the following 10 days could indicate the transmission from dying, diseased larvae to new larvae on the hosts. In 1994, overall counts of tobacco budworm and bollworm moths in the treated area between 10 June and 22 August averaged 53% less than the numbers in traps in the untreated areas, and the data indicated the bollworms were the most affected. In 1995, the average numbers of both bollworms and budworms trapped in the treated area were 60-70% less than the number in the untreated area, with an average total reduction of 66%. We expected the effects of the early virus treatment to be expressed during the emergence of moths in the June generation. That is what is indicated by the 1994 *H. virescens* trap captures (ca. 6 June through 4 July). The 1995 trap data not only indicate the reduction in June, but also suggested continued reductions through the July population. This was also suggested in our evaluation of the 1991 test. Although we had 4 areas picked for possible cage evaluations as in previous years, circumstances resulted in no cage data of any value from this year's test.

The baculovirus from the beet armyworm was produced in the lab using larvae supplied by the Gast Rearing Laboratory and the SIML insect rearing. Field tests were then conducted in Texas to compare the effectiveness of a commercial preparation and a local isolate of the nuclear polyhedrosis virus, and the effect of formulation and application in the level of control obtained. These studies showed that 78 to 92% of larvae on cotton were infected when the virus was applied using ground equipment compared to 52% when it was applied by aircraft. Results further showed the local isolate equal to the commercial virus, and that the addition of an oil-sugar formulation increased the percentage of larvae infected in the field. Tests were continued in the laboratory to examine new methods of producing entomopathogenic viruses for field application. The efficacy of producing the baculovirus from the beet armyworm was demonstrated, although additional information is needed prior to developing large scale methodology.

A *Microplitis croceipes* rearing enhancement study using *Helicoverpa zea* was completed. The study evaluated three oviposition methods (treatments) used to expose *H. zea* larvae to *M. croceipes* females. The three different oviposition methods evaluated were: (1) A multicellular rearing unit; (2) a 32-cell tray (27 x 15 x 1.5-cm) method which was a clear plastic tray with 32 cells that each contained the Nutrisoy/wheatgerm diet; one larva was placed in each cell and the tray was covered with a paraffin coated plastic sheet; and (3) a tray/cage method which consisted of a modified version of the multicellular rearing unit with another fiber-glass tray that was modified to serve as a lid. The lid had a 25.4 x 27.9 cm area cut in the center; the remainder of the top had rows of 6.4-mm diameter holes and a 3.2 cm stoppered hole for the introduction of parasitoids. The first two methods were evaluated by holding the trays in large wooden cages (inner dimensions 40.6 x 81.3 x 29.2 cm) with cast acrylic tops (6.4 mm); the cages have organdy in the backs and sides for ventilation. Each cage had a 1.3-cm diameter stoppered hole for the introduction of parasitoids. Three different density levels of *H. zea* larvae were used for each oviposition method tested: 100, 200, and 300, 4 to 5 d old *H. zea* larvae. A total of 10,800 larvae were used in the test. Females aged 6 to 8 d were used for parasitism; the test was replicated 6 times. A split plot, replicated in time, experimental design was used. The results showed method 2 generally gave higher mean percentages of the three methods tested. Cocoon formation: method 2, 60.72%; method 1, 55.50%; and method 3, 47.72%. Total parasitism: M2, 78.89%; M1, 61.94%; and M3, 54.72%. Total mortality: M2, 20.22%; M1, 27.72%; and M3, 37.94%. The 100 density had the higher percentages among the three densities tested. Cocoon formation: density 1, 57.78%; density 2, 54.33%; and density 3, 51.83%. Total parasitism: D1, 68.11%; D2, 65.94%; and D3, 61.50%.

Selected sites in Washington and Bolivar Counties were monitored for the incidence of sterility in the wild tobacco budworm, *Heliothis virescens* (F.), populations. Sites were selected to coincide with release sites of a three year pilot test program to suppress the wild population of *H. virescens*. The pilot test was conducted during 1991-1994. During the 1995 growing season wild males were collected from pheromone traps at three different locations. Two of the sites had been release sites in the pilot test project and a control location from a non-release site. Preliminary evaluations showed 2-4% sterility was found in the release sites. Further evaluations are in progress.
Seven treatments were evaluated for control of the cotton aphid in replicated small plots in cotton. All treatments were significantly more effective than the untreated check, and Karate was less effective than all other treatments except the untreated check.

Eight treatments were evaluated for control of the cotton aphid in replicated small plots in cotton. A pretreatment survey indicated a moderate aphid infestation. In general, treatments which included Provado or Bidrin provided greater control than other treatments, except that Thiodan was more effective than Bidrin after the second application.

Five treatments were evaluated for control of tarnished plant bug in replicated small plots in cotton. The tarnished plant bug population was at a low level when tests commenced. Admire provided control equivalent to Cygon and methyl parathion.

Nine treatments were evaluated for control of tarnished plant bug in replicated small plots in cotton. The tarnished plant bug population was at a low level when tests commenced. Provado and CGA 215944 provided control equivalent to Curacron, Orthene, and Bidrin.

Ovicides, including the newly registered product Provado, were evaluated in field and laboratory bioassay conditions using cotton for control of tobacco budworm. Susceptible and insecticide resistant insects were evaluated. Lower mortality to a pyrethroid in the resistant strain indicated possible resistance in the eggs. Provado, which is targeted at sucking pests, provided acceptable control.

A standard spray chamber bioassay was used to evaluate resistance levels in tobacco budworm, *Heliothis virescens* (F.), to pyrethroid, carbamate, and organophosphorus insecticides and *Bacillus thuringiensis* Berliner during the 1995 cotton season in Washington County, MS. An adult vial test was also used to evaluate the frequency of resistance to a pyrethroid, carbamate, and organophosphorus insecticide. An ovicide bioassay was also run on a susceptible laboratory strain and one of the field collected strains (generation 2). These bioassays evaluated different kinds of resistance and correlations were not always clear due to the expression of different resistance mechanisms in specific life stages. The spray chamber bioassay may have more clearly shown levels of metabolic resistance, while the adult vial test was an indicator of target-site resistance. The data suggested that metabolic resistance is becoming more important in tobacco budworm. Tests did not indicate resistance to *B. thuringiensis*-based insecticides in the tobacco budworm at the present time. The ovicide test indicated possible resistance to pyrethroids in eggs. High levels of resistance in the tobacco budworm to all classes of conventional insecticides remained a problem. Resistance management plans for tobacco budworm should emphasize strategies that involve conservation of all insecticides used against all pests in cotton.

Production of insects for USDA-ARS research by the Stoneville Insect Rearing Unit required maintenance of seven insect species: *Heliothis virescens*, *Helicoverpa zea*, *Anticarsia gemmatalis*, *Pseudoplusia includens*, *Spodoptera exigua*, *Cardiochiles nigriceps*, and *Cotesia kazak*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; College Station, TX; and Weslaco, TX, required production of 314,000 *H. virescens* pupae, 285,000 *H. zea* pupae, 334,000 *P. includens* pupae, 270,000 *A. gemmatalis* pupae, 264,000 *Spodoptera exigua* pupae, 54,763 *Cardiochiles nigriceps* cocoons, 13,735,200 *C. kazak* cocoons, 39,275,000 *H. virescens* eggs, 27,840,000 *H. zea* eggs, 35,222,000 *P. includens* eggs, 17,734,000 *A. gemmatalis* eggs, and 24,000,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 140,200 30-ml plastic cups and 996 3.8-liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1995 was 14,697 liters. Several short courses in insect rearing techniques were given to employees of: Abbott Laboratory, Chicago, IL, and BASF, Greenville, MS. Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in the Cotton Foundation and American Soybean Association Insect Distribution Programs.

Comparisons of plots of transgenic cotton (NuCotn 33) from Delta and Pine Land Company (Scott, MS), DP5415 (same as NuCotn 33 without Bt), Coker 312 (background parent of 1994 transgenic line), and MD51 (nectariless, smoothleaf) indicated (1) significantly fewer cotton bollworm/tobacco budworm larvae and lower percent worm damage in NuCotn 33 than all other varieties, and (2) significantly fewer cabbage loopers, saltmarsh caterpillars, garden webworms in NuCotn 33 than other varieties, and (3) approximately 50% as many beet armyworms in NuCotn 33 as in other varieties. Coker 312 had approximately 50% more tarnished plant bugs (TPB) than DP5415 and NuCotn 33 and over twice as many as MD51. These results suggest that the higher numbers of TPB observed in 1994 in the transgenic cotton were due to the Coker background and not the transgenic character. All other insect numbers, cotton characteristics, and yield were approximately equal.

A study of boll weevil emergence and movement of the boll weevil in the mid-delta of Mississippi showed that (1) boll weevils survived the winter of 1994-95 in extremely high numbers, (2) considerable movement of overwintered and first generation boll weevils occurs after bloom as detected by pheromone traps (approximately 50% of the weevils captured during the week of July 3 were first generation), especially 1-3 miles from cotton, and (3) extremely high late season numbers suggest the need for a harsh winter to reduce 1996 numbers.

Beet armyworm surveys to determine seasonal occurrence of beet armyworm moths were conducted as a continuation of the survey in 1994. Traps were set about 2.8 miles apart in a 76-mile line from Hwy 448 west of Shaw to 2 miles south of Valley Park. The trapline traversed 4 counties. Weather conditions were mild in the 1994-95 winter months (December-February) compared with conditions during these months in 1993-94. For example, the lowest soil temperature (2 in. deep) was 39°F on only the night of 5 January 1995, was 43°F for only 3 nights, and was above 47°F during all other nights of these 3 months. Average low air temperatures for the winter of 1994-95 were 4°F higher than the average for the 1993-94 winter. The soil temperature on 11-12 January 1994 dropped below 32°F for two nights. Captures of BAW were tallied weekly from 1 December 1994 to 29 November 1995, and plotted on graphs each week as BAW captured/trap/night in the 30 traps. Captures from 1 December to 28 February 1995, were less than 0.09 BAW/trp/nt. BAW were captured during all 3 winter months, but their activity was hindered when nightly temperatures dropped below 52°F. From 1March to 31 May, captures peaked once the last week of March and once in the middle of May, but both peaks were below 1 BAW/trp/nt. Starting the week of 28 June-5 July (3.48/trp/nt), moth captures increased at a continuous, geometric rate to the maximum seasonal catch of 371.8/trp/nt during the week of 7-13 September. From 14 September-23 October captures decreased at a comparable but inverse rate, to <130/trp/nt on 23 October. By 15 November, average BAW captures dropped to 30.1/trap/night due primarily to the increased frequency of low nighttime temperatures below 40°F. From June to November of 1995, there was only one single peak in captures of BAW, and there were no acute reductions or dips in average numbers that would delineate distinct generation spans. Condition and apparent age of the moths captured during the growing season indicated that they were mixed ages and from a population matrix of interlaced generations. Ancestral lines of these moths probably were the larvae and moths that feed on wild host plants in October-December 1994 and had survived the 1994-95 winter.

For the first time in the Delta, a liquid formulation of a single pheromone chemical was developed and applied aerially (Ag Tractor 400) for the purpose of disrupting tobacco budworm and bollworm mating behavior and suppressing populations. These applications were made on 90 A of cotton and surrounding insect host plants. The single pheromone was dispensed on 9 June, 14 July, and 10 August 1995 at 10 grams, 5 grs and 5 grs per acre, respectively. Inspections made of 250 cotton plants 5 and 9 days after the 9 June and 14 July treatments showed no damage of the squares or blooms caused by tobacco budworms and bollworms. No TBW/BW larvae were found during these inspections. Also, from 2 to 10 lady beetles (adults and larvae) were found per plant during these inspections. Numbers of moths captured in pheromone traps dropped significantly after each treatment for at least 7 days, i.e., from 31-42/night before treatment to 1-7/night average for 7 days after a pheromone treatment. Results were encouraging while indicating that the treatments effectively blocked chemical communications between the genders and reduced their chances of reproduction. Overall populations of tobacco budworms and bollworms were relatively low during the early 1995 growing season.

Surveys of bollworm and tobacco budworm moth populations using replicated installations of 30-in. diam. pheromone traps baited with appropriate pheromone baits showed that moth catches from clusters of 3 to 4 traps set 50 ft apart at 3 different field locations represented true population fluctuations. Cluster of traps nearly eliminates the daily variability in captures of moths caused by unique environmental conditions found at sites where single traps might be installed. These unique conditions, such as different vegetation types or soil moisture levels near a single trap, may vary greatly within a single County or from one side of a cotton field compared with another side. Significant oviposition on cotton preceded, by 3 days the sharp increase in moth captures in traps at the beginning of each moth flight during the season.

Population density profiles, based on captures in traps (baited with pheromone) and set in three locations as in previous years, were plotted for the 1994-95 winter months and from January-November 1995. Variations in rainfall and soil and air temperatures were also plotted and compared with captures of both tobacco budworms and bollworms. The graphs showed 5 distinct peaks in captures of tobacco budworm moths and 4 peaks in captures of bollworms. Wild geranium and crimson clover supported the first 2 generations of tobacco budworms and bollworms. Velvetleaf supported the 1st to 3rd generations of budworms. Corn and soybeans supported the 2nd and 3rd generations of bollworms. Plots of weather records showed that the low air and soil temperatures during December 1994-February 1995 were unusually warm. The lowest average air temperature was 35°F, occurring in January, and the lowest average soil temperature was 46°F also in January 1995. Temperature of soil at depth of 2 in. dropped to the low of 31°F only during nights of 16-17 February. Rainfall through the winter months was typical for the Delta area until the last of June. From 10 July to the end of the growing-season, rainfall amounts were far below average, and daytime temperatures averaged 5 to 6 degrees above normal reaching 100°F or more during some days in July, August, and September. High temperatures and little rainfall resulted in drought conditions during the cotton growing season, and there generally was a shortage of vegetation and blooms that would support high populations of budworms or bollworms. Cotton development was stressed during the 3 months critical for square and boll formation. Peak numbers of tobacco budworms and bollworms captured in late August and September averaged 100 to 150 moths/trap/night lower than in previous years. These moderate capture levels were attributed to the scarcity of vegetation and blooms preferred by both budworms and bollworms, and this shortage was undoubtedly caused by the drought conditions.

Initiated research to identify resistance in cotton to foliar feeding by beet armyworm. This study will require two or more seasons to complete.

Spray table and small plot studies were conducted with Provado (Bayer) and Fipronil (Rhone Poulenc) on tarnished plant bugs and boll weevils. Three formulations of Fipronil showed excellent activity on both plant bugs and boll weevils in spray table tests. Small plot tests indicated that Fipronil (two formulations) and Provado were highly effective on a resistant population of plant bugs.

A large field plot study to compare methods of sampling (sweep net, drop cloth, and visual) and thresholds recommended in the Insect Control Guide were evaluated in Sure Grow 501. Extremely low populations of plant bugs occurred in 1995.

A large field plot study to evaluate seed, in-furrow and sidedress treatments on early season insect populations and yield was evaluated. Heavy populations of the cotton aphid were present in most plots by June 30. Temik in-furrow and sidedress (0.60 + 1.5 lbs AI/acre) was the most effective treatment in reducing aphid populations. Highest yields were observed in Temik in-furrow and Temik in-furrow + sidedress treatments. No yield response was observed in either Payload in-furrow or Payload in-furrow + sidedress treatment.

Research on factors affecting silverleaf whitefly parasitoid efficacy and evaluation protocol was continued in 1995. Our earlier tests provided evidence for two climatic strains of *Encarsia formosa* (one from Greece and another from Egypt), the most widely utilized and commercially available parasitoid of whiteflies throughout the world. These studies clearly indicated the importance of searching for parasitoids which originate from areas with climates similar to the climates in the targeted areas for release or introduction. As a logical progression to these studies, investigations of the effect of host plant on parasitoid efficacy were initiated in 1995. These studies have expanded to include two additional strains of *E. formosa* (the commercial strain and the Beltsville strain), and have included a phylogenetically diverse group of economically important host plants: cotton, cabbage, tomato, bean, and cantaloupe, as well as hibiscus and poinsettia. Parasitoid biological parameters being measured include adult longevity, life long fecundity and percent parasitism, as well as parasitoid developmental rate and percent emergence. While *Bemisia argentifolii* 3rd instar nymphs are being evaluated, whitefly eggs and early instar nymphs are also being provided since these life stages are utilized as food by adult parasitoids. Host plant leaf area and hair density is being measured as potential factors which may affect searching efficacy of the adult parasitoids, and therefore the various biological parameters. These studies are in progress at the time of this report, and therefore comment on our findings would be premature.

In concert with these parasitoid evaluations, and as a prerequisite to subsequent field evaluation and release programs, a survey of the whitefly and associated parasitoid species was initiated in Mississippi in 1995. Similar surveys have been conducted or are in progress in other states in the southern U.S. Much effort was made to establish and coordinate collection of whitefly infested sample leaves from throughout the state, with ARS, APHIS and the Mississippi State University Agricultural Extension Service (county agents) representing the principle participants. To date, whiteflies have been collected from 35 host plant species in 18 counties. Among the host plants are 2 field crops (cotton and soybean), 15 vegetables, 11 ornamentals, 3 herbs, as well as 2 weeds. Although identifications are only tentative, whitefly species appear to include: bandedwinged whitefly, greenhouse whitefly, silverleaf whitefly, and sweetpotato whitefly. Parasitoids have been collected from 21 plant species in ca. 30% of the samples collected. Parasitoid identifications have not as yet begun due to the challenges associated with resource availability and taxonomic expertise. This survey will continue throughout the year and until at least December 1996.

Cotton fields located in 1,600 square miles of the Delta were sampled weekly for bollworm and tobacco budworm eggs and larvae during June and July 1995. The fields were located in 4 areas (each ca. 400 square miles) of which 3 areas were checks. The fourth area received an aerial application of an insect virus to all wild host plants in the area in early May to kill first generation bollworm and tobacco budworm larvae found on them. Each of the 4 areas were divided into quadrants and the location of cotton fields in each quadrant recorded. Fields were sampled by whole plant examinations in young cotton. Sampling changed to visual searches of terminals and fruit and foliage in the upper half of each plant when the cotton began to square. Each field was sampled by 2 people and in each sample 10 plants were examined. Fields were classified as small, medium, or large and 20 samples (10 per observer) were taken in small fields while 40 samples (20 per observer) were taken in medium and large fields. All eggs and larvae found were taken back to the laboratory for rearing and species identification. In each check area, 5 fields were picked at random from each quadrant (20 total) each week and sampled. In the single treated area 6 fields (7 in one quadrant, 25 total) were picked at random each week from each quadrant and sampled. Data entry from this test has been completed and checked for errors. This entailed entry of approximately 20,000 lines of data. Statistical analysis was completed in October. No significant reduction in bollworm or tobacco budworm populations in the treated area was found. Populations of both pest species were low in the treated and untreated areas which made the test hard to evaluate statistically.

A survey of the Arkansas, Louisiana, and Mississippi Delta was conducted in the spring (April-May) and fall (September-October) to determine how widespread pyrethroid resistance was in tarnished plant bug populations in the Delta. At least 50 adult bugs from each of 71 locations were collected from wild hosts and tested for resistance in the spring, while 72 (mostly the same locations as the spring) locations were sampled in the fall. The bugs were exposed in glass vials (2 adults per vial) treated with 15 μg of technical grade permethrin for 3 hours after which mortality was determined. In the spring survey, 30 locations had susceptible populations (mortalities > 90%), while in the fall survey only 11 locations had susceptible populations. The resistant populations were found scattered throughout the Delta. The greater number of locations with resistant populations in the fall showed the effect of the selection pressure exerted on plant bug populations in cotton with pyrethroids during the growing season.

On 2 June 1995, a single adult male tarnished plant bug was found that possessed unusual bright red eyes (as compared to normal dark red almost black eyes). To investigate this unusual condition, the male was mated with 7 virgin females. This mating produced 78 F_1 adults all with normal eyes. The F_1's were allowed to mate with each other and produced 703 F_2 offspring of which 60 were red eyed (37 males and 23 females). The presence of red eyed F_2 females eliminated the red-eyed trait as being sex-linked and recessive (if it was, no red-eyed females would be produced). Various crosses between red eyed and normal eyed F_2 adults are being evaluated in an effort to determine the genetic basis of the red eyed trait. In addition, all adults and nymphs collected in the resistance survey on wild hosts at 72 locations in the fall in the Delta (discussed previously) were examined for red eyes to see if this trait occurred in nature. A total of 6,661 adults and 4,126 nymphs were examined for red eyes, but none was found.

A large plot field test designed to evaluate treatment thresholds currently recommended by the Mississippi Cooperative Extension Service for the control of tarnished plant bugs in cotton, was conducted on a growers farm near Indianola, MS. Unfortunately, plant bug numbers found in the plots during June and July were too low to properly evaluate the test. **(USDA, ARS, Southern Insect Management Laboratory, Stoneville, MS)**

Missouri. A study on the distribution of overwintering boll weevils was continued. We established a grid of 4 miles by 4 miles across the entire Missouri cotton production region, and placed three traps at approximately 150 yard intervals in the edge of the cotton field nearest each grid intersection. This scheme resulted in a total of about 140 three-trap stations. Weevil distribution was similar to that observed in the previous year of the study, with the highest densities occurring along Crowley's Ridge along the western edge of the region. Populations along the Mississippi River were again relatively low, reflecting the very high floods of the Spring of 1995.

Temperatures in the overwintering habitat of boll weevils were observed at Campbell and Deering, MO from November 1994 through March 1995. Electronic weather stations were deployed in oak woods areas at each site and measured the air temperature, the temperature on the surface of the leaf litter, the temperature at the soil surface under the leaf litter, and the soil temperature at 4 inches depth. The coldest air temperature observed at either site was 10°F; the coldest temperature under the leaf litter was 18°F. These data were used to make a forecast for heavy weevil pressure in the Spring of 1995. This study will be continued with micro temperature loggers at approximately 5 sites this winter.

The cold tolerance of Missouri boll weevils was compared with that of populations from central Mississippi and the Coastal Bend of Texas through cold bath studies. There were no significant differences in the cold tolerance of these three populations. These data suggest that, while boll weevils have been present in Missouri for over 70 years, selection for cold tolerance has not been significant.

In another set of cold bath studies, we evaluated the effect of the presence of ice nucleators on the cold tolerance of boll weevils. While these studies are ongoing at this writing, preliminary results suggest that the presence of ice greatly reduces survival of boll weevils compared to that of weevils exposed to the same temperatures in the absence of ice. In every instance when ice formation was documented, less than 5% of exposed weevils survived regardless of the terminal temperature they experienced. In addition to the cold bath assessments, we are developing freezing characteristics curves for numbers of individual weevils to elucidate the relationship between cold tolerance and actual freezing points. These studies have not been completed at the time of this writing, but the results are presented in a paper in these proceedings.

A study to measure the impact of warm season, native, perennial grass strips (used to prevent wind erosion) on cotton field arthropod populations was initiated this year. The study looks at five treatments: warm season grass strips, grass-broadleaf forbs strips, rye strips, conventional cotton (no strip), and conventional cotton with a conventional insecticide regimen. All treatments but the last have no insecticide inputs. Plots are approximately 3/4 acre each replicated four times in a randomized complete block design at each of two sites. This first year was essentially devoted to establishment of the perennial vegetation; however, preliminary data indicate that there are significant differences in predator numbers and in the distribution relative to the strip of some pest insects (notably thrips and aphids). Ground beetles appear to decrease with distance from a vegetation strip while tiger beetles increase with distance from the strip. This study will be continued over the next two growing seasons.

A total of 15 randomly selected fields were surveyed during late September to assess late season boll injury. A total of 100 randomly selected bolls were included in samples from each field. On average, 7.0% of collected bolls had damage from lepidopterous larvae (bollworms, armyworms, and European corn borer); 18.4% showed some damage from plant bugs or stink bugs; and 14.8% were damaged by boll weevils. Virtually all bolls included in this survey which were damaged by either boll weevils or lepidopteran larvae lost at least one lock; the nature of the bug damage we detected suggests that these insects attacking late in the season probably had little impact on yield but may have caused some loss of quality. Boll weevil damage was highest in Dunklin County (which contains Crowley's Ridge), while worm damage was highest in Scott County (the northern-most Missouri cotton-producing county). Bug damage was fairly uniform across counties.

Pheromone trap grids for bollworm, tobacco budworm, boll weevil, beet armyworm, and European corn borer were monitored season long. Bollworm and budworm numbers were substantially higher in 1995 than in previous years. The only notable beet armyworm record concerned one pulse of approximately 450 moths over one week in one trap in early August; catches both before and after this pulse were less than 10/week. Large numbers of larvae were found in a cotton planting near this trap approximately 10 days later.

Portions of the Missouri cotton production region are still under quarantine for pink bollworms at the time of this writing; however, to date no positive captures have been made in the extensive grid of traps deployed by the state and federal departments of agriculture. If no significant captures are made for the remainder of this season, the quarantine will most likely be lifted.

Cotton insecticides were evaluated in six efficacy tests. These tests included: at-planting and early season insecticides for thrips control; herbicide-at-planting insecticide interactions and efficacy; imidcloparid seed treatment efficacy; aphid insecticides efficacy; bollworm insecticides efficacy, and boll weevil control. In addition, three large plot tests were conducted. **(University of Missouri Agricultural Experiment Station, Delta Center, Portageville, MO)**

New Mexico. Work with the GOSSYM-COMAX model was continued in the Pecos Valley with several growers using the program. Continuing research work is focusing on timing of the initial post-emergence irrigation. Data for 1995 showed no significant differences in treatments for yield. Plant heights were decreased by delaying initial irrigation until soil water potential had reached 0.80 bars. Multi-year analysis was not complete at this writing.

Ten sticky delta traps were compared to ten oil traps baited with the same pheromone lure for pink bollworm (PBW) adult moth trap catches. Traps were located randomly over 20 acres of upland Acala 1517 cotton at canopy height. Traps were monitored throughout the growing season from June-October 1995 (42 collection dates). It appeared that early season when PBW populations were low (10 moths per night or less) the delta sticky trap was more sensitive. During late season monitoring, trap catches exceeded 50-75 moths per night; oil traps effectively caught more moths than the sticky delta traps. Even though there was not a significant difference between the sticky delta and oil traps over the entire season, sensitivity was visually apparent at low numbers (1-10). If suggested economic trap counts are 10 moths or less per night, sensitivity may be important. Early and low population detection can help make early management decisions.

Applications of PBW micro-encapsulated pheromone disruptors were conducted to evaluate effectiveness in reducing PBW boll infestation for the 1995 growing season. Encapsulated PBW pheromone disruptor was applied at rates of 3-8 grams per acre when PBW trap catches reached 10+ adult moths per night. Cotton bolls were collected for percent PBW boll infestation. PBW boll infestation increased when applications of disruptor was terminated.

Upland cotton bolls collected throughout the 1995 growing season showed a positive correlation between timing of diapause and heat units (linear regression, R^2=.95). Heat unit accumulations were based on 86°/55ºF upper/lower temperature thresholds. Pink bollworm larvae were collected from infested upland cotton bolls September through November. Larvae were retained in small cups filled with artificial diet and monitored weekly for percent diapause. PBW larvae reached 77% diapause mid-September [Accumulated Degree Days (ADD) 3293] and gradually increased, reaching 100% diapause mid-October (ADD 3609). During the 1994 season larval diapause reached 63% in late September (ADD 3535); estimated R^2=.74. Lower data fit for 1994 may have been due to discontinuing larval collection in late September. Heat Units may be a good indicator to determine termination by chemical and or plowdown reducing populations of diapausing larvae.

Preliminary studies are underway evaluating effectiveness of the parasitic PBW nematode *Steinernema riobravis* for PBW control in the Mesilla Valley in cotton.

The automated insect counter experienced upgraded neural net and fuzzy logic programs for counting and classifying insects.

Techniques for evaluating PBW parasites are being developed. Over 1000 PBW larvae were collected from infested cotton bolls and retained in small cups filled with artificial diet and held for parasite emergence. Large cones will be placed over infested cotton this spring to collect emerging parasites. Introduced parasites have been released and establishment and overwintering will be determined the following spring. **(Cooperative Extension Service and Departments of Agronomy and Entomology, Plant Pathology, and Weed Science, New Mexico State University, Albuquerque, NM)**

North Carolina. A statewide damaged boll survey, initiated in 1985 to determine the temporal (year to year) and spatial impact of late-season caterpillar damage, was continued in 1995. Twelve randomly-selected fields from 17 counties accounting for just under 500,000 acres were surveyed. Additionally, stink bug assessments, late-season aphid ratings and plant heights were taken. *Helicoverpa zea/Heliothis virescens* (bollworm and budworm) damage, at 2.64%, was lower than the 10-year average of 3.91%; *Ostrinia nubilalis* (European corn borer) damage at 0.09% was far and away the lowest in the 10-year survey history which averaged 1.68%; *Spodoptera frugiperda* (fall armyworm) damage, at 0.0.27%, was approximately one half the 10-year average of 0.55%. Total caterpillar damage was 3.00%, less than half of the long-term average 6.14% damaged bolls. Aphid populations in general were much higher than in previous years, particularly in mid to late-season, although only 5 fields out of the 168-field survey total were judged to have been at threshold in opening cotton. Stink bug (mostly *Acrosternum hilare*, or the green stink bug) damaged bolls were a very low 0.29%, compared with the historical average of 1.21%.

A survey of North Carolina's licensed independent crop consultants working on cotton was conducted in 1995 to gather data on how both plant bugs and second generation (June and early July) tobacco budworm populations were being assessed and managed by these individuals. Thirty two consultants representing 23 firms participated in the survey, accounting for 270,020 acres, virtually all of North Carolina's cotton managed by licensed consultants. A high percentage of the acreage was scouted for early budworms (96.0%- all but 5,300 acres) and 87.6% scouted for either square retention, plant bugs or both. Six consultants advised treatment of 9,807 acres (or 3.7% of the total acreage) for budworms, and two consultants treated 660 acres or 0.28% of the total acreage for plant bugs. For tobacco budworm control, 98% of the acreage received a pyrethroid and the remaining 2% Larvin, while various organophates were used for plant bug control. With pyrethroid resistance getting closer to North Carolina in 1995, selectively treating limited acreage for June budworms remains our best hope of maintaining budworm populations susceptible to pyrethroids and other classes of insecticides. Likewise, the high percentage of consulted acreage monitored for square retention and the low acreage presently treated for plant bugs translates into far fewer secondary treatable outbreaks of early budworms.

Two early-season tobacco budworm management tests were conducted in 1995 in southern North Carolina. One of the tests evaluated pyrethroid alternatives, including a carbamate (Larvin), several organophosphates, an organochlorine plus a chlorinated foramidine, a naturalite (spinosad), a pyrethroid check and an untreated check. Of interest was that the spinosid treatment was very similar to the pyrethroid comparison in most parameters tested (terminal damage, live budworms, white bloom and green boll levels and yields). The second test contained biologically-oriented options (Design plus Ovasyn), Ovasyn, Larvin, a square removal (the 3 most-mature squares removed at initial bloom) treatment, and a square plus terminal removal plot (all squares and terminals removed approx. 1 week prior to initial bloom), and an untreated check. Partially due to light tobacco budworm pressure at this location, few significant differences were noted between treatments. However, both the square removal and the square plus terminal removal plots suffered significant maturity delays, although the square removal only treatment did not result in a yield loss for the third consecutive year.

A 14-treatment late season bollworm/budworm and fall armyworm screening test was conducted in southeastern North Carolina under moderate to high caterpillar pressure. Although the Larvin and spinosad treatments were somewhat higher than the pyrethroids at the last 21 August damaged boll assessment, most of the differences were not significant and both of these non-pyrethroids (at 8% each for damaged bolls) held damage to considerably less than the check (at 44% damaged bolls). Spinosad's performance was noteworthy in that it represents a new class of fermentation chemistry which will not likely be involved with cross resistance to the pyrethroids such as may be the case with the carbamates and the organophosphates in some budworm populations. No significant differences were noted in boll damage or live larvae. All treatments held fall armyworm damage to significantly less than the check. Numerically, Spinosad was the highest yielder, followed by Asana XL; no significant yield differences were found between treatments.

An 11-treatment, at-planting insecticide screening test was conducted. Payload (two rates), Temik, Thimet 15 G and the same treatment followed by an Orthene overspray, Di-Syston 15G, 8E and an 8E plus Furadan 4F combination, Orthene foliar spray alone and a Gaucho 480 seed treatment were evaluated for effects on stand, adult and immature thrips control (3 dates), bollworm and fall armyworm-damaged bolls, fruit retention, maturity and yield. All treatments resulted in significantly higher plant stands than the untreated check on the 20 June and 5 July assessments. The Gaucho seed treatment was only active at 3.5 weeks in preventing both immature and adult thrips establishment, although very few other differences were noted in the other parameters tested, partly as a result of the extended hot, dry weather observed at this location in 1995 (the plots were not irrigated).

A test was conducted in a Jones County cotton field following what was considered poor control: a level of approximately 8 to 10% live bollworms/budworms just 3 to 4 days following a second pyrethroid application, unusual for North Carolina conditions and raising the question of the potential beginning of budworm resistance to pyrethroids. A single application of Larvin (0.8 ai/acre), Karate (0.025), spinosad (2.0 oz./acre) and a check constituted the 40 ft. x 50 ft. x 4-replicate plots. All treatments performed equally well and held live larvae and damage to squares and bolls below that found in the check. This area's extended hot, dry weather, aerial application under these less-than-ideal conditions, and the presence of a significant proportion of tobacco budworms in the bollworm/budworm complex probably accounted for most of the reported "control difficulties".

Five *B.t.* transgenic cotton tests were evaluated in 1995. The first, a threshold evaluation trial, compared a protected, a protected preceded by an Orthene overspray, an unprotected Bollgard[R] 757 and the same line with pyrethroid protection at 5 and 10% square damage was compared with a standard unprotected and protected Coker 312 line. The selected treatments were evaluated throughout the season for stand establishment, plant height, maturity, bollworm egg deposition, caterpillar establishment and damage, stink bug damage and yields. Instar number was recorded for each caterpillar found. The highest boll damage was recorded on standard untreated Coker 312 "producer cotton" (no irrigation or disruptive overspray), at 40% boll damage on 8 August. On the basis of 4 averaged sampling dates, 8, 14, 21 and 28 August, overspraying the *B.t.* line with Orthene just prior to the initiation of the major moth flight raised the damaged boll level from 3.75% to 10.75%, showing that a single disruptive spray had a marked influence on seasonal boll damage. Such a disruptive spray just prior to the major bollworm moth flight would be almost unheard of under North Carolina conditions. For the second year, only the 5% square damage threshold was met, and was treated once. Fall armyworms and European corn borers were extremely light at this location in 1995, paralleling most of the remainder of the state. Yields did not square with the boll damage observed as well as in the previous two years, although the untreated check averaged less than one half the yields of most of the Bollgard treatments. Under grower conditions, for a 3-year average, yields for the Bollgard 757 line without protection were nearly identical to the pyrethroid-protected Coker 312 untransformed line.

The other 4 *B.t.* cotton tests, in Robeson, Jones, Greene and Halifax counties, involved evaluation of early season plant bug, terminal and lateral square retention assessments, and late season bollworm, fall armyworm, European corn borer and stink bug damage in DPL lines 5690 and 5415, both protected and unprotected with pyrethroids compared with their transformed, unprotected counterparts, Nucotn 33 and 35. As was the case in 1994, the transgenic lines held boll damage from caterpillars to approximately the same levels as the grower protected line(s). Plant bug levels were very low at all locations,

A 10-replicate study comparing the effect of skip row, Pix®, and row width (30 vs. 38 inches) and their interactions on late-season bollworm damage was conducted under moderate to high bollworm pressure. In looking at main effects, no significant differences in boll damage or in yields were noted in either row width or Pix use, but, surprisingly, a significant different difference in both higher boll damage, 11.75 vs. 6.75%, and lower yields, 482 vs. 654 lb. of lint/acre was noted in the inside vs. outside rows, respectively. In comparing interactions between variables, the 38 inch x Pix treatment, at 5.75%, had significantly lower boll damage than the 30 inch row x Pix (11.25%), the 30 inch row x No Pix (9.75%) and the 38 inch row x No Pix treatments (10.23%). **(Cotton Extension IPM Project, Department of Entomology, North Carolina State University, Raleigh, NC)**

Oklahoma. During the fall of 1991, a petri dish technique was developed to assess resistant trends in cotton aphids to four insecticides commonly used for aphid control. Field evaluations began in 1992 and continued in 1995. Aphid infestations from various production systems were monitored. Extreme variation in aphid mortality occurred in both the petri dish bioassay and field applications. Aphid mortality was less than 75% at many locations. Bidrin gave the best control of the 4 insecticides screened. Testing aphids prior to treatment with the petri dish bioassay did accurately predict actually field performance of the insecticides bioassayed.

A crop termination study was initiated in 1992 and continued into 1995. Favorable weather in 1995 allowed bolls to be tagged and plants mapped. Results suggest NAWF (nodes above white flower) is a reliable method to decide when the cotton is insect safe. Prior to 1995, only irrigated cotton was included. This summer dryland fields were also included and scouting and insect control terminated using the NAWF procedure. The NAWF method has proven to be an accurate and precise method of terminating the crop and eliminating unneeded insecticide applications without jeopardizing yields. **(Oklahoma Cooperative Extension Service, Altus, OK)**

South Carolina. A field study was conducted to compare selected seed mixes of the transgenic *Bt* cotton line, 'BTO1DP', expressing the delta-endotoxin from the bacterium, *Bacillus thuringiensis* subsp. *kurstaki* (Berliner) (*Bt*), and the nontransgenic cultivar, 'Coker 312' (non-*Bt*), for efficacy against the bollworm, *Helicoverpa zea* (Boddie), and the tobacco budworm, *Heliothis virescens* (F.). Ratios of seed (*Bt*:non-*Bt*) were 100:0, 90:10, 85:15, 80:20, 75:25, and 0:100. All seed mixes significantly reduced damage to squares and bolls compared with the 0:100 untreated cotton, but differences among mixes were nonsignificant. Yield of lint was significantly greater for the 0:100 treated as-needed cotton than for all remaining seed mixes, and differences among the remaining seed mixes were nonsignificant.

A field study was conducted to compare the relative densities, distribution patterns, and economic impact of bollworms and tobacco budworms in Monsanto's transgenic *Bt* cotton 'BT01DP', a 90:10 *Bt*:non-*Bt* seed mix, and nontransgenic 'Coker 312' cotton. These treatments received no applications of insecticides for control of lepidopteran insects. The bollworm was the predominant species, comprising approximately 95% of the bollworm/ tobacco budworm complex. Examination of ten consecutive plants in each of the two center rows of each plot revealed that the 16.7% of plants in the 90:10 *Bt*:non-*Bt* plots infested with third-instar and larger larvae was significantly greater than the expected percentage of 9.5. Similarly, the 9.2% of plants in the 90:10 plots infested with fourth-instar and larger larvae was significantly greater than the expected percentage of 4.9. These higher than expected percentages of plants infested with large larvae in the 90:10 *Bt*:non-*Bt* plots indicated that migration of larvae from non-*Bt* to *Bt* plants occurred. Results indicated that migration of bollworm larvae to *Bt* plants may result in a significant increase in damage and reduced yield in mixed stands of *Bt* and non-*Bt* plants. Additional studies are needed to determine the relationships which exist among seed mix ratios, population densities of bollworms/ tobacco budworms, injury, and yield reductions.

A field study was conducted during July and August to determine the effectiveness of foliar treatments of Larvin, Curacron, and Design applied alone and in selected combinations against the bollworm/tobacco budworm in cotton. Treatments (rate/acre) were Larvin (0.25 lb[AI], 0.40 lb[AI]), Design (1.5 lb), Larvin + Design (0.25 lb[AI] + 1.5 lb), Curacron (0.75 lb[AI]), Curacron + Design (0.125 lb[AI] + 0.5 lb), and Ovasyn + Design (0.125 lb[AI] + 0.5 lb). Curacron produced yields comparable to those produced by Larvin, although efficacy data indicated that Larvin was the superior insecticide against the bollworm/tobacco budworm complex. Design and the Design + ovicide (Curacron, Larvin, Ovasyn) combinations appeared inferior to the Curacron and Larvin treatments. Since tobacco budworms are relatively more susceptible to *Bacillus thuringiensis* subsp. *kurstaki* than bollworms, evaluation of Design during June, when the bollworm/tobacco budworm complex often consists primarily of tobacco budworms, likely would indicate greater efficacy for this product.

A field study was conducted during July and August to determine the efficacy of foliar applications of Spinosad against bollworms/tobacco budworms and its impact on beneficial arthropods. Treatments (lb[AI]/acre) were: Spinosad (0.045, 0.063, 0.089), Karate (0.025), and Larvin (0.60). Spinosad provided excellent control of relatively low densities of a population of predominantly bollworms. Densities of total predators appeared to be unaffected by the treatments.

The following combinations (lb[AI]/acre) were evaluated during mid-season as foliar applications in a field study against bollworms/tobacco budworms: Decis (0.019), Karate (0.025), Baythroid (0.028), FCR 4545 (0.017), and Larvin + Karate (0.125 + 0.025, 0.25 + 0.025). All treatments were effective against a low population of predominantly bollworms.

Foliar applications of Regent 80WG (0.025 and 0.038 lb[AI]/acre) and Orthene 75S (0.14 lb[AI]/acre) and Temik 15G (0.9 lb[AI]/acre applied in-furrow were evaluated for control of thrips in seedling cotton. Orthene, Temik, and the high rate of Regent provided excellent control of adult (predominantly *Frankliniella fusca* [Hinds]) and immature thrips. (**Clemson University Pee Dee Research and Education Center, Florence, SC**).

Tennessee. In early-season cotton insect control studies, foliar sprays of Bidrin and Regent; seed treatments of Garlic Barrier, Orthene and Gaucho; in-furrow spray of Di-Syston + Furadan and Regent; and in-furrow granular treatments of Dimethoate, Di-Syston, Payload, Temik and Thimet were compared for thrips control and impact on blooming and yield. Foliar sprays and Dimethoate granules did not suppress thrips damage compared to the untreated. Total early bloom counts were suppressed by treatments of Dimethoate and Thimet compared to the untreated. Yields from these treatments were also significantly lower than those from the untreated check. Only Temik produced significantly more lint than the untreated check. In a second test comparing early-season insect control strategies, only the Di-Syston treatment yielded significantly more than the untreated check. Thimet yielded significantly less than the untreated check. Yields from Gaucho- and Temik-treated plots did not differ significantly. In a test comparing formulations of Gaucho and Temik treatments, there was no significant yield difference.

Bt cotton from Monsanto, Hartz, and Stoneville/Calgene were evaluated in eleven experiments for efficacy against bollworm/tobacco budworm and yield. Bollgard Bt cotton was compared to non-Bt cotton in a date-of-planting study at two locations. Sprayed non-Bt cotton planted 27 April and 11 May yielded as much as the unsprayed Bt cotton planted the same dates, but yield of the non-transgenic line planted 23 May was significantly less than the Bt cotton yield from the same planting date. At a second location, Bt cotton planted 26 April and 9 May produced significantly more lint than Bt cotton planted 22 May or non-Bt cotton planted any of the three dates. Conventional and Bollgard cottons were compared at three locations under sprayed and unsprayed conditions. Bollgard plots did not reach the required 2% damage level at Milan, and yields were not different among treatments. At Jackson, results were similar except that the non-Bt plot required three sprays, while at Milan, one spray was required. At both locations, the unsprayed conventional cotton produced as much as the sprayed conventional or either Bt treatment. Under much higher bollworm/tobacco budworm pressure at the Ames Plantation, sprayed Bt cotton produced more lint than either non-transgenic treatment; the unpsrayed Bt cotton yield did not differ from the sprayed conventional yield; all were significantly greater than the unsprayed conventional yield. Stoneville/Calgene Bt cotton (sprayed and unsprayed) at the Ames Plantation produced slightly more cotton than the sprayed conventional cotton (though not statistically more); both Bt treatments produced more than the unsprayed non-transgenic cotton. Second harvest yields in Bt plots were significantly greater than from conventional plots. At Milan, where bollworm/tobacco budworm pressure was much less, non-transgenic cottons produced more lint than the Bt lines.

Spinosad was the most effective treatment for suppression of tobacco budworm at the Ames Plantation. First harvest and total yields were significantly greater in Spinosad-treated plots than in any of the eight other treatments.

Multiple applications of Provado for control of tarnished plant bug at pinhead square stage did not increase yields over the untreated check. Mustard planted in six foot strips between eight rows of cotton attracted adults and produced large numbers of F_1 bugs which moved into the pinhead square stage cotton after the mustard was cut.

Cotton aphid thresholds during mid-season were studied at two locations. Multiple applications of Bidrin kept aphid populations down in selected plots while infestations increased in unsprayed plots. As many as four insecticide applications were made, but yields did not differ among treatments at either location. **(University of Tennessee, West Tennessee Experiment Station, Jackson, TN)**

Texas. Small plot field evaluations of transgenic Bt cotton lines and varieties for Monsanto, Delta Pine and Land Co., Calgene/Stoneville, Hartz Seed Co. demonstrated good suppression of natural infestations of tobacco budworm (TBW) and bollworm (BW). Small plot studies and field cage studies of beet armyworm suppression by the Bollgard gene in a DPL variety showed only 35% mortality from the CryIA© protein in this variety. Treatment threshold studies in 8-row plots again showed the Bollgard cotton did not sustain enough square injury to trigger an insecticide spray for TBW and BW. Square injury on the Bt cottons has never exceeded 6% in 5-years of testing at Corpus and College Station, although the non-Bt sustained 40 to 55% square injury. These were naturally occurring insect infestations in 4 to 12 row by 35 ft. plots. Yield increases in Bt line evaluation trials over 5 years for the bollgard gene has averaged 14%, 157 lbs. of lint, without insecticide compared to Coker 312 with 4 to 8 weekly foliar sprays of Karate or Capture. The CryIIA protein in transgenic cotton plants appears as effective as CryIA© protein at controlling TBW and BW in the field in small plot trials. Larval movement studies in the field indicated that 3rd through 5th instars of TBW and BW move frequently in the cotton plant canopy in mixed plantings of Bt and non-Bt cottons, and in pure stands of either Bt or non-Bt cottons. They moved 2 to 15 feet in 24 hours.

Timing of insecticide termination at the end of the season, for five fields, were managed using the COTMAN model developed by University of Arkansas scientists. COTMAN determined that cotton cutout at 83 to 87 days after planting and optimum yield was obtained when insecticide applications were terminated at cutout plus about 350 heat units above the 60 degree F threshold. Defoliation was initiated at 850 HU after cutout. COTMAN appears to be an excellent model for consultants and growers to use to monitor plant growth, fruit set, insecticide termination, defoliation and harvest.

Small plot studies with cotton were conducted to evaluate Spinosad (Tracer) for control of TBW and BW. Control with Spinosad at 0.067 lb. ai/ac was equal to Karate at 0.03 lb. ai/ac and mixtures of other conventional larvicides. Yields were increased over 200 lb. of lint per acre with Karate or Spinosad compared to the untreated check. Interestingly, numbers of beneficial insects were not reduced in the Spinosad plots compared to the untreated check. Whereas the numbers of beneficial insects tended to be lower in the karate and conventional insecticide treated plots. **(TAES, Corpus Christi, TX)**

The overwintering boll weevil survival and emergence model was delivered to Plains Cotton Growers, Inc. early in 1995. This model predicted very accurately the unprecedented high overwintering survival of boll weevils in west Texas. Work is also nearing completion on the development of a boll weevil regional management program, which should be available in early 1996. **(TAES, College Station, TX)**

Overwintered boll weevil survival during the 1994-1995 winter in the Texas High Rolling Plains was the greatest ever recorded. Boll weevil winter survival in mott shinnery oak averaged (62.0%; survival in brush shinnery oak averaged 56.0%; survival in mesquite/native grass pasture averaged 45.0%.

A relay strip cropping system is being developed and evaluated to augment predator populations and to increase the effectiveness of biological control of cotton aphids. A relay strip cropping system utilizes a sequence of crops planted throughout the fall, winter and spring. Each strip crop provides predators with an aphid food source and shelter. As one crop matures and becomes unsuitable, another crop is planted. A strip cropping sequence is being developed utilizing canola during the fall and winter and sorghum during the spring and early summer. This system has increased predator numbers in cotton during July and August and has reduced cotton aphid populations during late August and early September.

A sequence of cultural controls for boll weevil management, that can be implemented during the spring, summer, fall, and winter, has been developed during the past 20 years. This system is based on using delayed, uniform planting in late May. Each recommended cultural control strategy enhances previous and subsequent strategies, and these systems have been shown to reduce boll weevil damage and to increase yields. **(TAES, Vernon, TX)**

Boll weevil infested squares were collected from cotton in the subtropical Rio Grande Valley during September and reared out in the laboratory at Lubbock. After feeding the Rio Grande Valley weevils were placed in overwintering cages in Stonewall County. Average winter survival of two Rio Grande Valley boll weevil cohorts was 39.0%.

Several cultural factors including planting date, plant density, leaf pubescence, leaf color and reflective wheat straw mulch exhibited an effect on the development of cotton aphid populations. The retarding effect of the wheat straw mulch on aphid development appeared to result from an increase in light intensity on the underside of cotton leaves.

Cotton aphid population densitites in untreated cotton plots were compared to those in plots receiving one and two applications of cyhalothrin, and one application of dicrotophos. Cyhalothrin applications resulted in rapid increases in aphid numbers within two weeks, resulting in significant yield reductions. Aphid numbers in dicrotophos treated plots were not significantly different from those of untreated plots. Increases in aphid numbers in cyhalothrin plots did not appear to be due to a reduction in predator numbers. **(TAES, Lubbock, TX)**

Corn earworm sized insects dispersing from senescing corn (in the Lower Rio Grande Valley) flew over a radar located 250 km downwind within 4 hours after sunset. During nights with wind speeds less than 9 m/s the overflight occurred later and continued until one half hour before sunrise. This apparent all-night flight of at least a portion of the dispersing insects can produce very long distance movements. A simple algorithm for estimating the minimum and maximum fallout area of dispersing insects was developed. The algorithm uses mean wind direction and speed, mean insect airspeed and heading, and mean duration of flight. Applying this algorithm provides a first approximation for estimating the potential spatial extent of economic impact of insects dispersing from a source area.

Mylar balloons were tracked from the Lower Rio Grande Valley (LRGV) of Texas to estimate trajectories of cotton bollworms, *Helicoverpa zea* (Boddie), migrating from mature corn in June. Entomological radars were operated in the LRGV and at distances of about 100 km and 200 km downwind to measure overflights of cotton bollworms. NEXRAD doppler radar imagery from Brownsville, Texas, supported the feasibility of measuring the abundance and displacement of pest insects migrating from about 500,000 acres of crop land in the LRGV of northeastern Mexico and southern Texas. Because the beet armyworm, *Spodoptera exigua* (Hubner), had become a major pest of cotton in the LRGV in June, research was conducted to determine its ability and propensity for long-distance flight. An insect-monitoring radar showed that beet armyworms ascended at night from mature cotton fields near San Angelo, Texas, in late August and early September and flew at altitudes where winds could have carried them nightly to infest cotton fields more than 200 miles away. Information about the timing, intensity and range of long-distance flights of pest insects will help producers, research scientists and regulatory agencies prepare more effective areawide pest management strategies.

The influence of droplet application and deposition parameters for improved efficacy of several insecticides on tobacco budworm, spider mites, and whitefly continues to be explored. Recent data confirm that application parameters can be optimized, but optimums are different for different insecticides; e.g., some insecticides are more effective with large droplets and/or high spray rates while others are more effective with small droplets and/or low spray rates.

Field crop environmental effects are known to influence production but not suspected to change the amount of spray actually collecting upon the plants. Field experiments were carried out in 1995 at Maricopa, Arizona, to induce drought-stress in cotton while measuring aerial spray deposition during the process. Data analysis revealed that the stressing effect increases the retention forces that bind the pesticide spray to the leaf surfaces. This applied knowledge could lead to reducing the use/amount of all liquid agricultural chemicals needed for crops/plants in general.

Using ten times less spray solution, electrostatic charged sprays of Danitol + Orthene at full label active ingredient (a.i.) rate reduced sweetpotato whitefly (SWF) adults comparable to conventional sprays. Electrostatically charged sprays of Asana + Curacron reduced SWF adults significantly greater than or equal to conventional sprays. Irrespective of application hardwares and a.i. rates, four consecutive sprays of Danitol + Orthene decreased susceptibility of SWF adults to the mixture of compounds 35 X.

Boll weevil trapping studies were conducted by four locations in Texas, one location in Mexico and one location in Mississippi. Traps were placed in or near cotton and at one mile intervals up to five miles from cotton. The results of these studies showed that boll weevil trap captures drop off significantly in traps in or near cotton once the cotton starts squaring. When traps are removed from cotton one or more miles, boll weevils continue to respond regardless of the cotton phenology. At Munday, Texas, over 70% of the total boll weevils captured were captured before the first 1/3 grown square while in Uvalde, Texas and Crockett, Texas only 50% of the boll weevils captured were captured before the first third grown squares. Gut analysis of boll weevils captured near Uvalde have revealed that the boll weevils have fed on over 50 types of pollen. Apparently the boll weevils use general pollen feeding to survive until it can locate cotton.

We have developed several new techniques for preparing boll weevils for pollen analyses. The first technique uses scanning electron microscopy to examine the exterior body of the boll weevil for pollen. This technique is faster and safer than previous methods. From the increased resolution of scanning electron microscopy, more foraging resources can be accurately identified. The second technique uses a chemical process that removes pollen from both the external and internal organs. This technique gives a more overall array of foraging resources. We are in the process of determining the foraging resources of overwintering boll weevils in Uvalde, Crockett and Munday, Texas. In addition, along with ARS scientists in Weslaco, TX, we are examining the long-range dispersal and foraging resources of boll weevils in Northeast Mexico and South Texas.

Considerable progress was made in the development of adult control technology for the bollworm and other noctuid pests of cotton using feeding attractants and stimulants. A highly effective feeding stimulant was identified that induced feeding by adult bollworm and tobacco budworm in the field over a period of several days, because its concentration was directly related to relative humidity and the material remained in a liquid phase. A commercially-available form of the feeding stimulant was found that was as effective as the laboratory-prepared solution. Field applications in small plots were most effective at a volume of 20 gallons/A than at 5 gallons/A. Numerous toxicants at different concentrations in mixtures with the feeding stimulant were evaluated for their effect on proboscis extension, gustation, and subsequent adult mortality of the bollworm. The effect of the feeding stimulant mixed with several toxicants was also evaluated for the tobacco bollworm. For the bollworm, the effects of increasing toxicant concentrations of most toxicants up to 10,000 ppm on proboscis extension and gustation were minimal; however, major differences were observed in the toxicity of the different insecticides to the adults. Two synthetic pyrethroids evaluated were the most toxic followed by two carbamates. Field evaluations of the feeding stimulants mixed with several toxicants indicated that the synthetic pyrethroids were repellent, and feeding in treated areas was very limited. This indicates that the repellency of the synthetic pyrethroids evaluated is due to factors that function before the adults contact the feeding stimulant and toxicant mixture, because the laboratory evaluation did not show any inhibition of proboscis extension or gustation by these insecticides even at very high concentrations. Some of the water-soluble carbamates evaluated did not repel the adults and resulted in high levels of mortality among the adults that fed on the field-applied materials. A mixture of chemicals originally identified in volatiles from flowering *Gaura spp.* and which showed some attractancy to bollworms in olfactometer bioassays was highly effective in attracting and inducing feeding by cabbage and soybean loopers, bollworms and tobacco budworms when dispensed from cotton dental rolls or mixed directly with a feeding stimulant solution applied to cotton plants. The mixture was also effective for trapping males and females of both looper species in wire cone traps when dispensed from cotton dental rolls. Preliminary evaluations of the feeding attractant/stimulant/toxicant mixtures were effective in killing large numbers of adult moths of different species which were attracted to and fed in relatively small treated areas in a cotton plot. **(USDA, ARS, Southern Crops Research Laboratory, College Station, TX)**

Field research with *Catolaccus grandis* has involved the release of "trained" females. Training has consisted of exposing third instar boll weevils for ca. two days to permit mated parasitoid females to feed on larval hemolymph and to oviposit; the assumption is that trained females continue host seeking and attack behaviors when released into the field, whereas, untrained females emigrate from the release area. However, the training process is costly due to materials and labor, and its presumed merits have not been directly tested. Thus, the field performance of *C. grandis* with respect to various pre-release treatment conditions was investigated. Treatments were release of females that were a) newly emerged [mated, 1-day old]; b) untrained [mated, 5-days old]; c) trained [mated, 5-days old; on 3rd day were exposed to hosts for two days]; and d) control [no release]. Based on parasitism of third-instar cohorts in the field, preliminary results indicate no difference in performance between untrained and trained females; however, parasitism by newly emerged females was lower than the former two treatments. Thus, effective suppression of boll weevil at considerably reduced costs may be possible through elimination of the training of female parasitoids. Efficacy of *invitro*-propagated *C. grandis* was demonstrated in the field at two sites in 1995. The artificial diet (meridic and oligidic) was approved and submitted by ARS to the U.S. Patent Office for disclosure. In cooperation with the U.S. Department of Energy's Kansas City Plant, eight systems for *in vivo* and *in vitro* mass propagation were process designed, four systems were conceptually designed, and one system for *in vivo*-mass propagation was detail designed, constructed, and used at the APHIS National Biological Control Laboratory in Mission, TX, in support of parasite augmentative releases in San Angelo, TX.

A farm that produces organically-grown cotton within the Southern Rolling Plains Eradication Zone was selected to release *Catolaccus grandis*. The main objective of this experiment was to create a sufficiently high parasite to host ratio during the first and second larval generation of boll weevil and greatly suppress or eliminate within-field reproduction of the pest. The test site consisted of 134 acres of cotton on the Ralph Hoelscher farm in Tom Green county, Texas. Besides SARL, other cooperators in this study were USDA/ARS/SIML, USDA/APHIS, Texas A&M University, the Department of Energy, and the Texas Boll Weevil Eradication Foundation. Releases began on July 19 at the rate of 350 females per acre per week and continued for a total of nine weeks. Release fields as well as comparison fields (insecticide-treated fields located in the general vicinity where control of boll weevil was by direction of eradication program protocols, and other pest control was by grower discretion) were sampled at weekly intervals to measure and compare boll weevil, other pests, and natural enemy populations. Mean trap captures of boll weevil adults on the organic farm throughout the release period were very low and no different than those of insecticide treated fields. Boll weevil population densities (measured by inspection of whole plant and ground samples) on the organic farm were maintained at very low levels during the release period and were no different than that in insecticide-treated comparison fields. The last release of *C. grandis* was made September 15, and because materials with efficacy against boll weevil are not available and/or approved for organically-grown certification, the organic farm will remain vulnerable (until occurrence of a killing freeze) to infestation by migrating weevils and any progeny produced after *C. grandis* release is terminated. The beet armyworm as well as other armyworms, bollworms, and loopers caused extensive damage in release as well as insecticide-treated comparison fields. Most worm damage occurred during mid-August; however, microbial insecticides and the natural enemy complex in release fields greatly limited damage by subsequent worm generations. Biological control strategies based on augmentation of one or more parasite species or pathogens provide a potential for effective suppression of pest densities without the potential hazards and expense associated with conventional insecticides. Such technology may prove useful in current boll weevil eradication areas or other cotton belt areas infested with boll weevil as a means to reduce insecticide usage in environmentally-sensitive sites or for cotton grown for organic certification.

Survival studies of in-season and late-season boll weevil cohorts under host-free conditions indicated that in the absence of food, few weevils produced during the normal cotton cropping season in the Lower Rio Grande Valley of Texas survived until the following cotton crop. Survival curves of cohorts held in a controlled environment during the starvation period were similar regardless of the time of season when cohorts were collected, and failed to indicate larval induction of diapause. Survival curves of weevils held under ambient conditions indicated a strong relationship between longevity and temperature. Dissections indicated few differences among cohorts in reproductive status, and survival curves did not demonstrate increased longevity resulting from a reproductive diapause. Relationships between juvenile hormone esterase titers and longevity were demonstrated, but these relationships varied widely among cohorts. No titer of juvenile hormone esterase could be used to discriminate between reproductive and diapausing boll weevils. Experimental artifacts that influence the outcome and interpretation of such survival studies were identified and are currently under investigation. Development rate studies demonstrated a strong temperature dependence of reproductive development. Preliminary host quality and feeding rate studies indicated that crowding, host condition, and availability of food impact subsequent reproductive commitment of female weevils. Males were less sensitive to food quality, but increasingly acquired the morphological characteristics of diapause with increasing physiological age. Males morphologically classed as diapausing subsequently inseminated virgin females, resulting in the production of fertile eggs. Preliminary findings from trapping studies in northwestern Mexico indicated that highest trap captures occurred near cotton production areas. Seasonality of trap captures differed between cotton production regions of northern and southern Tamaulipas. Consistent capture of small numbers of weevils at trapping sites distant from cotton production suggests the potential for continuous, low-level interchanges of weevil populations among the cotton producing regions of northeastern Mexico.

Surveys were conducted in the Lower Rio Grande Valley to assess the extent of damage caused by beet armyworm and other pests during the 1995 production season. A comparison of the cotton acreages in Cameron, Hidalgo, and Willacy Counties of Texas and adjacent Tamaulipas, Mexico revealed significant differences in the incidence of plant damage and densities of various cotton pests and associated natural enemy species.

Augmentative releases of the parasite, *Catolaccus grandis*, were conducted during the postharvest fallow season in an attempt to suppress boll weevil infestations occurring in stands of undestroyed cotton. In each of a series of fields, augmentative releases of *C. grandis* were accompanied by an appreciable increase in the incidence of parasitism, which served to destroy significant numbers of immature boll weevils which appear to have been predisposed to successful overwintering.

The effects of three irrigation methods (open furrow irrigation, T-tape, and spraying on the soil surface) and two nematode concentrations (200,000 and 400,000 nematodes per square meter) on the efficacy of a local entomopathogenic nematode, *Steinernema riobravis*, against three insect pests (corn earworm, tobacco budworm, and cotton boll weevil) were investigated in 1995. Nematodes supplied by biosys, Inc. were applied to a cotton field soil where corn earworms and tobacco budworms were contained individually in tissue capsules and buried in the soil (5cm deep). Cotton boll weevil-infested squares were placed on the soil surface. The greatest parasitism resulted with 400,000 nematodes applied via in-furrow irrigation against corn earworm prepupae and pupae (96%), tobacco budworm (96%), and boll weevil (74%). At this nematode concentration, parasitism diminished when nematodes were applied through T-tape or spraying against corn earworm (71 or 43%), tobacco budworm (84 or 41%), and boll weevil (21 or 38%). Parasitism in all plots that received nematodes was higher than the 6% natural parasitism observed in control plots. These results show the potential of using *S. riobravis* via in-furrow irrigation for controlling corn earworm, tobacco budworm, and boll weevil in the soil. **(USDA, ARS, Subtropical Agricultural Research Laboratory, Weslaco, TX)**

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 1995 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 1995 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.

State	Pesticide (lbs AI/A)	Target Pest
California	Scout Xtra	
	Provado 1.6F	
	Furadan 4f (Section 18 for 1995)	
Louisiana	Imidacloprid	Aphids
		Tarnished plant bug
	Bollgard	Lepidoptera larvae
Missouri	Gaucho seed trt	
	Provado	
New Mexico	Spod-X® LC	
North Carolina	Gaucho 480 seed trt	
South Carolina	Confirm (Section 18)	
Texas	Gaucho 480 seed trt	Thrips, Aphids
	Confirm (Section 18)	Beet armyworm
	Pirate (Section 18)	Beet Armyworm
	Furadan (Section 18)	Aphids
	Provado	Aphids

Table 2. Changes in state recommendations for treatment for arthropod pests of cotton for 1995.

State	Pesticide	Target Pest
Alabama		
Additions	Bollgard	Tobaccobudworms
	Provado (0.047)	Aphids
	Provado (0.047)	Whiteflies
	Dicrotophos (Bidrin) (0.25-0.5)	Stink bugs
Louisiana		
Additions	Imidacloprid	Aphids Tarnished plant bugs
	Bollgard	Tobacco budworms
Missouri		
Additions	Provado	Aphids
New Mexico		
Additions	Endosulfan (Phaser® 3E/Thiodan® 3E) (0.375-0.75)	Boll Weevils
	Spod-X® LC (100 ml)	Beet armyworms
Deletions	Carbofuradan (Furadan 4EC)	Aphids
North Carolina		
Additions	Imidacloprid (Provado 1.6F) (3.75 oz., 0.05 lb)	Cotton aphids
South Carolina		
Deletions	Curacron 6E	All uses
	Lannate 1.8L	All uses
Tennessee		
Additions	Imidacloprid (Gaucho)	Thrips
	Imidacloprid (Provado, 0.047)	Aphids
	Chlorpyrifos (Lorsban, 0.75-1.0)	Beet armyworm
	Thiodicarb (Larvin, 0.6-0.9)	Beet armyworm Loopers
	Bacillus thuringiensis (see product labels	
Deletions	Malathion (Cythion)	Aphids
	Phosmet (Imidan)	Boll weevil
	Sulprofos (Bolstar)	Plant bugs
	Chlorpyrifos (Lorsban)	Fall armyworm
	Azinphosmethyl (Guthion)	Stink bugs Spider mites
	Dicrotophos (Bidrin)	Whiteflies
	Methidathion (Supracide)	
Texas		
Additions	Dimilin (0.0625-0.125)	Beet armyworms Bollworms/
	MVP II (1.5-2 pts)	Tobacco budworm Aphids
	Provado (0.025-0.047)	

Table 3. Promising pesticides screened in 1995 for control of cotton arthropod pests.

State/Pesticide (lbs AI/A)	Target Pest(s)
Alabama	
Pirate (0.25-0.35)	Tobacco budworms
Spinosad (20-40 grams)	Tobacco budworms
RH2485 (0.3-0.4)	Tobacco budworms
MK-244 (0.01)	Tobacco budworms
Pirate (0.15-.2)	Beet armyworms
Spinosad (20-28 grams)	Beet armyworms
MK-244 (0.01)	Beet armyworms
Confirm (0.13)	Beet armyworms
RH2485 (0.1)	Beet armyworms
V-71639 (20-30 grams)	Beet armyworms
Provado (0.04)	Plant bugs
Gaucho (4.0 oz/100 cwt)	Seedling thrips
Provado (0.04)	Aphids
California	
Furadan 4F (0.25)	Cotton aphid
Aphistar 25W (0.125)	Cotton aphid
Pyriproxyfen 0.83 EC (0.044)	Cotton aphid
Gaucho 480F (seed trt) (8 oz/cwt)	Cotton aphid
Admire 2G (8 oz/acre)	Cotton aphid
Alert 3SC (0.01)	Spider mites
CM-006 (0.005,0.01,0.015)	Spider mites
Louisiana	
Pirate (0.35)	Tobacco budworm
Pirate (0.15-0.2)	Beet armyworm Soybean looper
Confirm (0.125)	Beet armyworm
Spinosad (0.033-0.1)	Tobacco budworm Bollworm Beet armyworm Soybean looper
Fipronil (0.33-0.67)	Tarnished plant bug Boll weevil
Imidacloprid (0.044)	Cotton aphid Tarnished plant bug
Missouri	
V-71639 (Knack) (0.044, 0.066)	Thrips
Fipronil (0.10,0.15) (in-furrow)	Thrips
Fipronil (0.025,0.038) (foliar)	Thrips
Decis (0.019,0.025,0.03)	Bollworms
Oklahoma	
Decis	Bollworm
NAF - 85	Boll Weevil
Ovasyn	Cotton Aphid
FCR-4545 1 EC	Bollworm/Boll Weevil
FCR-4545 125 SC	Bollworm/Boll Weevil
Tennessee	
Regent 80WG (fipronil) (0.1,0.15,0.25,0.038)	Thrips
Dimethoate 10G (0.75,1.0)	Thrips
Furadan 4F + Di-Syston 8E (0.5,0.75)	Thrips
Garlic Barrier (1%)	Thrips
Provado 1.6EC (imidacloprid)(0.47)	Plant bugs
Regent 80WG (0.038, 0.05)	Plant bugs
Decis 1.5E (0.025)	Heliothis
Orthene 90S + Danitol 2.4EC (1.0 + 0.3)	Heliothis
Larvin 3.2EC + Danitol 2.4EC (0.75 + 0.3)	Heliothis
Spinodad 4SC (0.0625)	Heliothis
TD-2344 0.834EC (0.025, 0.035)	Heliothis

Table 3. Continued

State/Pesticide (lbsAI/A)	Target Pest(s)
Texas	Beet armyworm
Pirate 3SC (0.2)	Beet armyworm
Spinosad (0.033-0.1)	Beet armyworm
Confirm (0.125)	Beet armyworm
V-71639 (0.037)	Beet armyworm
MK244 (0.0075)	Beet armyworm
Spod-X LC (1.7-3.4 oz.)	Tobacco budworm
Pirate 3SC (0.188-0.375)	Tobacco budworm
Spinosad (0.033-0.1)	Tobacco budworm
Confirm (20-40 grams)	Tobacco budworm
RH2485 (0.25-0.4)	Bollworm eggs
Provado (0.02-0.04)	Boll weevil
Fipronil (0.5)	Aphids
Provado (0.02-0.04)	Aphids
Gaucho 480 seed trt (8 oz/cwt)	Aphids
V-71639 (0,04)	Aphids
CGA215944 50WP (1.8-3.6 grams)	Aphids
Furadan 4F (0.125-0.5)	Spider mites
Pirate 3SC (0.188-0.375)	Cotton fleahopper
Provado (0.02-0.04)	Plant bug
Provado (0.02-0.04)	Thrips
Gaucho 480 seed trt (8 oz/cwt)	