52ND ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

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Foreword

There were 10,772,500 acres of U.S. Cotton (Upland and Pima) harvested in 1998 with an average yield of 618 pounds of lint per acre (USDA - January 11 report). Arthropod pests of cotton reduced yield by 7.98% in 1998. The bollworm was the predominant species to attack cotton in 1998 and was estimated at 70% of the population. Boll weevil is still a pest on 55% of our U.S. acreage and was the second most damaging pest at 2.30% loss. *Lygus* (1.04%), thrips (0.352%), and aphids (0.333%) rounded out the top five cotton insect pests for the year. Beltwide, direct insect management costs amounted to $63.08 per acre and losses were $51.20. Cost plus loss is estimated at $1.224 billion. (See M. R. Williams, this proceedings.)

Crop and Arthropod Pest Conditions

Alabama. Despite some replanting, cotton got off to an excellent start in 1998 in North Alabama. Thrips populations were high, but due to rapid plant growth few foliar applications were necessary. Tarnished plant bugs presented a moderate problem on the older portion of the crop during June. Conditions became dry during June and early July and resulted in the premature senescence of the earliest planted cotton even though the drought was broken in mid July. Tarnished plant bugs again produced widespread damage during mid season. Clouded plant bugs also contributed to this damage. Cotton aphids were a minor problem but did flare in a limited number of fields during mid-late July. Tobacco budworm and cotton bollworm eggs were almost non-existent until the last few day of July. From then until mid-August, pressure was spotted but heavy in some areas. Bollworm and budworm larvae presented problems on conventional cotton and bollworms presented some problems in *Bt* cotton. Heliothine problems generally began with bollworms and gradually shifted to a budworm problem. Determining the species mix in any one field at a particular time was very difficult. Control of budworms with pyrethroid insecticides was hampered by resistance. Huge numbers of fall armyworms were present on various grasses from mid season on, but only a low but persistent infestation occurred in cotton. Banded wing whitefly populations started building in early August, but a problem was never realized. The percentage of Bollgard® cotton planted in 1998 was approximately 80% and will likely increase slightly for 1999. Harvest of the crop was unusually early and yields should average nearly 700 lbs. of lint per acre.

As often the case, both insect and weather conditions varied somewhat from region to region within the state in 1998. After a wet winter, conditions became very dry during May and June. Not enough moisture was available to germinate seed in the southeastern section of the state and numerous fields were eventually disked under in mid to late July. Where stands were obtained, growth was stunted and thrips damage was very heavy. No at-planting treatment gave acceptable control, and many fields required foliar sprays for thrips. Due to the above average temperatures, cotton maturity and budworm and fall armyworm populations advanced faster than normal. Budworms occurred in late May and fall armyworms (FAW) in late June in the Gulf Coast Area. Localized populations of budworms were heavy and pyrethroids gave ineffective control. Bollworms peaked in late July, and a higher percentage of Bollgard was over sprayed than either of the previous two years. Pyrethroids gave excellent control of bollworms statewide. FAW occurred early and eventually spread statewide with three generations (June to September) occurring in South Alabama. Plants bugs were below economic levels over most of the state due to the impact of the extreme spring drought on wild host plants. Stink bugs appeared in cotton early (June) but were maintained below damaging levels throughout most of the season due to sprays targeted toward bollworms, budworms, or FAW. Beet armyworms were present at detectable levels in many fields throughout the season. However, not a single field statewide had economic levels for the third consecutive year. Insecticide applications ranged from two or three up to six or eight ad more were needed on many fields of conventional varieties. Growers were hesitant to invest in more insect control, due to the poor outlook for yields, resulting from the drought. Dry weather was the dominant factor in cotton production in Alabama in 1998. During harvest season a high percent of the cotton in a six county area of southwest Alabama was destroyed by hurricane George. Approximately 60% of the total Alabama acreage was planted to Bollgard varieties and this will likely increase in 1999. Other conditions being equal, Bollgard is out yielding conventional varieties due to the lack of timely applications for "worm" control. Statewide yields were estimated at 600 lbs. of lint but Hurricane damage and excessive fall rainfall will likely reduce yields by 10-15%.

Arkansas. The 1998 growing season was unusually hot and dry in Arkansas. Boll weevil trap captures in April were high, a result of the mild fall and winter conditions of 1997-98. Approximately 860,000 acres of cotton were planted in the state and it came up reasonably well in most areas. Some 103,000 acres of *Bt* transgenic cotton were planted. Southwest Arkansas (approximately 6,000 acres) was in the

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first year of boll weevil eradication. Very hot and dry conditions throughout most of the growing season, coupled with higher than average pest pressure, resulted in lower than average yields, particularly in dryland production fields. Average yields were estimated to be around 676 lbs.

The hot, dry weather preceded by a mild winter, resulted in above average overall insect pressure in 1998. Many fields were treated for overwintering boll weevil. Bollworm numbers were extremely high. Spider mites were also a problem in some areas due to the dry conditions. There were several outbreaks of fall armyworm, which resulted in fields requiring treatment solely for this insect, something which rarely occurs in Arkansas. Beet armyworms were also numerous in many fields.

Thrips began moving into the cotton crop within about one week of emergence and damage symptoms could soon be seen on untreated cotton. Many fields were treated at pinhead square for boll weevils and plant bugs, and several received a second overwintered weevil application one week after the first application. The hot, dry weather continued and early to mid-season weevil numbers were low due to the overwintered weevil sprays and the effects of the heat and lack of rain on the survival of boll weevil larvae in squares on the soil surface. Plant bug numbers were also generally lower prebloom than in past years in most areas.

June tobacco budworm populations showed up on schedule in Southeast Arkansas but were not especially heavy or difficult to control. The first 2-3 weeks of July were characterized by fairly heavy and sustained bollworm infestations. Beet armyworms began to show up in early July and were numerous in many fields in cotton near the Louisiana line in both Southeast and Southwest Arkansas. Aphids and bollworms caused problems in Northeast Arkansas during early and mid July. By late July, fairly heavy budworm infestations began occurring in southeast and Southwest Arkansas. Beet armyworms continued to be seen, and by late July and early August had spread and were being seen farther north. Hot, dry weather continued over the state. Spider mites caused problems along the edges of some fields. Many irrigated and dryland fields were in strong cut-out by the third or fourth week of July. Aphids were present in most fields in mid-July, but their populations collapsed due to the aphid fungal pathogen before the end of July in most fields. Fall armyworms were found in some cotton fields in the Southeast part of the state in July, resulting in some fields requiring treatment for this insect, something which rarely occurs in Arkansas. Boll weevils began to cause problems in areas of better overwintering habitat in July. Some fields had trouble with plant bugs in July.

Beet armyworms, fall armyworms, tobacco budworms, bollworms, and loopers were all present in Arkansas fields in August. Budworm populations were large, and the presence of resistance was evident as far north as the Missouri border. Beet armyworms required treatment in several areas of Southeast Arkansas and a few areas in the middle part of the state. A few areas localized areas in southeast Arkansas applied 3 or more sprays for beet armyworm control in July and August, and areas in Southwest Arkansas were also troubled by beet armyworms. Plant bug and banded winged whitefly populations increased in August. Prolonged rainy weather in August hurt the crop and prevented timely insecticide applications in Northeast Arkansas. Section 18's were obtained for the use of Pirate on resistant tobacco budworm and beet armyworm and also for Confirm on beet armyworm.

Cabbage and soybean loopers were present in some fields in September, and beet and fall armyworm pressure continued. Banded winged whitefly continued to be seen in some areas on later cotton. Boll weevil populations increased and damage was evident to late set fruit. Most fields escaped late season insect problems, however, because they cut-out early. Control of regrowth was a significant problem in many areas, and squares were available to feed boll weevils well into November. Mild fall conditions have set the stage for good weevil survival in 1998-99. Arkansas farmers averaged 674 lbs lint per acre with high production costs due to increased need for irrigation, increased insect pressure, and the increasing costs of inputs (seed, insecticides, equipment, etc.). In general, few problems (other than bollworm survival) were encountered with Bollgard technology. Many Arkansas growers remain dissatisfied with the yield performance of Bollgard cotton varieties, however.

California. In 1998, 834,000 acres of cotton were planted in California with 22% percent dedicated to Pima. This represented a 29% decline in planted acres from 1997. The San Joaquin Valley cultivated the bulk, with Sacramento Valley planting 10,635 acres, and southern California valleys planting 16,070 acres. The San Joaquin Valley received a special variance to plant non-Acala upland varieties that occupied about 30,000 acres. The legal planting date was advanced from March 20 to March 10 in the San Joaquin Valley.

For the San Joaquin Valley, the 1998 season can be rated as one of the poorest in many decades. Weather played a major factor in limiting yield potential, with disease and arthropods also contributing to yield decline. Yields are expected to be off by 22% for Acala Upland (911 lbs/acre) and 16% for Pima (913 lbs/acre) compared to the five-year average.

Weather was the major factor in reduced yield. Good early planting conditions deteriorated to inadequate planting conditions from late March through mid-April with rainfall and cool temperatures. The planting season was delayed by five weeks, with the majority of the cotton planting occurring during late April and through May. Poor growing conditions required replanting, resulted in increased disease, skippy stands and delayed crop development. The growth and development of the crop was four to five weeks behind normal schedule. June and July temperatures were moderate while August was hot and humid. Late September and early October were cooler than usual and robbed the crop of the needed heat for boll development in the upper positions and reduced the efficacy of defoliation. Rain in November further delayed the harvest.

Western flower thrips populations were unusually high due to the cool, wet spring conditions. Light to moderate terminal pruning occurred and some treatments were applied for thrips.

Late rains during April and May lead to the development of conditions for the buildup of western tarnished plant bug (WTPB), *Lygus hesperus*. An area along the west side of Fresno, Kings and Kern Counties experienced repeated migrations, requiring multiple applications of broad-spectrum insecticides for control. Square losses were substantial during July in this area. WTPB migrations in the east side of Tulare and Kern also required insecticide applications.

Spider mites were abundant mid to late season. Pima cotton was reported to be more infested this year then in years past. Aphid infestations were scattered and associated with areas of receiving insecticide treatments for WTPB. In limited but widely dispersed areas, multiple treatments were required to keep populations below economic levels. Silverleaf whitefly was not a widespread problem. Whitefly population buildup was delayed until late season due to cool temperatures. Beet armyworm was a problem later in the season, mostly along the west side of the Valley.

Georgia. The 1998 production year was plagued by significant weather influences. Heavy rains which began in September 1997 continued until mid-April and were followed by hot and dry conditions. Although scattered showers occurred in some areas during June, drought conditions were experienced in most areas from mid-June until late July which significantly reduced yields. In some situations, irrigation systems were not able to maintain water needs. Moisture relief came in late-July but was too late in most areas. Some dryland acreage was destroyed or abandoned due to limited yield potential.

Early season thrips pressure varied across the state. Preventive treatments were adequate in most areas but foliar sprays were needed on limited acres due to high populations and limited soil moisture. Plant bug populations were generally light with some sporadic problems. Aphid populations occurred later than normal but developed rapidly. Populations were controlled as rapidly by a fungal epizootic.

Infestations of caterpillar pests occurred one to two weeks earlier than normal during 1998. Tobacco budworm pressure in late May and early June was higher than normal in central and east Georgia. Heavy budworm pressure occurred on irrigated acreage during July and August. Drought stressed fields did not appear to be attractive egg laying sites. Bt cotton continued to provide excellent control of tobacco budworm. Corn earworms infested cotton in early to mid July and populations were generally high.

Fall armyworm populations were heavy in southwest and east Georgia. The first generation occurred in early July in southernmost Georgia where two economic generations occurred. Populations tended to be higher in fields which were not actively treated for other caterpillar species. Fall armyworm were present at detectable levels in most fields in the coastal plain. Beet armyworm populations were light and sporadic, but localized problems were observed in some parts of the state. Looper populations were generally low.

Stink bugs continue to demonstrate their presence as an economic pests. Populations began increasing in July, especially in fields which had not been treated with a broad spectrum insecticide. Boll injury was observed in late July and continued to increase as the season progressed.

Unusually high populations of cotton fleahopper were present late in the season. High populations of silverleaf whitefly occurred in a localized area near Tifton. Late in the season a few fields were defoliated by cotton leafworm in southernmost Georgia. Boll weevils were detected in Lowndes, Mitchell, Thomas, Macon, and Houston Counties. A total of 51 boll weevils were captured.

Weather was the limiting factor for the 1998 production season. The lowest yield in over a dozen years, a little over 500 lbs/acre, was harvested from 1,300,000 acres.

Florida. Adequate soil moisture allowed planting to begin on schedule in late April and early May. However, approximately 1000 acres planted after the first week of May had to be replanted. In some cases fields were replanted three times before a satisfactory stand was obtained. This was due to planting into marginal soil moisture followed by rapid drying conditions. Dry conditions prevailed throughout May and June delaying maturity and reducing yield in parts of west Florida and all of the eastern panhandle.

In west Florida, heavy rainfall and wind associated with Hurricane Georges on September 26-28 resulted in crop losses of approximately 50%. Growers harvested approximately 1200 acres with yields of 800-900 lbs lint per acre before the storm. After the storm yields, yields ranged from 500 lbs to less than 100 lbs of lint per acre. Several hundred acres were not harvested. In the eastern panhandle, the main effect of the storm was rainfall (8-10 inches). This occurred when bolls were opening and caused substantial boll rot. Yields were reduced by 150 lbs to 200 lbs of lint per acre. Statewide yields are estimated at 450 lbs of lint per acre in 1998.

Thrips populations were at normal levels. Granular insecticides were used on most fields at planting and provided adequate control. Where seed treatments were used control was good.

Tarnished plant bug populations were sporadic, and statewide approximately 15% of the acreage received an insecticide application for this pest. Early season square set was generally high.

Aphid populations remained at low levels in most fields through mid July. Heavy infestations developed the week of July 20, particularly in fields that had been recently treated for other pests. The beneficial fungus, *Neozygites sp.*, decimated aphid populations within a week. Infestations reappeared in some fields in late August, and the fungus eliminated these populations by early September.

In west Florida, bollworm and tobacco budworm populations were generally high in conventional cotton during July through mid-August. Conventional varieties required multiple applications (6-8) to provide control. Pyrethroid insecticides alone did not provide adequate control of budworms during late July and August. Phosphates, phosphate/pyrethroid tank mixes, and Tracer were used during this period. In the eastern panhandle, only moderate populations of bollworm and budworm were present throughout the season. In conventional varieties 3-4 applications were generally made. However, populations were usually mixed with fall armyworm.

Bollgard cotton varieties provided excellent control of budworms and bollworms. Beneficial insect populations were generally high in Bollgard cotton throughout the season. Counts during July and August were generally higher than 20 per 100 sweeps in untreated fields.

Fall armyworm populations were present from July 7 through August. From 60% (west Florida) to 90% (eastern panhandle) of the fields received one or more applications for the fall armyworm. Bollgard varieties had very little if any effect on the fall armyworm.

Beet armyworm populations were very low during early through mid season. Populations increased to treatable levels in some fields in west Florida during late August, but less than 10% of the fields were treated.

Stink bugs were present in low numbers through mid season. Populations increased in September and in west Florida; approximately one-half of the fields received an insecticide application for stink bugs.

Louisiana. Cool and dry conditions during early April resulted in most of the crop being planted during the last week of April and the first two weeks of May. Unfortunately, late April rainfall was the last precipitation most areas of the state would receive until early August. May, June, and July were recorded as some of the hottest and driest months on record. Temperatures on many days in June and July exceeded 100°F during the daytime and 80°F at night. These environmental conditions resulted in many areas of the state with yields 30 to 50% lower than average. Cotton produced near the Mississippi River, however, received some rainfall during June and July which helped to produce a near average crop. Louisiana planted approximately 525,000 acres of cotton with an average state yield expected to be in the 500 to 600 lb/acre range.

Early-season insect populations were moderate. Thrips populations were moderate to heavy in most areas of the state. In-furrow insecticide activity was hampered by dry soil conditions resulting in many fields being treated with a foliar spray for thrips. Cutworm populations were light with most fields receiving a prophylactic treatment for cutworm control at planting.

Overwintered boll weevil populations were moderate. Most fields received at least one pinhead square application for overwintered boll weevil control. Boll weevil populations were light until mid-August with an average of two insecticide applications for control of populations of field boll weevils. After mid-August, boll weevils reached high levels in many fields with, some receiving at least four insecticide applications for boll weevil control.

Boll weevil eradication is being conducted on approximately 50,000 acres adjoining the Red River. 1998 was the first full year of the eradication program in this area. The first pinhead square treatment was applied on May 15, in a field near Cheneyville. Boll weevil populations in the eradication zone were much lower than anticipated. Insect pest populations observed to be higher inside the eradication zone than outside the zone were aphids and whiteflies.

A referendum for boll weevil eradication in the remaining parishes of the state passed by 78% with the state agreeing to pay one-half of the cost of boll weevil eradication. Diapause applications will begin in August of 1999 in this area of the state.

Tarnished plant bug populations were light to moderate all season. Few fields were treated prior to bloom for plant bugs. Populations near corn were high in many cases. However, this phenomenon did not extend much greater than 200 ft from the edge of the corn fields.

Bollworm populations were moderate during most of the season, although the major cotton producing area of the state did see a significant increase in corn acreage. Most non-*Bt* cotton fields required 3 to 5 insecticide applications for bollworm control, while most *Bt*-cotton fields received

2 to 3. Resistance monitoring of bollworm populations indicated a change in susceptibility of bollworm to pyrethroid insecticides.

Tobacco budworm populations were generally light during 1996, with heavy infestations developing in some areas of West Carroll, Avoyelles, and St. Landry parishes. Pyrethroid resistance levels were again among the highest observed, with resistance levels in May and June being the highest ever observed. Pyrethroid resistance is becoming such that pyrethroids will probably no longer be an effective control means for tobacco budworms.

Bt-cotton was planted on approximately 65% of the state acreage (53% D&PL 33B and 12% Stoneville 4740). Highest levels of *Bt*-cotton planting were in the boll weevil eradication zone (80%+). Approximately 95% of the *Bt*-cotton acreage was treated for bollworm, the remaining 5% not treated was in Northwest Louisiana. There were some apparent differences among *Bt*-cotton varieties in bollworm susceptibility. Most reports were that Stoneville 4740 required more treatments for bollworm than did D&PL 33B. Bollworm samples from 10 *Bt*-cotton lines did show significantly higher bollworm populations in Stoneville 4740 than in D&PL 33B. However, there were a few D&PL lines that were not significantly different from Stoneville 4740.

Mississippi. Approximately 950,000 acres of cotton were planted in Mississippi in 1998, making this the second consecutive year that planting was below 1,000,000 acres. Availability of several new varieties of transgenic *Bt*-cotton, combined with a modified pricing structure that resulted in slightly lowered costs, prompted increased use of this technology. Approximately 55% of Mississippi's cotton acreage was planted to *Bt* varieties, with use continuing to be higher in the Hill region than in the Delta. Following initiation in the fall of 1997, the Hill region, consisting of approximately 365,000 acres, was involved in the first full year of boll weevil eradication, and the South Delta, consisting of approximately 126,000 acres, initiated boll weevil eradication in August of 1998.

Planting was initially delayed by cool wet conditions in April, and the majority of the crop was planted during the first two weeks of May. However, unusually warm conditions during May and June resulted in vigorous early grow and an early developing crop. Unfortunately, these warm conditions were accompanied by drought in many areas, which further hastened maturity at the expense of yield.

Because vigorous early seedling development resulted in a narrower window of susceptibility, thrips were not a particular problem. However, considerable acreage still required treatment because of high populations of migrating adults and poor uptake of in-furrow insecticides in field suffering from dry conditions. Cutworms also were treated on some acreage but were not a notable problem.

Historically, hot dry conditions have been observed to have an adverse impact on early season tarnished plant bug numbers, and this appeared to be the case in 1998, because pre-bloom plant bug populations were generally low. Also, pinhead square treatments of ULV malathion applied as part of the boll weevil eradication program in the Hill region served to further limit plant bug populations in this area. Most fields entered the bloom period with above normal fruit retention counts. However, many fields in the Delta did experience significant plant bug infestations and some control difficulties during mid to late season. This increase in mid and late season plant bug infestations is a continuing trend that is thought to be due to a variety of factors including: insecticide resistance, increased use of *Bt*-cotton, and shifts in acreage of alternate crops such as corn and early maturing soybeans. These mid and late season plant bug infestations did not appear to have a significant impact on yield, but information on plant bug thresholds during this portion of the season is one of the more pressing research needs.

The winter of 1997-1998 was the mildest on record in the past 20 years, with only 19 days when minimum temperatures below 32 degrees F were recorded at Starkville. These warm winter temperatures allowed survival of high numbers of overwintered boll weevils. Consequently, the Delta region of the state experienced unusually high boll weevil infestations and most acreage in the Delta received one or more pinhead square treatments for control of boll weevils. Considering the high populations of overwintered weevils, mid-season boll weevil problems in the Delta were lower than anticipated, presumably because the unusually hot dry conditions resulted in increased mortality due to dessication of developing larvae and pupae. Late season populations still reached damaging levels on many fields, and methyl parathion, applied for boll weevil, accounted for a higher percentage of foliar insecticide applications than any other single insecticide in the Delta.

Following the aggressive diapause program conducted in the late summer and fall of 1998 and the continuation of the eradication effort in 1998, boll weevil populations were extremely low throughout the Hill region. It was unusual to detect either boll weevils or weevil punctured squares in fields in the hill region and yield losses to weevils in this area were essentially zero. However, because of the extremely low treatment triggers used in an eradication program and high levels of late season migration of weevils from areas not involved in eradication, a large number of ULV malathion treatments, approximately 13.4/acre, were applied to cotton in the Hills. Fields in the south Delta, which began eradication in August of this year, received an average of 8.7 ULV malathion sprays/acre.

This intensive, season long use of ULV malathion in the hills greatly reduced populations of beneficial insects in the eradication area and, as is common during the early years of an eradication effort, resulted in increased populations of several species of secondary pests. Cotton aphid populations reached damaging levels on most fields inside the eradication area and a significant portion of these fields were treated. Furadan (carbofuran), which was available under Section 18 Emergency Exemption, was the most effective treatment. Aphid populations were unusually low in the Delta region and peaked later and at lower levels than inside the Eradication area. Aphid populations were ultimately controlled by the *Neozygites* fungal disease in both areas, although peak incidence of the disease also occurred later in the Delta.

Banded winged whitefly was another pest that was more common in the hills than in the Delta. Whitefly infestations began to appear in June, which is considerably earlier than normal, and began to exceed treatment thresholds in July. Heavy whitefly infestations were relatively uniform throughout the Hills, with populations being notably higher on the more hairy varieties, but treatable whitefly infestations were uncommon in the Delta. A significant amount of Hill cotton acreage was treated for whiteflies, with successive applications of Orthene (acephate) being the most commonly used treatment, albeit not an extremely effective one. Isolated infestations of silverleaf whitefly were again observed in the extreme southern portion of the state.

Approximately 85% of the cotton in the Hills was planted to transgenic *Bt* varieties, and tobacco budworm was not a problem on this acreage. However, much of the remaining non-*Bt* cotton in the Hills experienced severe tobacco budworm infestations that were difficult to control with older types of chemistry. Many of these non-*Bt* fields suffered severe yield losses despite high control costs. Tracer® was the most effective product for control of tobacco budworm infestations in non-*Bt* cotton. Although difficulties controlling the June generation of tobacco budworm were reported from several counties in the Delta, overall budworm pressure was considerably lower in this region.

Mississippi producers harvested approximately 515,000 acres of corn in 1998, representing an increase from the previous year. This increase in corn acreage resulted in significant numbers of bollworms moving from corn into cotton during July. Both *Bt* and non-*Bt* cotton were affected by bollworms, and the need for increased treatment for bollworms was one of the primary factors contributing to elevated insect control costs. Pyrethroids were the material of choice against bollworms on *Bt*-cotton or against infestations in non-*Bt* cotton that were known to be primarily bollworm. A newly released test kit (Heli-ID) for distinguishing between eggs and small larvae of bollworm and tobacco budworm proved to be a useful and cost saving, although somewhat time consuming, management tool. Monitoring for pyrethroid resistance in bollworm using the adult vial assay revealed no indication of resistance in the moths sampled, but there were a few undocumented reports of bollworms being more difficult to control with pyrethroids than in previous years.

Based on results of an end of season survey of 133 fields from 28 counties, *Bt* fields received an average of 1.2 treatments for bollworm, while non-*Bt* fields averaged 5.2 sprays for control of the bollworm/tobacco budworm complex. Many crop protection professionals observed that the transgenic *Bt* variety Stoneville 4740 appeared to be less effective against bollworm than other *Bt* varieties. This observation was verified by results of the previously mentioned survey which showed that the 4740 sustained an average 3.9% "worm damaged bolls", compared to 2.1% for the other *Bt*s, and 4.8% in non-*Bt* varieties.

Although the unusually hot, dry conditions prompted concern over the potential for a severe area wide outbreak of beet armyworms, especially in areas involved in boll weevil eradication, such an event did not occur. However, beet armyworms were somewhat more common than normal and a number of fields were treated with either Pirate (chlorfenapyr) or Confirm (tebufenozide), two products that were available under Section 18 Emergency Exemption for control of beet armyworm. Surprisingly there was only a slight difference in the beet armyworm pressure in the Eradication area compared to the non-Eradication area. Availability of these Section 18 products, combined with the wide-scale planting of *Bt*-cotton and coincidental beet armyworm control provided by applications of Tracer (spinosad) targeted against other caterpillar pests, are factors thought to have dampened the overall beet armyworm population. Fall armyworm infestations were more widespread than normal and were detected earlier and further north than normal, but relatively few fields were treated specifically for this pest.

Leafminers (presumably *Liriomyza* spp.) were one of the more unusual pests noted this season, but no significant yield loss was attributed to this pest. Several consultants reported infestations in pre-blooming and early blooming cotton that were severe enough to cause shedding of lower leaves, and a few fields were treated specifically for leafminers. Leafminer infestations were more common in the Boll Weevil Eradication Area, but a few severe infestations were also observed in the Delta.

Yellowstriped armyworms also were observed to be more common than usual, particularly on transgenic *Bt* cotton, but populations and damage were below economic levels. Cabbage loopers and soybean loopers also were especially abundant in 1998. Few fields required treatment for cabbage loopers, but a number of fields, including some *Bt*-cotton fields, did receive treatment for late season looper populations that typically are soybean loopers.

Although, late season boll populations appeared better than average, many fields suffered drought stress and entered "cutout" early. By late August it appeared that boll size was smaller than normal in most fields and many bolls were poorly filled. Weather conditions during harvest were excellent, and harvest was completed considerably earlier than normal. Statewide yield was 740 lbs of lint per acre (Jan. 1999 USDA Estimate), which is near the previous five year average of 744 lbs, but well below last year's record yield of 901 lbs per acre. Costs of insect control were above normal and were estimated at $96.30/acre in the Hills and $109.74/acre in the Delta, giving an estimated state average of $104.25/acre.

Missouri. In 1998, Missouri cotton growers planted 350,000 acres (20,000 less or 5.4% decline from 1997's acreage). Corn replaced cotton on most of this acreage. Weather was the primary reason yields declined from ≈750 pounds per acre in 1997 to ≈480 pounds in 1998. Wet soil conditions were prevalent during planting time, and several thousand acres were replanted to cotton or other crops. In late-May, two hail storms severely damaged between 10,000 to 20,000 acres in Dunklin, New Madrid, and Pemiscot Counties. A combination of high temperatures (particularly at night), two extensive drought periods lasting ≈6 weeks each, and sporadic but intense rainfall adversely affected boll set and growth during the summer. Drought stress also likely contributed to an outbreak of bronze wilt that affected several thousand acres. Overall, the bottom and middle cotton crop were fair and the top was very poor. Harvest conditions generally were favorable.

Insect losses ranked only second to weather losses in 1998. Missouri's pest pressure was high with substantial outbreaks of aphids, boll weevils, cotton bollworms, fall armyworms, and tobacco budworms. Overwintering conditions for boll weevils were drier and milder than in previous years, and this was reflected in the high spring trap counts that peaked during 11 to 25 May. Dunklin County had the highest peak of 118 weevils per trap during the week of 11 to 17 May. Despite the tremendous number of weevils present, early-season insecticide applications and estimated yield losses were lower than anticipated. A combination of the crop and weevils being partially out-of-sequence due to the poor planting weather and timely pin-head square insecticide applications helped to delay economic infestations. Fall trap counts were several fold greater than spring, with the peak flight during the first week of October. Pemiscot and Dunklin Counties had the highest trap counts with 339 and 324 weevils, respectively. Early insecticide termination, late-season fruit production, and delayed crop termination permitted weevil populations to build until the winter.

Cotton aphid pressure was high in 1998, and estimated yield losses from this pest ranked it second among all pests. Aphid infestations quickly developed beginning in early-June. Biological control with beneficial insects was fair but poor and delayed (late-July) with the *Neozygites* spp. fungus. Because of a lack of biological control and failures with some insecticides, a section 18 label for Furadan 4F was granted on 01 July.

Late-season pest control shifted towards combating fall armyworm, cotton bollworm, tobacco budworm, and some beet armyworm and European corn borer infestations. Fall armyworms were sporadic but heavy infestations did occur in some fields. Control failures were due to misidentification of the pest and mistiming or poor selection of insecticides. Beet armyworms were present in low numbers in sporadic fields.

Overall, the cotton bollworm was the most prevalent lepidopterous pest in most Missouri cotton fields. Early-season populations developed in large numbers in corn before the migration of adults to cotton. At Portageville, trap counts indicate four distinct flights occurred in southeast Missouri. The peak weekly count was 598 during 15 to 21 September. Cotton bollworms along with tobacco budworms were estimated to cause the greatest (≈6.9%) yield loss. Insecticide applications began in late-July with one to multiple applications required to control these pests. A few field failures occurred as a result of misidentification and poor control with insecticides.

In summary, thrips, plant bug, beet armyworm, spider mite, and European corn borer pressure was light in Missouri. Fall armyworm and tobacco budworm outbreaks were sporadic but heavy in some areas. Boll weevil pressure was delayed, widespread, and heavy. Cotton aphid and cotton bollworm infestations also were widespread and intense.

New Mexico. Environmental conditions in 1998 were unusual. Early spring was colder than usual delaying planting. Shortly after planting, conditions became much warmer and drier than usual with an extended drought however, since New Mexico cotton is irrigated, production was not affected.

Damage by beet armyworm and bollworm was extreme for New Mexico. Producers typically have relatively little damage by bollworm and no significant damage from beet armyworm. Most producers will make only 1-2 foliar insecticide applications, generally for bollworm or pink bollworm. In 1998, growers without *Bt* cotton made at least 4 insecticide applications. Many growers made 5-6 applications. Most of the applications were for bollworm, beet armyworm, pink bollworm, or boll weevil. This problem was likely due to the extended drought and resulting very low populations of beneficials.

Boll weevil damage was lower than expected, but nonetheless higher than the previous year. Emergence in the desert valleys peaked in early May. Emergence in the eastern High Plains was slightly later and peaked in mid-late May depending on habitat. Survival through the coldest portion of the winter in late December was high, with at least 60% survival in the Pecos River valleys. It is likely that the drought in late spring resulted in early emergence and high mortality in overwintering habitat as boll weevil numbers at pinhead square were lower than expected based on counts the previous fall. Late planting by design, or because of the cold early spring, also increased suicidal emergence dramatically. As a result of the reduced numbers, growers in the Pecos valley used an eradication threshold of 2 boll weevils per field in a voluntary effort to reduce boll weevil numbers.

Growers in Luna Co. in western new Mexico and the Mesilla Valley by the Rio Grande River initiated boll weevil eradication programs in the spring and fall, respectively. Luna County in the eastern high plains bordering Texas did not have any spring captures. Lea Co. in eastern New Mexico petitioned the New Mexico Department of Agriculture for a boll weevil control district in late 1998.

Bt cotton acreage increased dramatically in the Mesilla Valley. Over 85% of upland cotton fields planted were *Bt* varieties. In other areas of New Mexico, however, *Bt* cotton production remained very low, approximately 2% of total acreage.

September was warmer than average and made up for the delayed start in early spring. Picking was delayed due to high rainfall in October. Some fields, which were not picked before this extended rainfall, had very high yield losses as a result. Nevertheless, ultimately, despite a late start severe insect infestations, and late season rains, yields in most locations were at least average.

North Carolina. Cotton was planted on just under 700,00 acres in 1998; all but approximately 6,000 acres will be harvested, according to a late November estimate. In a moderate expansion, just under 17,000 acres of ultra narrow row cotton were planted.

Weather conditions were moderate to good early and ideal during most of the harvest period, but generally dry in many areas of the state throughout most of the growing season. Late in the season just prior to significant boll opening, Hurricane Bonnie hurt yield prospects in a number of eastern coastal plain counties but also helped drier counties further inland. Subsequently, heavy rains from Tropical Storm Georges helped some growers and hindered others. Despite good harvest conditions, dry mid season weather and early maturity helped create widespread areas of excessive regrowth. Yet, as of this writing, yields are expected to be between 700 and 750 lb. lint/acre.

Thrips levels were generally moderate throughout most of the state, down from last year. Approximately 95% of NC cotton growers used an at-planting insecticide (including seed treatments) in 1998. Foliar treatments for thrips were applied to 22% of our cotton acreage, down from a very high 52% in 1997.

Second generation tobacco budworms were very high, and persisted throughout later bollworm generations. Approximately 8.25% of the state’s cotton acreage was treated for these early budworms, up from 0.5% in 1997 and up from the 5% treatment average for the past 5 years.

Aphids were a more widespread and persistent problem in 1998, especially in drier areas in which the *N. fresenii* was not as `thick'. Aphids were still essentially wiped out by natural causes, primarily by the above fungus, by harvest. Just under 1% of the state's cotton acreage was treated for cotton aphids. Biocontrol remains the only practical effective means for consistently reducing or eliminating local populations of cotton aphids in North Carolina.

Plant bugs were more numerous than in previous years and seemed to persist more into the mid season in Bollgard cotton than was the case in either 1996 or in 1997. Approximately 6.6% of conventional acreage was treated for plant bugs this past year, considerably up from a 5-year average of less than 1%, and more than double the then-high of 3.2% in 1997.

Our major mid-July to early August bollworm moth flight generation averaged about 2-3 weeks earlier than last year (last year averaged about 2 weeks late), and flight intensity, egg deposition and larval establishment, especially under dried blooms, seemed on the high side, although state-wide damage to bolls by bollworms, at 4.2%, was just over the 13-year average of 3.9%. The average number of treatments required for bollworms and other occasional late-season pests was 3.02, somewhat higher than the 13-year average of 2.8 applications. Tobacco budworms made up a significant proportion of the surviving post-treatment population in some areas (check @ Rocky Mount = 39.3% budworms; Onslow County = 11.4% budworms; budworms more typically constitute 5% or less of the bollworm/ budworm population taken from various check plots). Some post-application collections ranged from 65 to 80% budworms. Consultants and producers reported more larval escapes this year than is typical, likely the result of a higher proportion of budworms in the late-season budworm/bollworm complex, along with high larval establishment under bloom tags. Additionally, in several northeastern counties, adult vial tests for bollworms revealed a mean of 3.4% moth survival at the 5 microgram level, and 3% survival at the 10 microgram level for budworms, the first such survival noted in North Carolina.

Bollgard cotton was planted on approximately 13% of NC's cotton acreage in 1998; a fair portion of that was due to grower demand for RR cotton, which came in the stacked form due to a shortage of RR-only varieties. Bollgard cotton was treated an average of 1.24 times, a significant increase from 1996 and 1997 (previous 2 years ave. = 0.50).

Mean boll damage to Bollgard cotton from bollworms was about half that found in conventional cotton (1.78% vs. 4.17%).

Except for some spotty troublesome fall armyworms (FAW) in a few of the SE counties, FAW did not account for much overall damage this year; European corn borers were very light across most of the state, continuing a trend begun in 1990.

A Section 18 Specific Exemption was granted for Pirate use against beet armyworms. High (10 to 60+ hits per 100 feet) populations were present in small to significant parts of 4 counties, and some treatable levels occurred in about 8 other counties. This marks the third time in 22 years (1977, 1995 and 1998) in which beet armyworms migrated into North Carolina and became established at damaging levels on cotton.

The details of a large-scale North Carolina boll weevil infestation are outlined below. These reintroductions have now been located by pheromone traps and eliminated for 16 years in North Carolina. The larger infestations graphically illustrate both the high reproductive capacity of 1 or 2 gravid females of this species under a low spray environment, as well as the importance of a sound trapping/containment program. (There was an unconfirmed sighting of 4 vehicles with SC license plates in the area just 1 week prior to the initial trap captures.)

Oklahoma. A total of 120,000 acres was planted. The boll weevil was responsible for the sharp reduction in planting intentions in 1998. This trend was apparent across Southwest Oklahoma as producers continued to abandon cotton in favor of a less risky crop. Above average temperatures were recorded throughout the growing season, and 3,414 heat units were accumulated between May 1 and October 1. The State production average is projected at 475 lbs. of lint per acre.

Widespread use of at-planting insecticides and over-the-top sprays limited thrips infestations and resulting damage. Cotton fleahoppers and boll weevils were targets of insecticide applications applied before bloom. Drought limited survival by overwintering weevils, delaying economically damaging populations until late-August. To prevent economic loss, irrigated cotton averaged 3 insecticide applications while dryland cotton averaged 1 insecticide application. Besides low survival, phase 1 of the Oklahoma Boll Weevil Eradication Organization began August 28, 1998, eliminating the need for late season protection in traditional weevil areas.

Bollworm populations started off slow but caused significant damage to irrigated cotton in Harmon, Greer, and Jackson County in August. Control difficulties were widespread. Bollworm control expenditures skyrocketed as intense pressure forced reduction in spray internals and use of tank mixes to maintain control. Damaging infestations existed in all production regions of the state. Approximately 16,000 acres of Bollgard cotton were planted in 1998. Approximately 60% of the Bollgard acreage required additional bollworm protection to prevent economic loss in 1998. Despite the added expense, total inputs for Bollgard fields were significantly less than non-Bollgard fields while maintaining yields that equaled or exceeded non-Bollgard varieties. Bollgard planting intentions in 1999 should reflect this economic advantage seen in 1998 with 70 to 90% of the irrigated acres planting Bollgard varieties.

The beet armyworm is normally a late-season pest in Oklahoma. However the prolonged drought favored beet armyworm development early. Damaging populations developed in July and persisted the remainder of the growing season. Confirm and Pirate were cleared for use to prevent excessive beet armyworm damage. Lower infestations were reported in Bollgard cotton. In many fields, this level of suppression either allowed beneficial insects to keep the infestation in check without need of insecticide control or reduced the number of insecticide applications required to prevent damage.

Drought conditions also limited cotton aphid infestations to irrigated regions of the state. Heaviest infestations occurred in cotton intensely managed. Damaging infestations were widespread by mid-August. Most of the spraying occurred in Harmon, Jackson, and Greer Counties in Southwest Oklahoma. Fields averaged two insecticide applications to control aphids. Furadan was the product of choice once it was cleared for use. Severe yield loss would have occurred if Furadan had not been available for use.

South Carolina. Cotton farmers planted over 280,000 acres of cotton in 1998 which was down just slightly from the acreage planted in 1997. There was a wide variability in cotton yields, with some fields picking less than 300 lbs of lint per acre where little rain fell, compared with a few that made close to three bales where moisture was adequate. We experienced a severe drought in June and July over most of the state, and yields are expected to average about 600 lbs.

Thrips infestations caused fewer problems than expected. Growers were generally late getting cotton planted, and by the time most cotton seedlings emerged, warm temperatures allowed for rapid growth and development which prevented thrips from being much of a problem.

June tobacco budworm infestations were the highest that have been observed in South Carolina for over 15 years. Infestations were high in tobacco as well. Budworms started showing up in cotton fields about the middle of June. At least 50% of the acreage planted to conventional cotton varieties was treated with insecticides for budworm control. Since 40% of the acreage was planted to cotton varieties with the *Bt* toxin, a total of about 30% would have been treated. We discouraged the use of pyrethroid insecticides, and where these products were used some control problems were encountered. A collection of budworm larvae from a field in Sumter County showed some pyrethroid resistance. When the adults were tested in cypermethrin treated vials (5µg), 95% survived. This was the first documented case of pyrethroid resistant budworms in South Carolina.

Aphids were a problem in July and early August. High infestations were found in some fields with copious amounts of honey dew deposits on the leaves because there was little rainfall to wash the sticky substance from the leaves. It was none too soon, but *Neozygites fresnii* did come to the rescue, and aphid numbers declined precipitously throughout the state by the first week in August.

Up to 40% of cotton plants were found infested with fall armyworms (FAW) in a field on June 29 in Calhoun County. This was unusual in two respects: (1) it was an unusually early infestation of FAW, and (2) the boring larvae caused economically important damage in at least one field. There were some mid to late season problems with FAW, but infestations were spotty.

Cotton was infested with bollworms as early as July 8 in the lower part of the state. By the end of the season growers had made an average of 5 pyrethroid applications in conventional cotton, while in *Bt* cotton they averaged close to 1.5 applications. Some *Bt* fields were not treated at all, while others received up to 5 treatments. Bollworms were generally more difficult to control than in past years. There were numerous reports of bollworms surviving two or three pyrethroid applications. Larvae were collected from a number of fields where there were control problems in the lower half of the state. Vial tests of adults confirmed that pyrethroid resistance was a factor in many of the "problem fields." Pyrethroid resistance was first discovered in Hampton County in 1996. Since then, resistance has been confirmed in a number of other areas of the state.

Beet armyworms problems were widespread with infestations scattered across the state. The Section 18's for Tracer® and Confirm® were triggered by an early infestation in Lee County.

Stink bugs were numerous in corn, tobacco, cotton and other crops. We estimate that more than 100,000 acres of cotton were treated in 1998. The majority of the fields treated were probably planted to *Bt* cottons, as the potential for stink bug damage is generally greater where there are fewer pyrethroid treatments applied for bollworm control.

A single boll weevil was captured in a field in Calhoun County in April. There have been no further catches in 1998. In-field trapping in two fields with reproducing weevil populations in 1997 appears to have been instrumental in preventing weevils from finding overwintering habitat.

Tennessee. Tennessee growers planted about 450,000 acres in 1998 which was a reduction of 50,000 acres from 1997. Corn followed by soybeans were the primary crops planted in place of cotton. 1998 was a significant year with insects in general in all row crops but especially cotton. A mild winter by anybody's standards for this area seemed to unleash a multitude of insects which rivaled the now famous 1995 season. Weather, like so many areas of the cotton belt, was a significant contributor to yield loss but was not devastating. In fact, insect losses were a very close second to weather in causing losses.

Ninety-eight percent of Tennessee's cotton acreage is planted in 19 West Tennessee counties. Most of the crop was planted the first half of May. Temperatures for May at Jackson, which is centrally located, were 4.5 degrees above normal (72.4) while rainfall was 1.24 inches above normal (6.71). An area across the southern counties experienced an extremely dry period during June and early July. Cotton and other crops suffered from lack of moisture. July and August saw above normal rainfall which was good and bad. The crop needed the moisture but took a fruit shed with excess moisture and cloudy days. Insect control was also hampered during this time.

Cutworms were spotty and limited to a few hundred no-till acres. Treatment was minimal.

Thrips infestations were normal and required additional foliar treatments (20% of acreage), although about 85% of the acreage receives in-furrow or seed treatments.

Overwintered boll weevil survival in West Tennessee was the highest on record, based on pheromone traps. Peak emergence occurred the last week of May. The average number of weevils per trap per week was 141, with a range of 21 in Lake county (along Kentucky border) to 344 in South Haywood county. Some individual traps captured 700-800 weevils in a week. Multiple pinhead applications were recommended for most counties. Growers responded to this alert, and approximately 68% of the acreage received two insecticide applications, 18% received one, and 4% received three. This area-wide effort held weevil development below treatment level on 80-90% of the acreage until first bloom. Isolated fields or farms which did not receive a pinhead application recorded as high as 40% punctured squares early. Threshold infestations developed earlier in the southern versus the northern counties. For example, Fayette county (along the Mississippi border) reported 68% of scouted acreage at treatable levels during the last two weeks of July while Gibson county reported 14% during this same time.

August began the long-awaited start of boll weevil eradication in six southern West Tennessee counties and a portion of a seventh (Haywood) south of the Hatchie River. Diapause applications using 10oz. of malathion were initiated on a five-day schedule starting the first week.

Three applications on a five-day schedule, five on a seven-day and four to five on a ten-day were made on about 113,000 acres. Pheromone traps indicated a 10 X increase in weevil numbers outside the spray zone versus inside during nine weeks of fall trapping. Peak trap captures were recorded the last few days of September with an average of 480 weevils/trap/week outside the spray area.

Middle Tennessee counties planted approximately 9800 acres. This area was enjoying being weevil free since late 1996 and finishing their last year of eradication when nine weevils were detected in September in two counties (Rutherford and Lawrence). At the present time, this re-infestation has involved four fields and 1060 total acres were treated.

Plant bug numbers were abundant on alternate hosts around field borders early. As adults moved into early squaring cotton, pinhead square applications held infestations in check. Some damage was attributed to plant bugs mid to late season but in comparison to most years will be minimal. Weekly monitoring of square retention has helped make better management decisions regarding plant bug control.

Pre-bloom economic infestations of bollworm and tobacco budworm were above normal. These developed primarily in the southern counties on non-*Bt* cotton. Some pyrethroid products were used at this time with mixed results. A few acres required a second application of non-pyrethroid chemistry to achieve satisfactory control. Second generation oviposition started July 14, peaked in 10-14 days, but never completely diminished before an August generation started. July populations were mixed bollworm/budworm, but August populations changed to a higher budworm ratio. Pyrethroid tank mixtures, which had been working, were not giving satisfactory control. Most treatments in the southern counties which have experienced resistance to tobacco budworm in the past, switched to phosphates, carbamates, or mixtures of both. Central and northern counties, which had not experienced resistance problems before, saw 40-50% control with pyrethroids used alone. Larvae from several of these locations were verified to be 75-100% tobacco budworm.

Bt cotton increased to approximately 60,000 acres. These varieties continue to be among the top producers. Tobacco budworm control has been excellent while bollworm would rate very good with estimates of about 30% being over sprayed for bollworm control.

Aphids infested more acres in 1998, with approximately 30,000 acres treated.

European corn borer infested more acres and contributed to higher yield losses than previously seen in Tennessee. Individual field surveys recorded 30-40% boll damage with yield losses estimated at 200-300 lbs. Increased corn acreage is thought to have contributed to higher corn borer populations.

Fall armyworm was present in more acres during mid and late season than previous years. Few acres were treated specifically for this pest but were considered in insecticide selection when treating for bollworm/budworm or other pests.

Stink bugs were observed more in late season this year after boll weevil and "worm" sprays subsided. They contributed a small amount to yield loss but will become increasingly important as *Bt* cotton acres increase and the boll weevil is eradicated.

Other pests which were present but required minimal treatment included: spider mites, loopers, whiteflies and beet armyworm.

In summary, 1998 was a busy insect year and experienced less than ideal weather, but in comparison to other areas of the cotton belt, survived with an average plus crop. Statewide average yields will be in the 615-625 range. Yield losses to insects are estimated at 13-14% which will compare back to the "insect years" of 1993 and 1995. This loss is slightly above the 14-year average estimate of 10%. Boll weevil and bollworm/budworm will rank number one and two for yield loss followed by European corn borer, plant bugs, thrips, aphids and stink bugs.

Texas. The 1998 drought had a persuasive impact on all production regions of Texas. Harvested acreage was reduced from a projected 5 million acres to 3.31 million acres, the usual acreage for the High Plains region alone. And except in those areas where supplemental irrigation was available, yields suffered. Hot, dry conditions were responsible for an estimated 40% reduction of the potential yields. While a warm fall provided additional heat units for late maturing fields in the north, lack of moisture and late developing pest populations negated much of this potential benefit. Moisture limitations and rapid heat unit accumulations encouraged early cutout.

Yield reductions due to insects was down from last year, again mainly due to the impact of the drought on insect mortality. Average yield reduction due to insects was 5.8%, with a high of 12.3% in the High Plains and a low of 0.6% in the Lower Rio Grande Valley. The boll weevil was still the number one pest for the state in spite of three active eradication zones reporting zero to minimal damage. This pest status was mainly due to weevil levels in the high Plains and Northern Blacklands. The other most damaging pests were the Heliothines, followed by cotton fleahoppers. Most fleahopper problems were concentrated in the Blacklands of Central Texas and South Texas. Even though conditions were right for a beet armyworm-problem year, this pest failed to reach the very high levels observed in some areas in 1995 and 1980. There were no substantial increases in beet armyworm problems in the eradication areas. Even so, Texas did request and receive a section 18 for Pirate® and Confirm®. Aphids were relegated to minor pests in most cases, due to high summer temperatures and perhaps increased light intensity levels in the cotton canopy. A section 18 was obtained for Furadan® 4F for the state and was triggered in most areas even though little was used as a consequence of light infestations. Bollworm and tobacco budworm infestations were generally light to moderate and chronic in nature.

Boll weevil eradication is ongoing in three zones in Texas: the South Texas/ Winter Garden Zone (ST/WG), the Rolling Plains Central Zone (RPC) and the Southern Rolling Plains zone (SRP). These areas involved approximately 800,000 acres of cotton or 25% of the total harvested acreage in Texas (drought reduced much of the Rolling Plains acreage). The SRP zone was in its final eradication year while the ST/WG and RPC zones were in their first full eradication year, following two fall programs. Most of the state is now divided into eradication zones with proposed referendum votes to establish an assessment to take place prior to planting the 1999 crop. Only a limited number of these zones will be able to initiate eradication in the fall of 1999, even if all of them pass their referenda.

Bt cotton acreage increased to a little more than 6% of the total Texas' planted acreage. This cotton has successfully managed most Heliothine and pink bollworm problems. There still are no commercially available stripper Bt cottons released for producer plantings.

Lower Rio Grande Valley (LRGV). The weather pattern was exceptionally dry except for the very earliest of plantings. February was the last rain of any significance until after the cotton was completely harvested. Early September was very wet and allowed the sprouting of cotton seed in virtually every field in the LRGV which had cotton grown for the 1998 season. Pests and "beneficials" were very light during the season, due primarily to the very hot and dry conditions. Boll weevil activity was again extremely light along with most other pests.

Rainfall was scarce during the largest part of the growing season. Late February rainfall was enough to slightly delay planting of cotton and grain sorghum in much of Willacy and Hidalgo counties. Virtually no rain fell in Cameron county from December 1997 until the September 1998 period. Heat units were high during most of the crop season except during late April and May when clouds and smoke from fires in the interior of Mexico provided continual overcast conditions and slightly reduced temperatures. Otherwise, the cotton crop matured rapidly due to the extremely hot and dry conditions this season.

Cotton fleahoppers were of concern to many producers. Numerous fields were treated at least twice, but most only received one application. Aphids were the next major concern for most of the LRGV. Aphids exceeded 50 per leaf by early May and continued to increase until a section 18 for the use of Furadan® was approved. Thereafter, aphids remained light until very near the end of the season. Only a few fields had aphids of concern at the end of the cropping season, but some honeydew was noted in the heaviest aphid infested fields. Silverleaf whiteflies (SLWF) were reported at treatable levels in a few fields, particularly along the Rio Grande in Hidalgo County and in the extreme southeastern part of Cameron County. Generally, SLWF could be found in most fields but at very low levels (less than 1 adult per leaf).

Boll weevils were at some of the lowest levels ever recorded in the LRGV. Punctured square counts did not indicate the need for treatment in most areas until late June. Many fields in historically bad weevil infestation areas did not require any insecticide applications for weevils or other insects this year. Bollworm/tobacco budworm infestations were similarly low key in 1998. Only a minor number of fields were treated for worms, and usually these fields were the same fields that required boll weevil treatments. In a few situations, worms would not have been treated at all had the combination of worm and weevil damage not exceeded the threshold acceptable to growers. Worm counts generally were less than 1 larvae per 100 plants for the entire season
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A scattering of rapid plant bugs, *Creontides* sp. were reported in many areas, but were not considered to be of concern in most fields. *Creontides* sp. has become more prevalent in cotton fields in the LRGV during the last 3 to 4 years but have not caused any widespread treatments

Coastal Bend(CB). Cotton planting was delayed by wet conditions accompanied by slow accumulation of heat units during the early growth phase. The soil profile was full of moisture at-planting, but little or no rainfall was received after mid-March. By the end of May, good fruit loads were present, but subsoil moisture was being rapidly depleted. Cutout occurred 3-4 weeks early, greatly reducing yields. Conditions were hot and dry from bloom through most of the harvest period.

Thrips populations were heavier than normal with extremely heavy populations damaging late planted cotton. Fleahopper numbers occurred in moderate numbers for the first two weeks of squaring in early planted cotton, but by the 3rd-4th week, fleahoppers began to move into cotton in large numbers. Most fields required two insecticide treatments. Bollworm and tobacco budworm numbers were generally low throughout the season. In irrigated cotton, tobacco budworm infestations required treatment unless it was a Bt cotton variety. Aphid infestations were highly variable, with a high percentage of fields sustaining heavy infestations for 3 or more weeks, or until early bloom. Parasite and predator activity on aphids was generally good except where insecticide treatments reduced their numbers. Furadan® 4F was used under Section 18 provision for aphids in areas where labeled products were not effective. Generally, labeled products were effective for the first treatment before bloom. Aphids again rebounded following insecticide use during the early bloom stage, and treatments at that time triggered spider mites in western areas of the region. Confirm® and Pirate® obtained Section 18 status for beet armyworm but very little was actually used since populations did not persist. Leafminers were severe over a large area causing some defoliation. Approximately 75% of the acreage was in the first full season of boll weevil eradication following two fall programs. Most fields triggered an application one time during early season. Boll weevil infestations and damage were very low during the season.

Cotton continued to deteriorate due to drought conditions, resulting in premature opening July 1, with harvest underway by July 15. Initial stalk destruction (shredding) was very good but later, wet conditions prevented timely removal of cotton as a host plant for the boll weevil.

Defoliators such as saltmarsh caterpillars, soybean and cabbage loopers, and beet armyworm were of significant concern in isolated areas but generally caused little economic damage. Cotton square borers were heavier than normal and a true bug, *Creontides spp*., caused damage to very late cotton in the extreme Upper Gulf Coast region.

Southern Blacklands (SB). In general, cotton insects were light to moderate in the area for 1998. Insecticide treatments were applied for the following pests (in order of importance in number of acres treated): boll weevil, fleahopper, *Lygus* and some late season budworms. Diapause sprays in the fall of 1997 for the boll weevil paid good dividends on the TAMU Plantation in 1998. In general, the area averaged 3 to 4 sprays for boll weevil and 1 to 2 treatments for Heliothines. Fleahoppers were a problem in early season in dryland cotton but decreased greatly with the continued hot dry weather. Yields in the dryland area were poor because of the drought. Irrigated cotton yields were average with most producers obtaining from 1.5 to 1.7 bales per acre.

Northern Blacklands(NB). Extreme drought dominated the growing season. The 1998 summer was second only to the record heat and drought of 1980. Soil moisture conditions were very good going into the season, and at least the northern region received some rain in early June. However, high temperatures and the lack of rain the remainder of the season resulted in an estimated average yield of only 175 lbs of lint per acre. Early season insect pests, thrips and fleahoppers, were at usual levels. Mid-season insect pest activity was very light, and given the low yield potential, few fields were treated with insecticides. Grasshoppers were persistent around margins of some fields and several treatments were often necessary to protect plants. Infestations of bollworms and aphids were very light and only rarely reached economic thresholds. Boll weevil numbers were also suppressed by the drought and heat but pheromone trap catches of weevils in late fall recovered to previous levels.

Northern Rolling Plains(NRP). The 1998 cotton crop started out under hot, dry conditions and these conditions prevailed throughout the entire season. From May 20 through September 10, maximum temperatures averaged 101 and 100.5° F at Chillicothe and Munday while minimum temperatures averaged 70.8 and 74.5° F. From May 20 to September 10 a total of 0.9 and 3.95 inches of rain was received at Chillicothe and Munday. Of the 450,000 acres planted, only 180,000 acres will be harvested. About 60% of the acreage did not make an acceptable stand. Another 170,000 acres was destroyed prior to September 5, 130,000 acres of which was in the Rolling Plains Central Eradication Zone.

Because of the lack of spring rains and the lack of other host plants, large numbers of thrips moved out of wheat and other spring weeds and grasses into cotton fields. Thrips continued to be a problem through much of June and into early July, causing much of the early square loss.

Fleahopper infestations were very light during early July apparently because of the lack of spring hosts, but in mid to late July, fleahopper numbers increased. By then most cotton plants had set as many squares as could be maintained under the dry conditions.

Boll weevil trap catches peaked from early to late May with largest numbers captured in most counties during the first half of May. Cotton was not planted until June because of insufficient moisture. Many irrigated cotton fields were watered prior to planting to insure stand development. By early July, boll weevil numbers were well below threshold levels in most dryland fields, but insecticidal applications prior to the 1/3 grown square stage were needed in most irrigated fields. With the hot dry conditions, the numbers of acres treated in the RPC Eradication Zone were well below the projected level, and excellent progress toward eradicating the boll weevil was made. During the 1998 cotton production season, heaviest boll weevil infestations were found in areas where cotton was irrigated. Boll weevil mortality was very high in dryland production areas. By late August, increased numbers of boll weevils were apparent in irrigated fields in the Rolling Plains Area, and by early September those boll weevil populations that developed were low as compared to numbers that developed in previous years. Population levels that developed in most irrigated fields were also reduced, but in a few cases they were very large and comparable to the large numbers produced in recent years.

Bollworm infestations were a problem only in irrigated fields. Damaging infestations requiring insecticidal control began developing in early July, and irrigated fields in the RPC Eradication Zone required several applications in July and August. Tobacco budworms became an increasing problem starting in early August in irrigated fields in the RPC Eradication Zone. Beet armyworm moths were present in large numbers over most of the area during the entire production season. In response to their development in early July, in up to 32,000 per acre in Knox County, the Texas Department of Agriculture approved a Section 18 for the limited use of Pirate® in cotton. Beet armyworms were a problem in both dryland and irrigated cotton in much of the area, and Confirm® was later approved for limited use under a Section 18 for beet armyworm control.

The 1998 cotton crop will be remembered for the extremely hot, dry conditions under which it was produced. Of the 180,000 acres to be harvested in the Rolling Plains, a yield of 218 pounds of lint per acre is expected. The average production in the Northern Rolling Plains is estimated at 198 pounds of lint per acre and the counties in the RPC Eradication Zone are expected to produce an average yield of 300 pounds of lint per acre. The boll weevil eradication program helped, but the larger amount of rain in the RPC Zone is the primary factor contributing to the larger yields.

Southern Rolling Plains (SRP). This report covers 380,000 planted acres, including 350,000 dryland and 30,000 irrigated acres. This season can only be classified as a disaster for the majority of cotton producers in the region. The area will harvest approximately 120,000 acres including the 30,000 of irrigated acreage. The area had an extremely dry fall and winter, and moisture conditions were poor going into the spring of 1998. Conditions did not improve in the spring, with only isolated storms in a few of the counties. Hot temperatures dominated the season and did not moderate until late August. Most of the dryland acreage did not emerge, or stands were thin and eventually destroyed. The only dryland acreage that had good emergence were those areas that received isolated rains or where wheat was harvested in 1997. Due to the dry conditions, most of the acreage was delayed planting until June.

Insect infestations were scattered but were light for most of the area. The late plantings avoided the heavy thrips migrations and only some irrigated acreage received thrips applications. Fleahoppers were not a problem because of the complete lack of wild hosts due to the drought. Despite scattered showers, bollworms were not a problem even in irrigated fields. The initial moth flight in late June and early July were heavy, but high natural enemies and the poor condition of the majority of the crop resulted in very few treatable populations. Tobacco budworm populations remained low throughout the season

Boll weevil numbers in the SRP and the RPC were low. The SRP is in the fifth year of eradication and the RPC is in the third year (the first full season) of eradication. The drought and late plantings helped keep boll weevil numbers low throughout the growing season. As of October 18, cumulative acres treated in the SRP was 182,700 and in the RPC was 795,606. Over 80% of the acreage in the SRP received no insecticides for boll weevils.

Beet armyworms and cotton aphids were problems in many of the fields in the RPC zone covered by this report. Dryland acreage went untreated because of the low yield prospects. Irrigated acreage was treated 1 to 3 times (average of 1) for beet armyworms with Pirate® and Tracer®. More Pirate® was used which resulted in aphid outbreaks that triggered the section 18 for Furadan®.

Dryland yields averaged 250 lbs lint/A (ranged 75 to 450) will be slightly below average (300 lbs lint/ac). Irrigated acreage will average 800 lbs lint/ac with ranges from 125 lbs (pre-watered or irrigated once) up to 1200 lbs lint/ac (adequate water). Irrigated yields are surprising considering the hot, dry weather conditions. Some of this increase is attributable to late bolls that boll weevils destroyed prior to eradication.

High Plains (HP). The 1998 season began with excellent deep soil moisture but a lack of Spring rains resulted in a delay in planting the dryland acreage and some of the irrigated acreage as well. While 3.34 million acres of cotton were eventually planted, continued lack of rainfall for most of the growing season resulted in all but 200,000 acres of dryland cotton to be failed before achieving an acceptable stand. This was a loss of 1.2 million dryland acres and about 140,000 marginally irrigated acres. Only 1.9 million acres were left at harvest time. The drought of 1998 produced heat units at a record rate, allowing the crop to get up to 3 weeks ahead of schedule in spite of earlier delays. Yields averaged 523 pounds, up slightly from 1997. This is misleading in that the loss of much of the dryland acreage was responsible for the elevated yield average. Irrigation costs were extremely high and resulted in sub-par yields on the sandier soils but record yields on the tighter soils. Significant rainfall amounts did not return until late August and September. Even so, 1998 rainfall totals were approximately 35% below average. The HP region is a supplemental irrigation production area and relies heavily on rainfall during the growing season to make an acceptable yield.

There were early extended thrips problems on seedling cotton but heavy infestations were a hit or miss proposition. Damage was high in the worst problem fields. There also appeared to be activation problems for soil-applied insecticides in some instances, perhaps because of the prevailing dry conditions. Additional foliar applications were often necessary. Good growing conditions allowed plants to grow rapidly in the absence of significant seedling disease pressure.

Dry conditions appeared to influence the appearance of some pests. False chinch bugs were a concern in many fields from the seedling stage well up into the bloom stage.

Lack of earlier rains resulted in fewer wild hosts for cotton fleahoppers to develop on prior to moving to squaring cotton. There were very few fleahopper problems. Beet armyworms appeared early in the season and persisted well into late season. Most infestations were chronic, below threshold in numbers, and did not justify treatment. However, there were often other pests associated with these beet armyworm infestations, including boll weevils and bollworms. The combination of these pests was often sufficient to warrant control but made insecticide selection difficult and costly. A section 18 for Confirm® and Pirate® was obtained for the area for beet armyworm control but most producers succeeded in controlling this pest with high labeled rates of Lorsban®.

Based on the numbers of boll weevils trapped late season in 1997, the mild winter (30% survival in the better habitats based on TAES entomologist Don Rummel's research), and the numbers of boll weevils recovered in a 21-county overwintering site survey conducted in March, emerging overwintered boll weevil numbers were predicted to be 4 times higher than observed in 1997. Producers were told to expect the worst. Rapidly drying overwintering sites appeared to increase overwintering boll weevil mortality significantly, and the late crop start delayed the appearance of early squares until most boll weevils had emerged and died. Suicidal emergence increased from 20% in 1997 to 80% in 1998. The summer drought continued to significantly suppress boll weevils that successfully established early infestations until late August when their numbers began to skyrocket and long distance movement commenced. While early and mid season boll weevil numbers were down significantly from 1997, these infestations covered most of the area with the exception of the northern and northwestern most counties. Many producers applied overwintering sprays, but with a few exceptions there was very little difference in boll weevil numbers or timing of late season boll weevil increases between sprayed and unsprayed fields. This was mainly due to the equalizing affect of the drought which increased heat mortality directly to larvae in shed squares through higher temperatures and indirectly because of reduced canopy shading as a result of the suppression in plant height due to moisture limitations. Mid summer mortality was estimated to be in excess of 95%.

In spite of the significant delay in appearance of in-season damaging weevil infestations, much of the irrigated acreage did experience extremely high boll weevil numbers in September. A higher percentage of fields was also infested as compared to 1997. While boll weevil damage to the crop was estimated to be less in 1998 than 1997, this was mainly due to the advanced maturity of most fields, a result of the continued above normal heat unit accumulations. This resulted in a crop that was less vulnerable to late damage than normal. Any late planted and irrigated fields suffered extensive losses and required up to 6 sprays to achieve any level of management. Producers, economically strapped by high irrigation costs and poor cotton prices, attempted to "poor boy" weevil management with limited success. The early maturing crop appears to have denied many of the late boll weevils an adequate food supply for successful overwintering. This may result in fewer emerging weevils in 1999, depending upon winter weather conditions.

For the second year in a row there was no area wide boll weevil management program. A referendum to establish an eradication zone for the Southern HP area had failed earlier. The HP is now divided into five zones including: the Western HP Zone, the Permian Basin Zone, The Southern HP/Caprock Zone, the Northwestern HP Zone and the Northern High Plains Zone. The largest zone encompasses over 1 million acres. There are several zones scheduled to hold a referendum to set an assessment following budget meetings with the Texas Boll Weevil Eradication Foundation. These will take place between December, 1998 and April, 1999.

Bollworm infestations were generally lighter this year and more chronic in nature, probably due to mortality resulting from drought conditions. Pyrethroids performed well, although other classes of insecticides were often used to either preserve beneficial arthropods or to target pest complexes. No tobacco budworm problems developed. Cotton aphids appeared to be suppressed by the high summer temperatures and were difficult to flare even with multiple pyrethroid applications. A section 18 for Furadan® 4F was obtained but not generally needed. Some late season infestations did develop in response to increases in pyrethroid use for combination boll weevil and bollworm infestations but the threat of sticky cotton was removed by excellent control by ladybird beetles and parasitic wasps. Late rains also removed any honeydew deposits.

Virginia. An estimated 91,000 acres were planted in cotton with an estimated per acre lint yield of 700 to 750 lb lint/acre. Percentage of total acreage harvested as of October 16, was estimated at 65%. With the exception of certain dry areas, cotton has done well, matured early and good yields and quality are expected. During early season, 100% of acres were treated with either an in-furrow or seed treatment insecticide and 75% treated with an additional foliar spray, either banded at cultivation, or broadcast with a herbicide (Round-up) on RR in strip-tillage systems for thrips. No acres were treated for aphids and less than 1% were treated for spider mites. No acres were treated for early season budworm. No acres were treated early season for plant bugs, but an estimated 5% of bolls showed damage later in the season (first time this was observed in Virginia). Yield losses would have been significant if bollworm sprays had not been applied. Five percent of total acreage was planted to *Bt* cotton, most due to being stacked with RR gene. Most *Bt* acreage was treated once for plant bugs, stink bug or bollworm mix. Bollworm appeared to have two activity peaks which resulted in a longer scouting season, and an increase in the number of sprays, compared with other years with a 2.3 average number of sprays per acre (ranging from 0 to 4). Budworms were more abundant than normal and lasted through the season, but no control problems were reported. Moths were abundant in peanut fields, but damage from larvae feeding in peanuts was not confirmed. Stink bugs were present in very few fields, but no fields were treated specifically for stink bugs. European corn borer (ECB) populations were higher than normal, and were present in 50-85% of fields, were often mixed with bollworms which 'tripped' the decision to make an additional spray, even after the normal 2-spray bollworm system in late season. Due to the increased length of the bollworm flight, the increased number of budworms, the increased number of plant bugs, and the increased number of ECB, more sprays were applied. Some fields suffered from plant bug damage which was not detected until several fruiting positions had been lost. However, even in those fields, yields were good. The cotton insect pest situation appears to be getting more complicated and will require more of our efforts to maintain good management programs.

Research Progress and Accomplishments

Arizona. The gut contents of over 60,000 individual predators representing 15 different genera were examined for the presence of whitefly and pink bollworm (PBW) egg antigens using an enzyme-linked immunosorbent assay (ELISA). *Collops vittatus, Geocoris* spp., *Orius tristicolor,* and *Hippodamia convergens* were the most frequent whitefly predators. The most frequent PBW predator was *Lygus hesperus*. The sensitivity of an indirect ELISA developed to detect PBW egg was shown to vary between predator species. Small predators were more reactive to the ELISA than large predators.

Investigation of digestive enzymes produced by nematodes and symbiotic bacteria carried within nematodes (Families Steinernematidae and Heterorhabditidae) identified several key enzyme groups responsible for the breakdown of insect tissues, namely type I collagenase, chondroitinase, tripsinase and various other proteases. Bacterial association studies regarding entomopathogenic nematodes and bacterial symbionts have revealed that other genera of bacteria commonly occur as secondary bacteria that proliferate in cadavers during the infection process. Therefore, antibiotics produced by the primary symbionts are not continuously produced, or secondary associated bacteria are resistant to the antibiotics produced. Biochemical investigation of bacteria associated with entomopathogenic nematodes indicates a variety of carbon sources are suitable for metabolism. Some discrete differences between bacteria isolated from nematode strains of the same species indicate subtle differences between bacterial symbionts commonly considered to be the same. Immunofluorescence-based studies so far support the production of a polyclonal anti-body for Xenorhabdus genera of bacteria. Bioassays were developed to investigate the effect of *S. carpocapsae* on beneficial insects and arachnids.

Life table studies revealed that predation and weather were major mortality factors for whitefly eggs and nymphs. In the laboratory, whitefly and *Lygus* parasitoids were marked with rabbit protein. Adults were marked internally by contact exposure or topical mist. ELISA tests specific to rabbit IgG indicate the IgG mark was retained throughout the entire adult lifespan of the parasitoids. Adult *Eretmocerus* were internally marked and released in a cotton field amid cantaloupe and okra fields. Preliminary analyses indicate that the marking technique was very effective for monitoring dispersal. Feeding behavior studies with *Collops vittatus, Geocoris punctipes, Orius tristicolor, Drapetis* sp., and *Hippodamia convergens* showed that adult whiteflies were preferred over eggs and nymphs by every predator species examined. Dusty wings (*Semidalis* sp.) were captured from 10:30 p.m. to 2:30 a.m., and whiteflies were captured mainly from 8:30 p.m. to 10:30 p.m. Starved dusty wing adults spent 21.7% of their time feeding. In choice tests, males consumed 8.7 eggs and 6.8 nymphs in 1 hour, while females ate 8.4 eggs and 11.6 nymphs. Oviposition packets made of stretched parafilm and filled with a solution of agar or gelcarin and other ingredients worked well for *Orius insidiosus* and *O. tristicolor*.

CC whitefly traps for monitoring whitefly activities were most effective on 15 cm or more below terminals of cotton plants, or near the terminals of melons or vegetables.

The depth of minor vascular bundles in Deltapine cotton leaves was significantly related to the whitefly density on leaves.

The sticky cotton sampling distribution based on 6 different sample units suggests that lint stickiness is uniformly to randomly distributed within cotton fields. Most variability is associated with differences between sample-units. Thus, more individual sample-units are needed from the field. Small reductions in variation with larger sample units were not offset by the much greater cost of collecting a large sample unit. The 2-plant sample unit was most highly correlated with stickiness of bulk harvest samples. A precision 0.25 or 0.10 could be achieved by collecting about 4 or 24 sample units per field, respectively, in 5-30 minutes. In 1996 smaller sample units was examined, including all open bolls on 1 or 2 consecutive plants, or 5, 10, or 20 open bolls collected at random.

The relationship between frequency of insecticide applications triggered by thresholds of 5, 10, 15, and 25 adult whiteflies per leaf and honeydew production by *B. argentifolii* feeding on cotton was determined. Whitefly densities and honeydew production were both affected by frequency of insecticide applications. Densities of adults per 5th mainstem leaf, adults per 10-3 vacuum sample, 1st and 2nd instars, and 3rd and 4th instars per square centimeter of leaf were generally higher in control plots (1 insecticide application), plots treated at 25 adults (4 applications), and untreated plots than in plots treated at 5, 10, and 15 adults (11, 6, and 5 applications, respectively). In general, numbers of honeydew drops per square centimeter were higher in control, 25 adult, and untreated plots than in 5, 10, and 15 adult plots. Honeydew production was generally lowest throughout the season in the 5 adult treatment, but not significantly different than the 10 or 15 adult treatments on 13, 20, and 27 August. Seed cotton yields differed only between 10 and 25 adult threshold plots. At Brawley, CA, insecticide treatments at 5 and 10 adults per leaf seemed equally sufficient for reducing whitefly honeydew production. However, fewer applications were needed to maintain the 10 threshold, which would reduce the immediate costs to growers and also would reduce longer-term problems associated with insecticide resistance.

The insect growth regulators, Knack (pyriproxyfen) and Applaud (buprofezin) were used in a "best agricultural practices" regime in upland cotton in central Arizona to determine if they performed effectively. Their efficacy was excellent and resulted in reduced conventional insecticide usage. Foliar application of an experimental systemic insecticide NI-25 on cotton significantly reduced whitefly density on leaves seasonal long. Two and three applications, respectively, of NI-95 experimental systemic insecticide at 0.05 and 0.1 lb. AI/ac controlled whiteflies season long.

The mechanism for synthesis of trehalulose was identified in the silverleaf whitefly. Trehalulose is synthesized by the enzyme trehalulose synthase (TS). A purification procedure for the isolation of TS from whiteflies was developed that can be used to prepare TS for inhibitor testing. Using the isolated TS, several compounds were analyzed for an inhibitory effect on TS. The most effective inhibitors were the fluorodeoxy derivatives of glucose, particularly 6-fluordeoxyglucose. Feeding experiments using artificial diets showed that this compound inhibited TS activity *in vivo*. Thus, the 6-position of glucose is particularly important for TS activity. Compounds resembling glucose, but with modifications at the 6 position, may be potential inhibitors of TS. Two other whitefly enzymes associated with carbohydrate metabolism have also been identified. These enzymes are alpha-galactosidase (a-gal) and an enzyme that converts sucrose to honeydew tri- and tetrasaccharides. Since whiteflies rely on a-gal when feeding on plants like melon, a-gal provides an attractive target for inhibition. Because a-gal is unstable, we are taking a molecular approach to understanding how to inhibit it.

Several unusual sugars have been discovered in *Bemisia* honeydew. One, named maltosucrose, has been previously discovered in other insect secretions. It constituted approximately 2% of the total sugars in this secretion. The second made up approximately 1% of the sugars in this honeydew and was named diglucomelezitose. This is the first report of this oligosaccharide, although a similar sugar was reported in the honeydew of the scale insect, *Eriococcus coriaceus*. Diglucomelezitose consists of melezitose with two additional glucose moieties linked alpha 1,4 to the two glucose units in this trisaccharide. Besides sucrose and melezitose, these two sugars are the first two fructose-containing saccharides reported in this secretion.

The polyol, sorbitol, was identified in whiteflies and shown to function as a thermo- and osmoprotectant. The gene and protein for a unique type of detose reductase that synthesizes sorbitol were isolated from whiteflies. Four species of aphids, including the cotton aphid, were shown to accumulate mannitol under the same conditions that led to sorbitol accumulation in whiteflies. It was discovered that a key photosynthetic enzyme, rubisco activase, was an early target of heat inactivation of photosynthesis. The different forms of the enzyme, within and between plant species, differ in response to thermal stress.

Analysis of Pima cotton genotypes representing 50 years of selection indicated an increased partitioning of biomass into reproductive tissues. Additionally, modern genotypes have earlier maturity and other improved heat tolerance mechanisms. **(USDA, ARS, Western Cotton Research Laboratory, Phoenix, AZ)**

Arkansas. Continued work on development and validation of the COTMAN model was some of the most important research conducted in Arkansas this year. Work on the Squareman component, and insecticide termination continued to support the value of COTMAN to producers. In addition, two new uses were introduced. A Scoutman component which can be used to track insect damaged fruit and may be used to validate pest thresholds was tested. The use of NAWF data to time irrigations was also tested. Both showed good results.

The regional program for monitoring for the aphid parasitic fungus, *Neozygites fresnii*, was successful in preventing insecticide applications in many areas of the Mid-South in 1998.

Work on methods for boll weevil eradication for areas with lower weevil densities continued. Trap crops with early transplanted cotton, bait sticks, and border sprays continue to be investigated. Associated with the need for a lower cost alternative for boll weevil eradication is the need to identify and reliably estimate the number of acres of cotton in these low density boll weevil areas which are located near overwintering quarters and become infested during normal spring emergence and colonization. Research in satellite imaging and GIS is being conducted to develop good working estimates of these acreages so that budgets and eradication program plans can proceed in these areas.

Work to compare Bollgard and other transgenic varieties for performance and in production systems was done. This research is providing information on the performance of these varieties relative to one another and in comparison with conventional cotton production systems. Results of this work will be presented at this conference.

Resistance monitoring is a continuing effort in Arkansas. This year 6 counties ran vial tests to monitor resistance levels in tobacco budworm (to pyrethroids, Curacron, and Tracer), and in bollworm (to pyrethroids). In addition, bollworm and tobacco budworm collections were made and sent to USDA-ARS at Stoneville, MS, to be tested for resistance to *Bt*.

Ultra narrow row cotton work was also done in 1998. Thrips control needs were assessed along with insecticide production inputs. This work continues to indicate that UNRC will be most economically successful with a low insecticide input strategy.

Insecticide testing demonstrated the effects of old and new insecticides against thrips, mites, aphids, tarnished plant bugs, boll weevil, tobacco budworm, bollworm, fall armyworm, and beet armyworm. Steward at .09 and .11 lbs ai/ac showed good efficacy against budworm, beet armyworm, and tarnished plant bug.

Work on natural enemies and the impacts of insecticides on the natural enemies continues. With boll weevil eradication and Bollgard cotton available, Arkansas producers will soon be in a better position than they have been in many years to take advantage of biological control. **(Arkansas Cooperative Extension Service, University of Arkansas and Arkansas Agricultural Experiment Station, Little Rock and Fayetteville, AR)**

California. Western tarnished plant bug (WTPB) efficacy trials were conducted with Capture, Baythroid, and Mustang provided the best control in replicated tests. Regent gave acceptable control but was not as efficacious in 1997. In addition, Regent flared spider mite populations significantly, which had not previously been observed in extensive testing. The organophosphate insecticides and Provado gave good WTPB control but less control then before mentioned products. In order to evaluate the value of using buffer strips to catch *Lygus* migration, 30-foot strips of California blackeye beans were planted on the upwind side of 160-acre cotton fields. Beans and cotton were sampled twice weekly and cotton fruit retention monitored. Preliminary analysis indicated that bean strips did attract and hold *Lygus* but not sufficiently to protect cotton.

Spider mite control evaluations were conducted at the West Side Research and Extension Center. Registered selective miticides (Kelthane, Comite, and Zephyr), registered broad-spectrum materials with some mite activity (Capture, Curacron, and Ovasyn), products registered under Section 18 (Savey and Alert), and experiment products (S-1283 and V-1283) were evaluated. Zephyr, Kelthane, Savey+Zephyr, and Savey+Kelthane provided best mite control. The residual control with several products, especially Zephyr, were less than in past years. A study was conducted attempting season-long arthropod management with biorational insecticides; spider mites were the most prevalent pest. Trilogy, a biorational material, was applied twice for spider mites and did reduce population levels, but not to a satisfactory level. Zephyr, the chemical standard, provided better control but was not 'outstanding.'

In cotton aphid control trials, the efficacy of pymetrozine (Fulfill) was compared against standard. Good, short-term control was seen with Fulfill at low aphid densities (12 aphids/leaf). Several projects were conducted to evaluate the effects of plant nitrogen levels on aphid biology. In one study, ten cotton aphids were confined on to the 5th MSN leaves of plants provided with differing levels of nitrogen. Aphid densities were monitored three times/week. There was a trend for higher aphid reproduction in plants with higher nitrogen levels. In another study, cotton aphids were exposed to plants with three nitrogen levels, 50 lb/A, 100 lb/A, and 200 lb/A. Aphid populations were lower than in 1997 but responded in a similar fashion. Aphid populations in he 200 lb. treatment were twice that in the 50 lb. treatment. Aphid susceptibility to insecticides was again effected by higher nitrogen levels on which the aphids fed. For example, with Provado, 90% and 76% aphid morality resulted with a 2 ppm bioassay dose from plants in 50 lb and 200 lb nitrogen trials respectively. Cotton aphids were monitored in eight grower field tests conducted by UC Cooperative Extension that examined the cotton yield/nitrogen interaction. Only one site developed aphid populations, and more aphids were present in the 100, 50, and 200 lb. nitrogen/acres than 86 lb/A, residual nitrogen only.

The damage potential of cucumber beetles as a pest of squares and flowers was examined. There was no evidence that this insect can inflict significant damage.

Silverleaf whitefly area wide management program is in its second year. Further analysis of the 1997 data has clearly shown the positive impacts of weed management, host crop sanitation, and management for an early cotton crop on the reduction of SLWF populations. In addition, a large database is being developed to describe the relationship between silverleaf whitefly, aphid populations and subsequent lint quality.

Insecticide resistance monitoring continued for whitefly, *Lygus*, spider mites, and cotton aphids. **(Cooperative Extension Service, Kern Co., Tulare Co., Kings Co., Kearney Agricultural Center, Parlier; UC, Davis; and UC, Riverside)**

Louisiana. The effects of tarnished plant bug density, duration of feeding, and boll age on cotton boll abscission were examined using artificial infestations in cage studies.

In the first study, 0, 1, 2, and 3 adults were caged on 1 day-old bolls (18.5-28.5 heat units). Boll abscission was recorded at 72 hours after infestation (HAI), 7 days after infestation (DAI), and at harvest. In the second experiment, 2 adults were caged on 1 day-old bolls (25-29 heat units) for 6, 12, 24, 48, 72, and 96 h, after which time boll abscission was recorded. Boll abscission was also recorded at 2 days after cage removal (DACR), 7 DACR (for each treatment) and at harvest for all treatments. In the third experiment, 2 adults were caged on bolls classed according to heat unit (HU) accumulation. Boll abscission was recorded at 72 HAI, 7 DAI, and at harvest. Boll abscission rates were significantly lower at infestation densities ≤ 1 tarnished plant bug adult/boll compared to densities ≥ 2 tarnished plant bugs/boll. In the second study, a significant increase in boll abscission was observed with increasing duration of feeding (6-96 h infestation) at all evaluation periods. Boll abscission rates ranged from 48.3% to 95.0% in this test. In the third study, at 72 HAI and 7 DAI higher rates of boll abscission were observed compared to the non-infested bolls until ca. 265 HU had been accumulated. At harvest, higher rates of boll abscission were observed compared to the non-infested until ca. 300 HU had been accumulated.

Fifth-instar fall armyworms, and third-instar beet armyworms, were caged on conventional ‘DP 5415' and transgenic *Bacillus thuringiensis* (*Bt*) ‘NuCOTN 33B’ cotton bolls of various ages to define the period of boll susceptibility to larval injury. Larval mortality, incidence of feeding, and boll penetration were examined on both cultivars. There was no significant linear relationship between incidence of feeding and boll age for either species caged on either varieties. However, a significant linear relationship between larval mortality and boll age was observed for both species caged on NuCOTN 33B (mortality increased as bolls matured), but no such linear relationship was found on DP 5415. A significant linear relationship between boll penetration and boll age was observed on both species caged on NuCOTN 33B (boll penetration decreased as bolls matured). Similarly, a significant linear relationship between boll penetration and boll age was observed for beet armyworms caged on DP 5415 (boll penetration decreased as bolls matured), whereas no relationship was found for fall armyworms caged on DP 5415. Fall armyworms penetrated >60% of DP 5415 bolls regardless of their age, but these bolls were tolerant (<10% boll penetration) to beet armyworms at 390 heat units. The NuCOTN 33B bolls were tolerant to fall armyworm damage at 361 heat units. These data suggest that fall armyworms and beet armyworms are able to successfully penetrate bolls of 350 heat units at unacceptable (>10%) levels.

Plant maturity and yield responses of selected cotton varieties (NuCOTN 33B and Stoneville 474) were measured after 7 levels (0, 2.5, 5, 10, 20, 40, and 80%) of simulated bollworm damage was applied during each of the first 4 weeks of flowering in 1997-98. All damage levels during the first two weeks of flowering did not significantly affect crop maturity or seed cotton yield compared to the undamaged plots for NuCOTN 33B. Damage levels ≥40% significantly delayed maturity compared to the undamaged plots during the third week. During the fourth week of flowering, boll damage levels ≥20% resulted in significantly lower yields than the undamaged plots. Boll damage levels ≥20% occurring during the fourth week of flowering significantly delayed crop maturity. No significant differences in seed cotton yields were observed among damage levels during each of the first 3 weeks of flowering for Stoneville 474. Boll damage levels ≥40% delayed crop maturity during weeks 2 and 3 of flowering compared to the undamaged plots for those respective weeks. Crop maturity and seed cotton yields were significantly affected during the fourth week of flowering. Plots with boll damage levels ≥40% had significantly lower yields than the undamaged plots. Crop maturity was significantly delayed at damage levels ≥20% compared to the undamaged plots. Both cotton cultivars did not show significant reductions in yield at any damage level during the first three weeks of flowering. Later in the flowering period, both varieties were more sensitive to boll damage with significant yield reductions occurring at damage levels ≥40%.

Field studies were conducted in 1997-98 to evaluate the effects of Roundup Ultra in herbicide-insecticide tank mixtures against thrips and cotton aphids. Treatments included Roundup Ultra alone and Roundup Ultra tank mixed with each of the following insecticides: Bidrin 8EC, Dimethoate 4EC, Regent 80WG, Karate 1EC, Orthene 90SP, Provado 1.6F, Thiodan 3EC, and Vydate 3.7L. At 4 DAT, all treatments except Dimethoate, Regent, and Vydate reduced numbers of aphids compared to the control. The addition of Roundup Ultra to Vydate significantly improved control compared with Vydate alone. No significant differences among treatments were observed 7 DAT for number of aphids. Only the Roundup Ultra-Orthene and Roundup Ultra-Karate tank mixtures reduced total numbers of thrips compared with the control 4 DAT. Except for the Roundup Ultra-Bidrin combination, no treatments reduced total thrips compared with the control 7 DAT. The addition of Roundup Ultra to Bidrin improved thrips control 7 DAT compared to Bidrin alone. For both aphid and thrips control, the only significant interaction observed between an insecticide and Roundup Ultra 4 DAT was the Vydate combination. A significant interaction was observed at 7 DAT between Roundup Ultra and an insecticide. Bidrin was the only insecticide in which the addition of Roundup Ultra improved control of thrips 7 DAT.

Another series of field studies were conducted in 1997-98 to evaluate the effects of Staple on herbicide-insecticide combinations against thrips and cotton aphids. Staple was applied alone or in combination with the following insecticides: Orthene 90SP, Bidrin 8EC, Provado 1.6F, Regent 80WP, Karate 1EC, Vydate 3.7L, Furadan 4F, and Dimethoate 4EC. Control of adult thrips with Staple plus Orthene, Bidrin, or Karate was no better than the untreated control, but these insecticides alone significantly reduced the number of thrips compared to the untreated control. Control of immature thrips with Staple plus Orthene, Provado, or Vydate was no better than the control, but these insecticides alone significantly reduced the number of immature thrips compared to the untreated control. Control of adult and immature thrips with dimethoate was enhanced when combined with Staple. Although statistical differences in control of adult and immature thrips among insecticides alone and Staple/insecticide combinations, up to 3.5 times higher thrips numbers were observed in Staple/insecticide combination treatments. Although the efficacy of Staple/insecticide combinations were variable, some appeared to influence insecticide efficacy.

Efficacy of conventional and experimental insecticides against the fall armyworm was evaluated in laboratory and field bioassays. In a laboratory diet bioassay, third instars of a laboratory strain were more susceptible to novel insecticides, including chlorfenapyr, methoxyfenozide, spinosad, and tebufenozide, than to a recommended insecticide, thiodicarb. In field bioassays, fall armyworm larvae were fed cotton leaves, white flowers, or bolls treated with one of two recommended insecticides, L-cyhalothrin or thiodicarb, or one of four experimental insecticides, chlorfenapyr, emamectin benzoate, methoxyfenozide, or spinosad. First instar mortality was significantly greater on leaves treated with chlorfenapyr, L-cyhalothrin, or thiodicarb than for the untreated control at 24 h after infestation (HAI). First instar mortality was significantly greater on leaves treated with all insecticides, with the exception of methoxyfenozide, than for the untreated control at 48 HAI. Likewise, first instar mortality was significantly greater on white flowers treated with all insecticides, with the exception of methoxyfenozide, than for the untreated control at 24 HAI. First instar mortality on white flowers treated with all insecticides was significantly greater than the untreated control at 48 HAI. Fifth instar mortality on bolls was not significantly different among treatments at 1 day after infestation (DAI). At 3 and 5 DAI, fifth instar mortality was significantly greater on bolls treated with all insecticides, with the exception of methoxyfenozide and spinosad, than for the untreated control. AT 7 DAI, fifth instar mortality was significantly greater on bolls treated with all insecticides, with the exception of spinosad, than for the untreated control. These data indicate that these recommended and experimental insecticides are effective in controlling early fall armyworm instars on cotton if larvae come in contact with these insecticides.

Field tests were conducted in North Louisiana during 1998 to evaluate the effects of terminating insect control strategies at selected intervals during late season on seed cotton yields. Termination intervals based on cotton plant development used plant mainstem nodes above white flower (NAWF) and heat unit (HU) accumulation. The treatment termination intervals based on crop development rules included NAWF5 and NAWF5 + 350 HU. The termination intervals based on weather oriented rules used 17 Aug as a final cutout date in Louisiana. Insecticide treatments wee terminated on ca. Aug 17 and Aug 17 + 350 HU. In two tests, seed cotton yields were significantly higher from terminating insecticide treatments on Aug 17 + 350 HU compared to NAWF 5 + 350 HU. Also, two tests were conducted to examine the effects of insect-simulated defoliation on seed cotton yield. As defoliation levels increased from 0 to 99% at the NAWF5 + 350 HU stage of development, yields consistently declined. Significant yield losses occurred at 66-99% defoliation levels in the two tests. Seed cotton yields were not significantly reduced by 50-66% bottom defoliation after plants matured to NAWF5+550 HU. **(LSU Agricultural Center's Macon Ridge Research Station, Winnsboro, LA)**

Field trials were conducted to evaluate the residual efficacy of selected at-planting insecticides against thrips on seedling cotton. These trials were conducted within three soil environments (Commerce silt loam, Sharkey clay, and Gigger silt loam) in Northeast Louisiana during 1998. The treatments in these trials included two seed protectants, Orthene 80S (6.4 oz AI/cwt) and Gaucho 3.84S (4.0 oz AI/cwt) and two at-planting in-furrow spray treatments, Orthene 90S (0.9 lb AI/A) and Admire 2F (0.2 lb AI/A). Also, included were an at-planting in-furrow granule, Temik 15G (0.5 lb AI/A), and an untreated control. In the Commerce silt loam trial, plots treated with Temik had significantly lower population densities of thrips adults compared to those in the untreated plots. All of the insecticide treatments, except for Gaucho, resulted in significantly lower population densities of thrips larvae compared to the untreated control. In the Sharkey clay trial, there were no significant differences among treatments for thrips adults. However, plots treated with Orthene 90S or Temik had significantly lower population densities of thrips larvae compared to those in the untreated plots. All of the insecticide treatments, except Gaucho, resulted in significantly lower populations densities of thrips adults compared to the untreated control, in the Gigger silt loam trial. Also, all of the insecticide treated plots had significantly lower densities of thrips larvae compared to those in the untreated plots. There were no significant differences among treatments for seed cotton yield, in any of the tests. **(LSU Agricultural Center's Northeast Research Station, St. Joseph, LA)**

Mississippi. Strategy research continued in the replicated field-sized plots in 4 counties in Mississippi to evaluate low thresholds for treatment of corn earworm in *Bt* cotton. Data are still being analyzed. Research to evaluate the benefits of a representative of each of five classes of adjuvants has documented their effect on droplet characteristics and has evaluated their effect in mixtures with representatives from several classes of insecticide relative to cotton aphids and tarnished plant bugs. Results so far indicate that little obvious benefit is to be expected in aphid or tarnished plant bug mortality under the conditions of the tests. Results will be field tested in 1999. Because of frequent malathion applications in the boll weevil eradication area, no tarnished plant bug efficacy trials were completed on field cotton. Thrips populations were heavy in North Mississippi and thiomethoxam, a new systemic insecticide, provided rate related increase in yield and yielded significantly more than the Temik standard and other entries in the test when applied in-furrow. Planting date studies were continued to ascertain if the date may be determined at which prophylactic thrips control materials need not be applied.

Studies examining the temporal variation in population substructure of Heliothis virescens and Helicoverpa zea over a three year period using both allozyme and RAPD markers have been completed. Both sets of markers suggest that there is little temporal variation in the population substructure of *H. zea*, indicating that this pest is mobile throughout the year. In contrast, both sets of markers show a significant increase in population substructure in *H. virescens* during the third generation, suggesting that *H. virescens* is less mobile during the summer. This may be due to the presence of flowering cotton during this period of the year. Almost all substructure is lost during overwintering, indicating that there is a large amount of dispersal during this period. Because the population substructure never reaches equilibrium, gene flow estimates will always tend to underestimate (during overwintering) or overestimate (during summer) movement. Simulations of the impact of *Bt*-corn planted in the mid-South on the rate of resistance evolution to *Bt*-cotton suggest that *Bt*-corn will always speed up resistance evolution to *Bt*-cotton in *H. zea*, even in the absence of cross-resistance between the toxins in cotton and corn. While any amount of Bt-corn in the mid-South will always have some impact on resistance to *Bt*-cotton, our simulations suggest that some proportion, perhaps as much as 50% of the corn acreage, could be planted to *Bt* varieties without sacrificing a large proportion of the utility of *Bt*-cotton.

At each of five randomly chosen sites in each of 41 fields randomly chosen from the 111 untilled fields (both *Bt* and non-*Bt*-cotton) near all-weather roads in a 40 section area in southeast Monroe Co., 38.1 row-meter were sampled using shovels on 24 January, 31 January, 7 February, 14 February, 21 February, 28 February, 21 March, and 4 April 1998. A total of 7,810 row-meter were sampled. The density of *Heliothis virescens* (TBW) pupae observed overwintering was 14.1 ± 20.3 (Ave±SE) ha^{-1}, and the density of *Helicoverpa zea* (CEW) pupae was 42 ± 30.9. The CEW densities in 1998 were significantly higher than the near zero densities observed the previous two years. The TBW densities in 1998 were higher than the zero density of the previous year but much less than the 320 ± 74 TBW pupae per hectare observed two years ago (the winter following the TBW outbreak of 1995). Of the 41 cotton fields sampled in 1997, variety information was obtained for 32. Of these 32 fields, 94% were planted to *Bt*-cotton. Given that *Bt*-cotton suppresses population densities of TBW and CEW, one might expect that much less than 94% of the overwintering pupae found during sampling these 32 fields would be found in *Bt*-cotton fields. Of the TBW pupae found, 67% were found in *Bt*-cotton fields; and of the CEW pupae, 79% were found in *Bt*-cotton fields. It appears that production of overwintering TBW and CEW pupae may be reduced slightly in Bt-cotton fields, but a surprisingly high percentage are produced in *Bt*-cotton fields. Five pheromone traps for TBW have been monitored at the same sites in southeastern Monroe Co. for each of the years 1996-1998. The total number of TBW caught per trap after emergence from overwintering was about the same in 1998 (23.9 ± 7.8) as in 1997 (18.1 ± 4.6) but was lower than the number caught in 1996 (89.8 ± 37). Variation among years in trap catch roughly parallels variation among years in density of TBW pupae overwintering in cotton fields (see density information above). Tillage has been shown by other researchers to kill TBW and CEW pupae or, at least, to prevent adult emergence. As in previous years, tillage in 1998 prevented the population of TBW pupae in cotton fields from contributing substantially to the regional population of TBW successfully emerging from overwintering. By 23 April 1998, 86% of the 111 cotton fields in the study area had been tilled; but no TBWs had been caught in the pheromone traps in the area. One week later (30 April), 99% of the cotton fields had been tilled; and only 16% of the TBW moths caught emerging from overwintering had been caught. The question of emergence of overwintering CEW from cotton fields is more complicated. In 1998, catches of CEW in pheromone traps started about two weeks earlier than did catches of TBW. If one assumes that these CEWs emerged locally, ca. 88% of the CEW moths caught emerging from overwintering had been caught by 30 April. In 1996, spring emergence of CEW also appeared to be two weeks earlier than emergence of TBW. However, first catches of CEW in the spring have been shown by other researchers to precede local emergence by ca. two weeks. Thus, substantial numbers of CEW apparently do not emerge from cotton fields in the spring.

Sida spinosa (PM) and *Jacquemontia tamnifolia* (SFMG) were documented as hosts for TBW and CEW in MS for the first time in fall 1997. Sampling for pupae under stands of mixed PM and SFMG in two fields (one abandoned soybean and one uncultivated) during the same period of time that cotton fields were sampled in 1998 resulted in estimates of 2150 ± 203 overwintering TBW pupae per hectare and 57 ± 57 CEW pupae. Three 15.9-m^2 emergence covers were placed over stands of mixed PM and SFMG in two abandoned soybean fields in the same area in the first week of May. Emergence of moths under these covers resulted in estimates of 840 ± 556 TBW moths successfully emerging per hectare and 0 ± 0 CEW. The estimate of successful emergence of TBW is only about 40% of the estimate of pupal density because, in large part, the emergence covers were put into place after ca. 60% of emergence of TBW from overwintering had occurred–as based on pheromone trap captures. Random sampling for pupae in the same two abandoned soybean fields in which emergence covers were placed resulted in estimates of 946 ± 30 overwintering TBW pupae per hectare and 0 ± 0 CEW pupae. Given it is likely that these pupae successfully produced moths, they could result in the infestation of 1,000 hectares of wild host plants in the spring at the rate of 5,000 eggs per hectare–even though the abandoned soybean fields had a combined acreage of only 10 ha. Sampling for wild host plants in Monroe Co., MS, on 8 Saturdays between 12 September and 31 October 1998 again indicated the presence of locally high densities of larvae on PM and SFMG and on several additional species of uncultivated plants at a number of sites. Rearing for species identification and parasitism status is in progress. Sampling of pupae overwintering in these sites is planned for January-April 1999.

The "F_2 screen" for resistance to *Bt* endotoxin of TBW collected as pupae January-April 1998 resulted in an estimated frequency and 95 % confidence interval of "resistance" of 0.125 ± 0.141 . All of the successfully screened individuals (N = 6) were collected from abandoned soybean fields adjacent to *Bt*-cotton fields. The resistance detected was partial: resistant larvae survived longer than did susceptible larvae, but their growth rate was much reduced. **(Department of Entomology, Mississippi State University, Mississippi State, MS)**

Efforts to upscale rearing of *Lygus* spp. and *Lygus* spp. predators is progressing well. An improved artificial diet, the Cohen diet, for *Lygus* has been developed. Both *L. hesperus* and *L. lineolaris* feed and develop well on this diet, which is considerably easier and 10% as expensive to prepare than the Debolt diet. *L. hesperus* oviposit well in flat gelcarin packets, but *L. lineolaris* do not. Efforts to further elucidate the differences in ovipositional behavior are in progress. An improved nymph/adult cage, for mass rearing of *Lygus* spp., has been developed. This cage will significantly reduce the labor required for mass rearing of *Lygus* spp. Mass reared *Lygus* spp. will support *in vivo* rearing of *Anaphes ioli* and *Peristenus stygicus*, two parasitoids with potential in augmentative biological control programs for *Lygus*.

An improved nymph/adult cage for large-scale rearing *Geocoris punctipes.* has also been developed, and studies of feeding and oviposition in this cage are currently underway. Again, the purpose of the improved cage is to reduce labor requirements for mass rearing of this potentially valuable predator.

An improved lepidopterous egg harvesting system for insects has been developed under a CRADA with DuPont. The hardware has been assembled and testing has begun. The new egg harvester is comprised mostly of plastic parts that will not deteriorate under the extremely corrosive environment of a sodium hypochlorite solution. The number of moving parts and electrical components has also been reduced, which will reduce maintenance requirements. Engineering drawing will be delivered to DuPont in January 1999.

A diet packaging machine for use in mass rearing of *Chrysoperla* spp. has been designed and built under a CRADA with Beneficial Insectary. The machine will package the diet at a rate of approximately 2100 packages/7-hour day. It will significantly reduce the labor required to prepare diet packets for *Chrysoperla* rearing.

The feeding apparatus of *L. hesperus* and *L. lineolaris* is being studied to develop a basis for making improvements in the rearing system for these two species. Key differences in the digestive enzymes between these two species have been identified, indicating that different sources of protein, starch, and lipids will improve the efficiency of rearing these two species. Even small improvements in feeding efficiency can have large economic and biological impact as the rearing of theses species is scaled-up.

Preliminary results indicate that *Chrysoperla rufilabris* has among the highest "knock down" capacities of any of the *Lygus* predators tested. Bioassays and newly developed feeding efficiency tests are being used to assess the ability of *C. rufilabris* to use *Lygus* as prey. The bioassay and quality assessment procedures used to measure the fitness of predators *(G. punctipes*) that have been reared for protracted periods on artificial diet have been used, and we have found that these predators have retained their qualities as predators that are efficient and competitive with their feral counterparts. This important discovery answers many of the concerns of researchers and biological control practitioners who felt that prolonged laboratory rearing, especially on artificial diet, would be detrimental to predators.

The Cohen entomophage diet (recently patented) has been used for successful rearing of several species of entomophagous insects, including *G. punctipes*, *Orius insidiosus*, and *Coleomegilla maculata*. The same diet has also been shown to have efficacy as a dietary supplement in the rearing of *Solenopsis invicta* and other ants.

Studies of the feeding biology of *Bemisia argentifolii* in association with cotton leaves have been completed. The Cohen et al. feeding model has been applied to studies of vascular bundle arrangement in several cultivars of cotton. Several new features have been added to the list of targets that can be used for host plant resistance efforts and possibly genetic manipulation of cotton. Several laboratories have taken up this line of work (USDA, ARS in Phoenix and Fargo, University of California, Riverside).

The BCMRRU continues to maintain cultures of *Helicoverpa zea*, *Heliothis virescens*, *Spodoptera exigua*, *Anthonomus grandis*, and *Cotesia marginiventris*. Material was supplied to many researchers around the country. The *A. grandis* culture will be eliminated by December 1999. **(USDA, ARS, Biological Control and Mass Rearing Research Unit, Mississippi State, MS)**

Sampling for plant bugs at low population levels is important for developing better management tactics against this major cotton pest. Several summers of effort on a commercial farm demonstrate a sampling technique that is efficient and easy to use and measures low population levels of plant bugs. The method is based on the use of the drop cloth, a readily available and familiar scouting tool. The drop cloth can be improved in its sensitivity to detect low numbers of plant bugs by arranging a series of samples into a straight line at least 8 rows long. Total numbers of plant bugs shaken onto the cloth along the line can be converted to numbers per acre using a simple formula, or a published look-up table of constants that can be applied to any row spacing of solid planted cotton, except ultra-narrow row. It was also demonstrated that improved understanding of the sample data can be achieved if remotely sensed image maps are available. Using these images maps, differences in crop growth patterns throughout the field can be quickly distinguished. By sampling different areas of the field identified on the image map, it was demonstrated that plant bug densities differed by crop growth stage. Used together, the potential exists for reducing the sample time and effort necessary to detect and monitor plant bug abundance in cotton and yet maintain high data integrity necessary for making appropriate management decisions against this pest. (**USDA, ARS, Crop Simulation Research Unit, Mississippi State, MS**)

Production of insects for USDA-ARS research by the Stoneville Research Unit required maintenance of seven insect species: *Heliothis virescens*, *Helicoverpa zea*, *Anticarsia gemmatalis*, *Pseudoplusia includens*, *Spodoptera exigua*, *Cardiochiles nigriceps*, and *Microplitis croceipes*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; Weslaco, TX; College Station, TX; and Gainesville, FL required production of 154,800 *H. virescens* pupae, 118,600 *H. zea* pupae, 39,800 *P. includens* pupae, 91,920 *A. gemmatalis* pupae, 32,975 *Spodoptera exigua* pupae, 53,077 *Cardiochiles nigriceps* cocoons, 34,599 *Microplitis croceipes* cocoons, 28,485 *Cotesia kazak* cocoons, 38,700,000 *H. virescens* eggs, 29,650,000 *H. zea* eggs, 19,900,000 *P. includens* eggs, 8,340,000 *A. gemmatalis* eggs, 16,487,500 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 35,720 30-ml cups and 666-liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1998 was 12,867 liters. Several short courses in insect rearing techniques were given to employees of Dupont Agricultural Enterprises, Newark, DE. Approximately 150 researchers located in 37 states, England, Canada, Japan, and Mexico participated in the Insect Distribution Program.

Preliminary results of a study initiated in 1997 in a portion of the boll weevil eradication program near Collins, Mississippi, showed some promise for using bait sticks as a substitute for pinhead square/diapause sprays. Near fields surrounded by bait sticks from planting to August 1, 1997, traps caught one weevil at 2 of 6 fields and no weevils were detected in the fields in 1998. Of 6 fields surrounded by bait sticks from August 1 to frost in 1997, no weevils were caught in traps or detected in the field in 1998. In contrast, of 9 fields receiving no bait sticks, weevils were caught in traps and/or detected in 8 of the 9 fields. The test was repeated in 1998 and will be similarly evaluated in 1999.

Monitoring for resistance in *Bt* cotton to bollworm/tobacco budworm was continued for the 3rd year by subjecting 44 colonies (10 budworm, 34 bollworm) submitted by 14 cooperators from 9 states to MVP II overlays in diet. A slight shift in tolerance was detected in both species, but because of the low number of colonies tested, one more year of expanded testing will be necessary before concrete conclusions can be drawn.

Results from a third year of testing for the best time to spray for cotton aphids failed to agree with results from 1996-1997 in that treating at the 4- to 5-lf stage (pre-pinhead square) produced higher yields than spraying one week (full-grown square) and two weeks (bloom) later. However, no treatment provided cotton yields significantly higher than the untreated check, indicating that in 1998 under the conditions of this test, insecticide treatments for aphids were not needed. The test will be repeated in 1999 for the fourth and last year.

Nineteen transgenic cotton varieties were compared to Sure-Grow 125 in unreplicated small plot tests near Elizabeth, Mississippi. No treatments were made for bollworm/budworm, whereas all plots received 10 applications of Vydate @ 0.25 AI/A for boll weevils/tarnished plant bugs. The 19 varieties averaged 35% higher yields than Sure-Grow 125 and differences ranged from +7% to +67%.

Several proprietary compounds from Novartis, Rhone-Poulenc, and Uniroyal Chemical were evaluated against cotton aphids and/or bollworm/budworm; yield records were obtained where possible. All data have been forwarded to all three companies.

We cooperated with scientists in the Southern Weed Science Research Unit in evaluating insect counts throughout the season in ultra-narrow-row (UNR) cotton. Another year's evaluations are needed, but preliminary results indicate that boll weevil numbers appear higher and more difficult to control in UNR than conventional cotton. There were no apparent differences in other insect numbers in the two systems.

In comparative tests of effectiveness of five insecticides, all materials significantly reduced numbers of beet armyworms when compared to an untreated check. Percent controls for each of the materials was Pirate - 97%, Tracer - 94%, Larvin - 81%, Spod-X - 77%, and Curacron - 71%.

Moth trap records in 1998 compared to 1997 collected at the same trap sites showed that (1) beet armyworm numbers were highest since 1995 (over 1.5 x 1997); (2) bollworms were 10% higher; and (3) tobacco budworms were almost double 1997, the first increase in the last 4 years.

Since 1992, we have made field collections of each generation (May through August) of bollworm/tobacco budworm for evaluation of response to five classes of insecticides in a spray chamber simulating field application conditions. As in the past three years, tobacco budworms became very difficult to control by the third and fourth generations (July and August) with all insecticides tested except Tracer®. Bollworms, however, showed no change in susceptibility to all classes of insecticides throughout the season.

An economic and entomological study of producing *Bt* and non-*Bt* cotton on fifteen farms that represent different regions of the Mississippi Delta began in 1998. This is a cooperative study between ARS and the Delta Research and Extension Center. Partial funding from Cotton Inc. began in 1998. A pilot study initiated in 1997 was used to establish cooperators and to purchase necessary equipment. Yields of *Bt* and non-*Bt* varieties were harvested, and information on insecticide costs of controlling insect pests on each variety from each farm was collected. On the majority of the 15 farms the cost of producing *Bt* was considerably less than non-*Bt*. On farms that planted NuCotn 33-B, yields were consistently higher than in the non-*Bt*. Yields obtained with other *Bt* varieties were mixed.

The effects of thirteen different insecticides were evaluated for tarnished plant bugs and boll weevil control in NuCotn 33B cotton in replicated small plots. All treatments were compared to an untreated check. The better plant bug suppression was observed in plots sprayed with Regent, Monitor, Karate, and CGA2933. Highest yields were in treatments with Regent and CGA2933.

Regent (Fipronil) was evaluated in large plots (3-4 acres) for tarnished plant bug and boll weevil control. Treatments were applied both by air and ground under Section 18 (EUP) and were compared to other standard insecticides and an untreated control. In the aerial study, Regent and Vydate were very effective in controlling the plant bug and boll weevil. In the ground study, plant bug and weevil control was better with Regent than in Vydate and Baythroid treatments. Yield from treatments of Regent and Vydate applied by air and the untreated control were 805, 764, and 326 pounds of lint per acre, respectively. In the ground study, yields from Regent, Vydate, Baythroid and untreated control were 880, 742, 752, and 326 pounds of lint per acre, respectively.

A large field study was conducted to evaluate effects of seed treatments, in-furrow application of temik and imidacloprid, and side dress applications of temik in 3-acre plots on thrips and tarnished plant bugs in NuCotn 33B and Sure Grow 125 cotton. Infestations of thrips and plant bugs were low in 1998 and differences in populations among treatments were inconsistent. In the 125 variety, harvested lint yields ere the treatments with the 1.0 lb ai/acre rate of temik and temik in-furrow plus sidedress. In the NuCotn 33B, the highest yields were in treatments with temik in-furrow plus side dress and the imidacloprid.

A field test using sticky traps baited with virgin male or female tarnished plant bugs was repeated. The traps were placed in weedy fields with abundant wild hosts with good populations of plant bugs. Three treatments were used in the tests, an unbaited control, traps baited with 10 virgin males, and traps baited with 10 virgin females. In all previously published literature, males were not thought to produce an attractive pheromone, and the virgin females were consistently shown to attract males. In our test in 1997, results indicated that the male might be producing an aggregating pheromone attractive to both sexes. Male-baited traps captured significantly higher numbers of males ($P = 0.08$) and females ($P = 0.03$) than were captured on unbaited check traps. In 1998, female baited traps caught significantly higher numbers of males than check or male baited traps. Also, male-baited traps captured numerically higher numbers of males than check traps (about 4-fold higher) but this was only significant at $P = 0.13$. Male-baited traps again captured numerically higher numbers of females (2-fold) than unbaited check traps. Thus both years indicated the possible presence of a male-produced aggregating pheromone.

The possibility of using tarnished plant bugs possessing an eye mutation for bright red eyes (normal eyes are dark reddish brown) in movement studies was investigated in 1998. Mated adults 7-10 days old were released into areas with abundant wild host plants in April and May. A total of 1,900 were released in 3 releases of 800, 700, and 400 adults. Adults were shaken out of their holding cages onto wild hosts in the center of each release area. Wild hosts around the release sites were then sampled at various time intervals over a 2-3 wk period in an effort to recapture the adults or their offspring. Over 3,000 adults and nymphs were collected in which only 1 red-eyed adult was found. To determine why the releases were not working, adults were caged on mare's tail, *Erigeron canadensis*, to see if the red-eyed adults could survive and produce offspring on a wild host plant. Results showed mare's tail to be a suitable host and offspring were produced. In a second test, normal-eyed wild adults and red-eyed adults were tested for flight ability by placing them on a 5 X 5 inch platform on the end of a 3 ft stake which was driven into the ground. Flight of both groups from the platform was the same. In October, 450 mated red-eyed adults were released into a large field of goldenrod, *Solidago altissima.* These adults were fed goldenrod blossoms in addition to green beans for 1 wk prior to their release to acclimate them to their main food source in the release area. Release was made on 8 October and samples from the goldenrod in the field were taken on 9, 13, 16, 29, and 30 October, and 5 November. On October 29 (21 days after their release), 2 red-eyed adult males and 1 red-eyed adult female were captured. These adults were dark colored (not light which would indicate a new adult) and were part of the original red-eyed adults released. One red-eyed 5th instar nymph was captured on October 30. A total of over 2,800 normal-eyed nymphs and adults were captured in the study. These results were encouraging, and the test will be repeated using a much larger number of bugs in 1999.

Studies on several aspects of reproductive diapause in the tarnished plant bug were begun in 1998. Beginning in February, adults were collected from wild hosts and sexed in the laboratory to determine sex ratios. In February-March this ratio was 74.8% female to 25.2% male (n=1553). In April the ratio was calculated from the mixture of overwintered and F1 adults collected, and it was 52.8% female to 47.2% male (n=797). In the period April-October the ratio was 51.8% female to 48.2% male (n=3385). The ratios for November-January will be done this fall and winter. Adults were collected in November and brought into the laboratory to determine the percentage in diapause and the percentage of those in diapause which are mated. No results are available, but these tests will continue in December-March and in August-October 1999. On February 27, 1998 overwintered adults (out of reproductive diapause) were brought into the lab and egg lay by the overwintered females was studied and compared to egg lay in a laboratory colony. Samples of wild hosts in late-February through March found no nymphs in 1998 until the 4th week in March. So, it is unlikely that the overwintered adults used in the laboratory study had laid any eggs prior to their being brought into the laboratory. Egg lay (number of eggs laid per female per day) in the 2 groups was different. Overwintered females laid the most eggs in the first week, then egg lay declined each succeeding week. Egg lay peaked in the laboratory colony at 16-18 days then slowly declined. Mortality in overwintered females was 40% in the 1st week and reached 90% after 3 weeks. Mortality in the lab colony was 7% in the first week and did not reach 90% until day 52.

Compounds with possible activity against tarnished plant bugs were tested in laboratory bioassays this spring. The compounds are from Mycogen Corporation and are being tested under a secrecy agreement.

A large area-wide experiment designed to evaluate control of tarnished plant bugs in cotton by reduction in numbers of wild host plants available for plant bug population buildups in the spring was conducted in 1998. Four areas (3 in Washington and 1 in Sunflower Counties), each 3 X 3 mi in size, were used. Three of the areas (checks) received no treatment, the 4th area (treated) was treated in April with Trimec (broad leaf weed killer), Roundup, or mowing. Treatments were applied only to those marginal areas by roads, fields or ditches, in which good stands of wild host plants were found. The objective of the treatments was to eliminate the best areas of wild hosts, but not all wild hosts. Prior to treatment, wild hosts were sampled for plant bugs in all 4 areas. In addition, densities of the most abundant wild hosts were determined. Treatments were applied in mid-April. Plant bug populations and plant densities were determined for wild hosts in the first 2 weeks of April, and again in mid-May. Adult plant bugs found in the samples were mainly F_1 with a few overwintered adults at the time the treatments were applied. In June and July through the 1st week in August cotton fields were sampled for plant bugs each week. In the treated area, 14 fields were sampled, while a total of 33 fields were sampled in the 3 check areas. All fields were chosen at random from all fields in each area each week. Ten early-planted group IV or V soybean fields (4 in the treated area and 2 in each check area) were sampled for plant bugs weekly during June and July. In addition to normal sampling, cotton fields that bordered corn or soybean fields had extra samples taken in them. These edge samples were taken within 25 rows or about 100 feet from the edge where the cotton bordered corn or soybeans. The most abundant wild hosts found in the 4 areas were cutleaf geranium, cutleaf evening-primrose, showy evening primrose, sour dock, vetch, calley pea, bur clover and white clover. As expected, areas treated with Trimec had a significant reduction in numbers of wild hosts. Numbers of hosts per square meter averaged 7.85 in the treated area as compared to 25.83 in the 3 check areas. Roundup was used only as a spot treatment for smaller areas of hosts and was applied using spray equipment mounted on all-terrain vehicles. One large section of wild hosts found along a road in the treated area was mowed with a tractor and bush-hog. This area had regrown when it was sampled ca. 4 weeks after treatment and had abundant hosts and plant bugs. It was retreated with Trimec. Mowing, to be effective, will have to be repeated 2-3 times at about 2 week intervals. Numbers of plant bugs found on wild hosts in the treated areas were not significantly different in the 4 areas in the samples taken prior to treating the treated area. After treatment, numbers of plant bugs on the wild hosts in the treated area were 4-fold lower than in the check areas. Most samples taken in cotton in June in the treated and 3 check areas had plant bug counts of 0. This made statistical analyses of the data impossible since the data were not (and could not be successfully transformed) normally distributed. A light infestation of plant bugs did occur in cotton in mid- to late-July in all 4 areas. The low numbers of plant bugs found in June were at least partly caused by insecticide treatments of most fields for large numbers of boll weevils. This masked any early-season effect that treatment of the wild hosts may have had. Samples taken in the edge of cotton fields where they bordered soybeans showed that the soybeans had no influence on numbers of plant bugs in the cotton field edge. Edge samples taken in cotton by corn during July showed that corn did have a significant effect on numbers of plant bugs in cotton. Samplers were significantly more likely to find plant bugs in the field edge by corn as they were in samples taken in the rest of the field. Plant bugs were found in all 10 of the early soybean fields sampled. The highest population in a single field was estimated at 1350 adults and nymphs per acre in early-June. All 10 fields averaged 320 adults and nymphs per acre in early June. Blooming in the early planted soybeans stopped by the end of June, and by the 2nd week in July plant bugs had dispersed from the soybeans. Although corn was not sampled in the experiment, plant bugs were found reproducing in corn by G. L. Snodgrass and other researchers in 1998. The ability of plant bugs to reproduce in corn and soybeans complicates its control by elimination of early season wild hosts. If wild hosts are treated when F_1 adults have already been produced (as they were in the present test), these adults live long enough (they can live and lay eggs for 50 days in the laboratory) to move from the treated hosts to other ones, such as corn or soybeans. However, overwintered adults are shorter lived (about 3 weeks in the laboratory) and it is these adults that the treatments should target. Treatments of wild hosts should be made in March when samples have determined that the overwintered generation is active and laying eggs.

A survey was conducted in August to determine if plant bugs in the Delta had increased insecticide resistance to Orthene. Plant bugs were collected from wild hosts (mainly mare's tail) in the Delta at 5 locations in Arkansas, 2 in Louisiana, and 13 in Mississippi. Resistance to Orthene was determined using a glass vial bioassay in which 210-300 adults from each location were tested at different concentrations of Orthene to determine an LC_{50} for Orthene for bugs from each location. These LC_{50}'s were compared to an LC_{50} value for Orthene determined using susceptible bugs collected near Crossett, Arkansas. The highest amounts of resistance found to Orthene was only 3-fold higher than the susceptible bugs. These results indicated that Orthene is still an effective insecticide for plant bug control in the Delta.

A critical factor in the effectiveness of insect viruses as microbial control agents is their short persistence on leaf surfaces. The objective of this study was to develop and evaluate additives to spray formulations that may increase virus persistence, and thus provide more effective microbial control agents. A small field test was conducted to determine whether field persistence of *Anagrapha falcifera* nucleopolyhedrovirus (AnfaNPV) could be increased using different starch/lignin formulations.

The area-wide test was conducted this field season to assess the effectiveness of a lower application rate of *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) (Gemstar^{TM}) with a virus enhancing agent on the emergence of Heliothine adults from early season wild geranium. A circular treatment area with a 7.5 mile radius was established near Bourbon, MS and encompassed approximately 30,000 acres. Aerial application of the bollworm virus was applied at a rate of 2.47×10^{11} occlusion bodies (OB's) per ha to the entire area. Adult emergence was reduced significantly in artificially-infested enclosure cages treated with the virus. Pheromone trap data suggested that total moth emergence was reduced 52% when compared with moth emergence in untreated areas.

A study was conducted to determine the intraplant distribution of beet armyworm (BAW), *Spodoptera exigua* on *Bt* and non-*Bt* cotton. In addition, a discriminating dose was determined from bioassays for BAW, and will be used to assess the potential for resistence to *Bacillus thuringiensis* in successive generations of BAW.

Preliminary evidence from a field study initiated to evaluate the impact of lower rates of *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) against *H. zea* on *Bt* cotton suggests that lower than recommended rates of HzSNPV may be efficacious against *H. zea* on *Bt* cotton.

Field populations of cotton bollworm and tobacco budworm were monitored for their tolerance to the *Bt* toxin CryIA(c). Quantitative genetic methods and traditional bioassays were used to look at differences in tolerance among and within populations of Heliothines from across the eastern U.S. cotton belt. Preliminary analyses of these data show that tolerance by CryIA(c) has a heritable component. Some evidence for a small shift in the tolerance of cotton bollworm from 1997 to 1998 is present. Selection experiments in the laboratory found that tolerance to CryIA(c) could be improved in bollworm populations.

The toxicity of Boll Weevil Attract and Control Tubes (BWACT's) has been measured by placing weevils on tubes for specified short periods (usually 30 sec.). Recent observations in Texas, especially on tubes in storage for extended periods of time, caused us to re-examine that technique. With tubes in storage for about 1.5 years, significantly fewer weevils that alit on the tubes died than weevils placed on tubes. Later tests with more recently manufactured tubes showed similar mortalities between the two types of evaluation. The most recent tubes tested killed weevils for only four weeks compared with a 6-week period in years past.

Data collection on diapause termination and effect of the host on whether or not a weevil develops diapause characteristics continues. We are gaining a clearer understanding of the course of diapause termination and host effect.

The diapause development model formulated in 1996-97 was used by eradication officials in Zone 4 of Mississippi during the late summer and fall of 1997. This model predicts spray intervals for diapause control applications. During 1998 we were requested to run the model for Zones 2, 3, and 4 in Mississippi and Zones 1, 2, and 3 in Tennessee. Running the model for this many sites would have been very time consuming using the original SAS research version of the code. We therefore translated the research code into C during 1998, making it far easier to run the model on more sites each day. This new code can also be used by "non-experts" to predict diapause control spray intervals throughout the late summer and fall. Model results were FAXed to 5 people every other day during August-October.

We conducted tests with a micro-respirometer delineating age-, sex-, and food-dependent respiration rates of reproductive and diapausing boll weevils. The respirometer was obtained, setup, and calibrated in late summer 1997. During the remainder of that field season, we tested respiration rates of no fewer than 56 females and 50 males; e.g., CO_2 levels were measured at 1-sec intervals over 6-min periods for each individual per observation, with as many as 22-24 observations taken at different weevils ages. This work created a tremendous amount of "raw" data in ppm CO_2/sec, for which we hired a student computer programmer in early 1998 to transform the data (into μl/mg/hr CO_2) and then begin to analyze it. Preliminary observations indicate that CO_2 rates of reproductive females remain relatively high throughout most of their adult lives, dropping off only as they approach death. The rates of diapausing females drop off during the initial feeding (prediapause) period, after which they asymptote at low levels. The rates remain low until the female begins to break diapause, whereupon the rates return to the higher levels typically of reproductive animals. Age-dependent respiration rates of males were similar to females, although it appears that both reproductive and diapausing males have somewhat lower rates than females. Feeding on squares or bolls did not appear to influence respiration rates. The ongoing analysis was halted with the initiation of 1998 experiments designed to replicate and expand on last year's work. A poster presentation describing some of the results will be given at the Beltwide Meetings in 1999.

We setup and conducted a method of overwintering test in 1997 to determine whether boll weevils spend the winter in diapause, *per se*, or in a state of post-diapause quiescence. These data were entered into the computer during 1998, but analysis has not yet begun.

We setup and conducted two food preference tests in 1997 to determine whether prediapausing adults prefer to feed on squares or bolls, and more importantly, how quickly diapausing females break diapause. These data were entered into the computer during 1998, but analysis has not yet begun. Preliminary observations indicate that prediapausing adults prefer to feed on squares over bolls. The tests were replicated and expanded in 1998, with hopes of learning how temperature influences female diapause development and termination.

We setup and conducted several tests examining the effects of food quality on boll weevil diapause in 1997. For example, we fed adults leaves immediately after emergence for 3-, 7-, 10-, and 14-d, and bolls thereafter until day 23, to see if a period of sub-optimal diet would influence their ability to achieve diapause. Preliminary observations indicate that weevils initially fed leaves attained lower diapausing rates (i.e., more were reproductive) than control weevils fed bolls throughout their adult life. We also put weevils on large bolls in the field to see if they could go into diapause on "low-quality" food. Most were able to achieve diapause. Some of these tests were repeated in 1998.

Preliminary studies were conducted on biological control of *Lygus lineolaris* by the egg parasitoid, *Anaphes iole*. Research objectives addressed aspects of the wasp's biology critical to the success of a conservation/augmentation biological control program. The first objective was to determine if perennial plants adjacent to agricultural fields harbor overwintering *A. iole*. More than 125 collections (20 species from 14 families) were made at six sites in the Delta. Collections were made in the late winter and consisted of the previous season's growth. However, no *A. iole* were reared from this plant material. These results suggest that *A. iole* does not use a 'host alternation' strategy associated with perennial vegetation. The second objective was to determine if the spring emergence of the wasp is synchronized with *L. lineolaris* oviposition. Results from sticky trap data indicate that *A. iole* emergence is synchronized with the onset of *L. lineolaris* oviposition in the spring. A third objective was to develop a better understanding of the weed hosts of *L. lineolaris* that are also utilized by *A. iole*. Collections were made in the spring and fall from common weed species known to support *L. lineolaris*. *A. iole* was reared from *Rumex crispus* (sour dock), *Oenothera speciosa* (showy evening primrose), and *Ambrosia trifida* (giant ragweed). Additionally, data from the literature were used to summarize known associations between *A. iole* and host plants of *L. lineolaris*. The results indicate that at least 14 *L. lineolaris* hosts from which *A. iole* have been reared occur in the Delta. This information is important both for conservation and augmentation of *A. iole* populations in the Delta.

A study was conducted in a commercial cotton field to determine the effect of distance from non-crop habitat on parasitism of *Helicoverpa zea* and *Heliothis virescens* larvae. The study was conducted in an 80-acre non-*Bt* cotton field bordered on one side by grain sorghum, on two sides by *Bt* cotton, and on one side by a creek with natural vegetation. Seven transects were established along a 500 m portion of the field edge adjacent to the natural vegetation. Each transect extended into the field perpendicular to the edge. Sample stations were established on each transect at 0 (field edge), 20, 100, and 500 m from the field edge. At each station 50 contiguous cotton plants were selected. One 3rd instar *H. zea* larva was placed on the terminal of 25 contiguous cotton plants; 3rd instar *H. virescens* were similarly placed on the other 25 plants. These sentinel larvae were recovered 3 days later, placed in diet cups, and held at 28°C until emergence of a wasp or moth. Sentinel larvae were established nine times during the growing season. Approximately 10% of the sentinel larvae were recovered, and of these more than 50% succumbed before parasitism could be determined. Data were thus pooled across dates. Parasitism of *H. zea* by *Microplitis croceipes* was rare (<1%). Parasitism of *H. virescens* by *Cardiochiles nigriceps* averaged ca. 45% across all distances. However, parasitism was independent of distance from the field edge ($P>0.05$). While preliminary, these results are promising because they suggest that *C. nigriceps* is capable of substantial parasitism in cotton far from non-crop habitats that may serve as refuges.

As a requisite to an investigation of parasitoid dispersal, a pilot study was conducted to validate a novel marking technique. The objective was to determine the retention of animal protein labels by *M. croceipes* wasps under field conditions. Wasps (<2 days old) were obtained from the SIMRU Insect Rearing Facility and were provided with honey and water *ad libitum*. A medical nebulizer was used to mist wasps with 1.0 mg/ml rabbit immunoglobulin (IgG) or chicken IgG. A third group of wasps was treated with fluorescent pink Day-Glo dust. Marked wasps were immediately released in separate cages (corresponding to the label) in a commercial soybean field. Live wasps were retrieved up to 9 days after being caged. A double antibody sandwich ELISA was performed on each live wasp collected from cages with IgG-labeled insects. Wasps recovered from the dust treatment were examined at 10x under a dissecting microscope for 1 minute and scored for presence or absence of dust. Average high and low air temperatures during the study were 36°C and 20°C, respectively. Precipitation (0.04") was recorded ca. 30 hours after wasps were caged. Wasps did not retain either protein label beyond 1 day after treatment. However, Day-Glo dust had 100% retention throughout the study. Clearly, technical hurdles must be overcome before IgG marking can be used to study parasitoid dispersal in the Delta.

E. I. Dupont de Nemours & Co. has several genetically-modified baculoviruses undergoing development that infect insect pest species of cotton. These genetically-modified viruses should provide better protection to cotton and offer another tactic to an integrated pest management program. Field activity and stability of the recombinant viruses were evaluated in small scale trials on cotton. Data were collected to evaluate a) percent larval infection, b) larval numbers, and c) crop damage. A non-target study assessed the impact of genetically-modified viruses on the abundance of non-target arthropods.

A study was conducted with the University of Arkansas to assess the effect of host plant on the persistence of the *Helicoverpa zea* single-nucleocapsid nucleopolyhedrovirus (HzSNPV) on six host plants; white clover, *Trifolium repens;* crimson clover, *Trifolium incarnatum*; velvetleaf, *Abutilon theophrasti;* soybean, *Glycine max;* geranium, *Geranium dissectum*; and cotton, *Gossypium hirsutum*. All virus treatments were equally effective with >85% mortality recorded at the 0 day sampling date. Virus inactivation was greatest on cotton foliage with < 44% OAR observed at 1 d post-application at the highest virus application rate. Inactivation of *H. zea* SNPV on wild host plants and soybean was not as rapid with some virus activity remaining at 5-7 d post-application. The percentage of original virus activity was positively related to virus application rate.

A field cage study was initiated to evaluate the efficacy of two rates of a genetically-modified virus for *H. virescens* against three commercially available treatments for the control of *H. virescens* of cotton. **(USDA, ARS, Southern Insect Management Research Unit, Stoneville, MS)**

Missouri. In 1998, several field trials were conducted to evaluate the efficacy of different products to control insect pests. Results from the thrips and bollworm trials were inconclusive, and generally no significant differences were found among treatments. The in-furrow and foliar thrips trials at Portageville were destroyed by hail before the tests were concluded. The remaining thrips trials and the two bollworm trials were in non-irrigated plots. The plants were drought-stressed and subsequent pest infestations were sporadic.

In a state Cotton Incorporated-funded project looking at boll weevil infestations and their economic impact, the data were inconclusive at both locations. This was partially due to the tremendous weevil migration into the plots and difficulty maintaining desired weevil infestations in these plots.

At Portageville, an eight-treatment cotton aphid trial was conducted in early-July. The top three treatments over both sampling dates were: Furadan 4F (0.25 lbs. AI/A), Provado 1.6F (0.0375 lbs. AI/A) plus an organosilicant surfactant (0.25% v/v), and Provado 1.6F (0.0375 lbs. AI/A) alone. The test was conducted during a prolonged drought period, and data indicate greater residual control when a surfactant was mixed with Provado. A more detailed summary of this trial is presented later in the proceedings.

Two, late-season (early-September) trials were conducted to evaluate insecticidal control of boll weevils. Multiple applications were made over a 15-day period, and plots were sampled five times each. In both trials, all insecticide-treated plots had significantly lower weevil populations than in the untreated control plots. The three treatments with the lowest weevil infestations on the last sampling date in trial one were: Karate Z 2.08CS (0.03 lbs. AI/A), Karate Z 2.08CS (0.025 lbs. AI/A), and Baythroid 2EC (0.028 lbs.

AI/A). In the second trial, Baythroid 2EC (0.025 lbs. AI/A) and Capture 2EC (0.06 lbs. AI/A) provided the greatest control. A more detailed summary of this trial also is presented later in the proceedings.

A total of 414 cotton bollworm male moths were collected in pheromone-baited cone traps and tested for susceptibility to cypermethrin. These treated vial tests were held in conjunction with the Insecticide Resistance Action Committee's *Helicoverpa zea* monitoring program. Corrected, mean survival of moths to 5μg and 10μg doses of cypermethrin was 13.1% and 0%, respectively. At the 5μg dose, the 1998 survival rate is considerably higher than 1994's (4.8%). The decreased susceptibility may have been partially due to prior exposure to pyrethroids when corn fields were widely treated for corn borers in 1998. **(University of Missouri, Agricultural Experiment Station, Delta Center, Portageville, Missouri)**

New Mexico. A number of tests were conducted with *Bt* cotton in various parts of New Mexico. Variety trials were conducted in both the Mesilla and Pecos Valleys on both commercial farms and experiment station farms. Tests were also conducted to evaluate the effect of nitrogen and vegetative growth on expression of resistance in selected *Bt* varieties. Nitrogen and high vegetative growth were, at times, associated with higher rates of damage. However, nitrogen effects were slight and not consistent even under very high nitrogen rates. Bollworm damage was higher in plots with high vegetative growth but was likely due to higher egg lay. In the lab, more highly vegetative plants had the same level of resistance as less vegetative plants. Differences in performance among varieties are the greater concern. DP90B has, at times, had lower levels of resistance compared to, for example, DP33B. This was evident both in yields compared to the recurrent parent and in lab bioassays. However, this difference also depends on specific conditions. In 1997, in two of the largest tests, DP90B unprotected with relatively low pressure did not produce higher yields than its recurrent parent while DP33B did have significantly higher yields compared to its recurrent parent. In 1998 under much higher pressure from bollworm and beet armyworm, DP90B did out-yield its recurrent parent.

Tests were also conducted to determine emergence curves for overwintering boll weevils in multiple locations in New Mexico and to determine the effect of New Mexico overwintering habitats on boll weevil establishment and control in New Mexico. In habitats in lea co. on the High Plains results were similar to those in the bordering Texas High Plains. Shinnery oak and CRP grasses provided favorable habitat. However, urban habitats had the greatest impact on boll weevil success. The highest numbers of overwintered boll weevils were captured in weedy habitats in urban areas. There was no evidence that buildings harbored significant numbers of boll weevils. In addition to having high numbers of overwintered boll weevils , urban habitats produced later emergence compared to rural habitats. Urban habitats in Lea Co. had peak emergence in late May and had the majority of boll weevils emerging then over only a 2 week period. This influence of urban habitats are found throughout New Mexico, becoming more significant in the desert valleys where the boll weevil hotspots are concentrated in and around the few urban areas of the Mesilla and Pecos Valleys. Boll weevil emergence was also earlier in the desert valleys compared to the High Plains. Emergence peaked in early May in the Pecos and Mesilla Valleys urban habitats but peak emergence in urban areas in the High Plains was in late May.

A project was also initiated this year to evaluate the effect of the desert microclimate on boll weevil, bollworm, and beet armyworm mortality under various management practices. Egg mortality was evaluated in rows oriented north-south vs. east-west, ultra narrow vs. narrow row cotton and okra leaf cotton. Ultra-narrow row cotton did increase survival of bollworm eggs however narrow row cotton mortality was similar to that in 38" row spacing. **(Cooperative Extension Service and Department of Entomology, Plant Pathology, and Weed Science, New Mexico State University, Artesia and Las Cruces, NM)**

North Carolina. The second of a multi year test of the effectiveness of several thrips control options in striper-harvested, Roundup Ready Ultra Narrow Row (UNR) cotton (7.5-inch row spacing) was conducted in north central North Carolina. The value (yield x $.7 minus chemical and application costs) of Temik @ 15.0 lb. ai/acre, Gaucho 480 seed treatment plus one broadcast Orthene 75 S spray (4.0 oz ai/cwt + 0.25 ai/acre), and two Orthene 75 S sprays (0.25 ai/acre) were virtually identical for the 2-year average, despite widely varying insecticide costs.

Two early season tobacco budworm tests were carried out in southern North Carolina in an area of high second generation budworm pressure. Treatments in the first small plot, replicated test included 50% terminal plus 50% manual square removal, 100% terminal plus 100% square removal, both coinciding with the establishment of budworms (June 26), 10 mature squares per foot in pre-bloom cotton (July 17), Karate @ 0.025 lb. ai/acre, Dipel 2X @ 1.0 lb. product/acre (both treated on June 22) and an untreated check. The two foliar treatments showed numerically more bolls than the check or the fruit removal treatments. Opened and total boll counts taken on September 21 revealed large differences in maturity, with the pre-bloom square removal treatment, at 9.7% opened bolls, showing significantly less opened bolls than the remaining treatments, while Karate at 60.5% opened bolls, showed a significantly higher percentage of opened bolls than the other treatments. Other treatments were intermediate in maturity (50% removal- 34.3%, 100% removal- 27.3% and the check-37.1%). However, despite these large differences in maturity, no significant yield differences were found between treatments. A second test, which evaluated pyrethroid alternatives for control of second generation tobacco budworms, compared Pirate 3 E (0.35 lb. ai/acre), Tracer (0.045 and 0.067 lb. ai/acre), Larvin (0.6 lb. ai/acre), a pyrethroid (Karate @ 0.025 lb. ai/acre)) and an untreated check.

Very few differences were noted between treatments in damaged terminals or squares, live budworms in terminals or squares, numbers of bolls in mid-August, or yields. However, Pirate generally lagged behind the other treatments numerically in the parameters evaluated. The two Tracer treatments had the highest yields numerically. For the third year at this location, the lowest labeled rate of Tracer (0.045 lb. ai/acre) has performed at a level at or above the candidate pyrethroids at the standard rate and Larvin at the above rate.

In a large-scale comparison of *Bt* (Bollgard) vs. conventional (pyrethroid-protected) fields under producer conditions, 75 Bollgard fields were compared with 75 conventionally treated paired fields, either managed by the same producer and/or in close proximity. This 'acid test' of the efficacy of Bollgard cotton has now been undertaken for three years (1996-1998). The 75 producer-managed Bollgard fields surveyed for boll damage from bollworms in 1998 sustained approximately one half as much damage: 1.78% percent versus 4.17% in the conventional fields. Stink bug damage in the conventional cotton fields averaged 0.45% vs. 1.88% in the Bollgard fields. European corn borer damage in the Bollgard fields was 0.03% vs. 0.12% in the conventional fields; fall armyworm boll damage was 0.58% in the Bollgard fields vs. 0.92% in the conventional fields. Overall damage for both protection systems, including stink bugs, favored the Bollgard fields, 4.24% vs. 5.56% over the conventional fields. This is in keeping with last two years' survey of conventional and Bollgard fields. Average plant heights for the Bollgard vs. the conventional cotton fields was 34.34 vs. 34.61 inches, respectively.

A survey of North Carolina's licensed independent crop consultants working on cotton was conducted again 1998 to gather data on how second generation (June and early July) tobacco budworms, late-season bollworms, thrips, cotton aphids, and plant bugs was managed by these individuals. A relatively high percentage (9.25) of the 250,800 acres managed by consultants was treated for budworms, mostly with pyrethroids (88.6%). More Tracer and Larvin (11.4%) were used in 1998 than in previous years. Consultants reported that approximately 22% of their managed acreage was in need of supplemental foliar control for thrips, 6.61% for plant bugs (very high by our standards), and 0.95% for the cotton aphid. Of their clients' Bollgard acreage, only 13% was untreated, 50% treated once, 35% twice, and 2% was treated three times. The 1.24 applications used for late-season insects is significantly up from the 0.5 average for 1996 and 1997.

Two Bollgard tests were undertaken in 1998 which addressed bollworm thresholds and the relative efficacy of various commercial Bollgard varieties against bollworms. The test of 11 Bollgard varieties, conducted without a disruptive over spray or irrigation, revealed bollworm-damaged boll differences which ranged from a low of 1% in DP 32 B to a high of 13% in ST 4740 BG . Thresholds evaluated in the second test on NuCOTN 33b included 1) 35% eggs in terminals or 8% on fruit, followed by 1% second instars on fruit, 2) 100% eggs in terminals, or 20% on fruit, followed by 3% second instars, 3) 6% fruit damage or 3% second instars on fruit, 4) completely protected Bollgard cotton, 5) untreated Bollgard oversprayed with Orthene, 6) untreated Bollgard without Orthene, and 7 and 8) untransformed ST 474, both untreated and treated . Under very high bollworm pressure (46.7% boll damage in the ST 474 check), all thresholds held boll damage to low, statistically similar levels. The Orthene oversprayed Bollgard line almost doubled the boll damage from the untreated Bollgard line without Orthene (14.2% vs. 7.6%), in keeping with past observations. The protected NuCOTN 33b (5 pyrethroid plus Larvin treatments) yielded 43 more lb. lint/acre than the average of the two threshold treatments which had been treated once (trts. 2 and 3), while the threshold which required 2 applications (trt. 1) did not add any additional yield. The 361 lb. lint/acre yield in the untreated 474 line compared to the 2-bale average yield in the various Bollgard threshold plots attested to the severe bollworm pressure at this test site. **(Cotton Extension IPM Project, Department of Entomology, NCSU)**

The boll weevil program assessment established by the North Carolina Boll Weevil Eradication Foundation was $3.95 per acre. Summaries of 1998 data indicate cotton was grown in 59 of 100 counties in the state. To monitor for the presence of the boll weevil, 151,862 traps were placed on 63,657 cotton fields.

The 1998 season represented a challenge due to the detection of moderate weevils in a small geographic area in the state. Single weevils were detected in traps in Iredell, Jones, and Wayne Counties. Follow-up intensive trapping at these sites did not detect additional weevils. By far, the most significant find during the 1998 season was in the Edgecombe/Pitt County area. Based on the detection of an initial single weevil on August 12th, and subsequent captures in the same area indicating reproduction, more than 8,000 traps were placed on 156 individual fields in this two-county area. Based on these detections, over 11,000 cumulative acres were treated with insecticides. Over 2,300 total boll weevils were trapped in the Edgecombe/Pitt County area. Of this total approximately 95% were found in just two fields of 9 and 12 acres each. In fields where reproduction possibly occurred, all harvested cotton was fumigated, and harvesting equipment was cleaned prior to movement to gins or other fields. An intensive network of traps will be maintained in fields where weevils were found this season throughout the winter and next spring. **(North Carolina Department of Agriculture, Plant Industry Division, Raleigh, NC)**

The effects of planting date on bollworm larval populations, fruit damage, and yield in *Bt* cotton (DPL 33B) were studied in a split-plot design where one-half of each plot was sprayed with a pyrethroid insecticide and the remainder was not sprayed. Planting dates were 4/27, 5/14, and 5/27. Bollworm damaged bolls in the non-treated subplots averaged 21%, 26%, and 15% for the early, mid, and late planting dates, respectively. Boll damage in the pyrethroid sprayed subplots averaged 1.2% or lower. Yields (seed cotton) were progressively lower with later planting dates, regardless of pyrethroid application. Yields in the pyrethroid-treated subplots were 3286, 3123, and 2474 lb. For early, mid, and late plantings, respectively. Yields in the non-treated subplots were 2455, 2388, and 1977 lb. For the early, mid, and late plantings, respectively. Seed cotton losses due to bollworm in the non-treated subplots were 25%, 24%, and 20% for the early, mid, and late plantings of *Bt* cotton. Despite a lower % boll damage and % yield loss in the late planting, there was a yield penalty for late planting of *Bt* cotton in NC. Thus, the effect of planting date on yield in *Bt* cotton is similar to that previously observed with conventional cotton in NC; planting after mid-May typically results in lower yields.

A test was conducted to determine whether bollworm damage and yield effects of bollworm feeding would be different among selected *Bt* cotton genotypes. Genotypes included were: DPL 20B, DPL 32B, DPL 33B, DPL 35B, DPL 428B, DPL 50B, DPL 90B, and ST 4740BG. The test design was a split-plot with one-half of each plot oversprayed with a pyrethroid insecticide and the remainder not sprayed. The DPL genotypes had similar levels of bollworm damage; the overall average % boll damage in the untreated subplots was 14.2. The highest and lowest of these values were 15.2% (DPL 32B and 35B) and 12.7% (DPL 20B). In contrast, the overall % boll damage for the ST 4740BG untreated subplots was 37.7%. The seven DPL genotypes had an average of 60.2% open bolls on 9/23, whereas the ST 4740BG had only 26.5% open bolls on that date. The seven DPL genotypes in treated and untreated subplots had average yields of 3189 and 2782 lbs. seed cotton/a, respectively for an average of 12.8% loss to bollworm in the unsprayed subplots. Yields for the ST 4740BG treated and untreated subplots were 3084 and 2107 lbs. seed cotton/a, respectively with a 31% less to bollworm in the unsprayed subplots. While the DPL genotypes were very similar in their field performance, the ST 4740BG had delayed phenology and was much more susceptible to bollworm.

A lab study was initiated to determine 1) whether there are maternal effects associated with *Helicoverpa zea* development on *Bt* crop hosts, 2) the initial gene frequency of resistance in field populations, and 3) the time frame for *Bt* resistance development in *H. zea*. Negative maternal effects were observed in a colony which originated from larvae collected from *Bt* and non-*Bt* corn. Within 5 generations in the lab a trend toward adaptation to the *Bt* toxin was observed. In the first 3 lab generations a 0.1 MVP *Bt* diet was used; the concentration was increased 10X to 1.0 MVP since and the larvae are responding well (i.e. survival is high and weights are not much different from larvae reared on the 0.1 MVP.). In subsequent generations a 5.0 MVP diet will be utilized to facilitate resistance development. **(Department of Entomology, North Carolina State University, Raleigh, NC)**

Oklahoma. Several Bollgard trials were conducted in 1998 to assess the value of this technology under Oklahoma conditions. Bollgard cotton provided excellent bollworm control and produced exceptional yields in 1998. Bollgard cotton out-yielded standard cotton varieties regardless of the spray regime. Yield advantages ranged from 88 lbs. to 479.8 lbs. lint per acre. Planting intentions in 1999 should favor Bollgard varieties as producers attempt to preserve beneficial insects important in regulating secondary pests, i.e., cotton aphids.

Research continued in 1998 to determine the impact of planting date on boll weevil management grown under dryland conditions. Previous research during years with high boll weevil survival indicates planting date is critical regardless of management scheme to raise profitable yields. Despite lower boll weevil numbers, 1998 results continue to emphasize May-planted cotton which outperformed June-planted cotton treated the same by at least 357.78 lbs. lint per acre. No yield advantage was seen by applying overwintering sprays before bloom in either planting date. **(Oklahoma Cooperative Extension Service, Altus, OK)**

South Carolina. A study was conducted to determine the combined effects of double cropping, conservation tillage, and rotation on population dynamics and management of arthropods in southeastern S.C. Densities of adult and immature thrips in cotyledon-stage cotton were reduced significantly by aldicarb. In two-leaf stage cotton, densities of immature thrips in untreated plots (no aldicarb) were reduced significantly by no-till, compared with conventional tillage. This reduction occurred in monocropped cotton, cotton following rye, and cotton following corn. Thrips injury to untreated cotton seedlings was reduced significantly by no-till, compared with conventional tillage, in cotton following rye and cotton following corn. Neither surface tillage nor double cropping significantly affected densities or damage to fruit for lepidopterous pests.

A study was conducted to determine the efficacy of S-1812 applied alone and in a tank mix with acephate against the bollworm/tobacco budworm complex in cotton. S-1812 applied alone at 0.063 - 0.156 lb (AI)/acre was effective against these species, but less effective than l-cyhalothrin.

Addition of acephate failed to enhance the performance of S-1812.

Gaucho, LS 222, LS 034, and LS 215 seed treatments were evaluated for efficacy against thrips in cotton. All seed treatments and aldicarb applied in-furrow (0.53 lb[AI]/acre) significantly reduced densities of immature thrips and injury to plants for two-leaf-stage cotton. Gaucho, LS 222, and aldicarb significantly increased plant heights compared with the untreated control. Although differences in yields were non-significant, Gaucho and aldicarb produced the highest yields.

A two-year study was conducted to determine the oviposition preference of bollworm/tobacco budworm moths for selected plant structures during mid-season (July, August) for NuCOTN 33B and DPL 5415. Moths oviposited primarily on terminal growth and fully expanded leaves of both cultivars, but a small but relatively consistent percentage of the eggs was observed on fruiting structures, especially bloom tags, squares, and bolls. During the peak oviposition period, whole-plant monitoring detected ca. three times as many eggs as terminal monitoring. **(Clemson University Pee Dee Research and Education Center, Florence, SC)**

Tennessee. Temik and Gaucho seed treatment were compared to the new Adage seed treatment at two rates for thrips control, plant effects and yield. More adult and larval thrips were observed in Gaucho and untreated plots, while Temik provided the greatest thrips control. Adage provided good thrips control, but declined in performance by 28 days after planting. All insecticide treatments resulted in more total lint than no treatment. There were no significant yield differences among insecticide treatments.

The effects of Roundup Ready technology and conventional weed control programs on the growth and development of cotton under different, early-season insect management programs were evaluated. Thrips damage was greater in plots treated with the conventional herbicide program. However, early bloom counts were reduced in the Roundup Ultra program. Lint yield was numerically but not significantly greater in the Roundup-treated plots (80 pounds/acre). Across both herbicide programs, thrips damage, bloom counts and yield were significantly affected by insecticide treatment. Thrips damage was least in Admire-treated plots (4X rate) and greatest in untreated plots. Bloom counts were greatest in the untreated plot and least in Thimet-treated plots. Lint yields were greatest in the Temik-treated plots and lowest in the Gaucho-treated plots. Within the interaction means, significant differences were determined for thrips damage, bloom counts and lint yields. Similar results were obtained at a second location.

In-furrow spray and granular treatments of Admire, Adage, Di-Syston, and Orthene and combinations of some produced yields equal to or better than the standard Temik treatment. Most of the treatments produced thrips damage ratings similar to the Temik treatment. Early thrips counts among the treatments were comparable and all differed from the untreated. Bloom counts did not differ significantly among the treatments.

After three sprays for boll weevil control, significant square damage differences were noted between treated and untreated plots. Only two of the nine treatments (Karate and Regent at 0.05 lbs) Produced first harvest and total yields significantly different from the untreated.

Bt cottons produced significantly higher yields than conventional varieties in most of six tests. Excellent control of European corn borer was documented in one test.

The effect of reduced tillage on in-season survival and emergence of tobacco budworm was evaluated. No significant differences were noted between the conventional and no-till production systems, although numerically more moths emerged from the no-till plots. **(University of Tennessee, West Tennessee Experiment Station, Jackson, TN)**

Texas. A M.S. student is researching a project on the biological control of the bollworm involves the use of the ELISA technique to determine the major predators attacking bollworms in High Plains irrigated cotton. Bollworm life tables also are being constructed. The project is in it's final stages, and it appears that *Orius* spp. are the major predators. Major mortality in bollworm is confined to the egg stage and 1st instar larvae.

A sticky cotton project involves experiments to determine if the LEPA irrigation system can be used to effectively remove honeydew from cotton lint. The system is being used with both overhead, and in-canopy sprays at 0.25 and 0.50 inches of water with 1, 2, and 3 applications.

The boll weevil ecology project involves studies of winter survival, emergence patterns, diapause studies, and effects of food quality, and quantity on winter survival. This also involves studies to determine the influence of body fat levels on the winter survival of diapause weevils. Studies are now being conducted on burning of CRP grasses to reduce boll weevil overwintering.**(Texas Agricultural Experiment Station, Lubbock, TX)**

Investigations continued to look at factors associated with late-season cotton aphid infestations that contribute to sticky cotton. All plots, including the designated dryland plots, were irrigated in mid-April because of limited rainfall at that time. Dryland plots were not irrigated during the remainder of the season. Plots designated for irrigation termination in early August were irrigated four times during the season, while plots designated for irrigation termination in late August received five irrigations. Aphid populations were monitored throughout the season by counting aphids on ten leaves from the upper half of the plants and on ten leaves from the lower half of the plants. Aphid populations reached peak numbers in early September. Numbers were highest in cotton with a final irrigation in late August, and the application of a pyrethroid, Karate®, magnified aphid numbers in both irrigation treatments in relation to numbers in the dryland treatment. The aphicide, Fulfill®, was more effective in limiting aphid buildup in dryland cotton and in cotton with irrigations terminated in early August, as compared to cotton with a final irrigation in late August.

Evaluations were made on the effect of planting date and row pattern on beet armyworm and cotton aphid infestations during boll weevil eradication. 'Sphinx' cotton was planted 29 April, 19 May, and 9 June. Row patterns within each planting date were solid 40" rows, and skip-row patterns of 2 x 1, and 2 x 2. The cotton was grown dryland, and the need for malathion applications during the season were made and applied by Boll Weevil Eradication personnel in Knox Co. Insect populations in the dryland cotton were suppressed by the heat and drought. Highest beet armyworm infestations occurred in the 9 June planting and in the skip-row spacings. Cotton aphids were not significantly affected by planting date, but aphid numbers were higher in the skip-row spacings. **(Texas Agricultural Experiment Station, Vernon, TX)**

Research continues in the extensive evaluation of stacked gene technology for caterpillar control, including evaluation of 25 new Bt varieties. Most of this work is under secrecy agreement with the particular companies. **(Texas Agricultural Experiment Station, Corpus Christi, TX)**

Projects are underway looking at some transgenic technology involving decarboxylase genes currently in tobacco that may be put into cotton. Tryptophan and tryptamine decarboxylase genes in transgenic tobaccos cause about 50% mortality to whitefly over the control. Additional studies are planned.

Other studies involve the role of key predators in regulating bollworm; movement of beneficial arthropods from sorghum to cotton in terms of regulating pest populations; development and validation of Scout Master, boll weevil survivorship and dispersal models; larval behavior on transgenic cotton, and resistance monitoring for boll weevil (malathion) and Heliothine complex resistance monitoring. **(Texas A&M University, College Station, TX)**

Insecticide efficacy trials were conducted against thrips, cotton fleahoppers, aphids, Heliothines, boll weevils, Lygus bugs, and beet armyworms. The relative importance of mortality versus repellency components of commonly applied insecticides for boll weevil control was evaluated.

Work continued on evaluating different sampling methods for predators. Also, predators were sampled in 32 fields to determine species composition and seasonal abundance. This information will provide a baseline to evaluate the impact of boll weevil eradication on predators.

Investigations continue to evaluate the transgenic baculoviruses for impact on natural enemies and effectiveness on target pests. We are also looking at predator movement and determining the contributions of natural enemies moving from sorghum. Movement appears to occur at the soft dough stage. Movement is also observed from cotton to sorghum. There may not be a net gain to cotton under certain conditions.

Validation of the COTMAN model continued in the South Texas and High Plains areas. Efforts were continued in evaluating the importance of a wild host plant on boll weevil eradication in south Texas and stripper *Bt* cottons for economic Heliothine management under different cropping systems in the High Plains. A survey was conducted of boll weevil overwintering sites in 21 counties in the High Plains, evaluating relative importance of various habitats on attracting weevils and their survival. The effectiveness of using pheromone traps as an indicator of which fields need treatment mid season in an eradication zone was determined and the number of traps necessary to obtain a consistent reading were evaluated. A sticky cotton project continued into its 2nd year, investigating the relationship between plant and insect sugar levels, stickiness measurements and their correspondence to processing difficulties at the textile mills. This project is in cooperation with the Texas Tech University Textile Research Center. **(Texas Agricultural Extension Service, Lubbock, San Angelo, Dallas, Corpus Christi, Weslaco, TX)**

Studies were conducted to investigate the effect of prevailing wind direction on the early- and late-season spatial distribution of boll weevils (BW). Networks of pheromone traps were installed near remote dryland cotton production areas (i.e., more than 9 mile from other cotton fields) near Caldwell and Waller, Texas. For the early-season study, BW were captured in pheromone traps, hand-marked with a unique color of paint, and released from eight directional sectors at a range of 2.5 miles from a 2-acre cotton plot at Caldwell. Thirty marked BW were re-captured (0.8%) from seven releases (total of 3,907 BW) at about the date of first third-grown squares in a 2-acre cotton plot at Caldwell. Boll weevils were re-captured at a maximum distance of 5.4 miles from release sites and a maximum duration of 11 days after release. Very low numbers of BW were captured in a radial network of traps at Waller, Texas, from mid-February through June 1998, and no mark-recapture activity was attempted at Waller. Late-season studies of the effect of wind direction on the movement and spatial distribution of BW were conducted at Caldwell in 1997 and 1998. In August 1997, sixty-seven pheromone traps were deployed around the perimeter of cotton fields in concentric rings at a 2- and 4-mile range, and at a 5-, 6-, 7-, 8- and 9-mile range along a northeast line from the approximate center of the dryland cotton production area. Traps were assigned to eight sectors that were centered on north and at 45-degree intervals. The non-uniform distribution of mean capture of BW by sector was significant using analysis of variance (df=>7, F = 19.13, P <0.0001). Logistic regression established a significant positive relationship between the daily relative frequency of wind heading and the proportion of daily mean capture by sector (chi-square = 26.19, P < 0.05). Mark-capture identification and 1-mile trapping resolution were incorporated in the 1998 study at Caldwell. Boll weevils were captured in pheromone traps, sprayed with a unique color of fluorescent paint, and released near the site of a 2-acre cotton plot on six dates from late-July to mid-September 1998. Seven-hundred seventy-seven marked BW were recaptured (~3%) from a total release of approximately 25,000 BW. Marked BW were recaptured at a maximum distance of 7 miles and maximum duration of 22 days after release. Statistical analysis is underway to determine the effect of wind direction and other atmospheric variables on the spatial distribution of marked and unmarked boll weevils in 1998.

A study was conducted to determine the effect of ambient temperature on the overwintering emergence of BW in undisturbed leaf litter. One-hundred emergence cages wee placed over leaf litter in a forest adjacent to a field in the Brazos Valley, Texas, which had experienced moderate-to-heavy BW pressure during the previous growing season. An automatic recording weather station measured hourly the ambient relative humidity, and the air temperature and leaf litter temperature both within and outside the emergence cages. Wind velocity, solar radiation, and barometric pressure were measured at a climate station in an open pasture located at a range of about 500 meters. Emergence cages were inspected on a variable basis (daily to weekly) from December 3, 1997 to May 17, 1998. A total of 15 BW emerged from the 70 m^2 of caged habitat (0.21 BW per square-meter). Several BW were marked on the elytra with Testor's enamel paint after emergence; returned to the leaf litter; and recaptured one or two times from 1 to 7 days later. Emergence of BW was associated with a daily maximum air temperature greater than 16 C.

Identification of flying bollworms, *Helicoverpa zea* (Boddie), and other nocturnal insects was investigated using IR-illuminated videographic recordings, a blacklight trap and pheromone traps to complement the non-specific insect counts made by an automated entomological radar. Approximately 1,000 sets (20 video frames each) of flying insects were recorded on 30 successive nights of peak emergence of *H. zea* from mature corn in the Brazos Valley in 1998. An electronic target-detection circuit was developed which recorded only scenes in which an illuminated target flew through the field of view. Videographic images are being processed to identify the length, width, shape, flight heading, and flight speed of individual insects. Successful development of a videographic insect identification system will significantly improve the agricultural value of entomological radar observations and pest advisories. **(USDA, ARS, Southern Crops Research Laboratory, College Station, TX)**

Trapping studies to examine boll weevil dispersal patterns in northeastern Mexico were completed. Results indicated probable movement of boll weevils among cotton production regions of northern Mexico and southern Texas. A study to evaluate suppression of overwintering boll weevils by mass trapping was completed. More than 48,000 boll weevils were removed from the 4,000 acre trapping area. Early season weevil populations in cotton were unusually low within the study area and in adjacent fields, and impacts of trapping were not demonstrated. Distinct differences in trap captures among trapping habitat types were again noted and may be used to improve efficiency of future trapping efforts. Studies using a tractor-mounted insect sampler to examine early season boll weevil colonization patterns were continued, but unusually low spring population levels caused results to be inconclusive. Boll weevil diapause induction studies indicating the independence of reproductive dormancy from photoperiod and temperature effects were completed. Feeding regime was identified as the primary factor influencing boll weevil reproduction/dormancy. Examinations of boll weevil response to bait sticks and resulting mortality indicated that bait stick efficacy decreased rapidly with increasing duration of field exposure. However, the bait stick did not supply a high level of boll weevil mortality in field tests or forced contact assays regardless of bait stick age. Initial prototypes of an experimental boll weevil pheromone trap were conducted and indicated the need for further trap modification. An experimental photoactive bait formulation supplied high levels of boll weevil mortality in laboratory and greenhouse studies, and toxic activity was demonstrated by bait aged in the field for 10 d. Preliminary studies of effects of feeding period duration on diapause status and host-free longevity indicated that boll weevils fed for 14 d at 85°F survived longer without food than did weevils fed either 7 or 21 d. Preliminary examinations of beet armyworm oviposition preferences in blooming cotton indicated most eggs were deposited on undersides of leaves in the mid-canopy. However, moths also deposited eggs in other parts of the canopy as well as on upper sides of leaves and on bolls and stems. Seasonal boll weevil population levels were unusually low because of hot, dry conditions and no serious secondary pest problems were observed.

Sulfur mallow, *Cienfuegosia drummondii*, grows in clayey, rangeland soils in South Texas coastal terraces and can provide sites (flower buds and fruit capsules) for boll weevil development from ca. mid-March through mid-December. The reproductive phenology of sulfur mallow and the seasonal extent of infestation and reproduction by the boll weevil on this host plant varied considerably among study sites. Trap captures of boll weevil at one site were highest in July when reproductive structures were fewest in number. At another site, percent weevil infestation of buds and fruit ranged from 0 to 31.8 (=8.1) and adult emergence from infested forms ranged from 0 to 62.5 percent (=26.6). Laboratory studies showed that weevil females fed only on sulfur mallow buds and capsules successfully oviposit in such fruiting structures; however emergence of adults was very low. Natural parasitism of boll weevils at one field site ranged from 0 to 33.3 percent with 95 percent of the total attributable to *Catolaccus hunteri*. *Bracon mellitor* was the other parasitoid recovered. In laboratory studies, the exotic parasitoids *Catolaccus grandis, Bracon compressitarsis*, and *Bracon thurberiphagae* successfully parasitized boll weevil infesting sulfur mallow capsules. Activities will continue to further assess the significance of sulfur mallow on boll weevil population dynamics and the feasibility of parasitoid augmentation for management of the pest in non-cotton habitat. **(USDA, ARS, Subtropical Agricultural Research Laboratory, Weslaco, TX)**

Virginia. Several thrips and bollworm experiments were conducted to continue evaluation of pest impact and management strategies. The most interesting findings related to a de-squaring study designed to 'simulate' loss of first position squares to early season insect pests during the primary squaring period. Plants were mapped prior to de-squaring using COTMAN procedures. First position squares were removed at 0,12, 20 and 30% (June 24), then again at 0,15, 25 and 40% (July 9). Yield components were measured at harvest time (October 8). There were no significant differences in number of bolls per 5 row feet, boll weight, percentage lint or lint yields among the treatments. Yields were 1509a, 1544a, 1615a, and 1553a lb lint/acre for the 0, 12-15, 20-25, and 30-40% square removal treatments, respectively (DMRT, P=0.05). These results are similar to those of some earlier de-squaring studies and indicate that cotton, even in our northerly location, can compensate for substantial square loss. How will this affect recommendations relating to early season square damage from plant bugs or bollworm/budworm? We feel further research is warranted and will seek funding this winter to continue these studies. **(Virginia Tech, Tidewater AREC, Suffolk, VA)**

<u>Additions to Insecticides/Miticides Registered for Cotton Pest Control</u>

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

<u>Changes in State Recommendations for Arthropod Pest Control in Cotton</u>

Additions and deletions of recommended pesticides by state extension organizations for the 1998 crop year are listed in Table 2. Included also are changes in thresholds or indications for certain pests.

<u>Insecticides/Miticides Screened in Field Tests</u>

Pesticides (experimental materials or pesticides not labeled/recommended for use yet on certain pests) tested by state and federal researchers during the 1998 crop year for control of arthropod pests of cotton are listed in Table 3 by the reporting state.

Table 1. New products registered for use against cotton arthropod pests in 1998.

State	Pesticide (lbs AI/A)	Target Pest
Alabama	None	
Arizona	None	
Arkansas	None	
California	Savey, Alert available under Section 18	Spider mites Silverleaf whitefly
	Knack, Applaud available under Section 18	Western tarnished plant bug
	Vydate C-VL	
Georgia	None	
Florida	Pirate available under Section 18	Beet armyworms
Louisiana	No new insecticides were labeled for cotton use in 1998. Pirate, Confirm, and Furadan did receive a Section 18 label in 1998.	
Mississippi	None	
Missouri	Furadan 4F (Section 18)	Aphids
New Mexico	None	
North Carolina	Pirate 3 (added to pre-approved Section 18 Specific Exempt)	Beet armyworms
Oklahoma	None	
South Carolina	None	
Tennessee	None	
Texas	Confirm (Section 18)	Beet armyworms
	Pirate (Section 18)	Beet armyworms
	Furadan 4F (Section 18)	Aphids
Virginia	None	

Table 2. Changes in state recommendations for treatment for arthropod pests of cotton for 1998.

State	Pesticide	Target Pest
Alabama	None anticipated	
Arizona	None	
Arkansas		
Additions	None	
Deletions	Guthion/Azinphosmethyl	Boll weevil
	Bolstar	Bollworm, budworm, fall armyworm
California		
Additions	Vydate C-LV	Western tarnished plant bug
Georgia		
Additions	Lorsban	Fall armyworm
	Knack	Silverleaf whitefly
Deletions	M-Pede	Aphid
Louisiana	No changes expected for 1999	
Mississippi	None	
Missouri	No Changes	
New Mexico	None	
N. Carolina	None	
Oklahoma	None	
S. Carolina		
Deletions	MVP	Bollworm
Tennessee		
Additions	Deltamethrin (Decis 1.5) (.019-.03)	Cotton bollworm/ tobacco budworm
	Spinosad (Tracer 4) (.045-.089)	Cotton bollworm/ tobacco budworm
	(.067-.089)	Fall armyworm
	(.067-.089)	Beet armyworm
	(.067-.089)	Loopers
Deletions	Sulprofos (Bolstar 6)	All uses
	Methyl parathion 2 + Thiodan 3	All uses
Texas		
Additions	Synthetic pyrethroids (with precautionary footnotes pertaining to resistance issues and aphid flaring)	Boll weevils Lygus
W. Texas Only	Orthene (0.25-1.00)	Lygus
	Vydate (0.375-1.00)	Lygus
Virginia		
Additions	Orthene 75S (0.67 lb)	Plant bugs
	Lorsban 4EC (6.1 oz)	Plant bugs
	Bidrin 8EC (3.2 oz)	Plant bugs
	Dimethoate 4EC (6.4 oz)	Plant bugs
	Dimethoate 2.76EC (9.3 oz)	Plant bugs
	Provado 1.6F (3.75 oz)	Plant bugs
	Methyl parathion 4EC (8 oz)	Plant bugs
	Lannate 2.4LV (12 oz)	Plant bugs
	Lannate 90SP (4 oz)	Plant bugs
	Vydate (1.o pt)	Plant bugs
	Bolstar (5.3 oz)	Plant bugs
	Tracer 4SC (1.4-2.9 oz)	Bollworm/ budworm
	Decis 1.5EC (1.6-2.6 oz)	European corn borer
	Tracer 4SC (2.14-2.9 oz)	Fall armyworm

Table 3. Promising pesticides screened in 1998 for control of cotton arthropod pests.

State/Pesticide (lbs AI/A)	Target Pest(s)
Alabama	
Adage (3.2 oz/cwt seed)	Thrips
Adage (4.8 oz/cwt seed)	Thrips
CGA-293343 (1.6 oz/cwt seed)	Thrips
CGA-293343 (0.13 lbs ai/ac)	Thrips
Steward (.09 lbs ai/ac)	*Lygus* sp.
Steward (.11 lbs ai/ac)	*Lygus* sp.
Regent (.038 lbs ai/ac)	*Lygus* sp.
Regent (.05 lbs ai/ac)	*Lygus* sp.
Admire (2.4-3.2 oz/ac)	Thrips
Steward (0.11 lbs ai/ac)	Bollworms/budworms, Fall armyworms
Steward (0.11 lbs ai/ac)	Stink bugs, plant bugs
Regent (.038-0.05 lbs ai/ac)	Stink bugs, plant bus
Strategy (8 oz)	Fall armyworms
Intrepid (0.2 lbs ai/ac)	Fall armyworms
TD 2344-02 (0.03-0.04 lbs ai/ac)	Bollworms/budworms
F-1002 (0.3-0.5 lbs ai/ac)	Bollworms/budworms
Karate (CS) (.028 lbs ai/ac)	Bollworms/budworms, Fall armyworms
Arizona	None
Arkansas	
RH 2485	Heliothines
TD-2344-03	Heliothines
Steward	Heliothines, plant bugs, beet armyworms
Legend	Heliothines, plant bugs, beet armyworms
CGA 293343	Plant bugs
Strategy	Plant bugs
TADS 12253	Plant bugs
Fipronil	Plant bugs
Costar	Beet armyworm
California	
Regent 6.2 (0.05 oz/ac, 0.038 oz/ac)	Western tarnished plant bug
Regent 2.5EC (0.05 oz/ac)	
BXP (TADS) 61685A 0.83 EC + Regent 2. EC (0.1 + 0.025 oz/ac)	
S-1283 (0.045 oz/ac)	
V-1283 (0.045)	Spider mites
CGA-293343 (0.044 oz/ac)	
CGA-215944 (0.086 oz/ac)	Cotton aphid
Florida	None
Georgia	None
Louisiana	
TD-2344 0.83EC/0.83SC	Bollworm, tobacco budworm, tarnished plant bugs, thrips
Karate-Z 2.09SC	Bollworm, tobacco budworm, tarnished plant bug, thrips, aphids
EXP 80667A 70 WP	Tarnished plant bugs, thrips, aphids
CGA-293343 25WG	Tarnished plant bugs, aphids
Steward 1.25SC	Bollworm, tobacco budworm, tarnished plant bugs, armyworms, soybean
Legend 2.7SE	looper
Emamectin benzoate 0.16EC	Aphids
	Bollworm, tobacco budworm, tarnished plant
S-1812 4EC	bugs
	Bollworm, tobacco budworm, armyworms,
Decis 1.5EC	soybean loopers
Confirm 2F	Thrips
Regent 2.5EC	Beet armyworms
	Tarnished plant bugs,
Pirate 3SC	thrips, boll weevil
	Bollworm, tobacco budworm, armyworms,

Table 3. Continued

State/Pesticide (lbs AI/A)	Target Pest(s)
Intrepid 80WP	soybean looper
	Bollworm, tobacco
	budworm, armyworms,
Fulfill 50WP	soybean looper
Regent 2.5EC	Aphids
	Tarnished plant bugs
Mississippi	
Adage 5FS (3.2 fl oz/cwt)	Bollworm, tobacco
LS034 (6 fl oz/cwt)	budworm, tarnished plant
LS222 (1.3 fl oz/cwt)	bugs, thrips
Orthene AG97 (0.9 lb(ai)/acre)	Bollworm, tobacco
WG	budworm, tarnished plant
Orthene (0.33 lb(ai)/acre)	bug, thrips, aphids
AG97WG	Tarnished plant bugs,
EXP61685 (0.2 lb(ai)/acre)	thrips, aphids
Regent 2.5 EC (0.05 lb(ai)/acre)	Tarnished plant bugs,
Steward 1.25 EC (0.09 lb(ai)/acre)	aphids
Strategy	Bollworm, tobacco
	budworm, tarnished plant
	bugs, armyworms, soybean
	looper
	Aphids
	Bollworm, tobacco
	budworm, tarnished plant
	bugs
	Bollworm, tobacco
	budworm, armyworms,
	soybean loopers
	Thrips
	Beet armyworms
	Tarnished plant bugs,
	thrips, boll weevil
	Bollworm, tobacco
	budworm, armyworms,
	soybean looper
	Bollworm, tobacco
	budworm, armyworms,
	soybean looper
	Aphids
	Tarnished plant bugs
Missouri	
Admire 2F (0.0375-0.05)	Thrips
Confirm 2F (0.06-0.25)	Thrips
Decis 1.8 EC (0.019-0.03)	Thrips
Karate 2.09CS (0.025-0.03)	Thrips
Provado 1.6F (0.0375)	Tarnished plant bugs
Regent 2.5 EC (0.038-0.05)	
	Tarnished plant bugs
	Tarnished plant bugs
	Heliothines, fall
	armyworms
	Fall armyworm
New Mexico	
	Thrips
	Bollworm
	Bollworm, Boll weevils
	Aphids, Bollworm, Boll
	weevils, Thrips
	Aphids
	Boll weevils, Thrips
North Carolina	None
Oklahoma	None
Tracer	
MP062SE	
Regent	
Tads 12253	
Legend	
Karate 2.09C	
Orthene Ag	
CGA-293343	

Table 3. Continued

State/Pesticide (lbs AI/A)	Target Pest(s)
South Carolina	
	Bollworm
	Bollworm
	Boll weevil
	Boll weevil
	Boll weevil
	Boll weevil
	Thrips
	Thrips
Tennessee	None
Adage ST (.2-.3 lb/cwt)	
Adage IFG (CGA293) (.046-.138)	
Adage IFS (.046-.092)	
Admire IFS (3.2 oz pr/a)	
Regent (.038-.05)	
Steward (.065-.11)	
Regent (.038-.05)	
TADS 12253 (.1-.2)	
Texas	
(CGA293343) Adage 5FS (5.1-7.7	Thrips
oz/cwt seed)	Thrips
CGA293343 25WG (4.29 oz/cwt	Thrips
seed)	Thrips
CGA293343 (5.3-8.0 oz/1000 row	Plant bug
feet)	Plant bug
Gaucho 480FS (8.0 oz/cwt seed)	Boll weevil
Steward 1.25SC (DPX-MP062)	Boll weevil
(0.055-0.11)	
Regent (ovicide)	
Tracer 4SC (0.0625)	
Pirate 3SC (0.2)	
Steward 1.25SC (DPX-MP062)	
(0.055-0.11)	
Tracer 4SC (0.0625)	
Pirate 3SC (0.2)	
CGA 215944 Fulfill 50WP	
(0.085-0.134)	
CGA 215944 Fulfill 25WP (0.044)	
CGA 293343 25 WG (0.022-0.66)	
CGA293343 (5.3-8.0 oz/1000 row	
feet)	
CGA 293343 Adage 5FS (1.6-2.4	
oz/cwt seed)	
CGA 293343 50WP (0.011)	
Strategy 0.16EC (0.01)	
Regent 2.5EC (0.05)	
Provado 1.6F (0.025-0.047)	
Knack 0.86EC (0.04-0.054)	
Gaucho 480S (8.0 oz/cwt seed)	
Orthene 97 Pel (4.12 oz/ac)	
CGA 293343 25WG (0.066)	
Strategy 0.16EC (0.01)	
Steward 1.25SC (DPX-MP062)	
(0.055)	
Orthene 97 Pel (4.12 oz/ac)	
Regent 2.5EC (0.05)	
Fulfill 50WP (0.085)	
Steward 1.25SC (DPX-MP062)	
(0.055-0.11)	
Decis 1.5EC (0.038-0.050)	
Regent 2.5EC 90.025-0.05)	

Table 3. Continued

State/Pesticide (lbs AI/A)	Target Pest(s)
Virginia	
	Thrips
	Thrips
	Thrips
	Thrips
	Bollworms
	Bollworms
	Bollworms
	Bollworms
	Beet armyworms
	Beet armyworms
	Beet armyworms
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Aphids
	Cotton fleahoppers
	Cotton fleahoppers
	Cotton fleahoppers
	Cotton fleahoppers
	Cotton fleahoppers
	Cotton fleahoppers
	Plant bugs
	Plant bugs
	Plant bugs
Virginia	None