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Crop and Arthropod Pest Conditions

Of 14.4 million acres of cotton planted in 2002 here were 12,861,400 harvested acres (Upland and Pima) with an average yield of 648 lbs of lint per acre (USDA-January, 2003 report) in 2002. Arthropod pests of cotton reduced yield by 4.31% in 2002. The bollworm/budworm complex reduced yields by 2.31%, but the bollworm was the predominant species to attack cotton in 2002. Bollworms were estimated to make up 83% of the population. No other pest exceeded 1% in reducing yields. *Lygus* (0.72%) were 2nd in losses with thrips (0.447%) and stink bugs (0.446%) were 3rd and 4th, respectively. Boll weevil (0.175%) rounded out the top five cotton insect pests for the year. Beltwide, direct insect management costs amounted to $59.51 per acre. Cost plus loss are estimated at $1.140 billion. (see M. R. Williams, this proceedings).

Alabama

2002 was a year of extremes; too dry, followed by adequate moisture and then too wet. Often these extremes were just the opposite 20 miles away. Insect pressure was as variable as the weather. Thrips numbers were heavy, as usual, and damage was evident even in fields treated with either Temik or Cruiser. Plant bugs were heavy early season in north Alabama but were almost non-existent in south and central during this same period. Caterpillar numbers were much heavier than the previous year, but this pressure was also quite variable. Some fields in central Alabama never reached threshold season long while nearby fields had 3-4 weeks of constant pressure. Several areas in south Alabama had egg lays that lasted for six consecutive weeks. The species mix varied also from one area to another. Three generations of tobacco budworms occurred in the Gulf Coast area while the population was 60%, or higher, bollworms in central Alabama. Bollgard cotton incurred the largest amount of escape bollworm damage since 1996. Up to 8% boll damage occurred in some untreated Bollgard fields. Fall armyworms were at sub-economic levels over most of the area but only caused measurable damage in a few counties. Beet armyworms were detectable in many fields but only required controls on a few hundred acres during the pre-square period. Soybean loopers were present across the area but did not require controls. The southern armyworm was the most widespread and abundant ever. Some specific controls were applied but most were suppressed by sprays targeted for budworms or bollworms. Stink bugs occurred earlier than ever during the season. They were numerous in many south Alabama fields pre-square, and controls were required as boll set began. However, this unusual abundance did not carry forward to late season, and the months of August and September were about as usual for this pest. Grasshoppers, primarily in conservation tillage systems, are becoming more widespread and abundant each season. Many of the fields under conservation tillage required controls. Three-cornered alfalfa hoppers exhibited about 1-2 weeks of seedling damage in localized fields within several counties. Both the clouded plant bugs and the leaf footed bugs were part of the bug complex that occurred in many fields in late season.

For North Alabama the season's weather was extreme, too cold, too hot, too dry and too wet, and caused all sorts of problems. Of our ca. 287,000 acres of cotton, approximately 40% constituted a Bollgard variety. Yields are variable in the extreme, but should average in the 600's.

Thrips occurred in normal numbers but there were control problems due to weather complications. Aphid pressure was average. Some problems occurred on seedling cotton, but the highest populations occurred in early June. There was a noticeable rebound of aphids in August resulting in some sooty mold on open bolls. Two-spotted spider mites presented widespread problems. Infestations appeared on seedling cotton and remained through defoliation.

Tarnished plant bugs were average. Problems began in late June and lasted on into early August. Stinkbugs could be found in low but noticeable numbers over a wide area during late July and August.

Worm pressure was above thresholds in many areas during late July and early August. The corn earworm predominated. Low to moderate numbers of fall and beet armyworms were scattered throughout the area during the latter part of the season.

Whiteflies were not a significant problem.

Arkansas

Statewide the season began with very favorable conditions in April. Warm temperatures and dry weather prompted many growers to plant their crop early with many having the majority planted by the first few days of May. However, a 2-week cold, wet period hit in early May, adversely affecting cotton growth and development. This was compounded by a high population of thrips. Poor performance from in-furrow insecticides and seed treatments was attributed to the cold weather negatively affecting the uptake of insecticides by plants.

Aphids were not really a problem anywhere in the state. Some areas had good populations, but the fungus quickly decimated their numbers. Very few fields were treated for this pest.

Spider mites were a problem in the traditional areas they always attack in Northeast Arkansas. One to two applications of Capture or Kelthane were used by many. A few growers used Zephyr to treat borders in order to prevent further movement into the field with some success. Most populations seemed to crash on their own by mid-July.

Plant bugs were in tremendous numbers in some areas of Southeast Arkansas. Difficulty in control was experienced due to excessive vegetative growth and thick canopy. Orthene, Bidrin, and Centric were the materials of choice. Numbers were moderate to low in Northeast Arkansas with about 25% of the acreage being treated for this pest alone. Numerous applications of malathion in eradication areas, coupled with applications for bollworm/tobacco budworm in both eradication and non-eradication areas, most likely kept numbers of this pest lower in the northeast part of the state.

Tobacco budworm/bollworm were not as big a problem in the south as they were in the northeast. Many growers in northeast Arkansas did not plant Bt cotton and found themselves treating multiple times for tobacco budworm. Tracer, Steward, Curacron, Larvin and Double Threat were used for control, depending on what was available. A section 18 for Denim was also in place, and many used this material as well. Tobacco budworm outbreaks occurred first along the St. Francis River in early July and had spread across the entire northeast area by mid-August. Cotton bollworms were reported and observed in higher-than-normal numbers in Bt cotton throughout the state. Although pressure was moderate to high, questions about possible reduced protein expression and loss of efficacy to this species were asked. Many Bt cotton fields were treated several times for bollworm.

Stink bugs were reported in squaring cotton early in the season. There is no evidence that supports the theory that economic damage is inflicted to squaring cotton by stink bugs. Control of stink bugs in pre-bloom cotton was not recommended. Although most were bracing for another big stink bug year, the problem was not as bad as it was thought it would be. Perhaps regular rainfall kept alternate plant hosts viable longer, and populations of stink bugs remained in those wild alternate hosts longer than in a year where drought turns irrigated cultivated crops into extremely desirable hosts. Control with Bidrin, Orthene, Centric, etc, was excellent to satisfactory.

Armyworms (Beet and Fall) caused sporadic problems requiring control. There were higher numbers of Fall armyworms in the northeast portion of the the state with some fields requiring applications for this pest alone.

Boll weevils were under control by BWEP in most of SE Arkansas, except for a few "hot" spots that need further attention in the future. In the Delta Zone, the only area not in an active eradication program, approximately 70% of fields received a pin-head square application. Populations did not get high until August, with a few “hot” areas requiring multiple applications. Many fields were past cutout and safe from weevil damage by the time weevils reached extremely high numbers. Weevils migrating from the Delta Zone into active eradication areas during the Fall caused significant problems for eradication.

Miscellaneous pests (saltmarsh caterpillars, whiteflies, other leps, etc.) were not really a problem in most of the state. There were a few fields treated for whiteflies in the north central portion of the state. Centric or Orthene were used for control.

California

There were 695,419 acres of cotton planted in CA in 2002. The San Joaquin Valley planted 94% of the total acres with the remainder split evenly between the southern deserts and Sacramento Valley. Within the San Joaquin Valley, 452,560 were planted to upland varieties (*Gossipium hirsutum*) and 200,805 acres planted to Pima varieties (*G. barbardense*). Transgenic cottons represented 43.6% of the acreage, but Bt varieties occupied only 3,481 acres or 0.8%. Herbicide tolerant varieties represented the bulk of the acreage planted to transgenics.

Yield was predicted to be 1439 lbs/acre for upland and 1301 lbs/acre for Pima. The planting period in March was generally poor until late March. Planting conditions were generally good through mid April, but several storms came through during mid to late April that cooled and slowed emergence. Conditions at the end of April and through May were excellent for early emergence plant development. Of the 60 days during which most of the cotton was planted, 55% were in the ideal planting zone, 10% in the adequate, 8% in the marginal and 27% in the poor planting zones.

Conditions for growth and development were excellent through the remainder of the year. Warm early conditions allowed the crop to vigorously develop, and cool nighttime temperatures allowed excellent retention of fruit and bolls. Cutout was early and dramatic with careful management required to take advantage of the growing season.

Insect pressure in general was very light. Although late, scattered spring rainfall provided host plants for Lygus; populations did not develop. Very few fields had treatable levels of lygus. Spider mites were very low in 2002. Aphids were widely scattered in mid-season but did not develop into large widespread problems. However, many of these populations persisted through the late-season, where these low populations were problematic in terms of production of honeydew. Worm pests were not evident in 2002. Silverleaf whitefly was the major concern between July and September. This pest has continued to extend its distribution over a wider area to include most of Fresno County. Widespread, multiple applications were made for whitefly and aphid. An educational program developed by Cooperative Extension and conducted through the industry raised the issue of preventing sticky cotton to a higher level.

Florida

Florida farmers planted approximately 120,000 acres of cotton in 2002. Approximately one-half of this acreage was planted in Jackson and Santa Rosa Counties. In Santa Rosa County nearly 60% of the crop was planted to transgenic Bollgard varieties, with Deltapine 458 BR and Deltapine 655 BR being the dominant varieties. Deltapine 5415 R was the dominant non-Bollgard variety. In the eastern part of the panhandle, approximately 45% of the crop was planted to one of Bollgard varieties.

Throughout north Florida, rainfall was limited during late April and early May. In west Florida where most of the cotton is planted early, stand establishment was delayed in some fields until mid-May. The later-planted cotton in the eastern panhandle generally had adequate soil moisture for stand establishment soon after planting. Rainfall continued to be spotty through August. Some areas had sufficient soil moisture for crop development, and others experienced drought conditions resulting in early “cut out”.

Excessive rainfall during September and early October (including a tropical storm in early October) caused considerable losses to the early planted cotton in west Florida. Growers were unable to harvest in a timely manner. Both yield and crop quality were severely reduced. As of mid-November, only about 25 percent of the crop had been harvested in west Florida. At the same time, an estimated 50% of the crop was harvested in the eastern part of the panhandle.

Thrips populations were at high levels during April and May. In west Florida, thrips injury was compounded in early-planted fields by dry soil conditions which were not conducive for uptake of soil applied insecticides used at planting. Foliar sprays were needed to supplement preventive treatments in some fields. In the eastern part of the cotton growing areas, thrips damage was isolated and largely restricted to a small percent of the planted acreage.

Grasshoppers continue to be an early season problem particularly in the western panhandle. Damage was more pronounced in reduced tillage fields where most of the stand reduction was observed and treatments were made. Pyrethroid insecticides provided control where applied.

Heavy aphid infestations developed in some fields throughout the panhandle as early as the first week of June. The beneficial fungus disease, *Neozygites* spp was first detected on June 21 and began reducing populations. Populations remained low for approximately 5 weeks but rebounded around August 1 and persisted for several weeks before declining.

Lygus bug populations were low all season throughout the area. Less than 2 percent of the acreage received an application for Lygus. Early season square set was generally high.

Beneficial insects were at high levels all season where insecticides were not used. They developed on the early aphid population and helped provide good suppression of worm pests in many fields. Fields receiving pyrethroid applications for sub threshold populations of worm pests frequently experienced resurgence in budworm and bollworm populations. Fire ants were abundant all season in fields grown under strip-tillage. (Approximately 70% of fields were grown using this method of conservation tillage.)

In west Florida, bollworm and tobacco budworm moth activity was extremely heavy during mid season. Large tobacco budworm moth flights occurred the first weeks of July and August and were sustained at high levels, along with bollworms, throughout the month of August. Conventional varieties treated for budworms during early July required three or more insecticide applications. Pyrethroids provided good control of bollworms but failed to control tobacco budworms. Tracer was the product of choice for budworms. Beneficial insects suppressed infestations in many untreated fields despite extremely high moth activity (75%+ eggs). Populations followed similar trends in the eastern panhandle but were generally at much lower levels resulting in fewer treatments.

Populations of both the beet and fall armyworm were generally low throughout the year. Few, if any, fields required treatment specifically for these pests.

Southern armyworm continues to be more of a problem each year. Infestations required treatment in scattered fields during early to mid August. Soybean loopers caused moderate defoliation in isolated fields in mid to late August.

Stink bugs populations increased in most fields during August and September. Both the southern green and brown stink bugs were present throughout the panhandle. Some fields experienced damaging levels following migration from peanuts during September. Highest infestations of stink bugs occurred in field borders adjacent to peanuts. Some growers obtained adequate control by treating peanut fields or field borders next to peanuts. Approximately 40% of fields received an application for stink bugs.

Overall, insect pressure was relatively high this year compared to the previous three years. This was due to the dramatic increase in numbers of bollworms and tobacco budworms. Stink bug damage was generally down from last year.

Although harvest is still not finished, state cotton yield will be lower than 2001. Estimates place the yield in 2002 at 450-500 pounds of lint per acre.

Georgia

Approximately 1.43 million acres of cotton were planted in Georgia during 2002. Droughty conditions during the growing season and excessive rainfall during harvest resulted in a disappointing crop. Insect populations were generally higher than during recent years.

Thrips populations were moderate, but plant injury tended to be greater than normal due to slow seedling growth. Preventive treatments applied at planting provided good control in most fields. Isolated problems of grasshoppers were observed in a few reduced tillage fields. Cutworms were also an isolated pest. However, difficult to control cutworm populations occurred in cotton following spring vegetables.

Beet armyworms were observed at treatable levels on seedling cotton during late May and early June. Populations lingered in parts of the state season long but were effectively controlled when needed. Plant bug populations were generally low prior to bloom, but populations built in some areas during mid and late season. Aphids built to fairly high numbers in parts of the state during late June and early July. Although some fields were treated, most growers chose to wait on the fungal epizootic which began during early July.

Tobacco budworm and corn earworm populations were significantly higher compared with recent years. Tobacco budworm appeared to make up a large percentage of the complex in central and southwest Georgia. Where pyrethroids were used for control of tobacco budworm, control was poor to fair. In some areas, producers encountered treatable populations of tobacco budworm and/or corn earworm for six consecutive weeks. Additionally, populations were extremely high in some fields. Bt cotton provided excellent control of tobacco budworm, but some fields required supplemental treatment of corn earworm.

Fall armyworms were generally reported at low numbers in southernmost and east Georgia during mid July. A second generation of falls infested cotton during mid-late August with some fields experiencing significant populations. Southern armyworms were observed in some fields from late July through September. Few fields required treatment, but some fields were defoliated late. Although most damage from southern armyworm occurred from foliage feeding, southern armyworms were also observed feeding on squares, blooms, and bolls. Soybean loopers infested cotton during late August; few fields were treated.

Stink bug populations were very sporadic. Higher than normal populations of brown stink bugs were observed in prebloom cotton. Southern green and brown stink bugs were both common during late July and early August. Silverleaf whitefly built to high numbers in Tift and Colquitt counties. Both of these counties have experienced sporadic whitefly problems during droughty years.

Boll weevils were detected in Wayne and Brooks counties. Two boll weevils were captured in Wayne County, but reproduction was detected in a Brooks county field. Boll weevil eradication personnel reacted in a timely manner to manage this situation.

Louisiana

Louisiana planted approximately 492,000 acres of cotton in 2002 with an estimated yield of 763 lbs of lint per acre. Planting conditions during early-April were ideal with adequate soil moisture and warm temperatures. Cool temperatures slowed planting considerably during mid and late April. Planting was then further slowed by excessively dry conditions during early and mid May. Rainfall in mid to late May resulted in two distinct planting periods, early April and late May. Approximately 77% of the acreage was planted to a Bt-cotton variety.

Insect pests densities were low to moderate in 2002 but were persistent in many cases. The prolonged periods of infestation resulted in an expensive insect control year for many areas of the state. In other areas, however, insect densities were so low that few if any insecticide applications were made (primarily south of Shreveport).

Seedling infestations of thrips were light to moderate. At-planting insecticides were used on at least 80% of the crop. Many fields planted in early April received a foliar application for thrips control, even though most received an at-planting treatment for thrips control. Aldicarb in-furrow, acephate seed treatment, and imidicloprid seed treatment accounted for essentially all at-planting insecticide treatments.

Tarnished plant bugs did not significantly infest fields until mid to late season. Late season tarnished plant bug infestations were moderate to high with densities generally increasing with closer proximity to the Mississippi River.

The Louisiana region (primarily northeast Louisiana) of boll weevil eradication entered the fourth year, while the Red River program area entered the first year of a maintenance program. Boll weevil population densities in both program areas were higher than expected. The higher densities are believed to have occurred because the weather pattern (primarly cool and wet) was considered to be conducive to boll weevil population development. Additional concerns are that few boll weevil sprays were applied during successive rain events (three hurricanes) in September and October.

Tobacco budworm populations ranged from minimal to high during 2002. Most non-Bt fields received at least two insecticide applications for tobacco budworm control. A few fields did receive up to 7 or 8 applications for tobacco budworm, but this was an oddity in comparison to most.

Bollworms were a particular problem during 2002. The average Bt-cotton field received over three insecticide applications for bollworm control with a few isolated fields receiving as many as seven. Several factors are believed to be responsible for the elevated bollworm pressure during 2002. Bollworm adult emergence from overwintering occurred approximately two weeks earlier than normal. Corn was also planted on considerably higher number of acres than normal. The bollworm flight from corn to cotton did not occur until mid-July, thus indicating that one more bollworm generation developed on corn before moving into cotton. This additional generation on corn allowed population densities to increase dramatically and also expanded the generational time. The additional generation time further prolonged the infestation period and thus increased the required number of insecticide applications for bollworm control.

Mississippi

Mississippi cotton producers planted approximately 1.18 million acres of cotton in 2002, which was a substantial decrease from the 1.62 million acres planted in 2001. Approximately 81% of the crop was planted to transgenic Bt varieties, with Paymaster 1218 BG/RR, Deltapine 451 BR, and Stoneville 4892 BR being the dominant varieties. Collectively these three Bt varieties were planted on 51% of Mississippi's cotton acreage.

Active Boll Weevil Eradication Programs (BWEP) were underway in all areas of the state in 2002. Although boll weevil numbers were very low through out the state, no area of the state has yet achieved eradication. The Hill Region, which contained approximately 415,000 acres, was in its sixth year of BWEP. The South Delta Region, consisting of approximately 175,000 acres, was in its fifth year, while the approximately 568,000 acres in the North Delta was in the fourth year of BWEP. This was the final year for the BWEP in the South Delta Region, but growers in this region voted to enter a ten-year Boll Weevil Eradication Maintenance Program in 2003. Growers in the Hill Region of the state voted in a similar maintenance program in 2001, and growers in the North Delta are scheduled to vote on a maintenance program in 2003. The annual assessment fee for these maintenance programs, which is not to exceed $12.00 per acre, will be used to complete the eradication effort, service any residual debt from the original program, and to run an effective eradication maintenance program.

Heavy, prolonged rainfall during late August and early September of 2001 prevented effective late summer and early diapause treatments, and the suspension of aerial application following the September 11 terrorist attacks further reduced the effectiveness of the 2001 BWEP diapause program. This less than desirable diapause program was followed by a mild winter, which allowed good survival of overwintering boll weevils. As a result, during the early part of the 2002 season, statewide weekly boll weevil trap captures were actually somewhat higher than they had been the previous year, even though considerably fewer acres of cotton were being trapped, and it was not until the first week of August that 2002 weekly captures dropped below those for 2001. Still, the total number of boll weevils being captured statewide during May, June, and July, was quite low, ranging from a high of 5386 in the second week of June to a low of 916 during the third week of July. Although weekly statewide boll weevil trap captures increased during late August and September as weevils began to enter diapause, these numbers were somewhat lower that those for corresponding weeks in the previous year, indicating that the BWEP had regained the ground it lost as a result of the disappointing 2001 diapause season and ended the season showing some progress toward the goal of completely eradicating the boll weevil from Mississippi. The total number of boll weevils captured statewide during 2002 was 191,570, compared to 346,420 in 2001, but the average number of ULV malathion sprays applied per acre was 1.5, which was actually higher than the 1.2 sprays applied in 2001.

Late April and early May of 2002 were dry, and unusually warm, and 70% of the crop was planted by May 12. Unfortunately, the following two weeks of May were unusually cool, with night temperatures dropping into the low 40s in some areas of the state. These low temperatures slowed seedling development, resulting in increased incidence of seedling disease and prolonging the window of susceptibility to thrips. Although thrips numbers were not unusually high, the number of foliar treatments applied to control thrips was higher than normal because of this prolonged period of susceptibility. Because of budget concerns, there also appeared to be an increase in the percentage of acreage that was not treated with an in-furrow insecticide, and this also contributed to an increased need for foliar thrips treatments.

Availability of transgenic herbicide tolerant varieties has fostered a large increase in no-till production, especially in the Hill Region of the state where the portion of fields planted no-till exceeds 80% in some counties. This increase in no-till acreage has resulted in an increase in unconventional pest problems, especially in seedling cotton. This year many no-till fields experienced particularly high populations of snails. Although they do not appear to cause any significant feeding injury, these snails often congregate on seedling cotton plants in extremely high numbers, causing the plants to lodge under their weight. This phenomenon has been sporadically observed in no-till cotton for many years but was more widespread this year because of the increase in no-till acreage. Although they were not causing any visible damage, these snails, which were identified as members of the genus *Succinea*, generated concern among growers because they were so numerous. The snails rest on the leaves and stems of the seedling cotton plants, causing them to droop and lodge. A number of fields were treated with foliar insecticide sprays in an unsuccessful attempt to obtain control.

Heavy, early spider mite infestations were another phenomenon that was observed in many no-till fields in the South Delta region of the state. Although this situation was not wide spread, there were a number of fields that required treatment to control infestations of spider mites on seedling cotton. In one case these mites were identified as Carmine mites, *Tetranychus cinnararinus.* Apparently the mites moved to the cotton seedlings from in-field infestations of weeds that were killed by burn-down herbicide treatments. It is likely that these mite infestations were exacerbated by applications of pyrethroid insecticides that are routinely applied at-planting in no-till fields to control cutworms. Fortunately however, spider mite populations were not particularly heavy during the remainder of the season.

Early season tarnished plant bug populations were highly variable across the state in 2002. As usual, plant bug numbers were much heavier in the Delta, which averaged approximately 3.5 foliar plant bug sprays, than in the Hills, which averaged approximately 1.1 treatments for plant bugs. Although, plant bug populations remained uncommonly low in many areas of the Delta through mid-July, the northern Delta, which experienced unusually heavy spring rainfall, experienced heavy early season plant bug pressure. As in recent past years, plant bug numbers increased through much of the Delta during mid and late-season, resulting in a considerable amount of treatment for plant bugs during the latter half of the growing season. Successful control of these heavy, late-season infestations required at least two successive applications of an effective plant bug insecticide.

Plant bugs in the Delta exhibit high levels of resistance to pyrethroid insecticides, and acephate and dicrotophos continued to be the most effective treatments for plant bugs. Although thiamethoxam (Centric) was used in many Delta fields, many of these early applications were made prophylactically when plant bug populations were low or absent, making it difficult to evaluate effectiveness. However, in small plot trials the performance of thiamethoxam was similar to that of acephate and dicrotophos. As in past years, Bt-cotton required significantly more tarnished plant bug treatments than non-Bt, because of the lower number of treatments required to control caterpillar pests and the corresponding reduction in coincidental control.

Cotton aphid populations were relatively low in 2002 with few fields requiring treatment. As in past years, fields that received multiple applications of ULV malathion as part of the BWEP were especially prone to aphid infestations. The new neonicotinoid products, Thiamethoxam (Centric) and acetamiprid (Intruder), provided excellent control of aphids in fields that required treatment, as did carbofuran (Furadan), which was again available for use under a Section 18 Emergency Exemption.

Following the mild winter it was anticipated that stink bugs might be more common than in past years. However, although stink bug infestations were heavier than usual in soybeans, treatable infestations did not occur in cotton to the degree expected. Still, there were a few fields that were treated specifically to control stink bugs, a situation that rarely occurred in the years before BWEP and wide spread use of Bt-cotton

With approximately 81% of the crop planted to Bt varieties, tobacco budworm infestations were relatively uncommon, but some non-Bt fields did require treatment for tobacco budworms. Statewide corn acreage was up approximately 140,000 acres, with much of this increase being concentrated in the Delta region. As a result, bollworm pressure was relatively heavy, particularly in the Delta where Bt fields received an average of 2.0 foliar treatments to control caterpillar pests and non-Bt fields received 5.3 caterpillar treatments. Bollworm/budworm pressure was much lower in the Hill region where Bt fields received approximately 0.7 caterpillar sprays and non-Bt fields received 2.1 caterpillar sprays.

It is especially noteworthy that there were many non-Bt fields in the Hills, including many large fields that were not being grown as a refuge for Bt-cotton, which required no treatments for caterpillar pests and sustained very little insect damage. The lack of insect pressure in these fields is attributed to three major factors. Most important is the boll weevil eradication effort, which by eliminating the need for boll weevil treatments favors season-long retention of beneficial insect populations. Also, many Hill fields are currently planted no-till, and no-till cotton fosters in-field establishment of fire ants, which are extremely effective predators on heliothine eggs, larvae, and pupae. In addition, the large percentage of acreage planted to Bt varieties serves to dilute the overall tobacco budworm population, resulting in lower numbers of tobacco budworm moths and lower tobacco budworm pressure in non-Bt fields.

Beet armyworms were only a sporadic problem in 2002, with most of the fields that required treatment for beet armyworms being located in the South Delta. Fall armyworm infestations were more widely spread across the state, but in most cases, fall armyworms were not detected until very late in the season. Few treatments were applied specifically to control fall armyworms, but it was not uncommon to encounter low level infestations of fall armyworms in fields during late season. In most cases these late season fall armyworm infestations appeared to be sub-economic.

Loopers were somewhat more common than usual and there were a number of fields, especially later-maturing fields that either received a treatment specifically to control loopers or received a treatment to control a mixed population of loopers and bollworms.

Damaging infestations of whiteflies were uncommon, and very few fields required treatment for whiteflies.

By early September it was evident that statewide yield potential was much better than average and early harvest reports indicated excellent yields. During late September, Hurricane Isadore resulted in extremely heavy rainfall across the state, causing significant crop loss and interrupting harvest for many days. Unfortunately, this event was followed by a prolonged period of unseasonably frequent rainfall that that lasted throughout October and November and further interfered with timely harvest. As of the first week of November the crop was only 60% harvested, which is well behind the 5-year average of 94% harvested by this time. This delay in harvest resulted in additional weather related loss, both in yield and quality, making this the second consecutive year that Mississippi growers have made an excellent cotton crop, only to see it severely diminished by excessive late season rainfall. Estimated statewide yield is approximately 826 lbs (January, 2003 NASS Estimate), which is well above the previous five-year average of 741 lbs, despite the adverse harvest season.

In summary, overall insect pressure was relatively low in the Hill region of the state, but was much heavier in the Delta, which experienced relatively heavy bollworm pressure, as well as late season plant bug infestations. Yield potential of the crop was considerably better than average going into harvest, but was diminished in both yield and quality by excessive, prolonged rainfall during the harvest season. Mississippi continued to make progress in its effort to eradicate the boll weevil, but low numbers of this pest are still present in all eradication regions of the state. Statewide, insect induced yield losses were estimated at 6.8%, and the estimated average costs of insect control were $94/acre. Total per acre costs of insect control were estimated to be substantially higher in the Delta, $109/acre, than in the Hills where estimated insect control costs were only $63/acre.

‘Different’ pests continue to crop up in the NE Mississippi area probably because of the changes in farming practices which are occurring. Grasshoppers were again in outbreak numbers in grass crops, but also in soybeans and cotton in early parts of the season. Fall armyworms appeared much earlier than usual in grass crops and a number of pastures and hay fields required insecticide applications to halt the pest. Stink bugs, a heavy hitter in 2001, did not materialize as a major factor in 2002. Spider mites were also present in 2002 in some area cotton fields and there was a general awareness of pest populations in corn. In general, the year was fairly light for arthropods.

Boll weevil just will not give up and go away. There continues to be trap captures in the Tupelo area and in a number of other ‘hotspots’. The hill counties currently grow approximately 550,000 acres of cotton. Arthropod losses in 2002 were again light. All arthropods reduced yields by 4.55%. The bollworm/budworm complex caused the most problems reducing yields of NE Mississippi cotton by 2.5%. Northeast Mississippi farmers combat these pests by 1) planting Bt transgenic cotton, and 2) spraying insecticides for their control. Only about ½ of the acres were treated with any insecticide in 2002, and about 60% of the acres were planted to the Bt transgenic varieties. Foliar applications of insecticide were low with an overall cost of $21 per acre in Northeast Mississippi. The total cost of arthropod management, including at planting insecticides, Bt use fees, eradication costs, scouting, and foliar insecticides was $63.22 per acre. Yields were higher again I 2002 than in a number of years with many farms reporting in excess of 2 bales per acre, but poor weather conditions delayed harvest until after Thanksgiving in many areas and took a toll on the excellent crop. A complete listing of all Cotton Insect Losses is available at http://www.msstate.edu/Entomology/Cotton.html.

Missouri
Planting started earlier than normal in southeast Missouri with much of the cotton planted in April and during the first week of May. In 2002, Missouri cotton growers planted approximately 385,000 acres of cotton. The crop was progressing well until the third week in May when the temperatures dropped, and it rained several inches. Seedling diseases became very severe, and thrips were present in above average numbers; thus, approximately 35,000-50,000 acres of cotton were either replanted or converted to other crops. The crop was very poor at the end of May but responded well to abnormally high DD60's and eventually produced a very good fruit load. There were dry periods during the growing season, but rains were fairly regular without being excessive and supplemental irrigation proved economical. In the fall, lodging was common due to high winds and a heavy fruit load (>85% fruit retention), and this caused some difficulty in applying harvest aid products. Multiple rains delayed harvest and reduced crop quality. The average estimated for 2002 (797 pounds) was 17.2% above the 5-year average (680 pounds) for Missouri. This year marked one of Missouri's best cotton crops, but it also was one of the most expensive ones because of heavy insect pressure.

Thrips infestations were above normal in most Missouri cotton fields. Cool, wet conditions during planting were a major factor in prolonging seedling exposure to thrips feeding damage and slowing the plants' uptake of soil- and seed-applied insecticide treatments. Isolated outbreaks of saltmarsh caterpillars and yellowstriped armyworms were reported in reduced- or no-till fields.

The Missouri Boll Weevil Eradication Program reported spring pheromone trap captures of overwintering boll weevils were down considerably in 2002 versus those reported in 2001. The Missouri Boll Weevil Eradication Program initiated early-season ULV Malathion applications at pin-head square growth stage during the June 6^{th}-10^{th} trapping cycle. An average of 5.3 ULV Malathion sprays were applied per acre for the 2002 season.

Aphid infestations were light for most of the season throughout southeast Missouri and generally were kept in check by above normal populations of various insect predators (particularly the ladybird beetles) and parasitoids throughout the growing season.

Plant bug infestations were about normal levels throughout the middle and later parts of the growing season. These infestations were partially suppressed by the boll weevil eradication sprays.

Bollworm and particularly tobacco budworm infestations were far above average in most southeast Missouri cotton fields during the 2002 growing season. Initial field infestations were first reported in early-July, and infestations rapidly built-up throughout the rest of July and into mid-August. Most fields received at least one insecticide overspray for bollworms and/or budworms. Extremely high levels of budworms were present in the latter part of the season and caused boll damage in many fields. The highest budworm pressure generally occurred along the western border of Missouri adjacent to the St. Francis River, and most fields in this area received multiple (as many as 5 or 6) insecticide oversprays. The greatest percent yield decrease among insect pests in Missouri for 2002 was attributed to the bollworm / budworm complex.

In summary, bollworm / budworm pressure was very high in 2002. Plant bug and thrips infestations were moderate with localized hot spots. Aphid, armyworm (beet, fall, and yellowstriped), boll weevil, European corn borer, looper, spider mite, stink bug, and whitefly infestations were light to absent in southeast Missouri.

New Mexico
Insect pressure was low in New Mexico in 2002. In other respects it was a fairly average year. Boll weevil eradication programs are in progress in all infested areas throughout the state. South-Central New Mexico is in the final stages of its program. The Pecos Valley began its second diapause treatment this fall. The eastern side of the state (Lea, Roosevelt, and Curry Counties) joined the Texas Boll Weevil Eradication Program. Quay County which has the only cotton not covered by a formal eradication program had no weevils captured in a voluntary trapping program.

The Mesilla Valley in south-Central New Mexico joined the pink bollworm eradication program that is in place throughout far West Texas. There were a few reports of economic damage from pink bollworm damage in the Mesilla Valley in the fall. Cotton acreage continued to decline, particularly in the southern part of the state which until recently had been offset by a concomitant increase in the northeastern side of New Mexico. Insect pressure in general was low. Yields are expected to average approximately 1.6 bales/acre.

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North Carolina
Thrips levels were perhaps the highest in over 30 years throughout much of North Carolina, with western flower thrips accounting for control difficulties some areas for the fourth year in a row. Approximately 95% of our growers used an at-

planting insecticide (including seed treatments) in 2002. Foliar treatments for thrips were applied to over 90% of the acreage, probably the highest on record. Some acreage was treated a second, and occasionally a third, time. This marks the third year in a row of high thrips populations and widespread foliar application for this pest complex.

Second-generation tobacco budworms (June to early July) were very low throughout the state in again in 2002. Less than 2% of the state's cotton acreage was treated for these early budworms, similar to the 1% and 0.5% treated in 2000 and 2001, respectively. However, budworms were an occasional problem in the next late-July to early August generation, confounding bollworm control in several of our northeastern counties.

Cotton aphids occurred low to moderate, in most cotton fields, but did reach treatable levels in some areas. Approximately 7% of the state's cotton acreage was treated for cotton aphids in 2002. The aphid-parasitic fungus, *Neozygites fresenii*, generally arrived on schedule to a little late relative to the generally dry early cotton crop present in most areas. By the end of the season, aphids in opening cotton were virtually nonexistent. Biocontrol remains the major means of consistently reducing or eliminating populations of cotton aphids in North Carolina.

Plant bug numbers were extremely low in the early part of the season (pre-bloom), and also generally low to low-moderate later in the season on Bollgard cotton. Essentially none of the state's acreage was treated for pre-bloom plant bugs this year, far less than our longer-term average of about 2 percent. Approximately 10% percent of the Bollgard cotton acreage cotton was treated specifically for post-bloom plant bugs in 2002, somewhat higher than the past two years.

The major mid-July to early-August bollworm moth flight generation averaged about 1 week earlier than our long-term average this past year. Flight intensity and egg deposition were up significantly from 2001, catching some by surprise. Statewide damage to bolls by bollworms on conventional cotton, at 5.12%, was on the high side, though similar to last year when low levels of bollworms occurred over a longer time period without treatment. The average number of pesticide treatments used for bollworms and other late season pests was 2.7, almost identical to our 15-year average of 2.8 applications, although pyrethroid usage rates have crept upwards in recent years. Bollworm establishment under bloom tags (dried flowers stuck to small bolls), was again common in both conventional and Bollgard cotton.

Bollgard cotton (varieties that have been genetically altered to express the caterpillar toxin of *Bacillus thuringiensis)* was planted on approximately 70% of the state's cotton acreage in 2002, up 5% from the prior year. Bollgard cotton was treated an average of 1.12 times, up slightly from the 0.99 applications in 2001. Mean boll damage to Bollgard cotton from bollworms one-fifth of that found in conventional cotton (1.02% versus 5.12%), and overall boll damage to Bollgard cotton was about half of that found in Bollgard cotton (3.17% vs. 6.28%). After relatively high boll damage on Bollgard cotton caused by stink bugs (and to a lesser degree plant bugs) in 2000 and 2001, boll damage was down in 2002 (2.06%).

Migratory beet armyworm moths and larvae were perhaps the highest on record in North Carolina in 2002, with the larvae found in every cotton growing county, occasionally at damaging levels. Beet armyworms had become established in prebloom cotton as early as the second week in June. With producers and consultants accustomed to employing a 3% live bollworm threshold on fruit, it was disconcerting to see up to 15 or more beet armyworms per foot, and such readily-apparent defoliation. However, in many cases consultants and producers withheld treatment in situations where defoliation did not threaten potential yields or where damage to fruit was only minimal or marginal. Approximately 14% of the state's cotton acreage was treated for beets, unprecedented here.

As of this writing (late-October), 14 boll weevils were trapped in October, 13 in Nash County near Spring Hope, and a single capture in Clayton at the Central Crops Research Station. These areas will continue to be pheromone-trapped during the winter and spring.

It would appear that North Carolina cotton producers will pick an average of approximately 460 pounds of lint from 930,000 acres in 2002, considerably down from the record of almost 825 pounds per acre harvested in 2001.

Oklahoma

Over 174,000 acres were planted in 2002. Rainfall in early July improved yield expectations across the state. A cooler than normal summer reduced heat unit accumulations by 182 units (May 1st to October 1st); however sufficient heat units occurred to produce a full crop. The state's production average is projected at 580 lbs. of lint per acre.

Despite widespread use of at-planting insecticides, thrips infestations built to damaging levels across the state. Cotton fleahopper infestations were widespread requiring many fields to receive two insecticide applications to prevent significant yield loss.

Bt cotton continues to be very popular in Oklahoma and represented 35% of the cotton acreage in 2002. Bollworm pressure was spotty, emphasizing the importance of scouting. Conventional cotton received 1 or 2 insecticide applications to prevent worm damage. Populations spilled over into Bt cotton requiring over-sprays in approximately 51% of the fields.

Cotton aphid infestations flared during August. Heaviest aphid infestations occurred in cotton intensely managed. This aphid buildup was short lived and did not reoccur.

South Carolina

The South Carolina Agricultural Statistics Service posted a harvested acreage figure of 286,000 of 300,000 planted (December 1, 2002). They expect an average yield of 252 lbs lint/acre. This would be the lowest yield since 1980, when 303 lbs lint/acre was reported. Total production is estimated at 150,000 bales, down 273,000 from last year. Although, 286,000 acres of cotton were grown through maturity, a sizeable proportion of this acreage was not harvested because production and quality were so poor that sales of the lint and seed would not have paid for the cost of defoliation, picking and ginning. A severe drought greatly limited cotton production, and a wet fall prevented farmers from harvesting their crop in a timely manner.

As expected, thrips were a problem on seedling cotton in most areas of the state. Growers treated over 90% of their acreage with aldicarb to control thrips, and many applied Temik 15G at rates of 5 lbs or more per acre to achieve nematode suppression as well. Thrips started showing up in economic numbers in cotton by the second week in May. Western flower thrips appeared to be the principle species involved in most cotton fields where economic damage occurred. Cool temperatures hampered seedling growth and allowed thrips to inflict some damage even where aldicarb was used. There were also some areas where low soil moisture inhibited the uptake of soil insecticides.

The spectrum of insect pests infesting seedling cotton has changed with the increasing acreage under conservation tillage. We have observed false chinch bugs during the last 5 years, and growers have apparently become so familiar with these pests that few inquiries about them were received in 2002. Grasshoppers were a problem throughout the state for the 3rd year in a row. Some growers had to apply insecticides to control grasshoppers in May, June and July. During the last couple of years, reports of negro bugs and burrower bugs have also become more common as pests on seedling cotton plants. There have been very few fields actually treated, but the potential for economic damage certainly exists, as growers are now utilizing conservation tillage practices on 50% or more of the cotton acreage.

A small flush of tobacco budworms occurred early in the season, with damaging infestations showing up in a few tobacco fields in the northeast part of the state during early June. But during the remainder of the growing season, budworm moths were hard to find, and few if any problems occurred with these insects in conventional cotton fields. We captured a few moths in pheromone traps in the Pee Dee area, but numbers were too low to even conduct vial tests for pyrethroid resistance in July, August and September. There are now fewer windows of opportunity for this species to proliferate with 70 to 75% of the cotton fields in South Carolina planted to *Bt* varieties .

Corn earworms numbers were higher above the lakes than at any time during the last 10 years. The percentages of infested corn ears ranged from 50 to 90% this year. Last year it was unusual to find as many as 50% infested. This resulted in greater numbers of bollworm moths being produced to lay their eggs in cotton, resulting in more pyrethroids being applied. However, there were no reported failures with pyrethroids in controlling bollworms for the forth consecutive year. Growers were generally able to control worms with two to six applications in conventional cotton varieties. About 70% of the Bt-cotton acreage was treated an average of two times for bollworms and/or stink bugs, while 25% was not treated at all.

Stink bugs have become a major pest problem throughout the state of South Carolina. This is not to say that every cotton field will have stink bug infestations, but it does mean that virtually every cotton field has the potential to suffer damage, and therefore, every field must be scouted for stink bugs and their damage symptoms. In 2002, Clemson University continued to recommend treating with insecticides on a boll-damage threshold of 15%, emphasizing the importance of examining quarter-sized bolls. Damage symptoms include: warty growths or probe marks on the carpal walls, discolored lint, and shrunken seeds. Since we have begun using a damaged-boll threshold, less emphasis has been placed on estimating actual stink bug numbers. Stink bug numbers were lower in 2002 than have been observed in several years. Although the average numbers of damaged bolls were lower than usual, there were still a few fields where damage was extremely high (50% or more of quarter-sized bolls). A few leaf-footed bugs were observed damaging bolls in cotton fields. Plant bugs have been prime suspects in some previous episodes of boll damage, but they did not show up in most fields this year.

Aphids appeared during the last week in June. By the third week in July most aphid infestations were eliminated by an epizootic of the fungus *Neozygites fresenii.* By the time bolls began opening there were few aphid problems. There were no economic problems from whiteflies.

In 2001, infestations of beet armyworms and fall armyworms could not be found in South Carolina. This year we started seeing infestations of beet armyworms in cotton with four to six true leaves in late May, and a few fields were treated then. Beet armyworms hung around the same fields and were still present in August in some cases. There were a few farmers who ended up treating three or four times to control beet armyworms. Fall armyworms were present, but numbers were generally below economic levels. Soybean loopers infested a few fields of cotton below the lakes, but few fields were sprayed.

Populations of beneficial insects were moderate to high in *Bt*-cotton fields. Fire ants have become one of the most important predators in minimum-tillage-*Bt*-cotton fields.

For the second consecutive year, there were no boll weevils captured in pheromone traps.

Tennessee

Tennessee planted 561,000 acres of cotton in 2002. Approximately 25,000 of these acres were lost to spring flooding of the Mississippi River and were not replanted to cotton. Between 80-85% of the crop was *Bt* cotton, with Paymaster 1218, Deltapine 451 BR, and Stoneville 4892 being the dominant varieties. Statewide yield is estimated to be between 670-680 lbs of lint per acre. This is above the previous five-year average (622 lbs) but below last year's record yield of 762 lbs. The lack of rainfall during July and early August reduced yield potential in parts of the state.

A Boll Weevil Eradication Program (BWEP) continues throughout West Tennessee. The southern portion of West Tennessee (Region 1) consists of 169,000 cotton acres and was in the fourth year of the BWEP. Regions 2 and 3 comprise 343,000 acres of cotton in the middle of northern portions of West Tennessee. Regions 2 and 3 started eradication in 2000. Progress toward boll weevil eradication continues but is being seriously hampered by the migration of weevils from areas of Arkansas that are not in an eradication program. 794,860 boll weevils were captured in 2002 on a total of 512,000 cotton acres in West Tennessee. This represents a 44% reduction in the number of weevils captured in 2001. No yield losses caused by boll weevils were reported. About 86% of these weevils were caught in the five counties, representing 28% of the acreage, adjacent to the Mississippi River. Growers in Regions 1, 2 and 3 were assessed a fee of $24, $19, and $15 dollars per acre, respectively, for boll weevil eradication efforts. Middle Tennessee, representing about 24,000 acres of cotton, is in a maintenance status of eradication and continues to be free of boll weevils.

Cutworm infestations were light in 2002, but most growers are using preventative pyrethroid applications, often applied in a band at-planting, for cutworm control. Thrips infestations were especially damaging in 2002 because of slow cotton growth caused by cold weather. A combination of seedling diseases and thrips injury forced the replanting of 100,000-125,000 acres. Most cotton fields were sprayed with foliar insecticides one or more times for thrips despite the extensive use of seed treatments or at-planting insecticides.

Cotton aphid populations were low in 2002, and few insecticide applications were made specifically for this pest. The use of insecticides such as dicrotophos (Bidrin), imidacloprid (Trimax) and thiamethoxam (Centric) for control of tarnished plant bugs also suppressed aphids. Light to moderate populations of tarnished plant bugs were treated in many fields, particularly prior to bloom. Spider mite infestations developed to treatable levels in some fields beginning in early July. A limited number of treatments for this pest were made.

Prior to bloom, green stink bug infestations were found in isolated fields. Significant square loss was observed in fields where nymphs were present. Damaging infestations of stink bugs in cotton prior to bloom are rarely reported. Because stink bugs were a significant pest in 2001, and because high populations of green stink bug were being observed during the early summer of 2002, we anticipated problems with this pest. However, stink bugs populations were not especially high once cotton began to bloom. A boll injury survey in late August and early September found 3.4% boll damage due to sucking pests, attributed primarily to stink bugs. Slightly more damage was observed in *Bt* cotton (4.2%) than in non-*Bt* cotton (2.7%). Nevertheless, isolated fields were heavily damaged, with maximum boll injury observed at 19%. This pest continues to be important in the low spray environments resulting from boll weevil eradication and the use of *Bt* cotton.

In the southern half of West Tennessee, clouded plant bugs were observed prior to bloom in many fields. After first bloom, populations of 10-20 insects per 100 plants were not uncommon and persisted throughout the season. Injury caused by clouded plant bugs was similar to that of tarnished plant bugs, causing "dirty blooms" by feeding on large squares. Nymphs were most commonly seen in blooms. "Cat facing" of small bolls was also observed. Few insecticide applications were made specifically for this pest. Applications targeting stink bugs or bollworm/budworm infestations helped to suppress clouded plant bugs populations.

Even though more than 80% of the cotton was planted to *Bt* varieties, bollworm and tobacco budworm were important pests in 2002. Moth traps indicated that bollworm was the predominant species, but high infestations of tobacco budworm on non-*Bt* cotton were found in localized areas. A late-season survey found an average of 9.4% boll damage caused by caterpillar pests in non-*Bt* fields. A maximum boll damage of 23.7% was observed in non-*Bt* fields. Non-refuge, non-*Bt* fields were often treated repeatedly with non-pyrethroid insecticides because of the presence of tobacco budworm. On average, 2.4% of bolls in *Bt* fields were damaged, with a maximum damage level of 6.3%. This injury was almost exclusively caused by bollworm populations that persisted for several weeks at moderate levels in many areas. Most *Bt* fields were sprayed at least once for bollworms, and a few fields were treated as many as three times. Pyrethroids were used and coincidentally helped to control stink bugs that were present.

Armyworms and loopers were not major pests this year. Beet armyworms required treatment during August in a few fields. A single application of methoxyfenozide (Intrepid) worked well at controlling infestations. Fall armyworms were present in low numbers in many fields of *Bt* and non-*Bt* cotton, causing a generally low percentage of late-season boll damage. Very few fields were treated with insecticide for this pest. Soybean loopers were found at unusually high numbers in 2002, but infestations were not severe enough to justify insecticide applications.

Other pests that were observed sporadically and usually in low numbers were grasshoppers, cotton fleahoppers, banded-winged whiteflies, and European corn borers. Overall, insect damage to cotton could be characterized as moderate but highly variable. Statewide, insect-induced yield losses were estimated at 7.2%, with an average insect control cost of $83/acre.

Texas

The 2002 harvested acreage was up again this year with over 5 million projected for harvest. Considerable acreage was lost in the Lower Rio Grande Valley (LRGV) and High Plains (HP) due to early and mid-season droughty conditions. Additional acreage was lost in the HP due to June severe weather, but this was less than in previous years. Texas encompasses a large geographical region, and hence rainfall and moisture conditions can and were highly variable. The LRGV, some parts of the Rolling plains, and the southern HP had below normal rainfall amounts until later in the season, and dryland acreage yields suffered accordingly. Other areas of the state, such as the Blacklands, had excellent rainfall patterns, and yields were increased over 40%. Late rains did hamper harvest operations in many areas of the state but did not appear to significantly impact yields or fiber quality.

Heat unit accumulations were again above normal, although May was a little cool. Where water was available in sufficient amounts, yields were at record levels in some areas. Four and five bale per acre yields and good fiber quality will put money in some producers pockets since management expenses were generally light. The absence of damaging boll weevil populations in most of the state due to a successful eradication program allowed for the development of a significant top crop.

Much of the state's acreage continues to be planted to Roundup Ready. Bollgard type cotton was planted on more acreage this year because of the start of new boll weevil eradication programs and the potential threat of increased secondary pest problems. Fibermax varieties continued to expand their acreage coverage because of high yields and excellent fiber properties.

The 2002 pest situation was better than previous years, but bollworms did rise to the top of the list as far as yield losses and management costs. Bollworms had been absent as a serious pest for most areas over the preceding two years. Tobacco budworms were not a factor in most cotton fields but did cause some pyrethroid failures in the Blacklands. In areas such as the Blacklands, High Plains and Rolling Plains, heavy bollworm numbers if not controlled resulted in high yield losses. A section 18 for Denim was in place as an alternative for budworm control. Both beet armyworms and fall armyworms infested many fields in the Lubbock and surrounding area in August, and Intrepid was highly effective in providing control.

Early season pest problems were light, except maybe in the South Texas and High Plains areas. Early thrips damage did not impact yields much as excellent growing conditions permitted compensation. Cotton fleahoppers and early Lygus were not much of a factor this year.

Boll weevils have been limited in most areas by the eradication program. The LRGV did have a serious potential problem, but droughty conditions prevented most of this potential from being realized, at least in the dryland acreage. Irrigated acreage did have a problem with this pest with up to 9 applications required for control. The LRGV is one of only three areas not currently enrolled in an eradication program. Boll weevil pressure was high in the Upper Gulf Coast (UGC) area which started its program this fall. The same was true of the southern Blacklands zone which entered its first full season year. Some weevil damage was recorded in this latter program area. The TBWEF program was generally successful in 2002, although no new zones have been declared functionally eradicated since the Southern Rolling Plains and Rolling Plains Central zones. There were some problem areas this year, probably due to better than average boll weevil population development conditions. The program suffered from some detection problems as well as migration and late rain interference with applications. The zones experiencing the most problems were the South Texas/Winter Garden (ST/WG), Permian Basin (PB) and Rolling Plains Central. The ST/WG program had migration problems from the LRGV and the UCB programs. The RPC program had problems with migration from the PB zone which developed weevils on cotton plants hidden in failed cotton fields replanted to other crops. And for the first time since 2002, a few boll weevils were trapped in fields near highways and railroad right-of-ways in the functionally eradicated SRP zone. All these problem areas were dealt with through aggressive spray programs. Texas is still on track for boll weevil eradication.

Dry conditions did create situations where grasshoppers invaded margins of cotton fields, especially in the southern HP and Rolling Plains areas. One or two applications of Bidrin or a pyrethroid usually solved the problem. But the pyrethroid applications did create some additional aphid problems. Aphids as a whole were not a serious problem for most cotton fields in much of the state. Natural enemies and other unknown causes prevented most infestations from persisting very long. Furadan 4F was again available through a Section 18 but little was used. Most producers opted to use either Intruder or Centric.

Some additional pest problems involved late *Lygus hesperus* and conchuela stink bug problems in the Far West Texas area, brown and southern green stink bugs in the South Texas area, pink bollworms in the Gaines County area of the HP, and late silverleaf whitefly problems in the El Paso area. There have been no reported instances of sticky cotton in Texas thus far.

Lower Rio Grande Valley (LRGV). Moisture was inadequate for most of the LRGV's cotton and grain sorghum crops in 2002. No significant rainfall was recorded during most of the production period of February through mid-May, except in isolated spots. Significant rainfall occurred after mid May. Unfortunately, that moisture was not timely enough to help the dryland farms and much of the irrigated land. Cotton had bloomed out the top of the plants, and there was not time enough to produce new squares and small bolls, as well as finish those bolls into an economical yield before the crop had to be terminated. The shortfall of rain resulted in approximately 70% of the crop being destroyed without harvest. Those farms with adequate irrigation water and helpful, though spotty, rain showers, produced very good yields in excess of 2 bales per acre. However, for the majority of the cotton crop, the yields were less than economical. Overall, yields were slightly above 200 pounds per acre, based on planted acres.

Insects were of concern in the 2002 crop season. However, only boll weevils posed any significant threat to the yield potential of this year's crop. Boll weevils were a threat to many area fields in 2002. Had adequate moisture been available, it can be speculated that boll weevils would have been a major part of any insect crop loss due to the potential the pests were to this year's crop. Trap captures in the spring and early summer were considered of concern, though not at record levels such as were seen in some previous seasons. Due to short moisture conditions early in the season, many weevil punctured squares yielded only dead grubs in the few squares found on the ground, especially in dryland cotton fields. Irrigated fields had many more weevils but not at levels seen in many years previous. Only after significant rains fell in late May and later did boll weevil numbers begin to climb to high levels in traps and fields. Irrigated fields had to be treated much more frequently after the rains fell in late May and beyond. Some irrigated fields received as many as 9 insecticide applications for weevils in 2002. The overall range of treatments ranged from 0 in most dryland fields to 9 in some irrigated fields.

Cotton aphids appeared about the same time as usual in 2002, but overall, aphid infestations were light compared to most recent years. A section 18 emergency clearance for the use of Furadan insecticide was cleared in the LRGV this year, but the amount of Furadan used was relatively small compared to many previous years of need.

Cotton fleahoppers were very light with some fields requiring treatment. Overall average yields were not threatened by fleahoppers.

Bollworms/tobacco budworms were noted early in the season, particularly in the mid-Valley. Most of the worm population appeared to be bollworm, but some budworms were reported in a few fields in late April. Generally, bollworms/budworms did not pose a major threat to the overall cotton crop in the LRGV this year.

Beet armyworms, loopers and all other worm pests did not appear in any large numbers in 2002, and no reports of insecticide applications for any of these pests were received.

Fiber quality was considered good in 2002. The percent of high micronaire (5.0 and above) was down considerably this year at only 10% compared to many previous years of 20-35% high mic. All other quality factors were good for 2002.

Coastal Bend(CB). Cotton was planted during March and April along the Gulf Coast. Planting conditions were extremely dry and stand establishment was difficult to achieve; no-till ground was too hard to plant. Generally, these dry conditions prevailed for many weeks. Adequate rainfall was finally achieved to produce a moderate to excellent crop; it all depended upon timeliness and amounts received. Given the dry conditions, yields were surprisingly good and ranged from about 400 lb/acre to over 1500 lb/acre with the higher yields on the Upper Gulf Coast. Excessive rainfall delayed harvest in the Upper Gulf Coast and interfered with boll weevil eradication. This season marked initiation of boll weevil eradication in the Upper Gulf Coast counties. Rainfall after harvest resulted in widespread cotton regrowth and heavy expense for boll weevil eradication in both the Lower Gulf Coast and Upper Gulf Coast programs.

Thrips infestations ranged from low to high, with heavy infestations generally confined to areas near range and pasture land. Generally, greater numbers of thrips occurred in upper coast counties. Aphids reached treatment threshold on about 50% of the acreage between the 4-leaf and early bloom period, with the majority on infestation along the lower coast. Natural enemies reduced aphid numbers for the remainder of the season. Cotton fleahoppers required 1-2 treatments. Bollworm and tobacco budworm infestations were generally higher than in past years, and about 50% of the acreage required one treatment. No control problems were observed, except where pyrethroids were used for tobacco budworms. Initially, spider mites developed but finally disappeared without need for treatment. Boll weevils were low in the established eradication zone except for an outbreak along the southern boundary. Some movement into the zone occurred between the older zone and the newly initiated zone in the upper coast. Boll weevil infestation was very heavy by late season along the Upper Gulf Coast (boll weevil eradication was initiated in July in the area). Other insect pests that required treatment included small acreage treatments for saltmarsh caterpillar. Brown stink bug and southern green stink bug required treatment in upper coast counties (30% of acres treated 1 time).

Northern Blacklands(NB). Early planting and significant and timely rainfall during May and June demonstrated that water is the limiting factor to cotton yield in the northern Blacklands. Average yield were estimated to be about 600 lbs, compared to annual average of 420, and 2 bale yields were not uncommon. For the first time in several years, bollworms reached economic levels in mid-season, requiring many fields to be treated for this pest. Also, boll weevils and early season thrips were at somewhat higher numbers than past years. Growers and landlords will vote in the first boll weevil referendum for the Northern Blacklands Zone in November 2002.

Southern Blacklands (SB). Early season Insects, thrips, aphids, and fleahoppers were light to normal. Boll Weevil pressure was light throughout the season as a result of 1st full season of eradication. Light feeding and egg laying activity (up to 8% in few fields) occurred in mid- July, but the weevil program brought those numbers down quickly. Bollworm/budworm pressure was very heavy as a result of heavy weevil spraying. Counts exceeded 2 per plant in a few fields. Worm pressure lasted from late June to late July which accompanied the 6-8 inches of rain that fell in early July. Bt fields held up well to worms, but non Bt cotton was sprayed an average of 2.5 times for worms.

Northern Rolling Plains(NRP). No report available.

Southern Rolling Plains(SRP). The moisture situation varied widely traveling from north to south in the Southern Rolling Plains. In the northern part of the zone, moisture was marginal to good. Cotton was planted on time (from mid-May to mid-June). South of Interstate 20, moisture was marginal to poor. Available moisture depleted rapidly after May 1 and many fields were planted late. Even many of the irrigated fields that are normally planted in the first two weeks of May were not planted until the first week of June.

Most early season insect populations were low. Thrips were a minor problem in the northern part of the region, but very few fields were treated. Fields were planted so late in the southern part of the region that thrips were not a concern. Grasshoppers were the primary early season pest and continued to plague cotton until the first week in July. The majority of the acreage was infested, and many fields received one to two treatments. The problem was light in the northern part of the zone and became worse going south. Primarily field margins were treated, with pyrethroids and dicrotophos being the two primary insecticides used. Most field margins treated were sprayed once; however, it was not unusual to find some producers who had to treat up to five times to save their stand.

Cotton progressed slowly, and fruit retention was lower than average during the first three weeks of squaring. Cotton fleahoppers were only a minor concern, but about ten percent of the acreage was treated due to the low square sets.

Moisture conditions improved through the month of June with the northern area receiving most of the rainfall. Rainfall events were not heavy with a total of 1.4 inches and 1.5 inches in June and July, but the rains were timely and kept the cotton growing during the squaring stage. Bollworm populations seemed to develop from north to south. The northern region had a significant egg deposition during the second and third week of July. This was during the late square/early bloom stage, and bollworms caused significant damage if left untreated. The southern part of the region escaped most of this population, and only slight damage occurred. However, with the early pyrethroid use for grasshoppers, aphids became a concern in the southern part since natural enemies were depleted.

The rains in July seemed to help the cotton progress rapidly, and the northern part of the region was able to recover from the bollworm damage. Moisture conditions were fair going into August and the blooming period. However, rainfall continued to occur in a timely fashion and cotton conditions continued to improve. The northern part of the area had few pest problems through August and took advantage of improving moisture conditions. The southern part of the region experienced a heavy bollworm flight and populations reached damaging levels, especially in areas where rainfall was plentiful. A small percentage of the Bt transgenic cotton acres were treated at this time. The additional applications of pyrethroids and the cloudy weather increased aphid populations, and five percent of the acres were treated with primarily acetamiprid, thiamethoxam and imidacloprid.

The crop progressed and fruited well during the month of August. Rainfall events became more consistent over the area during the month of September, and producers were able to take advantage of the moisture to make average to above average crops despite the late start in the southern part of the region. Harvest was delayed with the rainfall in September, and October however yields are expected to remain above average.

The region includes two of the zones in the Texas Boll Weevil Eradication Foundation program. The northern part of the region includes the Rolling Plains Central. The western edge of this zone has experienced a large migration from other zones, and trap catches and insecticide applications in this part of the zone increased in 2002 from 2001. The southern part of the region includes all of the Southern Rolling Plains. This zone caught boll weevils late in the season along highways and railroad right of way. These were the first weevils trapped since 2000. Overall, the program continues to make good progress, and producer satisfaction remains high.

High Plains (HP). The 2002 season, like 2001 began with considerable promise due to the good soil moisture conditions from winter rains. Also, another cold winter promised to provide some relief from pests. Unfortunately, from May through mid-September only June provided normal rainfall amounts. The remaining period was generally dry for most of the area. Significant rainfall did not occur again until October, when rainfall events actually caught us back up to historical averages for the year. This dry period and soil surface moisture loss due to excessive winds, resulted in a loss of about 684,000 planted acres, which never achieved a stand during the acceptable window and were failed for insurance purposes. Later spotty rains did cause some of this cotton to germinate in fields that had been replanted to sorghum or haygrazer, causing later problems for the boll weevil eradication program. Severe storms, mostly as 3 events prior to mid June, resulted in more losses totaling 210,000 acres, of which 160,000 did not get replanted back to cotton. This resulted in a total of 3.65 million acres planted but only 2.85 million acres surviving to harvest. Bollgard cotton varieties represented about 235,000 planted acres. Fibermax varieties prevailed.

The harvest period was plagued with rainy conditions delaying stripper operations but fortunately not causing much yield or quality losses. Growing conditions for irrigated cotton were near optimal for the first time in the last 26 seasons. Over 2,500 heat units were accumulated during the growing season for the Lubbock area. Nighttime temperatures were warm while daily highs were moderate, with only 3 days recording a temperature of 100^0 or higher. Higher than normal humidity levels probably moderated temperatures and moisture conditions as well. Losses due to diseases was low (2%) as was the case for insects (2.4%). With boll weevil eradication in progress across all acreage, the top crop was assured of making it to the gin. Consequently, record yields exceeding five bales per acre were reported in several fields with either sprinkler or drip irrigation. But since the dryland crop was limited by moisture and represents a large portion of the acreage, the average yield across the area was 545 lbs. per acre.

Early season thrips infestations were again a problem across much of the area, and significant damage was documented in several tests conducted this year. However, because environmental conditions were near ideal, this early damage was more than compensated for by the end of the season. Both Lygus bugs and cotton fleahoppers were a minor issue again this year. Some consultants suggested that Lygus was a problem in some fields with lowered square retention levels, but surveys did not detect any significant numbers of either pest. With only a very few exceptions, no fields were infested at damaging levels during any part of the season. In fact, two tests planned to address these 2 pests were unsuccessful because of their absence.

The biggest story as far as insects were concerned was the near absence of boll weevils for the first time since 1995. Early trapping and surveys of overwintering sites indicated very low survival of boll weevils during the winter. Consequently, the Texas Boll Weevil Eradication Foundation (TBWEF) decided to use 3rd year field application trap trigger values in the two new areas entering their first full season programs. Overall the eradication program was a success with only a few isolated problems. A field north of Levelland in the Southern High Plains/ Caprock zone developed very high boll weevil numbers as evidenced by September trap catches averaging between 600-800 weevils per trap week. This field, along with other problem fields was put on a 5-day schedule of treatment. Another serious problem developed in the Permian Basin zone where there was a blowup which was not detected early enough to prevent many fields in the surrounding area and adjacent Rolling Plains Central zone from being infested. This problem probably resulted in an additional a million-acre applications. Migration from northern Glasscock County (not in an active zone) and undetected boll weevil infestation development on late germinating cotton plants in failed cotton fields planted back to sorghum or haygrazer were two causes of this problem. It would appear the TBWEF has succeeded in gaining control of these problems by the end of the season.

Bollworms appeared to "blow" into the area from the southeast on winds that normally come from the southwest. The epicenter of the problem was in Lubbock County. Other areas were also affected to a lesser degree. There were several complaints about pyrethroid performance. Larval examinations indicated populations were 100% bollworm. Coverage issues were thought to be the main cause of some of these control problems, but the resistance issue was still a consideration. A statewide resistance monitoring program will be initiated next year. Following on the heels of this bollworm flight was an invasion of beet armyworms. While the epicenter was again in Lubbock County which occupied a zone that was in its first full season year of eradication, there was no consistent pattern of beet armyworm infestations to sprayed fields. However, the TBWEF did alter the trap triggers for this county and some work units in Hockley and Hale counties for a period of 4 weeks. This reduced accumulative weekly sprayed acreage by work unit 10 by 10-15%. Fall armyworms appeared toward the tail end of the beet armyworm problem in August. Intrepid worked very well for both armyworm species.

Aphid infestations developed in late July and early August but did not persist very long. Their short duration was generally not due to predation, parasitism, or diseases. Because infestations did not persist, insecticide screening was difficult and sticky cotton was a non-issue. Intruder was the insecticide of choice even though Furadan was available through a Section 18. Intruder provided outstanding control.

Far West Texas (FWT). Cotton producers across the Far West Texas production area generally experienced average spring and early summer temperatures and rainfall in 2002. For the first time in several years, normal to above normal rainfall during spring and early summer resulted in decent dryland production. Dryland cotton generally began cutout in mid to late summer due to low rainfall. Heat unit accumulation across the region was normal to slightly below normal.

Early season insect pests did not cause much economic damage across the Far West Texas region. However, several mid to late season pests did cause significant cotton yield loss across the region. El Paso and Hudspeth county cotton producers contended with *Lygus hesperus* and whitefly problems, Pecos and Reeves county cotton producers contended with concheula stinkbugs, and most of the dryland production area experienced problems with cotton bollworm and cotton aphids.

Bt cotton acreage decreased slightly because of poor cotton prices and generally low pest pressure during previous growing seasons. The El Paso/Trans-Pecos eradication zone is finishing up its 4th year of boll weevil eradication and the 2nd year of pink bollworm suppression. Boll weevils were not caught in traps until September and never exceeded 0.0034 weevil/trap for any one trapping period. While pink bollworm adults were caught in traps throughout the season, average trap catches were only 16.25% of the 1st year's average trap catches .

Virginia

An estimated 103,000 acres were planted in Virginia. Early season conditions were generally challenging for cotton with cool, dry conditions slowing seed germination and seedling growth. During the season, overall, rainfall was well below normal with some fields never achieving potential plant growth. Isolated areas did receive rains at times critical to crop growth and maturity. With these challenges, the average projected lint yield is estimated to be no more than 500-550 lb/acre, well below what has been normal for Virginia.

Transgenic Cotton Varieties. An estimated 20% of the cotton acreage was planted to Roundup Ready varieties. An estimated 65% was planted to stacked gene (RR/BG) varieties with the bollgard gene, which was up slightly from the 2001 season.

Insect Pest Overview. Cool, dry early-season conditions resulted in both heavy thrips populations and slow seeding growth – the worst possible combination for creating the potential for excessive thrips damage. For a number of postulated reasons (trend of warm winters that have favored survivorship of both thrips and their alternate winter weed hosts, increase in grain cover crop, increase in logging activity and leaving cutovers with large populations of alternate weed hosts) thrips populations seem to be on the increase. Damage was severe in insecticide-unprotected cotton. Preliminary data showed 245 lb lint/acre losses in insecticide-unprotected vs. protected cotton. Most producers applied Temik 15G in furrow, or on a limited basis Gaucho 480 to seed, for thrips control. The heavy thrips pressure required most producers to make an average of 1-3 foliar insecticide applications/acre, up from the normal 1 application/acre. Several collections of adult thrips, both from the research farm and from growers' fields, were identified to species (Jack Reed, MS State). All but the last sample was comprised of primarily, *Frankliniella fusca*. The last sample from a grower's field in Southampton County contained a large percentage of western flower thrips, *Frankliniella occidentalis*.

Cotton aphid populations were reported in some fields early in the season, basically disappeared, then reappeared (along with white fly, species unknown) after bollworm sprays later in the season (mid-August and September). Natural enemy populations were aggressive and in most cases, eliminated aphids before insecticide treatments were needed. No acres were known to have been treated. Some honeydew collected on leaves and terminals, but no cotton was known to develop sooty mold on open boll lint.

Plant bugs and stink bugs damaged fruit, especially young bolls in a few fields in June and July. Most appeared to be caused by *Lygus* rather than stinkbugs, although stinkbugs were evident in some fields. An effort was made to begin documenting levels of bug presence and damage. Forty-six growers' fields across the cotton area were surveyed weekly from pinhead square to when bollworm spray programs were initiated by growers. Results showed that: mean plant height was 30.5 inches; mean node number was 14.5; mean position of the first reproductive node was 5.7; 80% of the fields had plant bugs (range = 0-3/6 row ft, range = 0-2/25 sweeps) – 4% at threshold based on sweep net sampling (*Current thresholds: 8/100 sweeps*); 38% had stink bugs (range = 0-1/6 row ft, range = 0-0.5/25 sweeps) – 4% at threshold based on beat sheet samples (*Current threshold 1/6row ft*), none at threshold based on sweep net samples (*Current threshold 1/25 sweeps*); 88% had flower damage (range = 0-53%) – 21% (9 fields) over threshold (*Current thresholds15% dirty blooms*); 32% had boll damage (range = 0-18%) – 7% over threshold (*Current thresholds10% damaged fruit*). An estimated 1000 acres were treated with pyrethroids for bug problems, and this was prior to the initiation of bollworm sprays. Once bollworm sprays commenced, bug problems subsided. There was a small amount of bug damage evident on small top and outer canopy bolls after crop defoliation, indicating that late season populations resurged in some areas after bollworm spray residues diminished.

Bollworm populations were extremely high, began earlier, and lasted longer compared with previous years. This was predicted based on the mid-July field corn survey. Percent infested corn ears for the cotton growing counties averaged 75.1% compared with 26.4% in 2001. There were essentially two corn crops in terms of rate of maturity. Much of the corn crop was drought stressed and dried down early. However, there were some fields with more normal corn in areas that received a few timely rains. This created two major moth flights, the first one early as moths migrated out of drought-stressed corn, and a second as moths left corn that dried down at the normal time. Many fields reached the egg threshold by late July. Because of the two moth flights, most producers made at least one additional spray, 3 vs. 2 in conventional cotton, and 2 vs. one in Bollgard cotton. *The additional spray was also used against beet armyworm (see below).*

A third year cypermethrin and second year spinosad adult vial testing program was conducted (G. Payne supplied pre-treated vials). 1147 moths were tested from two locations with mean survival rates of 5.0% and 1.7% at the 5ug and 10ug cypermethrin rates, respectively; and 5.5% survival at the 15ug spinosad rate. These were similar to survival rates in 2001, which were low compared with survival rates as high as 23% with cypermethrin in 2000.

Twenty different egg samples from grower fields were tested with the Agdia Helid egg test (Z. Harrell, FMC – sponsored) from July 24-Aug 30. There were 80% TBW on July 24, dropped to 5% by mid August, increased to an average of 14% through the end of August. 618 larvae were determined to species by examining mandibles. Collections came from cotton, soybean and peanut fields. TBW was present in all crops: peanut – range 0-10%, mean 5%; soybean – range 0-11%, mean 4%; cotton 5-45%, mean 10%.

Spider mites persisted at low levels in many fields causing some leaf reddening. An estimated 2500-5000 acres were treated for spider mites. No boll weevils were trapped. Beet armyworm (BAW) moved into Virginia in the last week of July. At least three generations followed with larvae appearing in fields into early September. Most damage was scattered and often concentrated on field edges or areas in fields with poor stands. Foliar damage was significant in a number of fields, and many were treated. The occurrence of BAW is highly unusual in Virginia and has never been previously reported in cotton. There was no damage attributable to cutworm, European corn borer, and fall armyworm.

Research Progress and Accomplishments

Alabama
Most of the new and novel chemistry and genetically altered technology were field evaluated to determine were they best fit in the Alabama cotton IPM production system. This included chemicals such as Cruiser, Centric, Vydate, Denim, Intruder, Trimax, Steward, Intrepid, Tracer, S-1812, XDE-225, F-0570, Novaluron; and genetically altered varieties with Bollgard II and Cry1Ac/Cry1F traits. (Department of Entomology and Plant Pathology, Auburn University, Auburn, AL)

Arizona
Transgenic Cotton (Bt). Studies were continued to evaluate natural enemy conservation in transgenic and non-transgenic cottons and comparative rates of predation and parasitism on sweetpotato whitefly (SPW) nymphs and pink bollworm (PBW) eggs. Results suggest that there are no direct or indirect effects of Bt toxins on populations of natural enemies, but spatial distributions of predators appear to be consistently less aggregated in Bt-cotton compared with non Bt-cotton. Since no measurable non-target effects of transgenic cotton on the natural enemy community occur, fewer samples may be required to estimate densities of natural enemies, leading to cost reductions in monitoring activities.

PBW and Bt Susceptibility. PBW colonies have been established from field populations collected in Arizona and California and maintained in the laboratory to determine baseline Bt susceptibility. LD_{50}s with 95% confidence intervals have been generated as a baseline to compare to future field generations of PBW.

Bt Cotton and PBW Evaluations. Bt cotton has been a major factor in PBW management since it was introduced commercially in 1996, but resistance is a constant threat. Our studies show the toxic protein content in bolls decreasing from 0.14 ppm at 83 days after planting to 0.05 ppm on day 152 after planting with 100% PBW mortality occurring at the lowest concentration. It appears that PBW larvae are extremely susceptible to the Bt toxic protein and its use in > 60% of Arizona's cotton acreage has avoided resistance development.

Cotton Plowdown. Cultural control is the most important PBW management tool. Cooperative studies with USDA-APHIS and the Arizona Cotton Research and Protection Council are developing and validating sampling methods for determining compliance with state of Arizona cotton plow-down requirements and are determining level of risk associated with current guidelines for minimizing overwintering PBW populations.

Moth Pheromones. Semiochemicals are the basis for communication in some lepidopterous insects. Qualitative and quantitative analysis of moth pheromone research has been initiated at the Western Cotton Research Laboratory in order to find trends and relationships between use of moth pheromone components and species to understand principles of mating systems, speciation processes, chemical ecology, and evolution.

Lygus. *Lygus* dispersal has a major influence on its role as an economic pest. Cooperative studies of the comparative flight behavior of *Lygus hesperus* and *Lygus lineolaris* are being conducted using a tethered flight system and a free-flight chamber. Results are being used to characterize the flight behavior of the two species in relation to sex, age and reproductive status for possible use in development of management strategies.

Response of *Lygus Hesperus* to Visual and Host-Plant Cues. Studies were conducted to ascertain the response of 5th instar and adult *Lygus hesperus* to alfalfa volatile compounds alone or in combination with a green light-emitting diode. Adult females but not males were attracted to odors associated with flowering alfalfa with conspecifics, and to vegetative and flowering alfalfa that had been fed on by *Lygus*. Nymphs and adult females chose all treatments over clean air, and males exhibited a preference to vegetative alfalfa with conspecifics.

SPW Parasite Dispersal. Knowledge of parasite dispersal within and between infested crops is essential for evaluation of biological agent impacts. We protein marked SPW parasitoids, *Eretmocerus emiratus*, to measure their dispersal pattern in cotton, melon and okra fields. A total of 1388, 637, and 397 marked and unmarked wasps were captured in suction traps during each of three trials, most between 0600 and 0800 h. Almost all of the marked parasitoids recaptured in the cotton plot were at or adjacent to the release site; marked parasitoids were recaptured more frequently in distant traps located in the cantaloupe plot rather than in distant traps located in the cotton and okra plots.

SPW Predators. Little data are available on how many SPW a predator can consume or which of the lifestages are most vulnerable to attack. Feeding behavior of six predators on SPW life stages was evaluated by recording feeding, resting, grooming, walking, and probing. Results showed: a) piercing/sucking predators (e.g., big-eyed bugs, *Lygus*, and minute pirate bugs) and the predatory fly, *Drapetis,* fed almost exclusively on adult SPW; b) chewing predators (e.g., lady beetles and collops beetles) fed equally on SPW eggs and adults, and c) none of the predators examined in this study fed on SPW nymphs. *Lygus* can cause damage and reduce cotton yields, but information on *Lygus* as predators of SPW eggs and adults shows the need to further evaluate the capacity of their impact on SPW since under certain conditions predation on SPW may outweigh plant damage.

SPW Chemical Control. Biorational insecticides, including the IGRs buprofezin and pyriproxifen, entomopathogens, and neem products were evaluated for effect on SPW predators. The biorationals studied were generally safe for predators with the exception of pyriproxifen on coccinellid lady bird beetles.

SPW Insecticide Resistance. Imidacloprid is a key insecticide in cotton, vegetable, and melon integrated pest management studies in the Southwest. We monitored SPW susceptibility to imidacloprid as a resistance management strategy to detect changes and modify use patterns to maintain its effectiveness. SPW populations have remained susceptible for 9 years compared to SPW populations in Guatemala that were tested as over 100-fold resistant to imidacloprid relative to Imperial Valley populations.

SPW Population Dynamics. We are examining and quantitatively describing the year-round SPW population dynamics to identify potential vulnerable links that may be used in control strategies. Plots of alfalfa, fall and spring cantaloupe, broccoli, cotton, ornamental lantana, and native weeds have been established at Maricopa, Yuma and Marana University of Arizona Agricultural Centers. Results show: a) differential mortality on different hosts and are identified as key factors in SPW population dynamics; and b) several common predators of SPW may preferentially prey on parasitized SPW.

SPW Predators. Selective insecticides that conserve natural enemies are urgently needed in SPW-IPM. Toxicological studies with predators *Geocoris punctipes*, *Orius insidiosus,* and *Collops vittatus* found in cotton areas are significantly affected by insect growth regulators, buprofezin and pyriproxifen used for SPW control. Broad-spectrum insecticides predictably reduce populations of most natural enemy species. All insecticides effectively reduced SPW populations, but the IGRs lead to more favorable predator to prey ratios across the season.

SPW Sticky Cotton. Cotton lint stickiness is the most important quality concern of the cotton textile industry. Sampling plans for the estimation of lint stickiness due to SPW honeydew contamination suggested that stickiness can be reliably detected using thermodetector technology with relatively few samples. Sample plans developed may be useful for research purposes, but the required number of samples make the methods impractical for large scale quality testing at classing offices.

Honeydew Cotton Contamination. SPW is the number one cotton pest causing sticky cotton throughout the world. We conducted research to determine factors affecting SPW honeydew cotton lint contamination. Results have shown that trehalulose and melezitose, in the SPW produced honeydew, are major contributors to stickiness, and amount of SPW honeydew produced is affected by the host plants it is feeding on. Action and economic SPW stickiness thresholds have been established and are updated as needed to assist the cotton industry reducing or eliminating sticky cotton.

SPW Trapping. Sampling methods are urgently needed for SPW monitoring. Light emitting-diode equipped yellow sticky card (LED-YC) and CC SPW (LED-CC) traps are being researched as possible decision-making tools. Our results show: a) increased SPW yellow sticky card trap and CC trap efficacy when we added a green light emitting diode to the traps; and b) the LED-equipped trap efficiency was increased by 50-600% in greenhouse studies depending on insect species trapped (in cooperation with Dr. Alvin Simmons of U.S. Vegetable Laboratory, Charleston, SC). LED-yellow sticky card equipped traps may have potential in combination with SPW parasite releases for SPW control in greenhouses.

SPW Plant Resistance. Cotton losses from SPW infestations are extensive. A 5-year study to document the effect of okra-leaf cotton varieties on SPW populations with Eric Natwick, University of California Research and Extension Center in Holtville, CA is identifying the factors that result in lower SPW population densities on okra-leaf cottons.

Effect of Temperature on Artificially-Reared Whiteflies. Temperature conditions are an important parameter in rearing of SPW. SPW were reared in four environmental chambers controlled at 24 ± 1, 26 ± 1, 28 ± 1 or 30 ± 1ºC. 3. Egg hatch at Day 7 was greatest for 24 and 26ºC. Survival rates were lowest throughout the experiment for SPW reared at 30ºC; development beyond the 3rd instar for day 21 counts was highest for SPW reared at 26 and 28ºC. This information will help us optimize conditions for artificial diet-reared whiteflies.

SPW Predation Studies. The impact that predators have on SPW populations in the field is poorly understood. We made observations on the feeding behavior of the SPW predator, *Semidalis* sp. at the Western Cotton Research Laboratory in Phoenix, AZ. The results have shown *Semidalis* adults are voracious feeders on SPW eggs and nymphs. The predators may have potential impact on non-crops, including urban host plants of SPW and may be an overall areawide IPM tool. (USDA-ARS-Western Cotton Research Laboratory, Phoenix, AZ)

Arkansas

Efficacy trials on plant bugs, stink bugs, bollworm, tobacco budworm, thrips, and cotton aphid were conducted throughout the state. A study on the effects of applications of new chemistries for bollworm/tobacco budworm on beneficial arthropods in conventional and Bt cotton continues. Research on the effects of new pesticide chemistries on beneficial arthropods also expands and continues. Research on the COTMAN management system continues, verifying termination of insecticide applications for more pests, including plant bugs and stink bugs, as well as irrigation termination. A systems study continues comparing inputs for several Bt and stacked gene varieties and conventional varieties.

The aphid fungus sampling program finished it's 10th year, having been utilized in six states. Attempts at establishing the fungus early in Arkansas for the fourth year in a row have shown mixed results.

In cooperation with the USDA Southern Insect Management Research Unit at Stoneville, Mississippi, population structure of *Helicoverpa zea* was studied in Drew and Desha Counties. The focus of the study was the relative contribution of different crop plants to overall populations and the potential importance of different crops as a refuge for endotoxin susceptible genotypes of the insect (i.e. refugia for Bt cotton). The study was coordinated with similar studies with the USDA at Stoneville, Louisiana State University, University of Georgia, and North Carolina State University. Adult densities were monitored weekly from late May to early September by pheromone trap captures at the boundaries of Bt cotton and conventional cotton, Bt cotton and Bt cotton, Bt cotton and early soybean, Bt cotton and late soybean, Bt cotton and corn, and Bt cotton and grain sorghum. Samples of the moths from each weekly collection were sent to Monsanto scientists for subsequent analysis of the carbon contained in the insects' forewings. Resulting data should provide information about the host plants (C3 or C4 plants) that produced the captured moths. Larval populations were followed in the survey fields adjacent to the pheromone traps, and a replicated study containing the different crops in ¼-acre plots was closely monitored to relate larval production to timing and production of adults measured as measured by the pheromone trap captures. Preliminary observations indicate that *H. zea* is widely distributed across the study area. Larval numbers were found in all crops, but higher densities were associated with corn and grain sorghum. June and July pheromone trap captures were highest near corn.

An exploratory study was initiated in 2002 to organize COTMAN and agricultural production records from existing databases and use resulting spatial and temporal trends to develop management strategies for large farms or communities. An elaborate 7-year data base for Wildy Farms in Leachville, Arkansas is being used as a prototype for eventual expansion of the concept to other production areas. Preliminary results suggest relationships between tillage and overwintering habitats with resulting need for insect control and the use of insecticide in the system.

A monitoring program for insecticide resistance in key pest species was established in the Department of Entomology at the University of Arkansas during 2002. The program is designed to measured susceptibility of lepidopteran pests to endotoxin and other insecticidal proteins in transgenic crops. A vial assay program was also developed to collect information on a wide range of insect pests exposed to contact active insecticides. Colonies of *H. zea, Heliothis virescens, Pseudoplusia includens* and *Spodoptera frugiperda* were established from field collections or other laboratories during 2002. Progeny of the different colonies were assayed for response to CryI and CryII endotoxin proteins in a diet incorporation assay. Variation in $LC\text{-}_{50}$s was as high as 40-fold but no more variable than that previously reported in the literature. Higher $LC\text{-}_{50}$s were associated with colonies collected from Bt-cotton fields, but is uncertain at this time if these $LC\text{-}_{50}$s are higher than those previously measured. Additional confirmation is needed.

Vial assays were conducted on a wide range of pest species found in cotton, in adjacent crops and natural vegetation, and captured in pheromone traps. Most assays included a pyrethroid (cypermethrin) and two organophosporous insecticides, acephate and malathion, widely used in Arkansas production systems. Assays with spinosad were included with some of the lepidopteran pests. Species assayed, mainly for preliminary base-line information, included *H. zea, H. virescens, P. includens, Spodoptera exigua, Trichoplusia ni, Lygus lineolaris, Acrosternum hilare, Oebalus pugnax, Pseudatomoscelis seriatus*, and *Spissistilus festinus*. Responses were generally within the range of those expected from the literature. Others were simply base-line information for future studies. Expansion of the field assays is anticipated in 2002 with detail spatial mapping of the resulting data. Samples of the various collections and assays are being preserved for subsequent genetic studies and searches for various resistance mechanisms.

Research plots in southeastern and southwestern Arkansas exposed to a range of different insect management strategies and technologies were closely monitored by COTMAN mapping procedures and standard insect sampling procedures throughout the growing season. Box mapping of the resulting yields by main-stem and branch node positions are being related to the within season monitoring information to explore options for economic decisions. The box mapping procedure produces an index of crop production as a function of date of fruit initiation and survival of fruit of different age classes. These data include 2002 observations in Drew, Desha and Little River Counties and significant crop damage from caterpillars and plant bugs. Previous data collected over a three-year period in Mississippi are also being studied for similar relationships. (University of Arkansas Cooperative Extension Service, Little Rock, AR)

California

Populations of late-season sucking insects continue to be problematic in California. Silverleaf whitefly infestations have intensified and expanded in range the last 2-3 years, and cotton aphid remains an important pest. The most critical period for these insects is often from near the time of defoliation to harvest. After the 2001 season, questions were asked, such as should an insecticide be included with the harvest aid materials to control populations of these insects, what effect will the harvest aids have on whitefly/aphid populations, are the harvest aid materials equally effective in preventing regrowth, will these possible differences influence pest populations, etc. A defoliation/insecticide study was conducted at two locations to address some of these questions. The Tulare County location was primarily infested with whiteflies, and the Kern County location had an aphid infestation. The infestations at both locations were near the treatment threshold level for silverleaf whitefly or cotton aphid. Various combinations of harvest aids with and without an insecticide were evaluated. Pest levels, honeydew production, defoliation success, regrowth amount, and lint stickiness were evaluated in this team effort of entomologists and agronomists.

Efficacy studies were conducted on lygus bugs, spider mites, and cotton aphids. On lygus bugs, 17 different treatments were compared; populations of natural enemies as well as the secondary pests cotton aphids and spider mites were evaluated. On spider mites, 20 different treatments were compared; these included six standard materials and four experimental compounds, which are nearing registration. Finally, two evaluations were done on late-season cotton aphids. One test was applied in mid-August and the other in early September. The objective of these tests was to determine how the registered insecticides would work during this critical late-season period. Differential populations of cotton aphids and spider mites were set-up in field plots at the Shafter Research and Extension Center, and remote sensing technology, in cooperation with the USDA-ARS Western Integrated Cropping Systems Research Unit, was used to record the plant response to these pests and pest damage. (Cooperative Extension Service, Kern County, Tulare County, Kings County, Kearney Agricultural Center, Parlier; UC, Davis; and UC, Riverside)

Louisiana

Several tests evaluated insecticide efficacy against thrips in 2002. Seed treatments of Cruiser 5FS, Gaucho 4FS, Orthene 90S and an in-furrow granular application of Temik 15G provided effective control of thrips (primarily *Frankliniella* spp.) larvae across three cotton cultivars. However, the seed treatments were more inconsistent than Temik 15G due to significant variation among thrips densities on individual plants within the same row. This intra-row variation is likely caused by poor coverage of seeds with the insecticide. All treated plots yielded significantly more seedcotton compared with the non-treated plots. In another test with similar treatments, all insecticides, with the exception of Temik 15G reduced thrips larvae compared with the non-treated plots. The Cruiser 5FS seed treatment resulted in fewer thrips on seedling cotton than Temik 15G. All other insecticide treatments provided equivalent thrips control. In that study, Temik 15G at a higher rate (5.0 lb [form]/A) reduced plant density compared with the non-treated, Cruiser 5F, and Gaucho 4F treated plots. Treatments were equivalent for aphid counts and tarnished plant bug damaged square counts. Seedcotton yields among the insecticide treatments were not different. Temik 15G and Gaucho 4F produced higher seedcotton yields than the non-treated plots.

The effects of cotton aphid densities during pre-flowering stages of cotton plant development on yield were evaluated in a field experiment. Insecticide applications were used exclude cotton aphid infestations at selected cotton plant growth stages. Treatments were initiated at pinhead square and applied weekly until 14 days after first flower. Cotton aphid populations increased during June and peaked during mid-June with densities >80 cotton aphids per plant terminal (all apical growth including first fully expanded leaf) in non-treated plots. The insecticide treatments effectively reduced cotton aphid densities and allowed aphid infestations to persist in the fields for specific intervals. Regardless of application timing, no significant differences in seedcotton yields were detected among treatments.

Insecticides were compared to determine differences in susceptibility and effectiveness against stink bug adults and nymphs encountered in Louisiana. Orthene 90S, Karate-Z 2.08CS, methyl parathion, Centric 40WG, Trimax 4F, and Intruder 70WP were applied to cotton bolls in the field. All treatments produced significant levels of mortality against southern green stink bug, *Nezara viridula* (L.), adults and nymphs.

In laboratory studies using the adult vial test (AVT), there were no significant differences in the response of brown stink bug, *Euschistus servus (Say)* and *N. viridula* adults to dicrotophos. Of the pyrethroids tested, *E. servus* adults were most sensitive to bifenthrin, followed by *lambda*-cyhalothrin, and cypermethrin. There was no significant difference between the responses of *E. servus* adults and *N. viridula* nymphs when exposed to bifenthrin. In another study, *Euschistus quadrator* (Rolston) adults, *E. servus* adults and nymphs, *N. viridula* adults and nymphs, and green stink bug, *Acrosternum hilare* (Say), nymphs were exposed to *lambda*-cyhalothrin. All species and stages, with exception of *E. servus* nymphs, were significantly less sensitive than *N. viridula* adults. The LC_{50} for *E. servus* adults, *E. quadrator* adults, *N. viridula* nymphs, and *A. hilare* nymphs was approximately 83, 56, 14, and 5 times, respectively, higher than that of *N. viridula* adults.

Field studies were conducted to determine the impact of *E. servus* infestations on pre-flowering and flowering cotton plants. Cotton seedlings (pre-squaring), cotton with a small (match-head) square, large (pre-candle) squares, and bolls were infested with one adult in a no-choice test. There were no significant differences in height, height to node ratio, square retention, and flower initiation for seedling cotton plants or cotton plants with a match-head square between infested and non-infested treatments for pre-flowering studies. There were no significant differences in abscission of large squares or bolls for infested and non-infested treatments. Boll infestation studies evaluated the relationship between boll maturity, as determined by heat units beyond anthesis, and boll growth, abscission, and seedcotton yield was measured. Boll growth was significantly lower for bolls infested with *E. servus* through 266.5 heat units beyond anthesis compare to that for non-infested bolls. *E. servus* induced boll abscission through ca. 350 heat units beyond anthesis. Seedcotton yield was significantly reduced for infested bolls as compared to non-infested bolls through ca. 550 heat units beyond anthesis.

Area-wide experiments on Panola Plantation in Tensas Parish were continued in 2002 to evaluate the potential of reducing tarnished plant bugs by destroying native winter/spring hosts along cotton field borders during February and March. Weed species and density, tarnished plant bug density and reproduction in native hosts, and tarnished plant bug density in adjacent cotton fields were recorded during the season. Tarnished plant bugs were observed during February and March but at very low levels. These insects in the non-treated areas followed a cyclic pattern and reached peak densities on April and again in May. Differences between the treated and non-treated areas were uncommon during most of the season. Tarnished plant bug adults and nymphs in the treated area were low and never exceeded two insects/ 25 sweep sample on any rating date.

Field studies were during 2001 and 2002 investigated the effect of Bollgard cotton refuge row width on Heliothine damaged bolls and seedcotton yield in the Bollgard® cotton adjacent to non-Bollgard refuge. Embedded non-Bollgard refuge sizes were configured in 48, 24, and 16-row widths. Neither the refuges nor the Bollgard® cotton was sprayed with an insecticide for Heliothines. Heliothine damaged bolls decreased and seedcotton yield increased in Bollgard® cotton as plants were sampled farther away from the refuge compared to cotton adjacent to the refuge. In 2001 and 2002, 12% and 20% damaged bolls, respectively, were observed in the 16-row width refuges. In the 24-row width refuges, 5% and 23% damaged bolls were observed in 2001 and 2002, respectively. In the 48-row width refuges, 5% and 22% damage were observed in 2001 and 2002, respectively. In the adjacent Bollgard cotton, damaged bolls ranged from 0.7% to 4% across all refuge widths during both years. Lint yield averaged 200 pounds higher in the Bollgard cotton compared to the average yield in non-Bollgard refuges.

The temporal occurrence and density of bollworm, *Helicoverpa zea* (Boddie), larvae on alternate host crops was monitored throughout the 2002 season. The objective of this study was to quantify production of bollworm larvae from representative alternate host crops, and to compare their temporal synchrony with those in Bollgard cotton. Non-Bollgard cotton, Bollgard cotton, field corn, grain sorghum, and maturity groups IV and VI soybean were planted in three-0.25 acre blocks. Samples were initiated in early June and continued until crop maturity. Representative larval samples were collected when present, maintained on artificial diet, and identified to distinguish between bollworm and tobacco budworm, *Heliothis virescens* (F.). No lepidopteran-active insecticides were applied on any of the plots. Grain sorghum and corn were infested with the highest number of larvae/acre, whereas Bollgard cotton and maturity group IV soybeans had the lowest numbers. In field corn, bollworm*s were* most abundant during the R2 to R4 growth stages (late June) and ranged from 11000 to 18000 larvae/acre. Bollworm infestations in grain sorghum were greatest during growth stages 4 to 8 (mid-July) with 26,000 to 41,000 larvae/acre. In non-Bollgard cotton, larvae were present primarily from 7 NAWF to 7 NACB (late July to late August) with ca. 2744 larvae/acre. Similarly, bollworms in Bollgard cotton were present during 7 NAWF to 6 NACB (early August to late August) and ranged from 130 to 650 larvae/acre. Group VI soybeans in the R2 to R6 stages (late Jul to mid-August) produced larvae ranging from 261 to 4704 larvae/acre. No larvae were found in Group IV soybeans throughout the entire sampling period. In addition, pheromone traps were used to quantify the production of bollworm adults. Bollworm adult trap captures increased throughout the season and peaked during the third week of July. Trap captures declined until the last week of September, when monitoring ceased.

In 2002, 16 pairs of pheromone baited wire cone traps were used to survey species composition of tobacco budworm and bollworm. The adult vial test (AVT) was used to monitor pyrethroid resistance levels in these species. Approximately 400 tobacco budworm moths were assayed for pyrethroid susceptibility from Jun to Sep 2002 using a discriminating concentration of 10 µg in the adult vial assay. Percent survival observed during Jun, Jul, Aug, and Sep was 67%, 69%, 47%, and 68%, respectively. These data further indicate that pyrethroids are no longer a viable option for tobacco budworm control in Louisiana. Over 829 bollworm moths were assayed using a 5 µg/vial concentration of cypermethrin. Percent survival observed for Jun, Jul, Aug, and Sep was 28%, 42%, 26%, and 28%, respectively. No field control failures of bollworm infestations associated with pyrethroid usage were reported in Louisiana during 2002. Field populations of bollworm and tobacco budworm were also monitored for susceptibility to spinosad using the AVT. Bollworm survival ranged from 47% to 63% for the 5 µg/vial concentration of spinosad from Jun to Aug and from 18% to 12% for the 15 µg/vial concentration of spinosad from Jun to Sep. Tobacco budworm survival at the 5 µg/vial concentration ranged from 31% to 70% during Jun to Aug and 20% to 0% for the 15 µg/vial concentration of spinosad from Jun to Sep. Some field control problems of mixed bollworm and tobacco budworm infestations with spinosad occurred in Northeast Louisiana during 2002. Further laboratory testing of collections from these areas indicated responses similar to those of the 2001 collections.

A USDA-IFAFS and NASA-AG2020 sponsored project was initiated during 2002 to adapt precision agricultural technologies for use in Mid-South cotton production strategies. Initial tests were designed to validate relationships between biological variables in fields and data in remote sensed images. Preliminary analyses suggest that densities of selected insect species are related to variation in plant growth patterns detected by remote-sensed image data including the normalized difference vegetation index (NDVI) calculations. A prototype pesticide application system for an aircraft is being developed with current GPS/GIS technologies to automatically spray selected zones within fields. These prescription pesticide applications are based on the images (NDVI) obtained from aircraft or satellites based platforms and yield maps. (LSU AgCenter's Northeast Research Station, St Joseph and Winnsboro, LA; Louisiana Cooperative Extension Service, Winnsboro, LA; and Department of Entomology, Baton Rouge, LA)

Mississippi

A survey of tarnished plant bugs and stink bugs was made in cotton and adjoining soybean and corn fields season long in several sites along Highway 8 in Mississippi in 2002. Sweep net, beat net and shake sheet samples were used in an attempt to sample upper, mid, and lower levels of the canopy well. Results are being tabulated but indicate that tarnished plant bugs are prominent in soybean and less so in corn, and that stinkbug movement from maturing soybean into corn is a probable source of stinkbug in cotton. Work in 2003 will include examination of the inside carpel walls for stinkbug damage for correlation with counts of stinkbug and tarnished plant bug found in cotton during the season.

Early season thrips control studies indicate the efficacy of Gaucho, Cruiser, and Temik was unchanged when used in combination with three different fungicides. The functionality of the COTMAN program was examined for use in ultra narrow row cotton in conjunction with a multi-state trial. Results are yet to be tabulated. (Department of Entomology, Mississippi State University, Mississippi State, MS)

During 2002, the first efforts at evaluating the use of geographic information systems (GIS), global positioning systes (GPS), and remote sensing in area wide control programs of the tarnished plant bug (Heteroptera: Miridae) were completed. The evaluations were accomplished at farm landscape scales. One farm (ca. 14, 000 ac cotton) was located in the Mississippi Delta (Bolivar County, MS), while the second farm (ca. 1000 ac cotton) was located in the Black Prairie region (Noxubee

County, MS). Imagery was obtained at both locations via several vendors and with cooperative efforts with the Remote Sensing Technology Center (RSTC), Mississippi State University and the Mississippi Space Commerce Initiative (MSCI), Stennis Space Center, MS. Imagery utilized in season at both farms was multispectral imagery from two-three different airborne systems at ground spatial distances (GSD) of 1-4 m^2 per pixel. Limited multispectral (3-4 bands) imagery from satellite (and with larger GSDs) was utilized at the Delta location, primarily during the month of July. Hyperspectral imagery (48 bands) will be available for analysis post-season at the Delta location, but not at the Black Prairie site.

Using both composite images and products derived from unsupervised classifications steps, directed scouting efforts by both research and farm consultants were completed at both locations. The imagery readily (unprocessed or processed) showed variability (*i.e.*, habitats) in cotton growth within fields. Sweep net, drop cloth, and/or visual counts (along with square set) were obtained in these different habitats. At least weekly throughout the season, GPS data was tagged to the scouting data across many fields on these farms.

During the early season of 2002, both locations had historically high densities of plant bugs in all habitats, including the less vigorous growing cotton, which had been unoccupied by economically important densities of TPB the previous 2 (Noxubee County) to 5 (Bolivar County) years. Therefore, at both locations, early season (June) blanket sprays were applied to fields, as recommended by both consultants and researchers in coordination with the producers. At both locations, border sprays (but not by prescription) were applied to supplement these initial applications over the next several weeks. Decisions to apply border sprays did not apply to all fields. Those fields which had border sprays were influenced by their relationship to other crops (primarily corn), woodlands, or proximity to extensive collections of wild hosts in nearby non-cropping areas.

As the season progressed into July, scouting data supported by imagery clearly showed at both locations the development of strong, spatially dependent differences in TPB density according to multifarious effects of crop phenology, proximity to nearby corn or sorghum sowings, soil type, recent weather, and past spray history. To the extent that all data could be assimilated and processed, then either blanket or spatial prescriptions were applied. Eventually, a complex mosaic of spray inputs developed throughout the months of July and August at both locations. Some fields were sprayed frequently, other fields with yet fewer applications, and a few fields had only one application. For all cases in these two months, sprays were either a blanket or spatial application; therefore, the spatial technologies are amendable to either tactic of application. Also, as the season progressed, sprays for other pests (aphids, Heliothines, beet or fall armyworms, or stinkbugs) were also super-imposed with TPB applications. These additional pests clearly demonstrated that efforts at wide-area control of the TPB have to be coordinated with the influence of other pests.

To summarize, the initial efforts in the first year of work with diverse spatial technologies was both encouraging and frustrating with respect to wide area control concepts. Both research and consultant efforts were made more efficient by use of the imagery to assist scouting efforts. Without spatial information, both timing and frequency of applications would have been poorly administered for many fields having only incidental or low occurrences of TPB. Both researchers and consultants taking part in this study believe that thresholds for TPB should be revised. The efforts, however, were discouraging in that all participants (at times) were presented with too much information (with too little time) to adequately process and apply as many spatial prescriptions as hoped. Therefore, 'work-arounds' or delays longer than desired frequently occurred at both farms. Much work needs to be devoted toward eliminating many information bottlenecks that hamper the efficiency and timeliness of the value offered by spatial information from imagery and by variable-rate controllers on sprayers. Therefore, research goals in years two and three of this project will primarily address these limitations. (USDA-ARS, Genetics and Precision Agriculture Research, Mississippi State, MS)

Experiments were conducted to determine if there was a genetic basis for expression differences among Cry1Ac (Bt) cotton varieties. Bt cotton varieties were crossed in the green house and the subsequent generation allowed to self-pollinate. In addition to the segregating F_2 population, the parental and F_1 generation of plants were planted in small-scale field plots in a randomized complete block design. The amount of Cry1Ac was quantified on a per plant basis. Segregation analysis showed that a strong genetic component existed among the varietial differences. Furthermore, it was estimated that a single gene conferred these differences in expression levels.

Production of insects for state, private and USDA-ARS research by the Stoneville Rearing Unit required maintenance of six insect species: *Heliothis virescens, Helicoverpa zea, Spodoptera exigua, Microplitis croceipes, Cardiochiles nigriceps, and Anticarsia gemmatalis,*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA, Mississippi State, MS, College Station, TX, and Weslaco, TX required production of 312,500 *H. virescens* pupae, 585,600 *H. zea* pupae, 324,000 *S. exigua* pupae, 291,600 *A. gemmatalis* pupae, 37,171 *M. croceipes* cocoons, 54,679 *C. nigriceps* cocoons, 77,800,000 *H. virescens* eggs, 14,640,000 *H. zea* eggs, 40,500,000 *S. exigua* eggs, and 36,450,000 *A. gemmatalis* eggs,. Additional research support to private industry included 104,000,000 *zea* eggs; mixing, dispensing, and filling 570, 30 ml plastic cups and 14,360 3.8 liter multicellular trays with artificial diet. Total diet mixed and dispensed in 2002 was 15,497 liters. Also several tours were given to students and several short courses in insect rearing techniques were given to employees at

Monsanto and Mycogen at Leland, MS. Approximately 150 researchers located in 37 states, England, Canada, Republic of China, United Kingdom, and Japan participated in the Insect Distribution Program.

A collaborative project between USDA-ARS-SIMRU, Monsanto Ag, and university researchers is currently being conducted to determine the contribution of cultivated hosts of *Helicoverpa zea* (Boddie) in a resistance management plan for Bollgard cotton. This study was conducted by university researchers in Arkansas, Georgia, Louisiana, and North Carolina. Scientists at the USDA-ARS-SIMRU in Stoneville, MS conducted the research in Mississippi. Hartstack-style moth traps baited with artificial *H. zea* pheromone lures were placed at the interfaces between Bollgard cotton fields and known alternate crop hosts of *H. zea*. The crop interfaces included Bollgard-Bollgard, Bollgard-conventional cotton, Bollgard-field corn, Bollgard-soybean, and Bollgard-grain sorghum. Traps were monitored every week throughout the season and lures were replenished every two weeks. Moth samples were transported to the laboratory, counted, preserved in ethanol (90%), and shipped to Monsanto where scientists prepared the moth samples for further analysis to determine the larval hosts of the moths. Those samples were shipped to a laboratory at the University of Georgia for carbon isotope analysis. Recent advances in carbon isotope analysis provide information about the larval host plants of lepidopteran adults. Specifically, the ratio of $^{13}C/^{12}C$ can be used to determine if the larvae fed on C3 plants such as cotton and soybeans or on C4 plants such as corn and grain sorghum. In addition to moth trap catches, larval densities were monitored in each of the crop hosts. Also, larval densities were measured in the previously mentioned crops in a replicated small plot (0.125 acre) experiment near Stoneville, MS. During periods of peak moth flights, differences were observed in the numbers of moths caught at the different crop interfaces. The highest moth numbers occurred at the Bollgard-conventional cotton and Bollgard-Bollgard interfaces. Larval densities were highest in corn and grain sorghum; however, those populations occurred before larval populations in cotton. Larval densities remained low in soybeans and were more variable both spatially and temporally than other crop hosts. Bollgard cotton had the lowest larval densities. Results of carbon isotope analyses have not been completed.

To determine the effects of bollworm, *Helicoverpa zea* (Boddie), on yield and maturity of Bollgard cotton, six rows each of conventional cotton (Stoneville 4793 RR) and Bollgard cotton (Stoneville 4892 BR) were planted in 0.125 acre field cages. Plot size was two rows by 1-m. Treatments were arranged in a split-plot design with three replications. Duration of infestation was the main-plot factor and included 1, 2, 3, or 4 weeks of infestation. Level of infestation was the sub-plot factor and included 0, 50, or 100 percent infestation of white flowers. First instar bollworm larvae were placed in white flowers with a small paint brush. Bollworm feeding in white flowers resulted in significant delays in maturity of Bollgard cotton when 100 percent of white flowers were infested for one week and when 50 or 100 percent of white flowers were infested for two to four weeks. All levels of white flower infestation resulted in significant reductions in yield of Bollgard cotton, regardless of the duration of infestation.

To determine the emergence pattern of *Helicoverpa zea* (Boddie) adults from field corn, field corn was planted in two 0.125 acre cages. Feral *H. zea* populations were allowed to become established in the ears before the cages were enclosed. Moth emergence was monitored from the corn with two Hartstack-style traps (one baited with pheromone and one baited with kairomone), four bucket-style traps (baited with sugar water), and a light trap. *H. zea* emerged over a seven week period with peak emergence occurring over a three week period.

Comparison of numbers of boll weevils captured in 34 traps in Washington Co., MS from March-October for 1995-2001 showed that before boll weevil eradication (1995-1998), numbers averaged 60,500. For the same period in 1999-2001 the (eradication program began August 1, 1999), numbers averaged 5,304, 200, and 4, respectively, indicating strong progress toward total elimination of the boll weevil from this part of the state. For 2002, however, the numbers increased to 14, creating some concern on the part of program personnel.

All four generations of bollworm and tobacco budworm were again evaluated in spray chamber tests for tolerance to five classes of insecticides. Budworms remained resistant to pyrethroids but reasonably susceptible to all other classes; bollworms were susceptible to all classes.

Results from the 2nd year of a 3-state, 6-location test to determine the best time to spray for cotton aphids again produced inconsistent data due to extremely low numbers of aphids in almost all areas in 2002. The test will not be repeated in 2003.

Evaluation of over 75 colonies of bollworm and tobacco budworm moths collected in pheromone traps in 9 cotton-growing states revealed no significant change in tolerance of F_1 larvae to toxic proteins in Bt cotton.

Bioassays were conducted to compare the virulence of four isolates of entomopathogenic fungi against *Lygus lineolaris*. These assays included the following: 1) two isolates used in commercially-available formulations of *Beauveria bassiana* (Mycotrol, Emerald Biosciences and Naturalis, Troy Biosciences), which had been previously evaluated in field trials against *L. lineolaris*; 2) an isolate of *Metarhizium anisopliae* (ARSEF 3540), that was the only isolate indigenous to the United States found to be more virulent to *L. lineolaris* than the commercial isolate used in Mycotrol in a study on the virulence of 32 fungal isolates against *L. lineolaris*; and 3) a *B. bassiana* isolate obtained by Don Stienkraus from *L. lineolaris* in Arkansas

(ARSEF 3769), which until this time was the first and only entomopathogenic fungal isolate obtained from *L. lineolaris* in the US. The most virulent isolate was found to be the one obtained from *L. lineolaris* (ARSEF 3769) followed by the isolate used in Mycotrol and then the remaining two isolates. The relatively low virulence of the isolate used in Naturalis formulations may, in part, explain poor field performance of this product against *L. lineolaris* in published field trials. The results we obtained with the *M. anisopliae*, which conflict with those previously published, are being further investigated. It is suspected that the difference may be related to the temperature conditions under which the bioassays were conducted (27 ºC in our bioassays vs. 20 ºC in previously published bioassays).

Four new *B. bassiana* isolates have been obtained from *L. lineolaris* in Washington, Co. MS. Two of the new isolates were evaluated for virulence against *L. lineolaris* adults in bioassays that also included all of the isolates described in the preceding paragraph. The two new isolates were found to have similar virulence to the *B. bassiana* isolate (ARSEF 3769) obtained from *L. lineolaris* in Arkansas and were more virulent than the two commercial isolates and the *M. anisopliae* isolate. In addition, preliminary evidence indicates that those isolates obtained from *L. lineolaris* sporulate more rapidly from cadavers of *L. lineolaris*, which may enhance horizontal transmission within the population following application. This will be evaluated more closely in subsequent bioassays. The remaining two isolates are presently being evaluated for virulence against *L. lineolaris*.

The six fungal isolates that were evaluated in bioassays against *L. lineolaris* were also tested at a single high spore dose in a screening bioassay against green stink bug nymphs. All of the isolates demonstrated very low virulence to green stink bugs. Stink bugs possess natural chemical defense compounds that inhibit germination of spores on their surface. This, in part, explains the relatively few entomopathogenic fungi that have been isolated from stink bugs throughout the world (none in the US). However, there is some evidence that the susceptibility of fungi to these defensive compounds varies among isolates, and it may be possible to find a resistant isolate.

All of the entompathogenic fungal isolates used in bioassays against *L. lineolaris* described above have been evaluated for their ability to survive exposure to simulated sunlight in the laboratory. These experiments are currently being repeated at lower exposure conditions due to the rapid death of spores, but our preliminary results underscore the need for developing formulations that will protect these spores from solar radiation.

Collaborative work was conducted with Robert Behle (NCAUR, Peoria, IL) to develop formulations of *B. bassiana* for protection from solar radiation. This research group recently improved a method for spray-drying *B. bassiana* spores with water-soluble lignin derivatives to produce particles of spores coated with cross-linked lignin. Cross-linking lignin with calcium ions reduces the water solubility of the particles and, thereby, lowers the potential for particles to wash-off leaves following application. As a part of our collaborative research effort, we expanded this formulation technology to evaluate particles containing non-cross-linked lignin that was highly water soluble. These two spore-coating strategies are being evaluated in combination with water-based (0.04% Silwet L77 in water) and oil based (70% Shellsol OMS : 30% cotton seed oil) carriers. These formulation strategies were tested with regard to protection from solar radiation and infectivity to *L. lineolaris*. The following formulations of the Mycotrol technical powder were evaluated in bioassays against *L. lineolaris* and simulated solar radiation assays: 1) non-coated spores in a water-based carrier; 2) non-coated spores in an oil-based carrier; 3) spores coated with cross-linked lignin in a water-based carrier; 4) spores coated with non cross-linked lignin in a water-based carrier; 5) spores coated with cross-linked lignin in an oil-based carrier; and 6) spores coated with non cross-linked lignin in an oil-based carrier. The most infective formulation was found to be strategy 1, followed by 2, 3, 4, and 6, which were equally infective. The least infective was formulation 5. Formulations 3, 5, and 6 greatly improved the survival of spores following exposure to simulated solar radiation over the other formulation strategies.

A second-year field experiment was conducted to evaluated the potential of augmenting natural infection rates of the cotton aphid fungus, *N. fresenii,* in *Aphis gossypii* populations using reduced rates of insecticides. Aphid population densities and infection rates within the population were monitored throughout the growing season, as well as humidity and temperature within the cotton canopy. Aphid populations were artificially "flared" with a pyrethroid once they were detected in low densities. Half rates of Bidrin were applied at the onset of squaring and one week after squaring, or at one and two weeks after squaring. Positive controls received full rates of Bidrin at bloom or as needed to control aphid populations, and controls received no aphicide applications. Aphicide applications were initiated in mid-June. One-acre plots of each of the four treatments were replicated four times in a randomized complete block design. Aphid populations crashed between the last week of June and the first week of July. Although we are still in the process of evaluating slide-mounted aphids for the presence of *N. fresenii*, this population crash did not appear to correspond with the presence of *N. fresenii*. After observing more than 300 aphid specimens around this time the aphid fungus was not observed. These data correspond with those obtained by the Aphid Fungus Sampling Service for 2002 which found no fungus present in Washington, Co. in samples from June 18, July 8, and July 10. The first samples to have fungus were taken on July 23rd. A second set of aphicide treatments was made on August 12th in an attempt to temporally match aphicide treatments with the second seasonal *N. fresenii* epizootic. Aphids collected on August 12th, 15th, and 19th demonstrated up to 50% infection levels. This percentage was from a relatively low number of aphids (N=4 to 15 aphids/replicate), although we examined 125 plants/acre. Initial results of aphicide treatments with this late season *N. fresenii* epizootic do not indicate an interaction between aphicide treatment and infection levels; however, the variability among replicate test blocks was large. Additional data need to be collected on aphid population densities, infection levels over the growing season, and interactions between initiation of epizootics with aphid population densities and physical parameters.

In 2002 a large field plot study was carried out to determine the effects of various insecticide treatments on the control of tarnished plant bugs. Treatments were Orthene 90S at 0.33 lbs ai/acre, Trimax 4 at 0.31 and 0.47 lbs ai/acre, Steward 1.25 at 0.104, Vydate 3.77 + Asana .66 at 0.25 + 0.036 lbs ai/acre, Asana .66 at 0.036 and 0.04 lbs ai/acre, Centric 40WG at 0.047 lbs ai/acre, Vydate 3.77 at 0.33 lbs ai/acre, Intruder 70WP + MSO at 0.05 lbs ai/acre + 1 pt, Intruder 70WP + COC at 0.05 lbs ai/acre + 1 pt, Intruder 70WP at 0.05 lbs ai/acre, and Intruder 70WP + Decis 1.5 at 0.05 + 0.025 lbs ai/acre. Each treatment was replicated four times. Individual plots were 32 rows wide. It was necessary to blanket treat the entire field prior (6/19/02) to receiving all insecticides. Individual treatments were made on July 2, 11, and 18. On July 18 the entire field was sprayed with Tracer for bollworm/budworm control. The test field was blanket treated again in July 29 with Steward at 0.11 lb ai/acre and August 7 with Trimax + Baythroid 0.047 + 0.03 lbs ai/acre. On July 22 after the third application of the individual treatments, tarnished plant bug populations sampled by drop cloth and sweep net indicated that all treatments were effective in maintaining control of the tarnished plant bug. Slightly higher populations were found in the treatments with Asana alone and in combination with Vydate. Green boll counts made in all treatments on July 22 indicated a large variability between treatments, probably due to soil variability in the soil within the field. The higher boll counts were noted in treatments of Trimax, Vydate + Asana, Asana, and Intruder + COC. Lint yields among treatments were not what were expected due to soil variation.

A study was carried out to determine the effects of three different nectariless cotton varieties (119B, 119H, and MD51) in suppressing tarnished plant bug populations. Check varieties were nectaried 747 and 474. Each treatment was replicated four times in plots 40 rows wide by 60 feet long. The entire field was treated with Tracer only until the test was terminated on July 22. For the remainder of the season all pests were controlled until cotton maturity. All plots were rogued twice and undesirable plants were removed. Data were taken on June 11 to determine percent purity in each variety. Sure-Grow 747 and Stoneville 474 were 100 percent. MD51, 119H, and 119B were 99, 96 and 99 percent purity, respectively. Percent square set data were collected on June 18, 25, July 3, 10. An average of 300 sites in each variety was checked. During all four weeks the three nectariless varieties had higher square set than the nectaried varieties. On July 22 five plants from each rep and variety were removed from the field for plant mapping. The results of these data are not complete, but indication is that there were more green bolls on plants from the nectariless cottons.

For the third year a large field plot study was carried out to compare cotton insect control in conventional cotton with insecticides applied in a 20-inch band and a broadcast application by ground. Five field locations were selected for the study. Each treatment (20-inch band and broadcast) was replicated four times at each location. The tarnished plant bug and bollworm/budworm were the major pests throughout the season. Insecticides and rates per acre used were determined by insect pests present each week. Measures of success were plant mapping and harvested yields. Plant mapping consisted of collecting 40 plants from each treatment and field location three times during the season. Data have not been summarized at this time. Yield data have been taken by machine harvesting four or eight rows from each rep and treatment and dumped and weighed in a boll buggy equipped with load cells. There was no difference in yield between treatments at either location.

Studies begun in 1998 on reproductive diapause in tarnished plant bugs were continued in 2002. In January of 2002 adults were collected with a sweep net from plant debris not associated with any living winter host plant. These adults were found to complete their emergence from diapause about one month later than adults which were active on winter host plants in December and January. This indicated that plant bugs overwinter in different intensities of diapause and break diapause at different times. This allows plant bugs which break diapause in December (those active on winter hosts) to take advantage of mild winters and produce a new generation of plant bugs by mid-March (as occurred in 1999 and 2001). The winter of 2002 was a cold one (winter host plants were stunted or killed), and new generation adults were not produced until mid-April. In cold winters adults which break diapause in January would be more favored for reproduction since they would still be alive when late winter and early spring host plants became available.

Orthene is an extremely important insecticide that is widely used for control of tarnished plant bugs in cotton in the Delta. A survey to determine if plant bugs in the Delta are developing increased tolerance to orthene (begun in 1998) was conducted again in the fall of 2002. The same 20 locations (4 in AR, 2 in LA, and 14 in MS) were used in all five years. Resistance was determined using a glass-vial bioassay. LC_{50} values obtained at each location were compared to an LC_{50} value obtained with orthene and susceptible plant bugs from Crossett, AR. The highest amount of resistance found in any of the five years was 4.6-fold found in bugs from near Cummins, AR in 1999. Results from 2002 were very close to those found in 2001 and indicated that orthene should still be an effective insecticide for plant bug control in cotton.

A glass-vial bioassay developed in 2001 for determining insecticide resistance in stink bugs was used to continue to develop baseline resistance levels in brown, green, and southern green stink bugs in the fall of 2002. In all 8,300 stink bugs (2,500 green, 3,200 southern green, and 2,600 brown) were tested using four pyrethroid (permethrin, bifenthrin, cypermethrin, and cyhalothrin), four organophosphate (dicrotophos, malathion, methyl parathion, and acephate), and one carbamate (oxamyl) insecticides. Stink bugs were mainly collected from soybeans near Stoneville, MS and Eudora, AR for use in the bioassays. LC_{50} values for brown stink bugs from Eudora for all the insecticides were very similar to LC_{50} values found for brown stink bugs from Stoneville. This occurred again when results with the insecticides were compared for green stink bugs from the two locations. LC_{50} values were significantly higher in most comparisons for southern green stink bugs from Eudora as compared to southern green stink bugs from Stoneville. LC_{50} values for brown stink bugs were higher (brown stink bugs were more tolerant) for every insecticide as compared to LC_{50} values for green or southern green stink bugs. The most toxic insecticides to all three stink bug species as a group were the pyrethroids. Among the organophosphates, methyl parathion was most toxic. The least toxic of the insecticides tested to stink bugs was malathion.

Treatment of marginal areas near fields, roads, and ditches with a broad leaf herbicide in March leaves annual ryegrass as the most abundant plant in these areas during April and May. The suitability of ryegrass as a reproductive host for tarnished plant bugs could affect management of tarnished plant bugs in these early season host areas. To determine its suitability as a host, first instar plant bugs were placed on flowering seed heads of rye grass in the laboratory and reared. As controls, plant bugs were also reared on *Erigeron philadelphicus* (a preferred wild host) and broccoli. Development of plant bugs to adults was not significantly different on *Erigeron* or broccoli (76 and 78%) but was significantly lower (56%) on ryegrass than both of the other treatments. The mean number of days to become an adult was also significantly longer on ryegrass than on the other two treatments. When third instar nymphs were placed on flowering seed heads of ryegrass and reared, percent survival to adults was 92% as compared to 96% for broccoli. In another test, five female and 2 male plant bugs (all 14 d old) were placed into a one gallon carton with green beans, or into a one gallon carton with the flowering seed heads attached stem and leaves of several ryegrass plants held in a water pic. The beans and ryegrass were removed and the eggs laid in them counted after 24 h. The test was repeated during the next 24 h, but this time the plant bugs fed beans the previous 24 h were given ryegrass and those fed ryegrass were fed beans. The adults fed beans laid 44 eggs while those fed ryegrass laid 0 eggs in the first 24 h. In the second 24 h those fed beans laid 34 eggs (0 in the previous 24 h on ryegrass) while those fed ryegrass laid 0 eggs (44 in the previous 24 h on beans). These results showed that small nymphs had a difficult time surviving on ryegrass, while third instar or larger nymphs did very well. Plant bugs did not like ryegrass as an oviposition host under the conditions of the test. It would be best to kill broad leaf weeds (the favored plant bug hosts) at a time when rye grass does not have a seed head, since nymphs which crawl from dying broad leaf weeds can not develop on rye grass until a seed head is present.

A large experiment designed to evaluate control of tarnished plant bugs in cotton by reduction in numbers of wild hosts available for plant bug reproduction in the spring was conducted in 2002. Six treated and six check areas, each one square mile in size, were used . A treated and check area were paired at six locations. Four of the locations, Arcola, Tribett, Holly Ridge, and Dunleith were in Washington County. The Twin Bayou and Choctaw locations were in Sunflower and Choctaw Counties, respectively. The treated areas received an application of broad leaf weed killer (Trimec) in March to all margins around roads, fields and ditches. The check areas did not receive this treatment. Previous use of this treatment in larger areas (9 square mile) had been effective in reducing plant bug numbers found in cotton in 1999, 2000, and 2001. The purpose of the 2002 design (one square mile areas) was to determine if a smaller treated area could be as effective for plant bugs as the larger treated area. A smaller area would be less expensive and easier for cotton producers to use as part of their insect control program. Prior to and after treatment wild hosts in all 12 areas were sampled for plant bugs to help determine the effectiveness of the treatment. Post treatment samples of wild hosts continued weekly through May in the areas. During the growing season, June-July, all cotton fields in the 12 areas were sampled with a sweep net each week for tarnished plant bugs. All soybean fields were sampled weekly for plant bugs from late-May through mid-July. Data on insecticide use and cost for plant bug control in cotton were also collected from growers in the areas for use in economic analyses. Tarnished plant bugs averaged 0.183 and 0.216 adults and nymphs per ten sweeps in cotton in the treated and check areas, respectively, during June and July 2002. These two means were not significantly different, although the mean number of plant bugs found in the treated areas was 15.4% lower. These means can not be interpreted as to their importance until the economic analysis of the data is completed. If growers spent the same or less money on controlling plant bugs in the treated areas to obtain the lower mean number of plant bugs found, then the treatment worked. Economic analyses of the data (by Fred Cooke) is currently incomplete. Tarnished plant bugs averaged 500 adults and nymphs per acre, or less, each week in the soybean fields (18) sampled in 2002. These were the lowest average numbers of plant bugs found in soybeans in the four years of the study. Analysis of data on number of plant bugs found on wild hosts pre- and post-treatment during March-May is presently incomplete.

The November 2001 Summary of Research Progress Narrative postulated that a pathogen in the tarnished plant bug (TPB) colony might be responsible for unexplained swings in mortality observed during sterility experiments undertaken during that year. In February 2002, a yet unidentified microsporidian was discovered in both the TPB and the *Lygus hesperus* colonies. The colonies were ridded of the disease organism, and both its identification and an investigation of its effects on mortality, egg production, egg hatch, and egg to adult survival are underway. A procedure to infect test insects with measured amounts of spores produced by the microsporidian has been developed, and significantly higher mortality in infected than uninfected bugs has already been verified. Sudden, unexpected, and unexplained incidences of high mortality in bugs fed artificial diet continue to occur, even in the absence of the microsporidian.

Sterility experiments comparing effects of irradiating TPB with 0, 5, 10, 20, and 40 krad are nearing completion. The 5- and 40-krad dosages are unacceptable. Five krad does not produce sufficient sterility, and 40 krad results in unacceptably high mortality. Ten krad is currently the dosage, but further experiments comparing 10 and 20 krad will be undertaken. Though significant egg hatch occurred with the 10-krad group, F_1 sterility, as measured by egg to adult development, in both the 10 and 20-krad dosages was near 100%. The accuracy of the radiation dosage we are administering with our ^{137}Cs source has been verified by MDS Nordian, a part of MDS Inc., an international health and life sciences company.

Sperm production is an important component of competitiveness. Sperm were counted from bugs treated with 0, 5, 10, 20, and 40 krad over a 2-week period following treatment. Sperm production was inversely related to dosage. Percent sperm reduction caused by irradiation of TPB was notably lower than that reported for the boll weevil, and bugs treated with all dosages appeared to have adequate amounts of sperm. Quality of irradiated sperm was not tested.

Environmental cabinets, programmed to simulate field temperature and photoperiod corresponding to daily changes in those parameters, were used to study diapause in TPB. Based on discussions with Gordon Snodgrass, cabinets were set to mimic photoperiods with starting dates of August 7, August 22, or September 6, because experiments with field-collected bugs around those dates had resulted in near 0%, near 59%, and near 100% diapause, respectively. Each starting date was replicated in four cabinets and two containers of bugs were placed in each cabinet. All cabinets were set at 80°F. Bugs were dissected about two weeks after appearance of adults and classified as diapausing, reproductive, or of undetermined status. Preliminary results produced diapause classifications of 14, 57, and 89% for the August 7, August 22, and September 6 starting dates, respectively. These results indicate that our laboratory colony is capable of attaining diapause and that cabinet conditions can be set to mimic those in the field. Additionally, we confirmed that photoperiod is a major factor in the initiation of diapause in TPB, and that within a 30-day period, the number of TPB entering diapause increased more than 6-fold.

In cooperation with researchers at Arkansas State University (T. G. Teague and S. Coy), we examined the effects of TPB feeding on plant maturity and yield. Results indicated that injury to cotton plants in the 2-leaf stage by 5th instar TPB nymphs can cause a significant 6-day delay of maturity. Additionally, a 6-day delay of maturity was seen in plots sustaining TPB damage caused by bugs introduced into the plots, but not in plots where numbers of squares similar to those caused by TPB were damaged by mechanical means. These results reiterated the need to use live insects in studies of cotton plant response to feeding by TPB. In other studies in which 3rd instar TPB nymphs were released into cotton plots weekly for four weeks after physiological cutout (NAWF=5), no yield penalty resulted from the late-season bugs compared to plots protected by four applications of Centric 40 WG.

The effect of host plants on parasitism of *Lygus lineolaris* eggs by the parasitoid *Anaphes iole* was evaluated with the aid of a polymerase chain reaction technique. The PCR technique permits accurate detection of the immature parasitoid within the host egg. Sexually mature, mated female *L. lineolaris* were caged on field-collected host plants for 2 days at 25°C, 75-90% RH, and 16:8 light:dark photoperiod. The bugs were then removed, mated female wasps were added to the cages, and the cages were held as noted above for several more days. At this time, host eggs were individually dissected from the plant tissue, placed in a labeled microcap, and frozen at -80°C until PCR analysis. Parasitism rates differed significantly between the eleven host plant species studied. Average parasitism rates ranged from ca. 10 to 95%. Parasitism rates in spring hosts, such as shepard's purse, henbit, cutleaf geranium, and curly dock, were highest (60 to 85%). Parasitism in cotton was ca. 50%, while parasitism in alfalfa varied from 40 to 95%. Location of host eggs on individual plant species had considerable influence on rates of parasitism. For example, host eggs deposited in the receptacle of *A. trifida* flowers suffered >80% parasitism, while those laid in the anthers were subjected to only ca. 25% parasitism. Similar results were observed for alfalfa and marestail. These results suggest that *L. lineolaris* eggs are vulnerable to parasitism by *A. iole* regardless of the plant host. However, it also appears that intra- and interspecific factors affect the vulnerability of *L. lineolaris* eggs to *A. iole*. These results suggest that the presence of some spring weeds might enhance the impact of *A. iole* on *L. lineolaris* following inoculative releases of this parasitoid.

Investigations on the development of a selective food source for parasitic wasps were continued. The effect of different carbohydrates present in nature (i.e., nectar and honeydew) and temperature on longevity of *A. iole* wasps was evaluated. Overall goals of this project are to identify food sources that selectively benefit *A. iole* more so than *L. lineolaris*. Results indicated that longevity of *A. iole* was correlated well with gustatory discrimination responses from previous studies. Longevity of the wasps was significantly greater at 20°C than at 27°C. This suggests that provision with the appropriate food might enhance the effectiveness of *A. iole* under springtime conditions when suppression of *L. lineolaris* is important. We identified several sugars that show promise for future testing with *L. lineolaris*.

Mass releases of *A. iole* were made at several sites in the delta. Several thousand wasps were released in unsprayed alfalfa, marestail, goldenrod, and ragweed supporting *L. lineolaris* populations during the summer and early fall. Prior to release, the surrounding vegetation was sprayed with 10% sugar water to ensure the presence of food. Host plants were collected 1 week after release, and *L. lineolaris* eggs were dissected and subjected to PCR analysis to assess parasitism. Parasitized host eggs were recovered 30 m from the release sites. These results suggest that *A. iole* has potential to establish feral populations in the delta. Collections will be made at the release sites in 2003 to determine the overwintering success of *A. iole*.

A new colony of *A. iole* was established from field collections in southern Arizona and California. Wasps were reared from parasitized host eggs in alfalfa, common lambsquarters, and London rocket. Collections were made at the same sites from which the colony currently at USDA-ARS BCMRRU was begun ca. 15 years ago. The colony at BCMRRU has been reared under laboratory conditions without infusion of feral wasps since its inception. Establishment of the new colony will facilitate comparative studies to determine the effects of long-term rearing on *A. iole*, and provide a source of wasps for other studies.

A three-year study of the species composition and population dynamics of stink bugs and their natural enemies in alfalfa was completed. Three insecticide-free alfalfa, *Medicago sativa*, fields were monitored in Mississippi from April through October. Densities of stink bugs and beneficial insects were assessed weekly by sweepnet sampling. Plant development was assessed weekly as well. The most abundant stink bug species present were the brown stink bug, *Euschistus servus*; red-shouldered stink bug, *Thyanta accerra*; and the rice stink bug, *Oebalus pugnax*. Together these species comprised 75% of the phytophagous stink bugs collected. A predaceous stink bug, the spined soldier bug, *Podisus maculoventris*, was also common. Two other phytophagous species, the southern green stink bug, *Nezara viridula,* and green stink bug, *Acrosternum hilare,* were uncommon. Stink bug populations did not show distinct peaks, possibly due to the disruptive effects of cutting hay. Generalist predators were common and abundant throughout the growing season. Tachinid flies, primarily *Trichopoda pennipes*, that parasitize nymphs and adults were also present, although parasitism rates were less than 5%. Our results suggest that alfalfa may be useful as a trap crop with cotton for suppression of *E. servus*. Alfalfa is a preferred host of this stink bug, therefore cutting hay when late instar nymphs are abundant may reduce subsequent damage in cotton.

A complex of stink bugs causes damage to Midsouth row crops, including cotton, soybean, corn, and sorghum. This complex consists of four species: brown stink bug, *Euschistus servus*; green stink bug, *Acrosternum hilare*; red-shouldered stink bug, *Thyanta accerra*; and southern green stink bug, *Nezara viridula*. Studies on the biology and management of these insects necessitate the establishment of laboratory colonies. In the spring of 2002 stink bugs were swept from wild host plants in the delta and the hill country between Greenwood and Starkville. Stink bugs were separated by species and placed in rearing cages, which consisted of 5 gallon white plastic buckets covered with fiberglass window screen. Tree seedling protector tubes were added to increase surface area, and paper towels served as oviposition substrate. Fresh green bean pods, and raw peanuts and sunflower seeds were placed on the screen covers. Cages were held in an environmental chamber at 25°C, 65-90% RH, and 16:8 light:dark photoperiod. Cages were inspected daily; newly deposited egg masses were cut out of the paper towel, and food was replenished. Cages were cleaned weekly. Field-collected adults were added to the colonies throughout the summer and fall. More than 600 egg masses were obtained from the colonies; they were used for experiments and to propagate the lab colonies. The number of eggs on each mass was counted and each mass was numbered to facilitate cross-reference to the colony rearing log. Some unused egg masses were stored at -80°C and will be used for field studies on predation and parasitism in 2003. Specimens of *Euschistus* and *Nezara* were shipped to USDA-ARS BCMRRU at Ms. State to facilitate initiation of colonies there. In September, egg production in the colonies began to decline considerably, and the photoperiod was increased to 24 h (constant light) in an effort to increase egg production. Nevertheless, egg production continued to decline, probably due to an 'internal clock' that initiates diapause regardless of photoperiod. By October there was only minimal egg production in the colonies and this was limited to *N. viridula*. In early November the colonies were placed outside where they will be subjected to ambient conditions for several months. After this vernalization procedure the colonies will be returned to the environmental chamber where egg production will hopefully resume.

A field study was conducted to evaluate mortality factors (parasitization/predation) on stink bug egg masses. Egg masses obtained from laboratory colonies of brown stink bug, *Euschistus servus*; green stink bug, *Acrosternum hilare*; red-shouldered stink bug, *Thyanta accerra*; and southern green stink bug, *Nezara viridula,* described above were established in weedy vegetation along a turnrow adjacent to cotton. The study was conducted from May to October along a 300 m section of the vegetation. A separate trial was setup about every two weeks. Egg masses stored at 4°C for less than 10 days were used. Sentinel egg masses were attached with a metal hair clip to the underside of plant leaves. The plant species to which egg masses were attached were chosen in a haphazard manner but was representative of the species composition present at the site. Plant species and height of egg mass were recorded for every egg mass. Egg masses from the different stink bug species were randomly placed along the 300 m transect. Sentinel egg masses were separated by at least 5 m. After 4 days sentinel egg masses were recovered and the number of eggs on each egg mass was counted and subtracted from the number present when placed, thus giving an assessment of predation. Notes were also recorded on the appearance of the egg masses, especially any observations that might provide a clue as to the identity of the predator. The egg masses were then placed individually in ventilated petri dishes and held for several days at 25°C, 65-90% RH, and 16:8 light:dark photoperiod. Egg masses were inspected every few days for the presence of egg parasitoids, thus giving an assessment of parasitization. The gender of wasps emerging from each egg mass was recorded, and wasps were preserved for taxonomic identification. Data are still being processed, however some trends are apparent. First, stink bug egg masses were preyed upon by arthropods with both chewing and piercing-sucking mouthparts, and were parasitized by at least two species (*Telenomus* sp. and *Trissolcus* sp.) of scelionid wasps. Second, predation tended to be relatively low (ca. 10-20%) in May and June but increased as the season progressed. Parasitization appeared to have a bimodal pattern with relatively high rates (ca. 60%) in May and early June, then a period of reduced parasitism in the summer, followed by increased parasitism in September and October. Finally, eggs of *A. hilare* appeared to suffer less parasitism than those of the other stink bug species studied.

In addition to two Cytochrome CYP6 P450 cDNAs cloned from pyrethroid-susceptible and resistant strains of *Lygus lineolaris* in 2001, a third P450 cDNA was cloned and sequenced from an independent resistant strain. Predicted cytochrome P450s from cDNAs were classified as the first three new members of subfamily CYP6X, CYP6X1v1 for a susceptible strain and CYP6X1v2 and CYP6X1v3 for two resistant strains. All three cDNAs contained a 1548-nucleotide open reading frame encoding a 516 amino acid residue protein. In all 26 nucleotide substitutions were revealed between cDNAs of susceptible and resistant strains. Two nucleotide substitutions resulted in amino acid changes, Asp^{373} to Ala^{373} and Ser^{487} to Ala^{487}, between susceptible and resistant strains. One nucleotide change in the resistant strain resulted in amino acid change S487A. This substitution was present in two independent populations with resistance to pyrethroids and was never detected in the susceptible strain. The results of this study indicated that cytochrome P450 gene mutation, coupled with up-regulation, was present only in the pyrethroid resistant strains, and was possibly related to resistance development in the tarnished plant bug.

Full CYP4 P450 cDNA was cloned from a pyrethroid susceptible strain of the tarnished plant bug. This CYP4 cytochrome P450 is another metabolic enzyme responsible for pyrethroid resistance development in insects.

Cadherin is a potential Bt receptor. Bt resistance was linked to the truncated cadherin gene in a resistant strain of the tobacco budworm. A 1069-bp cadherin-like DNA fragment was sequenced from Bt-resistant strain of European corn borer(ECB). One pair of specific primers was designed based on cloned sequence. PCR amplification of individual ECB DNA revealed a 963-bp band only from resistant ECB. No such band was amplified from the susceptible strain.

Two additional serine proteinase cDNAs were cloned and sequenced from both salivary gland and gut tissues of *L. lineolaris*. Inhibitory study showed that trypsins were major digestive enzymes in the salivary glands and are strongly inhibited by aprotinin, PMSF, and soybean trypsin inhibitor. Zymogram gel analyses with both casein and gelatin substrates showed different enzymatic profiles between salivary gland and gut. Gut enzymes were relatively less inhibited by aprotinin, PMSF, and soybean trypsin inhibitor. Maximal azocaseinase activity in the gut occurred at pH 4, and bug BapNase activity peaked at Ph 8, which was different from pH optimum (ph=10) in salivary glands.

Ribosomal ITS2 DNA fragments have been sequenced from four wasp species and two plant bug species. Primers were designed based on ITS2 DNA sequences. PCR amplification with these specific primers could distinctly separate each species from the others. By using this molecular approach, we could determine if the tarnished plant bugs were parasitized by multiple wasp species, and to trace down to specific species involved. PCR system was very sensitive and could detect *Peristenus stygicus* DNA at a concentration of 0.01 pg/µl or $7.5X10^{-7}$ wasp DNA equivalent. Early detection was successfully achieved, and egg stage of *P. stygicus* was detectable. Nearly all *Lygus hesperus* nymphs were detected to be parasitized by a single female of *P. stygicus* after one hour contact between the parasitoid and the hosts. Nymphs of *L. lineolaris* were collected from a field with no documented information about biological control agents. Approximately 10% nymphs were parasitized and contained wasp DNA. ITS2 sequence comparison and phylogenetic analysis indicated that the tarnished plant bugs were parasitized by a wasp closely related to *P. pallipes* or *P. howardi*.

Experimental transgenic cottons (Cry1Ac, Cry1F, and Cry1F stacked with Cry1Ac) (DowAgrosciences) were evaluated. Plots were artificially infested with fall armyworms and beet armyworms. Natural populations of pests were evaluated. These cottons have the potential to offer superior control of tobacco budworms, bollworms, loopers, and armyworm species similar to Bollgard II. (Southern Insect Management Research Unit, USDA-ARS, Stoneville, MS)

Missouri

Both experimental and registered cotton insecticides were evaluated in several field trials. Test results from an at-planting thrips trial and a plant bug / fleahopper trial are reported here.

Thrips. An in-furrow thrips trial was conducted at the MU Delta Center Lee Farm near Portageville, and the predominant thrips species present was the tobacco thrips, *Frankliniella fusca* (Hinds). At 10 days after planting plots treated with Gaucho and Cruiser (seed treatments) and Temik (0.525 lbs. AI/A) had lower thrips infestations than in the other insecticide-treated and untreated plots. By 24 days after planting plots treated with Temik (0.75 lbs. AI/A), Cruiser, and Orthene (seed treatment) had lower thrips infestations than in the other insecticide-treated and untreated plots. The top three treatments with respect to yield (lbs. seed cotton/A) were: Cruiser (seed treatment), Orthene (seed treatment), and Temik (0.75 lbs. AI/A).

Plant Bugs. Pretreatment counts indicated low, sporadic plant bug [predominantly tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois)] and beneficial (ladybird beetles, lacewings, and big-eyed bugs were most common) populations were present in a trial conducted at the MU Delta Center Lee Farm. At 3 and 7 DAT, no differences in total plant bug infestations [adults and nymphs of the clouded plant bug, *Neurocolpus leucopterus* (Say); the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter); and the tarnished plant bug] and beneficial populations were observed among the insecticide-treated and untreated plots. All insecticide treated plots had higher yields than in the untreated plots, and the top three treatments with respect to yield (lbs. seed cotton/A) were: Trimax (0.0313 lbs. AI/A), Orthene (0.3 lbs. AI/A), and Bidrin (0.331 lbs. AI/A).

Insecticide Resistance Monitoring. A total of 732 male cotton bollworm (Pemiscot County) and 554 male tobacco budworm (Dunklin County) moths were collected in pheromone-baited cone traps and tested for susceptibility to both cypermethrin and spinosad. These vial tests were held in conjunction with Dow AgroSciences and Cotton Incorporated (Insecticide Resistance Monitoring Program). Average survival of bollworm moths at the 5 and 10µg cypermethrin doses was 23.5 and 9.4%, respectively, whereas, average survival of budworm moths at the 5 and 10µg cypermethrin doses was 80.7% and 56.5%, respectively. At the 15µg spinosad dose (Vial source was Dow AgroSciences.), average survival of bollworm and budworm moths was 10.0% and 4.1%, respectively. Average survival in the control vials was 91% (budworm) to 96% (bollworm). (University of Missouri, Agricultural Experiment Station, Delta Research Center, Portageville, MO)

New Mexico

Yield compensation tests were conducted in the Mesilla and Pecos Valleys, which are following up on, yield partitioning tests that have been conducted for the last three years. The impact of microclimate on insect pest populations is also being evaluated with an emphasis on bollworm mortality. Results to date have been very variable but have shown less impact than was evident with boll weevil, which had extremely high mortality under hot, dry desert conditions. The impact of alfalfa on bollworm predation in cotton is also being evaluated. Results to date did not indicate differences in predation in relatively small cotton fields adjacent to alfalfa. Predation studies with bollworm eggs are continuing in the Mesilla Valley with correlations to populations of specific predators. (Departments of Entomology Plant Pathology and Weed Science and Extension Plant Science, College of Agriculture and Home Economics, New Mexico State University). (Cooperative Extension Service and Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM)

North Carolina

Several insecticide screening tests were carried out in 2002. 1) In a 12-treatment at-planting and foliar insecticide test for thrips, few yield differences were found between treatments due to poor, extended fall harvest conditions at this Rocky Mount location. Gaucho and Cruiser seed treatments showed high immature and adult thrips levels at 3 weeks after planting, in keeping with previous data collected here. A foliar application of Orthene 90S at 0.25 lb. AI/acre timed to coincide with the 1st true leaf stage provided thrips reductions, stand survival, and plant heights on a par with the high rate of Temik (0.75 lb. AI/acre). 2) Eighteen standard new bollworm insecticides were evaluated under high bollworm pressure in Richlands, North Carolina. The pyrethroids again showed numerically better bollworm efficacy than the non-pyrethroids Steward and Tracer, while Steward continued to show a slight numerical advantage over Tracer at the rates evaluated (0.104 and 0.063 lb. AI/acre, respectively).

An early season small plot, replicated test included various square and terminal removal plots, coinciding with the arrival of the second generation tobacco budworm flight. Except for the 100% square/100% terminal removal treatment, neither the 50%/50% square/terminal removal, the 10 large square removal per row foot or the Tracer and Karate insecticide ‘checks’ showed yields significantly greater than the untreated check. Under most insect and weather conditions in North Carolina, June treatment for second generation budworms seldom pays.

A test to evaluate the potential early fruit retention enhancement (and other) attributes of Trimax 4SC insecticide via multiple applications was conducted in SE North Carolina. This test was confounded by the presence of a high population of beet armyworms; therefore the more subtle plant effects which might have been caused by the Trimax treatments were not revealed.

In a late-season insect (bollworms, European corn borers, fall armyworms and stink bugs) boll damage comparison of Bt (Bollgard) vs. conventional(pyrethroid-protected) fields under producer conditions, 76 Bollgard fields were compared with 76 conventionally treated paired fields, either managed by the same producer and/or in close proximity. This 'real world' evaluation of the efficacy of Bollgard cotton has now been undertaken for 7 years, 1996 through 2002 (1082 total fields). The producer-managed Bollgard fields sustained approximately 2/3 as much overall boll damage as the conventional cotton fields, and were treated almost 2 less times (see Cotton Insect Report in previous section for individual late season pest differences).

Two cotton aphid tests, evaluation of the efficacy of the new choronicotinoids at selected rates revealed very good aphid control with all 3 compounds, Trimax 4SC, Centric 40WP and Intruder 70WP. Numerically, Intruder was the most active, followed by Centric, then Trimax.

An annual survey of North Carolina's licensed independent crop consultants working on cotton was continued in 2002 to gather data on how second generation (June and early July) tobacco budworms, late-season bollworms, thrips, cotton aphids, and plant bugs were managed by these individuals in conventional and in Bollgard cotton. Additional growers and selected county agents were contacted to make the survey more representative of the overall producer population. Most of the results from this survey are provided in the North Carolina Cotton Insect section above. Only 20% of the Bollgard cotton was not treated in 2000, while 67%, 13%, and 0.5% of the remainder of the Bollgard acreage received 1, 2 and 3 applications, respectively, primarily for bollworms but also for stink bugs and occasionally for plant bugs.

Two Bollgard II tests were undertaken in 2002 under moderate to high bollworm and low stink bug pressure. To help duplicate grower conditions, neither of these small plot tests was irrigated or over-sprayed with a disruptive insecticide. The Bollgard II line was essentially caterpillar-free, while the Bollgard line (50B) line sustained bollworm damage to bolls in the 3% range. It would appear that Bollgard II and similar Bt-stacked lines will very seldom require caterpillar control under grower conditions in North Carolina

A study of the effect of conservation tillage on thrips, bollworms and fire ant *(Solenopsis invicta)* populations was continued in 2002 at several locations. A wheat cover/strip till test in Edgecombe County and a weed cover/stale seed bed test in Scotland County were conducted. Early results suggested that thrips levels are at least two-fold less in conservation tillage. Paired field comparisons (6 each) of strip and no-till vs. conventional tillage for thrips levels, boll damage by bollworms and stink bugs, fire ant levels, and aphid colony establishment were made in SE North Carolina, an area in which fire ants have been established for approximately a decade. The data from the above test are still being analyzed as of this writing.

An initial test of the suitability of a Bollchecker (a thin device of Plexiglas or other material with a 1.25-inch diameter hole) as a means of determining boll sizes which may too large to be susceptible for stink bug damage was carried out in NE North Carolina in 2002. It is hoped that this or a similar device might form the basis for increasing stink bug thresholds during the boll development period to accommodate a maturing, and less stink bug-susceptible, boll population via quickly assessing boll diameters in the field to correlate with 3+ week-old ‘safe' bolls. First and second position bolls from ten cotton varieties representing a wide range of boll sizes (selected by the NCSU cotton breeder) were tagged early and late during the boll development period, and the diameters measured weekly with calipers. The data are also presently being analyzed. (Cotton Extension IPM Project, Department of Entomology, NCSU. Raleigh, NC)

Oklahoma

Several Bt cotton trials were conducted in 2002 to further evaluate the value of this technology under Oklahoma conditions. Since 1996, Bt cotton provided sufficient bollworm control and increased yields to compensate for rental fees under irrigation. During this 7-year period relying on the Bt technology enhanced profits by $22.44 per acre annually. For the third straight year Bt stripper varieties yields failed to compensate for rental fees under dryland conditions.

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

Research continued in 2002 to determine the impact of planting date on boll weevil management grown under dryland conditions. Previous research during years with high boll weevil survival indicates planting date is critical regardless of management scheme to raise profitable cotton. Yields favored May-planted cotton. Yields in neither planting regardless of treatment regime were not profitable due to the prolonged drought.

Nodes Above White Flower (NAWF4) is a reliable method to determine the last cohort of bolls that will contribute significantly to yield and accurate termination of scouting activities. The second of a three-year study begun this summer to see if the absence of late-season boll weevil infestations enhanced the value of the top crop. Preliminary results indicated there is no change in the value or the last cohort of bolls that contribute to yield. (Oklahoma Cooperative Extension Service, Altus, OK)

South Carolina

Pyrethroid insecticides continued to perform well on bollworm in both conventional and Bollgard cotton; no confirmed field failures were reported. No evidence of increased pyrethroid resistance was found in vial tests. Continued studies comparing conventional, Bollgard, and Bollgard II cottons confirmed Bollgard II to be more effective than Bollgard on bollworm, beet/fall armyworm, and soybean looper. It appears that Bollgard II cotton may not need to be treated for bollworm. Predaceous arthropod populations are similar in all three genotypes. Several new insecticides were tested for aphid efficacy, including acetamiprid (Intruder), thiomethoxam (Centric), and imidacloprid (Trimax). Intruder and Centric provided better control than Trimax, which was better than the standard–Bidrin. South Carolina continues to recommend no early season control (June) for aphids or plant bugs because of predaceous arthropod disruption and subsequent increased numbers of bollworm in July. Continued research of the piercing/sucking bug complex indicates our current threshold of 15% boll damage may be conservative. (Edisto Research and Education Center, Blackville, and Pee Dee Research and Education Center, Florence, SC)

Tennessee

Nine Bt (*Bacillus thuringiensis*) cotton varieties were compared at the Milan Experiment Station to four conventional varieties of similar parentage for efficacy against caterpillars and for yield. Highest yields were obtained with PM 1218 BR, but these did not differ from five other Bollgard varieties. They yielded higher than the conventional cotton varieties. A similar study was conducted at the Ames Plantation. FM 958 BR sprayed produced the highest yield followed by the unsprayed FM 958 BR. PM 1218 BR sprayed was third followed by the PM 1218 BR unsprayed. The best conventional was FM 958 sprayed which was 12th of 26 comparisons. At the Jackson location, eight of the nine Bt varieties and one conventional, FM 958, did not differ from the yield leader, DPL 555 BGRR. In 5 of 6 tests evaluating control of thrips on seedling cotton, there were no yield differences among treated plants, but treatments differed from the untreated check. Cruiser seed treatment led 4 of the tests and Gaucho led one. In a test evaluating plant bug control, there were no yield differences among plots. Six days after treatment (DAT), Centric and Karate had the highest level of control, but did not differ from 10 other treatments. Six treatments were compared for stink bug control. Stink bug numbers did not differ among treatments at 3 DAT, but all were different from the untreated check. Yields did not differ among treatments. At two locations, Bollgard II cotton with two Bt genes did not improve yield over the conventional Bollgard cotton with a single Bt gene. (University of Tennessee, West Tennessee Experiment Station, Jackson, TN)

Texas

Over 3,000 adult boll weevils (*Anthonomus grandis grandis*) were tested for resistance to malathion in Texas during 2002 using coated glass vials and exposing weevils for 48 h. Weevils from Burleson, Hidalgo and Wharton Counties were 2-3 days-old and had been collected from squares. Weevils from Jim Wells County had been trapped and thus, were of unknown age. Weevils from Burleson County were considered susceptible, while a few weevils from Wharton and Hidalgo Counties survived high dosages of 60 µg/vial. It is recommended that monitoring continue in Wharton, Hidalgo and Jim Wells County for 2003.

During 2002 resistance monitoring concentrated on field-collected budworms (*Heliothis virescens*) from Burleson County. Cotton fields were checked periodically throughout the summer for budworm eggs and/or larvae. No larvae collected on Bt cotton fields were of *H. virescens*; therefore, we collected them in non-*Bt* fields adjacent to Bt fields. Larvae were brought to the laboratory during the summer, reared to adults, mated, allowed to oviposit, and a total of 920 neonates emerging from these first laboratory generation were tested in five independent diet incorporation assays using the MVPII formulation containing the Cry1Ac Bt insecticidal toxin. The results indicate that the larvae were as susceptible to the Cry1Ac toxin as a laboratory maintained colony not previously exposed to Bt.

Research on predator movement in the Southern Rolling Plains (SRP) continued during 2001 and 2002 showed that predator movement out of grain sorghum benefitted cotton, with about 3 predators entering cotton for each predator leaving cotton for nearby sorghum. The ladybird beetles, *Hippodamia convergens* and *Scymnus loweii,* showed a particular tendency to colonize cotton from adjacent plots of sorghum. Cage experiments suggested that this beetle movement was caused by differences in crop attractiveness, due to both crop phenology and the density of aphid prey. Research covering three counties in the SRP suggested that movement measured at small scales extended to an area-wide effect; grain sorghum and uncultivated areas explained up to 14% of the early and mid-season variation in predator numbers in 60 cotton fields across the region. Areas not planted to cotton contributed to high predator levels in cotton, though effects on pest suppression and yields have not yet been documented. (Department of Entomology, Texas A&M University, College Station, TX)

Blue and yellow sticky traps (16 oz. plastic Solo® cups) in wheat and cotton and washing of cotton plant leaves have been used for the past three years to monitor thrips. Data are collected once a week from wheat from mid-April to early June and from cotton from early June to early July. Sampling is conducted in Hardeman and Knox counties. Ten species of thrips have been captured in wheat, and *Frankliniella occidentalis* comprises 99.1% of the total captured on blue traps and 72.8% on yellow traps in wheat. Eight species of thrips have been caught on sticky traps in cotton, and *Frankliniella occidentalis* comprises 93.3 and 94.4% of the total catch on blue and yellow traps, respectively. Only five species of thrips have been obtained from the cotton plant washing samples, and *Frankliniella occidentalis*, the western flower thrips, and *F. fusca*, the tobacco thrips, comprise 63.2 and 30.6% of the total captured. The yellow sticky trap captures more *F. fusca* than the blue trap in both wheat and cotton, but thrips are much easier to count on the yellow traps. It is apparent that more species are captured on the sticky traps than actually occur on the cotton plants, and that captures on the yellow traps are more representative of the species complex that actually infests cotton.

Sweep net sampling was used to determine species composition, distribution and abundance of *Lygus* bugs in the northern Texas Rolling Plains. Samples were taken in 15 counties during May and July in 2001 and 2002. Samples taken in May were from alfalfa, vetch, and blooming roadside weeds, and samples taken in July were from alfalfa and cotton. Of the 409 *Lygus* spp. identified from 20,646 sweeps, 15.9, 32.3, and 51.8% were *L. lineolaris, L. hesperus,* and *L. elisus*, respectively. *Lygus lineolaris* was present in low numbers throughout the Rolling Plains, while both *L. hesperus* and *L. elisus* were most numerous in the northwestern region of the northern Rolling Plains. There was an apparent species ratio shift in alfalfa, and *L. lineolaris* was more abundant in July than in May, while *L. hesperus* and *L. elisus* were more abundant in May than in July. Sweep net sampling data taken in 1976 and 2001/2002 indicate that there has not been a significant change in *Lygus* abundance in cotton or alfalfa since the mid-1970's. Only 8 *Lygus* bugs, in 10,675 sweeps (0.07/100 sweeps), were detected in cotton in only four counties, and there was no evidence to suggest that *Lygus* bugs pose a current threat to cotton production in the Texas Rolling Plains.

Field experiments were conducted to quantify the effect of nitrogen fertilizer on cotton aphid population dynamics under the drip irrigation system. Five levels of nitrogen (0, 50, 100, 150, and 200 lbs per acre) were evaluated in a randomized block design with 4 replications at the Helms Farm near Halfway. Soil residual nitrogen was determined for each treatment plot before treatment application, and leaf nitrogen was monitored weekly for 5 weeks in July-August. Unfortunately, cotton aphid abundance was almost negligible in this year's test plots; therefore we were unable to make meaningful correlations between nitrogen fertility and aphid abundance. However, this year's data will be used to establish any relationship between soil nitrogen and leaf nitrogen. In the laboratory, aphid consumption rate of lady beetles was studied. These data are being incorporated into the population dynamics model. (Texas Agricultural Experiment Station, Vernon, TX)

Quantifying natural enemy profile and developing a decision-rule system. The natural enemy complex, including arthropod predators and parasitoids, was investigated in cotton as affected by crop management practices, including planting date, tillage system, and cotton cultivar. The study was conducted at the AG-CARES Farm at Lamesa. Two tillage systems, conservation and conventional systems, and two planting dates, normal and late planting, were evaluated for both conventional and transgenic-Bt cotton cultivars for their effect in supporting arthropod natural enemies. Natural enemy sampling was conducted throughout the growing season to quantify the seasonal activity patterns of each species. Sampling methods included visual sampling, beat bucket, sweepnet, dropcloth, and vacuum sampling. Ground-dwelling predators were monitored using pitfall traps, and cotton aphids were monitored by visually inspecting 20 leaves per plot. Preliminary analyses suggested the following: 1) Ground-dwelling predators were more abundant in conservation tillage plots than in conventional tillage plots during early season; 2) Tillage system had no significant effect on foliage-dwelling predatory arthropods; 3) Predaceous beetles were the most dominant foliage-dwelling predators in both tillage systems, followed by spiders, predatory bugs, and lacewings; 4) Overall, visual method detected the highest abundance of all predator groups, followed by beat bucket, dropcloth, sweepnet, and vacuum sampling methods; 5) Cotton aphid abundance was significantly influenced by tillage system and planting date but not by cotton cultivar; and 6) A significant negative relationship was observed between cotton aphid abundance and predator abundance.

A project on the biology and ecology of Lygus and other plant bug species was initiated to investigate the biology and seasonal activity patterns of Lygus species in cotton as affected by planting date, irrigation management, and crop cultivar. Two planting dates (normal and late planted) and four commercial cotton cultivars (Paymaster 2145RR, Paymaster 2167RR, Paymaster 2326RR and Stoneville 2454R) were evaluated at the Helms farm near Halfway. Three irrigation water levels (50, 75, and 100% ET replenishment), two irrigation methods (low energy precision application or LEPA and low elevation spray application or LESA), and four cultivars (Stoneville 4793R, Deltapine 5415RR, Paymaster 2326RR, and Stoneville 2454R) were evaluated in Gaines County near Denver City. Lygus abundance was monitored throughout the growing season. Preliminary analyses suggested the following: 1) Beat bucket captured the most Lygus compared with several other sampling methods; 2) Paymaster 2326 had significantly higher Lygus abundance compared with other cultivars at both study sites; 3) Late-planted cotton supported significantly more Lygus than cotton that was planted during the normal planting window; 4) Lygus numbers were lower at the lowest irrigation water level; and 5) LEPA irrigation system supported higher abundance of lygus than the LESA irrigation system.

Beet armyworm biology as affected by planting date and a wild plant host (pigweed) was investigated in Lubbock in a study of two planting dates (normal and late planting) and two cultivation practices (weedy vs. clean cultivation) for beet armyworm larval abundance. A modified dropcloth method was used to estimate beet armyworm larval population during the peak beet armyworm activity. A vacuum sampler was used to monitor predator activity in the test plots throughout the season. Data are being summarized.

Investigations of host source of Lygus bugs in the Texas High Plains were conducted in mid- to late April in each of the 25 counties of the Texas High Plains that comprise what is called the Plains Cotton Growers (PCG) service area. The standard sweepnet sampling method was used to survey prominent weed hosts along roadsides in each county. Approximately 1,000 sweep samples were taken per county, and approximately 200 sweeps were taken per host plant species. In an effort to establish a host plant sequence of Lygus movement from wild habitat to cotton, surveying was continued at a 4-week interval in

Hale, Lubbock, and Gaines counties. All 25 counties were again surveyed in late July to coincide with cotton blooming/fruiting. The last survey was conducted in early September, coinciding with boll maturity. A seasonal total of 67,330 sweep samples were taken from non-cotton hosts, with a survey sequence of mid-April, mid-May, mid-June, late July, and early September. Cotton in all 25 counties was also surveyed for Lygus population levels in late July. Cotton sites surveyed for Lygus were adjacent to the non-cotton survey sites in each county. A second survey was conducted in cotton in Hale, Lubbock, and Gaines counties in early September. Over 33,000 sweeps were taken from cotton. Data summary will be presented at the 2003 Beltwide Cotton Conferences.

Cotton aphid abundance patterns as affected by precision application of nitrogen and irrigation water were monitored in 135 experimental units (precision management plots) at the AG-CARES farm for 5 weeks. Precision management units were designed to evaluate the effect of three fertilizer treatments (zero nitrogen application, blanket application of nitrogen, and variable rate application of nitrogen based on residual soil nitrogen level) under three irrigation water levels. Cotton aphid abundance was estimated by examining 20 leaves per plot; all 135 plots were monitored on the same day. Percentage leaf moisture and leaf nitrogen of the 5^{th} leaf from the mainstem node were estimated by picking 10 leaves per plot per week to coincide with the aphid sampling. Data are being summarized. (Texas Agricultural Experiment Station, Lubbock, TX)

Cotton varieties from the same recurrent parent breeding lines that did or did not contain Bollgard® technology were compared economically for their usefulness in the defense of cotton bollworms and budworms and from other insect pests that are not affected by this technology at a northern and southern location on the Texas High Plains. The most intense insect pressure came from beet armyworms, an insect not targeted for Bollgard® control, in the southern location. Conventional insecticides applications saved an average of 200 kg/ha of lint cotton, but this was not economically feasible because of the number of applications and cost of the insecticides. The northern location did not have any insect pest surpassing the economic threshold, especially those targeted for Bollgard® control. The results reported here indicate that Bollgard® technology developed in determinate type varieties for the Texas High Plains may not be economically justified in the northern counties of the Texas High Plains.

A preliminary collection of *Lygus* species from cotton, *Gossypium hirsutum* L., on the Texas High Plains in 1999 indicated that *Lygus hesperus* Knight and *Lygus elisus* Van Duzee were the most common economically damaging species, followed by very low densities of *Lygus lineolaris* (Palisot de Beauvois) and *Polymerus basalis* (Reuter). Further intensive surveys from 2000 and 2001 revealed that during June and July, the probability of finding *L. hesperus* and *L. elisus* in production cotton or alfalfa, *Medicago sativa* L., is essentially the same. Alternate weed hosts such as kochia, *Kochia scoparia* L., lambsquarter, *Chenopodium album*, yellow sweet clover, *Melilotus officinalis* and redroot pigweed, *Amaranthus retroflexus* L., were acceptable hosts for both *L. hesperus, L. elisus,* and also *Polymerus basalis (Reuter)*, a related species that feeds mostly on weed florets and not a damaging pest of cotton. The Texas High Plains is the only known production region where *L. hesperus* and *L. elisus* pose equal threats to cotton production. Information is available on insecticide choice and management of *L. hesperus,* but little information is available for *L. elisus*, which accounts for at least one-half of the *Lygus* problem. Misidentification has probably occurred for a number of years on the two *Lygus* species. Damage assessment, insecticide efficacy and other management options need to be developed for *L. elisus* on the Texas High Plains.

Both species of Lygus have been found to be almost equal in distributions in the cotton ecosystem on the Texas High Plains; however very little is known about the damage potential of *Lygus elisus* as compared to *Lygus hesperus*. The field portion of this study involved enclosing both species on first position 6^{th}, 9^{th} and eleventh node, one-third grown cotton squares and following each square from abscission or to seed-cotton yield. Feeding damage was very similar from both species, resulting in significant reductions in seed cotton yields and boll abscission compared to squares that were enclosed but not infested with either species. In three out of six laboratory feeding trials where both species were enclosed on squares maintained in the laboratory, *L. elisus* damage was significantly higher than *L. hesperus* The results of this study indicate that the threshold for *L. elisus* will be equal to or slightly lower than that of *L. Hesperus.* (Texas Tech University, Texas Agricultural Experiment Station, Lubbock, TX)

Aphid numbers were reduced significantly in a test by F1785 DF (FMC), Trimax, Furadan, Intruder, and Centric but not by 6 oz/ac of Bidrin. Intruder and Centric were most consistent in reducing aphids and lowering the damage rating for 20 days after treatment. Intruder and Centric (2.0 oz/acre) treated cotton produced significantly more lint than the untreated cotton (over 200 lb lint/acre).

In a study on treatment timing for fleahopper with Centric, statistical differences were not observed in lint production; however, there was a trend in that treatments which averaged < 16 fleahoppers/100 plant terminals produced more cotton (72 lb lint/acre) compared with those treatments where fleahopper numbers averaged > 16/100 plant terminals. No differences were found in response of FM 832 (okra leaf) and FM 958 (conventional leaf) cotton varieties to fleahoppers. This study will continue.

Pyrethroids were not effective in tests in reducing tobacco budworm larvae, but Steward, Asana, Tracer, and Denim effectively reduced their numbers and damage.

Temik, Cruiser, and Gaucho were generally effective in providing 50+ lb/acre lint yield increases in 50% of the field experiments conducted for thrips control. Temik appeared to be more effective in reducing thrips numbers, but it was generally not reflected in greater lint yields compared to the other treatments. A study was conducted to measure impact of at-planting systemic insecticides on fleahoppers, but useful data were not obtained. This study will be continued.

Bidrin and Orthene were more consistent in reducing brown stink bugs than any other insecticide or combination of insecticides tested. Other insecticides provided control of southern green stink bug but in mixed populations, Bidrin and Orthene were superior. (Texas Cooperative Extension Service, Corpus Christi, TX)

Sampling studies were continued for Lygus and cotton fleahopper by evaluating the beat bucket, drop cloth, visual whole plant and sweepnet methods of sampling. (Texas Cooperative Extension Service, Ft. Stockton, TX)

New research projects included developing screening procedures to identify resistance to cotton fleahopper in cotton through field and greenhouse screening of 20 genotypes. Research was conducted to monitor the movement of cotton fleahopper into cotton using sticky cards and malaise traps in cooperation with ARS. Research on the impact of boll weevil eradication spraying on beneficial insects was initiated in the Southern Blacklands Zone. Research continued on evaluating survival of weevils in harvested cotton from the field to the gin in cooperation with USDA-ARS.

Cruiser and Gaucho were compared to Temik at various rates for control of thrips in two trials. Intruder and Centric were compared to the standards Bidrin and Orthen for control of cotton fleahopper. (Texas Cooperative Extension Service, Dallas, TX)

A trial was initiated at first bloom to evaluate different insecticides for their effectiveness on bollworm. Indoxacarb (Steward®), spinosad (Tracer®), emamectin benzoate (Denim®) and an experimental compound from FMC (F0570) significantly reduced bollworm numbers below threshold three days after treatment (DAT). However, 5 DAT none of the treatments was significantly different from the untreated control. Methoxyfenozide (Intrepid®) did not perform well in this trial, which corresponds to other trials on the cotton belt.

A trial was initiated during the third week of bloom to evaluate different insecticides for their effectiveness on a mixed population of bollworm/budworm larvae. Mixtures of indoxacarb (Steward®) and esfenvalerate (Asana®), spinosad (Tracer®) and a pyrethroid (F0570), emamectin benzoate (Denim®) and lambda cyhalothrin (Karate®), and Denim® alone significantly reduced larval numbers below threshold 3 DAT. The same treatments performed well 7 DAT. Methoxyfenozide (Intrepid®) did not perform well in this trial, which corresponds to other trials on the cotton belt when bollworm is the dominant species.

The use of seed treatments or at-planting soil insecticides in cotton in the Southern Rolling Plains has been a marginal practice. This trial evaluated two seed treatments (Gaucho® and Cruiser®) and an at-planting soil insecticide (Temik®) for early season insects. None of the treatments was significantly different from the others. Insect pressure was light, but thrips numbers in the treatments were significantly less than the untreated check. This trial also shows the disadvantage of reducing the rates of soil insecticides.

We also evaluated reduced tillage and conventional tillage operations and their effects on arthropod populations, concluded a study on insect movement between grain sorghum and cotton fields, and evaluated a Bollgard® II trial. (Texas Cooperative Extension Service, San Angelo, TX)

We found that 2,4-D (Savage brand) when applied at 1 pound formulation at 0 days post shredding to 14 days post shredding and then followed by a second application of 1 pound formulation at 27 days post shredding resulted in 100% mortality of cotton stalks. This practice would greatly enhance boll weevil control in our area.

An aphicide screening trial was conducted in 2002 with the following materials: Centric 40 WG at 2 oz/ac, Leverage at 3 oz/ac, Intruder 70 WP at 0.8 oz/ac, Furadan 4F at 8 oz/ac and Trimax 4F at 1.5 oz/ac

A silverleaf whitefly control test was conducted in 2002 involving the following treatments:

Novaluron 0.83 SC @ 0.013 #AI/ac, 0.026 #AI/ac, 0.052 #AI/ac; Oberon 2SC @ 7 oz/ac, 8.5 oz/ac, 12 oz/ac; Danitol 2.4 EC @ 8 oz + Orthene 90S @ 0.5 # formulation/ac and Applaud 70WP @ 0.54 # formulation/ac. (Texas Cooperative Extension Service, Weslaco, TX)

The GRID boll weevil trapping project was continued into its 8th and final year in the High Plains area. This is a cooperative project between Extension and Plains Cotton Growers, Inc. and involves about 900 traps in 28 counties. Results from 2002 clearly demonstrated the impact of boll weevil eradication activities in those zones that have been active, including the two new ones. Less than 5 boll weevil adults were trapped all season. We also continued an 8-year survey of boll weevil overwintering sites in 13 counties in the High Plains, evaluating mainly broadleaf litter, consisting mostly of elm. The number of counties was reduced to only those in the two new zones that initiated their program with a diapause program in the fall of 2001. Very few dead boll weevils were found, and no live ones were detected. These data provided evidence that the eradication effort and winter mortality had greatly reduced weevil numbers. Both GRID trapping and overwintering site surveys will be discontinued in 2003 because of the very low weevil numbers from success of the eradication program.

Validation of the COTMAN model continued in the High Plains area. This included evaluations of SQUAREMAN in IPM programs, BOLLMAN as a tool to determine when to terminate insecticide applications for bollworms and plant bugs, as well as when to terminate the crop. The latter 2-year study was conducted by a graduate student from West Texas A&M University at Canyon involving the value of the top crop in high yielding systems were boll weevils are no longer a factor. The SQUAREMAN project was continued into its second year of a 3-year study looking at developing a compensation function for pre-blooming square loss in the High Plains area. Five square retention levels were evaluated in a factorial design under a normal planting date regimen. Target development curves, box mapping of yield by position, and economic analysis by boll position are being studied. Preliminary analysis indicates that while some vertical compensation took place, most node replacement occurred out on the fruiting branches. It was also observed that increased boll retention may be a more important means for a plant to compensate for early fruit loss. The yields from the 2001 study indicated that plants super-compensated in all square removal treatments, significantly out-yielding the check. There were no significant differences in yield between any of the treatments in the late planting date treatment. COTMAN studies were initiated on dryland cotton for square removal compensation values in 2002. Irrigation termination studies were also initiated.

Insecticide efficacy trials were conducted with new and existing insecticides against thrips, cotton aphids, and bollworms. Both Temik and Cruiser were efficacious, while Gaucho and the Orthene seed treatment were again not effective in 2002. Foliar sprays of Orthene based on TCE thresholds were effective while applications timed with the Roundup application window were too late. COTMAN was run on this test to determine target development curves and earliness. A subsection of this test involved a Temik rate study ranging from 2.0 pounds to 5 pounds per acre. The 4 and 5 pound rates significantly outperformed the lower rates. Because of these findings and earlier observations, our Temik recommendation have been increased from the 2.0-2.5 pound rate range to 3.0-3.4 pound rate range. An aphid control trial was initiated, but infestations declined rapidly following treatments resulting in only a 0 and 3 day post treatment evaluation. Intruder performed the best but Centric and even Trimax performed well. Furadan provided adequate control but less than Intruder. F1785 did not provide sufficient control, with Bidrin performance somewhat less than Furadan. Aphid Pruf, an organic aphicide produced locally, did not provide any control of aphids.

The bollworm control test involved 14 treatments. Pyrethroids did not perform well. Steward, Tracer and Denim provided less than satisfactory control. The best treatments involved Larvin. This test had only one generation cycle through during the evaluation period. (Texas Cooperative Extension Service, Lubbock, TX)

Research was continued on the threat of reintroduction of boll weevils to eradication zones through transport on modules and survival in cotton gins, in cooperation with A. Brashears (USDA-ARS) in Lubbock, TX; M. Parajulee, S. Carroll, and M. Arnold (Texas Agricultural Experiment Station) in Lubbock, TX; J. Norman and A. Knutson (Texas Agricultural Extension Service) in Weslaco and Dallas, TX, respectively. We have found that adult weevils were present in defoliated cotton (up to 2300/acre) and that live adults were packed in modules even when field populations were low (200 – 1200/module). Most weevils on the module surface disperse by flight as soon as possible. Our data indicate that the probability of weevils being transported on the surface of a module to disperse later in an eradication zone, either en route or at the gin yard, decreases rapidly with time after module construction. The greatest threat would occur when a module is constructed and transported during cool, cloudy weather, followed by warm weather favorable for flight at the gin yard. If a field cleaner is used, it will remove about 85% of harvested weevils from the seed cotton before it is packed into a module. In experiments with gin dryers, no weevils survived 24 h after passage through 1 dryer at 300°F or through 2 dryers at 185°F. Previous experiments indicated no evidence of survival through seed cotton cleaning and to the gin stand. We tested the fate of any weevils that might survive that far and found that about 0.1% of weevils approaching the gin stand are separated alive into the seed fraction, and 30% of those survive the passage through the conduit to the seed bin. Thus, the probability of live weevils occurring in cottonseed after ginning is extremely low. If any weevils survive to the gin stand, we have no evidence that any can make it through alive into the lint fraction. Other experiments provided no evidence that any weevils can survive passage through one lint cleaner. Experiments with infested bolls indicated that a device which cracks open green bolls at their natural seams would greatly reduce, and perhaps prevent, survival of weevils exiting a gin in the gin trash and passing through a fan operated at any speed. The design of potential devices for cracking bolls are being considered.

Boll weevil flight behavior was studied on computerized flight mills. Both the duration and speed of flight was similar between weevil sexes, and the duration of flight increased with weevil age to a peak at 9-11 days old. The duration of flight per day was similar for weevils fed diapause-inducing (boll) or reproductive (1 square/day) diets through 11 days of age. However, weevils fed a diapause-inducing diet for 14-28 days flew 4.6-times longer per day than weevils fed a reproductive diet. These results suggest feeding on late-season bolls is more likely to promote dispersal than in-season square feeding.

Mitochondrial DNA (mtDNA) haplotypes were determined for weevil populations from Texas, New Mexico, Oklahoma, Louisiana, Arkansas, Missouri, Mississippi, Tennessee, and Mexico. Significant differences in haplotype (~genotype) frequencies were observed among populations, and marked differences were observed between weevil populations in the Southeast (LA, AR, MO, MS, TN) and those in the Southwest (NM, OK, TX). Several weevil populations were found to exhibit distinctive haplotypes. Haplotype frequencies of respective weevil populations revealed a positive correlation between genetic and geographic distances among populations. Genetic diversity was greatest in collections from Mexico, and generally decreased with increasing latitude. Levels of divergence at the regional scales so far examined suggest little net movement between sampled populations. A possible exception is that weevil populations in the Lower Rio Grande Valley may be receiving immigrants from the Tampico area of Mexico. The results so far suggest that long-range (> 100 miles) movement is a relatively rare event. Genetic structuring between populations on a finer geographic scale is likely and awaits further analyses. (USDA-ARS-SARC, Integrated Farming and Natural Resources Research Unit, Weslaco, TX)

Field studies were conducted from 2000 to 2002 to characterize and compare the season-dependent morphological/physiological status (mating status and fat body, midgut, and reproductive development) of trap-captured weevils with those of weevils infesting the standing cotton crop. Prominent differences between the two sources suggest many trap-captured weevils originate from sources other than cotton, particularly during the early- and mid-growing season. Also, presence of oocytes and egg remnants in overwintered weevils captured in traps prior to planting of cotton suggests some weevils overwinter with eggs and/or attain substantial reproductive development on pre-fruiting cotton.

In laboratory studies overwintered and newly-eclosed female weevils exhibited substantial reproductive development on pre-fruiting cotton (cotyledon and 4-leaf stage plants). The proportion of weevils initiating egg development was higher in overwintered weevils compared with newly eclosed weevils, but <5% from either source produced mature eggs.

Effects of diet switching on termination of reproduction (switching from squares to bolls) and subsequent host-free longevity were examined in a laboratory study. Females switched from squares to bolls exhibited reduced egg complements, increased incidence of oosorption, increased fat body complement, and extended host-free survival compared with females fed squares. Host-free survival was greater for males than females, but some females known to have oviposited survived >20 weeks.

Previous diapause induction studies were supplemented by studies of the responses of overwintered weevils to diet. Trap captured overwintered weevils were fed either reproductive (square) or diapause-inducing (boll) diets. Weevils fed squares developed reproductively. A small, but significant, proportion of females fed bolls re-acquired the diapause characters. A large proportion of both sexes acquired hypertrophied fat bodies on the boll diet, and subsequent host-free longevity was significantly longer than for unfed weevils.

Studies at temperatures between 65 and 85°F (18.3 and 29.4°C) indicated development of diapause characters was only slightly temperature dependent. At early ages (≤6 d) lower temperatures increased the perceived proportion of diapause because of the marked temperature dependence of reproductive development. These differences were not evident at older ages. Ongoing studies examining survival of weevils fed bolls for 14 d at temperatures from 65 to 85°F (18.3 and 29.4°C) indicate no differences among the temperature treatments after 11 weeks of starvation.

The rate of food passage through the boll weevil gut was examined for utility in detecting recent association with cotton. The rate of food passage was estimated for boll- and square-fed weevils held at 18.3 and 29.4°C. Rate of food passage was similar for both food types but varied between temperatures. Presence of solid food in the midgut indicated feeding within the past 2 to 4 d. Presence of intact cotton pollen in the midgut indicated square feeding within the past 12 to 36 h. In addition to gut contents, atrophy of accessory glands in males and occurrence of oosorption in females were examined as supporting evidence of recent association with cotton. The degree of accessory gland atrophy and the proportion of females exhibiting oosorption increased daily through a 4-d starvation period. These results suggest that well-developed accessory glands or well-developed ovaries lacking signs of oosorption in trap-captured weevils are indicative of recent (1 – 4 d) association with cotton.

Cold bath studies examined supercooling points of reproductive and diapausing adult weevils and the impact of diet on weevil supercooling. No significant differences in supercooling points were observed between reproductive (-16°C) and diapausing weevils (-17°C), or between sexes. Weevils with boll material present in the midgut supercooled to a lower temperature (ca. 3°C difference) than weevils with square material (primarily pollen) in the midgut. However, following a 2-d starvation period no significant differences in supercooling points were observed between boll- and square-fed weevils.

Field studies were initiated to determine the feasibility of using sticky or malaise traps to detect cotton fleahopper movement into cotton. Fields with the highest numbers of cotton fleahoppers, indicated by mechanical KISS samples, also had the highest captures on sticky traps and tended to have the lowest percent square set by the third week of squaring. Yellow sticky traps in the field interior exhibited the greatest potential for monitoring cotton fleahoppers in cotton.

A laboratory study was conducted to identify boll weevil punctures and monitor temporal development of a plant response to these punctures. We monitored the development of a plant response for unsealed punctures and punctures sealed with frass or wax at 1-, 2-, and 3-d intervals on squares remaining intact with the cotton plant. Punctures were monitored daily to establish known puncture ages. Punctures sealed with frass elicited more plant responses than did wax-sealed or unsealed punctures. At 1 d of age, low frequencies of unsealed oviposition punctures (0.0 - 7.7%) and oviposition punctures sealed with frass (6.5 - 9.8%) or wax (1.2 - 3.8%) generated a plant response. A high frequency (91.8 - 96.3%) of oviposition punctures failed to produce a plant response, while some punctures not containing eggs produced a response. Unsealed oviposition punctures (43.5 - 44.4%) and oviposition punctures sealed with frass (58.4 - 64.7%) and wax (33.3 - 48.2%) exhibited a plant response at 2 d of age. At 3 d of age, unsealed oviposition punctures (65.2%) and oviposition punctures sealed with frass (74.8%) and wax (63.2%) exhibited a plant response. At puncture age intervals of 1, 2, and 3 d, some oviposition punctures failed to produce a plant response, while other punctures not containing eggs produced a response. Lack of a plant response for oviposition punctures and presence of a response at non-oviposition sites suggest plant responses are not restricted to egg presence. These results suggest closer examination of unsealed and wax-sealed oviposition punctures eliciting plant responses, in addition to frass-sealed punctures, can provide additional tools for accurately detecting boll weevil infestations.

The research literature is split on whether or not thrips are of economic importance in cotton. However, cotton producers routinely use a systemic, restricted-use insecticide for early season thrips control, even in years where there is not an economically damaging level of thrips. Control of thrips through aerial application, if shown to be effective, could reduce the amount of soil insecticides used in cotton production. Second-year studies were conducted to evaluate the efficacy of conventional and electrostatic aerial spray systems on control of early-season thrips populations in cotton. Contrary to the first-year results, electrostatic application did not consistently deposit more material on seedling cotton than did conventional application. Conventional and electrostatic aerial applications of insecticide were effective, but not significantly different, in controlling thrips on seedling cotton.

A new endocrine gland (the first found in insects in 50 years) has been found at the base of the antennae of the bollworm, *Helicoverpa zea*, and several other species of moths including the gypsy moth, *Lymantria dispar*. Products are released from this gland into the circulatory fluid supplying the antennal nerves. The antennal nerves are the main olfactory sensory organ of moths through which they receive environmental signals such as pheromones and chemical cues of oviposition sites. Thus, the products of this new gland regulate the input of these critical environmental signals that are required for maintaining the life cycle and survival of these agriculturally important pests. Because the products of the antennal glands appear to modulate the reception of species-specific pheromones, it is likely that these glands synthesize products specific for each species of moth, thus enabling them to compete in their environmental niche. The discovery of this gland (found thus far only in Lepidoptera) will provide a new target for research in controlling these agriculturally important pests, and will permit development of control agents that will be harmless to non-target organisms.

Field research was conducted to assess the value of Mexican free-tailed bats, *Tadarida brasiliensis,* to crop protection. A significant portion of the bat's prey consists of bollworm moths, *Helicoverpa zea*, a major insect pest of cotton, corn, and other field crops. Ultrasonic detectors and red/infrared-illuminated video recorded flight activity of moths and bats above cotton and corn canopies during peak emergence and dispersal of adult *H. zea* from mature corn. Additionally, "Virtual Bat" ultrasonic transmitters were designed, constructed, and deployed to broadcast a random sequence of simulated search phase calls, approach calls, and feeding buzzes in treatment plots. Virtual Bat broadcasts increased bat flight activity above cotton and corn fields approximately ten-fold compared to control plots as determined by video recordings. Flight activity of moths above cotton and corn fields was not consistently influenced by Virtual Bats broadcasts, but on-going research will examine effects of bat flight activity and ultrasonic calls on mating and oviposition activity of *H. zea*. (USDA-ARS, Areawide Pest Management Research Unit, College Station, TX)

Virginia

Eight field trials were conducted evaluating a total of 80 insecticide treatments for levels of thrips control and effect on lint yield. Treatments consisted of selected insecticides applied in-furrow as granules or liquids, seed treatments, or foliar applications. Treatments included 15 insecticides applied at different rates and timings (Gaucho 480, Gaucho 600FS, Cruiser 5FS, Temik 15G, Orthene 97, Karate Z, Baythroid 2EC, Decis 1.5EC, Capture 2EC, Fury 1.5EC, Provado 1.6, Admire 2F, Bidrin 8, Trimax 480, Centric 40WG) and 2 experimental compounds. Treatment timings included seed treatment, in-furrow at planting, or as foliar applications at either the late cotyledon-1st true leaf, or 2-3 true leaf stages. Lint weights were higher with most treatments compared with untreated controls, and many were significantly higher with some being as much as 200-400 lb higher. Seven field trials were conducted to evaluate a total of 47 treatments for control of the bollworm/budworm complex. Treatments included nine cultivars (DP 50BG, DP 50BGII, DP 50, DP 425 RR, DP 451 BR, SG 125BR, SG 125RR, FM 989 R, and FM 989 BR) and 13 insecticides (Steward 1.25EC, Asana XL, Tracer 4SC, S-1812 35WP, Orthene 97, Karate Z, Baythroid 2EC, Leverage 2.7, Fury 1.5, F 0570 0.8EC, Capture 2EC, Decis 1.5EC, and XR-225). Lint weight increases compared with untreated controls ranged, depending on treatment, with some significantly higher by as much as 100-170 lb . In one test, 0, 5, 15 or 20% of all 10-14 day old bolls were systematically removed 14, 18 or 23 days after first flower. There appeared to be no reduction in lint yields, except in the 15 and 20% removal rates imposed on the latest removal date. (Virginia Tech, Tidewater AREC, Suffolk, VA)

Additions to Insecticides/Miticides Registered for Cotton Pest Control

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

Changes in State Recommendations for Arthropod Pest Control in Cotton

Additions and deletions of recommended pesticides by state extension organizations for the 2001 crop year are listed in Table 2. Included also are changes in thresholds or indications for certain pests.

Insecticides/Miticides Screened in Field Tests

Pesticides (experimental materials or pesticides not labeled/recommended for use yet on certain pests) tested by state and federal researchers during the 2001 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 2002.

State	Pesticide	Target Pest
Alabama	Acetamiprid (Intruder)	
Arizona	Applaud® (buprofezin)	Whiteflies
	Actara® (thiamethoxam)	Whiteflies
Arkansas	Trimax 4SC	
	Intruder	
California	Assail	Aphid, whitefly, Lygus
	Centric	Aphid, whitefly
	Courier	Relabeled, originally Applaud
	Onager	Relabeled, originally Savey
Florida		
Georgia		
Louisiana	Instruder 70SC	
Mississippi	None	
Missouri	None	
New Mexico	None	
North Carolina	Intrepid 2F (methoxyfenozide)	Beet armyworm, fall armyworm, soybean looper, cabbage looper
	Intruder 70W (acetamiprid)	Cotton aphid, plant bug
	Trimax 4F (imidacloprid)	Cotton aphid, plant bug
Oklahoma	None	
South Carolina	Trimax 1.0-1.5 oz/acre	Aphids, plant bugs
Tennessee	Intruder 70WP	Aphids, whiteflies
	Fulfill 50WG	Aphids
	Trimax 4F (replacing Provado 1.6F)	Aphids, plant bugs
Texas	Intruder	Aphids
	Trimax	Aphids, cotton fleahopper, Lygus
	Furadan 4F (Section 18)	Aphids
Virginia	Steward 1.25SC	
	Intrepid 2F	
	Trimax	

Table 2. Changes in state recommendations for treatment for arthropod pests of cotton for 2002.

State	Pesticide	Target Pest
Alabama		
Addition	Acephate, chlorpyrifos, dicrotophos, diflubenzuron, and pyrethroids	Grasshoppers
	Acetamiprid	Aphids, plant bugs, whiteflies (both bandedwinged and silverleaf)
	Oxamyl	Stink bugs
	Dicofol and proparqite	Spidermites
Deletion	Chlopyrifos, diflubenzuron, profenofos, thiodicarb	Beet armyworms
	Tralomethrin	Bollworms, cutworms
	Acephate	Tobacco budworms
Rate Changes	Denim -.0075-.01	Bollworm, budworm, soybean looper, southern armyworm, plant bugs, stink bugs
	XDE-225 – 16g/H	Bollworm budworm
	F -0570-.018	Plant bugs, stink bugs
	Novaluron -.045-.094	Bollworm, budworm, plant bugs, stink bugs
Arizona	None	
Arkansas		
Additions	Trimax	Aphids, plant bugs
	Intruder	Aphids, whiteflies
	Intrepid	Loopers
	Capture	Stink bugs
	Added section on "Multiple Pests" with guidelines for us of Leverage and Double Threat under this section.	
Deletions	Provado	Aphids, plant bugs
California	None	
Georgia		
Additions	Intruder	Aphids, plant bugs, whiteflies
	Trimax	Aphids, plant bugs
	Intrepid	Beet armyworm, fall armyworm, loopers
Deletions	Capture	Aphids
	Cimeothoate	Aphids
	Endosulfan	Aphids
	Lorsban	Aphids
	Metasystox-R	Aphids
	Monitor	Aphids
	Curacron	Beet armyworm
	Lannate	Beet armyworm
	Lorsban	Beet armyworm
	Provado	All uses
	Scout X-TRA	All uses
Louisiana		
Additions	Intruder 70SC	Aphids
Mississippi	None	
Missouri	None	
New Mexico	None	
N. Carolina		
Additions	Intrepid 2F (methoxyfenozide)	Beet armyworm, fall armyworm, soybean looper, cabbage looper
	Centric 40WG (thiamethoxam)	(rate change) Cotton aphid, plant bug
	Intruder 70W (acetamiprid)	Cotton aphid, plant bug
	Trimax 4F (imidacloprid)	Cotton aphid, plant bug
Deletions	Payload 15G	Thrips (at-planting)
	Provado 1.6F (imidcloprid)	Cotton aphid, plant bug
Oklahoma	None	
S. Carolina		
Additions	Intruder 0.6-1.1 oz/acre	Aphids
	Centric 3 oz/acre	Aphids, plant bugs, whiteflies
Tennessee		

Additions	Cruiser 5F	Thrips
	Centric 40WG	Plant bugs, aphids, whiteflies
	Intruder 70WG	Aphids
	Trimax 4F	Aphids
	Steward 1.25	Armyworms, loopers, bollworm budworm
	Tracer 4SC	Loopers
	Bidrin 8E	Stink bugs
	Karate 2.08E, Decis 1.5E, Scout 0.9E, Fury 1.5E, Capture 2E, Baythroid 2E	Green stink bug, southern green stink bug
Texas		
Additions	Centric	Aphids, cotton fleahopper
	Trimax	Aphids, cotton fleahopper, Lygus
	Intruder	Aphids
	Address	Brown stink bug, green stink bug
	Orthene	Brown stink bug, green stink bug
	Bidrin	Brown stink bug, green stink bug
	Methyl Parathion	Brown stink bug, green stink bug
	Capture	Brown stink bug
	Baythroid	Green stink bug, grasshopper
	Karate	Green stink bug
	Decis	Green stink bug
	Scout	Green stink bug
	Fury	Green stink bug, grasshopper
	Leverage	Green stink bug, grasshopper
	Asana	Grasshopper
Deletions	Sevin	Overwintered boll weevil, grasshopper, cutworms
	Design	Bollworms/budworms
	MVP	Bollworms/budworms
	Ammo	Cutworm
	Decis	Cutworm
	Asana	Cutworm
	Methyl Parathion	Cutworm
Virginia		
Additions	Trimax 1.0 oz/A	Plant bug
	Centric 25WG 3.0 oz/A	Plant bug
	Steward 1.25SC 11.3 oz	Bollworm
	Vydate C-LV 8.5 oz/A	Stink bug
	Centric 25WG 3.0 oz/A	Aphid
	Trimax 1.5 oz/A	Aphid
	Steward 1.25SC 9.2-11.3 oz/A	Fall armyworm
	Intrepid 2F 4.0-10.0 oz/A	Fall armyworm
Rate Changes	Lannate LV 0.75 pt/A	Plant bug
	Lannate SP 0.5lb/A	Plant bug
	Vydate C-LV 8.5oz/A	Plant bug
	Methyl parathion 1.0 pt/A	Sink bug
Deletions	Cygon	Plant bug
	Leverage 2.7	Bollworm
	Bolstar	Aphid, bollworm
	Metasystox	Aphid

Table 3. Promising pesticides screened in 2002 for control of cotton arthropod pests.

State/Pesticide (lbs AI/A)	Target Pest(s)
Alabama	
Denim 0.0075-.01	Bollworm, budworm, soybean looper, southern armyworm, plant bugs, stink bugs
XDE-225 16g/H	Bollworm, budworm
F-0570 .018	Plant bugs, stink bugs
Novaluron .045-.094	Bollworm, budworm, plant bugs, stink bugs
Arkansas	Plant bug, stink bug
SC-AU-44-JO (1 qt/A)	Heliothine, stink bug, tobacco budworm
XDE-225 (0.015)	Heliothine, stink bug
F0570 (0.018)	Tobacco budworm
F0570 (0.015 – 0.018)	Plant bug
F0570 (0.016)	Plant bug, stink bug
F1785 (0.071 – 0.088)	Heliothine, tobacco budworm, stink bug
Baythroid SL (0.015 – 0.018)	Plant bug, stink bug
Novaluron (0.045 – 0.090)	Heliothine
S-1812 (0.10 – 0.150)	Thrips
L0263 + L0110 (3.84 + 4.8 oz/CWT)	
Arizona	None
California	None
Georgia	
Intruder	
Trimax	
Louisiana	
Karate-Z 2.08CS	Brown Stink Bug
Centric 25WG	Stink bug
Steward 1.25 SC	Stink bug
Intruder 70WP	Thrips, tobacco budworm green and brown stink bug
Denim 0.16EC	Bollworm, tobacco budworm, soybean looper, beet armyworm
S-1812 35WP	Bollworm, tobacco budworm, soybean looper
Decis 1.5EC	Aphid
Trimax 4SC	Bollworm, tobacco budworm, brown stink bug
Novularon 0.83EC	Bollworm, tobacco budworm
Poncho	Cutworms, thrips
Baythroid 1EC	Bollworm, tobacco budworm
Mississippi	None
Missouri	None
North Carolina	
F0570 0.8E	Bollworms, stink bugs, grasshoppers
South Carolina	
S-1812 (35 WP and 4 EC)	Budworms, bollworms, loopers, armyworms
Novaluron 0.83 EC	Budworms, bollworms, loopers, armyworms
Tennessee	
Bollgard II	Plant bugs
Centric 40WG 2-2.5 oz	Plant bugs
Steward 1.25EC 11.3 oz	Plant bugs
Intruder 70WP 1.7 oz	Plant bugs
Denim 0.16EC 8 oz	
Texas	
Cruiser 5 FS 7.6 oz/cwt seed	Thrips
Admire 2F 6.4 oz/acre	Thrips
Gaucho 600 6.4 oz/cwt seed	Thrips
Novaluron 0.83SC 0.013-0.052 lb AI/ac	Silverleaf whitefly
Oberon 2SC 7.0-12.0 oz/acre	Silverleaf whitefly
Applaud 70WP 0.54 lb/acre	Silverleaf whitelfy
Furadan 4F 8.0 oz/acre	Aphid
Intruder 70WP 0.6-1.1 oz/acre	Aphid
Centric 40WG 1.25-2.0 oz/acre	Aphid
Trimax 4F 1.0-1.5 oz/acre	Aphid
F1785 1.3-2.82 oz/acre	Aphid

Leverage 2.75EC 0.064-0.08 oz/acre	Aphid
Intruder 70WP 0.85-2.27 oz/acre	Cotton fleahopper
Centric 40WG 2.56-5.3 oz/acre	Cotton fleahopper
Intruder 70WP 0.9-1.71 oz/acre	Brown stink bug, green stink bug
Centric 40WG 1.9-2.5 oz/acre	Brown stink bug, green stink bug
Denim 0.16EC 8.0 oz/acre	Brown stink bug, green stink bug
Steward 1.25SC 10.65-11.39 oz/acre	Brown stink bug, green stink bug
Leverage 2.75EC 0.08 lb AI/acre	Brown stink bug, green stink bug
Bollgard II	Bollworm/budworm
Tracer 4SC 0.0446-0.089 lbs AI/acre	Bollworm/budworm
Denim 0.16EC 0.01 lb AI/acre	Bollworm/budworm
Steward 1.25SC 0.104-0.15 lbs AI/acre	Bollworm/budworm
Leverage 2.75EC 0.08 lb AI/acre	Bollworm/budworm
XR 225 1.25SC 0.0143 lb AI/acre	Bollworm/budworm
Virginia	
Bollgard II®	Bollworm/budworm
S-1812 35WP (0.15 and 0.1 ai/A)	Bollworm/budworm
XR-225 (0.014 lb ai/A)	Bollworm/budworm
F 0570 0.8EC (0.018 lb ai/A)	Bollworm/budworm