



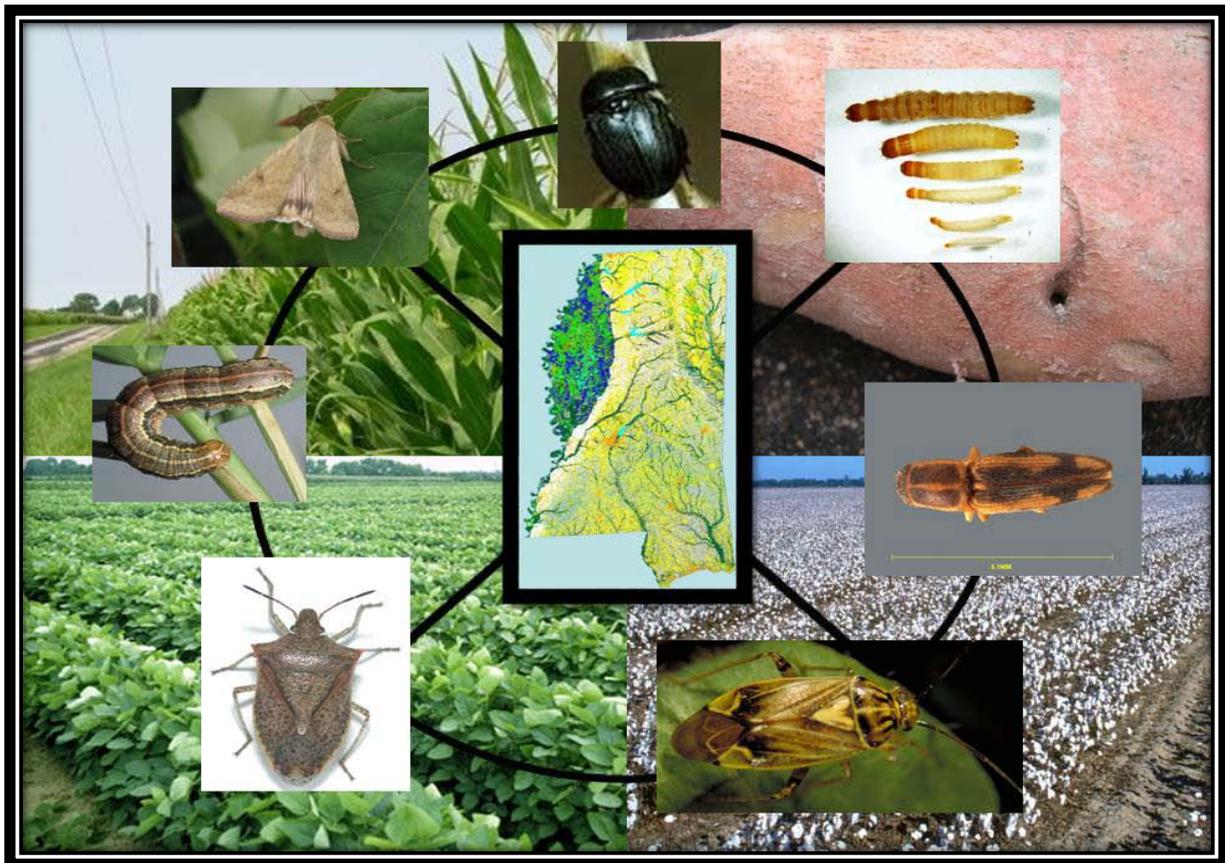
United States Department of Agriculture

Research, Education and Economics

Southern Insect Management

Research Unit

Stoneville, MS



2011 Annual Progress Report
&
2012 Research Plans

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Mission Statement

**Southern Insect Management Research Unit
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The mission of the Southern Insect Management Research Unit (SIMRU) is to generate new knowledge of arthropod pest biology, ecology and management and integrate this knowledge into contemporary farming systems that will promote economical and environmentally stable pest management practices for the southern U.S.

The vision of SIMRU is to be a recognized center of innovation for negating agricultural pest problem through deployed scientific knowledge of pest biology, ecology and management options.

Disclaimer and Purpose of Report

This report summarizes progress made on research objectives for 2011 and plans for research activities in 2012.

Many of the results are preliminary and others are being released through established channels. Therefore, this report is not intended for publication and should not be referred to in literature citations.

Intent of this report is to give the reader an overview of the Southern Insect Management Research Unit (SIMRU) activities. The activities (progress and plans) address the research unit mission. Formal annual reports of research progress as submitted to the CRIS system are included in the summary.

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- **Tashanika Knight**, Biological Science Aid, (Resigned February, 2012)

Overall Summary and Perspective of 2011 SIMRU Activities

The Southern Insect Management Research Unit (SIMRU) team in 2011 included seven Category I scientists; one Category II scientist; two Category III scientists; 32 science technicians, aids and office assistants; and 19 part-time STEP employees. The team maintained productivity and began to build strategies for a new SIMRU mission and a new SIMRU vision in 2011. This focus on future opportunities is encouraging given the environmental challenges during the year and changing Agency programs. The threat of flooding from the Mississippi River dominated activities in the spring and required emergency planning and relocation of genetic materials to storage facilities at Mississippi State. We were thankful when the level of the river declined and we were able to plant our research plots. Renovations to Building 1 created a challenging work environment at times, but SIMRU employees maintained their dedication to research, often working around noisy and clutter conditions. The team is looking forward to moving into new facilities on the 3rd floor in 2013. Repeated budget uncertainties and an overall reduction in ARS programs, including reassignment of ARS employees from terminated ARS research facilities, challenged scientific planning, but created opportunities for improving and optimizing future SIMRU research.

Research productivity increased in 2011 over that of 2010, but more importantly SIMRU began to build a solid foundation for even greater research productivity and contributions to southern agriculture in future years. A priority for 2011 was recruitment of two additional Category 1 scientists. Aggressive recruiting efforts resulted in the Unit's interviewing of nationally competitive young scientists from the University of Florida, University of Georgia, Mississippi State University, and University of Wisconsin. Although we were impacted by the freezing of positions by the Agency and could not hire finalists, we are pleased that Maribel Portilla, a former Category II scientist in our Unit, joined our team as a new Category 1 scientist. Maribel is currently studying *Beauveria bassiana* and alternative methods to control tarnished plant bug. We are hopeful that another new scientist can be attracted to our Unit, either through relocation or competitive recruitment in 2012. We also lost valuable members of our team in 2012. Charles Landford and Rosie Ford retired after 42 and 32 years of federal service, respectively. Amanda Walters relocated to the Jackson area in 2011, and Logan Phillips accepted a position with a regional bank. Zibio Guo accepted a position with the University of Mississippi Medical Center.

In addition to maintaining focus and improving research productivity, SIMRU had several notable accomplishments in 2012. Tabatha Ramsey and O.P. Perera were promoted to GS-8 and GS-14 positions, respectively. Gerald Gipson, Donny Adams, Gordon Snodgrass, and Kenya Dixon were recognized with Service Awards of 40, 30, 25, and 10 years of federal service, respectively. Anita Cain, a STEP student, received the prestigious Louis Stokes Mississippi Alliance Scholarship for Minorities Scholarship that recognizes exceptional students in STEM disciplines. This award will finance her graduate education through the doctoral level at a university of her choice. SIMRU emphasized the STEP program in 2011. Guidelines for recruiting, selecting and mentoring STEP students were developed, and 27 STEP students prepared written and oral presentations of their research experiences in August. Gordon Snodgrass and Ryan Jackson, as part of the Mid-South Entomologist Working Group, received 2011 Friends of IPM Pulling Together Award for outstanding contributions to integrated pest management in the South. Cathy Warren received the Mid-South Area Award for Office Professional of the Year.

The SIMRU team looks to 2012 with great anticipation and a sense of opportunity. We plan to interact with National Program Leaders and key clientele groups including agricultural consultants, farmers and commodity groups in 2012, and begin to strategically organize future research to address pest problems of southern crops.

Randall G. Luttrell, Research Leader
USDA ARS Southern Insect Management Research Unit

CRIS Projects

Research Project: *Insecticide Resistance Management and New Control Strategies for Pests of Corn, Cotton, Sorghum, Soybean, and Sweet Potato*

Project Scientists: Ryan Jackson (Lead Scientist), Clint Allen, R. G. Luttrell, O. P. Perera, G. L. Snodgrass, Y. C. Zhu

Project Number: 6402-22000-063-00D

Project Type: Appropriated

Start Date: Sep 01, 2010

End Date: Aug 31, 2015

Objectives: The long-term objective of this project is to develop an improved understanding of how the changing cropping landscape impacts insecticide resistance development and management of various insect pest species in order to increase profitability and sustainability of mid-South row crops. Objective 1: Improve tarnished plant bug control and insecticide resistance management by gaining new information on the pest's ecology and biology using multi-disciplinary approaches, e.g. molecular genetic tools, stable carbon isotope analysis, gene expression and proteomics, and insecticide resistance assays coupled with field sampling. Objective 2: Determine the effect of bollworm ecology (corn earworm) on resistance to pyrethroid insecticides by developing and utilizing genetic markers linked to resistance traits, stable carbon isotope analysis, gossypol detection in adult insects, and insecticide resistance monitoring. Objective 3: Develop pest control strategies for the U.S. Mid-South's Early Soybean Production System by determining accurate treatment thresholds, understanding the impact of changing cropping systems on farm-scale pest ecology, and developing effective insecticide resistance management practices for the stink bug complex, three-cornered alfalfa hopper, bean leaf beetle and soybean looper. Objective 4: Improve low input systems of pest control for sweet potato by evaluating the efficacy and proper use of newly registered insecticides to enhance their integration with crop rotation and other low cost control strategies.

Approach: We plan to improve tarnished plant bug control and insecticide resistance management by gaining new information on the pest's ecology and biology using multi-disciplinary approaches. Analytical techniques, such as stable carbon isotope analysis, will be used to determine the influence of C4 host plants, such as field corn or pigweed, on populations of tarnished plant bug adults infesting cotton fields. This information will identify sources of tarnished plant bugs that may lead to alternative control measures prior to infestations into cotton fields. Tarnished plant bug populations will be monitored for resistance to various classes of insecticides commonly used by mid-South producers. This will provide real-time information to decision makers that will allow them to adjust their control recommendations based on the type of resistance that is found in their area of the mid-South. Detoxification enzyme activity surveys will be conducted in an effort to correlate and quantify insecticide resistance levels in field populations of the tarnished plant bug. Molecular genetics techniques will be conducted on tarnished plant bug populations that could lead to assays to evaluate the extent of field resistance in tarnished plant bug populations and provide input for insect management decisions. We also plan to determine the effect of bollworm ecology (corn earworm) on resistance to pyrethroid insecticides. Analytical techniques, such as stable carbon isotope analysis and a gossypol detection technique, will be used to determine the impact of bollworm larval plant host on

pyrethroid resistance levels measured in adults collected from pheromone traps. Molecular genetics tools will be used to identify candidate genes and biological pathways associated with insecticide resistance in bollworm populations. Successful identification of loci associated with insecticide resistance and the development of genetic markers for those will provide a method to obtain quantitative estimates of field evolved resistance by estimating the allele frequencies via population studies. We will also develop pest control strategies for the U.S. Mid-South's Early Soybean Production System by determining accurate treatment thresholds and developing effective insecticide resistance management practices for the stink bug complex and bollworm. Field studies will be conducted to evaluate treatment thresholds for stink bugs and bollworms in early season soybeans. Stink bug populations will be monitored for potential resistance to various classes of insecticides, and this effort will provide real-time information to decision makers regarding the proper use of insecticides for control of these pests. We also plan to improve low input systems of pest control for sweet potato by evaluating the efficacy and proper use of newly registered insecticides to enhance their integration with crop rotation and other low cost control strategies. Field and laboratory studies will be conducted to determine the impact of crop rotation on populations of insect pests of sweet potatoes, as well as information of insecticide efficacy and proper application techniques.

Summary: We are currently nine months into our five-year project and approximately half way through our first cropping season. Research has been initiated on all research objectives associated with this project. Twelve-month milestones are at least partially met and will be complete upon the end of the field season.

Research Project: *Control of Tarnished Plant Bugs by Biocontrol and Other Methods*

Project Scientists: G. L. Snodgrass, R. G. Luttrell, M. Portilla

Project Number: 6402-22000-064-00D

Start Date: Jan 03, 2011

Project Type: Appropriated

End Date: Jan 02, 2015

Objectives: Determine the effect of temperature and reproductive state on susceptibility of tarnished plant bugs to *Beauveria (B.) bassiana* (ARSEF 8889). Determine the effect of exposure to insect growth regulators (IGRs) and *B. Bassiana* (ARSEF 8889) on immature tarnished plant bug survival. Determine the effect of host plant and application timing (season) on susceptibility of tarnished plant bugs treated with ARSEF 8889 and IGRs (in situ).

Approach: The effect of temperature and reproductive state on the susceptibility of tarnished plant bugs to *Beauveria (B.) bassiana* (ARSEF 8889) will be determined in replicated laboratory tests. The two reproductive states tested will be normal reproductive adults and nymphs and diapausing adults and nymphs that produce diapausing adults. Temperatures tested will range from 10°C to 30°C. Insect growth regulators (IGRs) will be tested with nymphs in replicated laboratory tests to determine which IGRs are effective and the rate at which to use them. The most effective IGR(s) will be tested in laboratory tests in combination with ARSEF 8889 to determine the most effective combination treatment. Results from the laboratory tests will be tested in the field in replicated tests in cotton (for in-season plant bug control) and in the fall and winter on wild host plants (for control of the diapausing overwintering generation). The effect of IGRs and ARSEF 8889 treatment on beneficial arthropod populations will be evaluated in the field tests and with additional laboratory tests.

Summary: The effectiveness of ARSEF 8889 (NI8) against reproductive and diapausing tarnished plant bug (TPB) was evaluated in several laboratory tests at temperatures from 10° to 30° C. The fungus was found to be equally effective against reproductive and diapausing TPB with higher infection rates at the warmer temperatures. A replicated small plot test in cotton was conducted during July 2010. Treatments tested were NI8, NI8 + novaluron, novaluron, and an untreated check. Results were inconclusive because of adult movement between the plots. A large replicated test in cotton is currently being conducted in which plot size is one acre. This should allow us to have a valid evaluation of the results. A preliminary test was conducted in October and November 2010 in which NI8 was used alone and in combination with novaluron to kill overwintering TPB adults and nymphs on pigweed and tall goldenrod. Beneficial arthropods found on the wild hosts were also identified and their populations estimated before and after treatment. The novaluron and novaluron plus NI8 treatments were very effective in reducing numbers of nymphs on both wild hosts with infection rates as high as 41.5%. Infection rates among adults with NI8 were as high as 77.7%. This test will be conducted in October 2011 using replicated plots. The most abundant beneficial arthropods on both wild hosts were spiders in the families Thomisidae (crab spiders) and Salticidae (jumping spiders). Crab spiders made up 48.5% of the total number of beneficial arthropods while jumping spiders were 22.2%. Crab spiders and jumping spiders were evaluated in laboratory tests for susceptibility to NI8 infection. Crab spiders were mostly immune while a low percentage of jumping spiders were infected. Green lacewing, ladybird beetle and big-eyed adults were also tested in the laboratory for susceptibility to NI8. Infection rates were low for these predators.

Research Project: *Effect of Resistance on Insect Pest Management in Transgenic Cotton*

Project Scientists: O. P. Perera (Lead Scientist), Kerry Clint Allen, Ryan Jackson, R. G. Luttrell

Project Number: 6402-22000-065-00D

Project Type: Appropriated

Start Date: April 26, 2011

End Date: March 31, 2016

Objectives: Determine the impact of a changing cropping landscape on host plant ecology and insect resistance management practices for bollworm using analytical techniques. Determine gene flow and migration patterns by analyzing tobacco budworm and bollworm populations in temporal and spatial scales using genetic and/or empirical/mathematical approaches. Identify possible mechanisms of resistance to Bt toxins by profiling gene expression patterns and develop a marker based genetic linkage map.

Approach: More than 95% of the second generation bollworm within each growing season utilizes field corn as a host. Impact of corn plants expressing multiple Bt toxins on the bollworm populations will be studied by comparing historical pheromone trap data with current and future population estimates influenced by increased acreages of Bt corn expressing multiple Bt toxins. Stable carbon isotope analysis will be used to identify bollworms using corn as a host plant. Influence of local cropping landscape on bollworm populations will be studied using sentential plots of conventional and Bt corn and cotton and early maturing soybeans. Large field cages will be used to evaluate the impact of pyramided-gene Bt corn hybrid/refuge system on resistance management strategies. Expressed genes of tobacco budworm and bollworm will be identified by transcriptome sequencing, and genetic markers developed from polymorphic nucleotide regions will be used in ecological genetic studies of tobacco budworm and bollworm populations. Gene expression profiles will be used to identify biological processes involved in physiological response to ingestion of Bt toxins. Markers developed for candidate loci associated with resistance to Bt toxins will be used to estimate allele frequencies in natural populations. Genetic loci under selection will be identified using statistical methods. A genetic linkage map of the bollworm developed using polymorphic markers will be used to study inheritance of loci of interest to Bt resistance.

Summary: This is the first report for the project 6402-22000-065-00D that started in April 2011. Field and laboratory studies have been initiated, and insect samples are being collected and held for future analyses. Twelve-month milestones will be complete upon the end of the cropping season.

Transcriptome of tobacco budworm was assembled using over 20 million nucleotide sequence reads. All nucleotide reads and assemblies were submitted to public databases. Glass slide microarrays containing 44,000 features were developed using curated transcriptome sequences. BW transcriptome sequencing using Roche 454 and Illumina platforms was completed. Assembly and bioinformatic analyses were performed to identify expressed genes in the transcriptome assembly. Nucleotide sequence reads were re-assembled (overlaid) using curated reference gene sequences to identify single nucleotide polymorphisms. Nucleotide reads and assemblies of tobacco budworm and bollworm were submitted to public databases.

Primary cell cultures generated from susceptible YDK strain and resistant KCB and CXC strains of tobacco budworm were treated with Cry1Ac and Cry2Ab toxins. Treated and control cells were harvested and total RNA and proteins were extracted. RNA extractions are being used in RNA-Seq based gene expression profiling experiments. Protein fractions were subjected to two-dimensional differential gel electrophoresis to identify differentially expressed proteins. The protein spots identified were excised from the gels and were submitted to a core facility for mass spectrometry based determination of amino acid sequences. Laboratory screening of bollworm larvae collected from transgenic corn plants was initiated to select a bollworm line resistant to Cry1Ac. Bollworm larvae collected from various field sites were used to establish laboratory strains to obtain genetic material for mapping studies.

2011 Research Program Accomplishments

Adams Research Program

In 2011 USDA, ARS, SIMRU completed a study evaluating four nematocides (*K-Pam*, *Telone II*, *Nemout* .6 lbs/A and *Nemout* .9 lbs/A) and one insecticide (*Mocap*) for suppression of reniform nematodes in sweetpotato. Mid-season nematode samples in the product evaluation study indicated a decrease in the reniform nematode population in all treatments except *Mocap* when compared to the untreated control. The *Telone II* treatment continued to suppress the reniform nematode population in the pre-harvest nematode samples. *K-Pam*, *Telone II* and *NemOut* .9 lbs/A treatment yields were significantly higher than the untreated control. (L. C. Adams and R. G. Luttrell)

During the 2011 growing season USDA, ARS, SIMRU compared three sweetpotato varieties (*B63*, *Covington*, and *Evangeline*) with and without a nematocide treatment (*K-Pam*) and with and without an insecticide incorporation treatment (*Lorsban* TRT) to study varietal differences suppressing nematode populations in sweetpotato. Nematode samples were taken twice during the season to assess reniform populations. All treatments in the varietal differences study showed a response to the *K-Pam* treatment in the mid-season and pre-harvest nematode samples with the exception of the *K-Pam* TRT *B63* and the Control TRT *B63* treatments at mid-season. There was no indication that *Lorsban* treatment with or without *K-Pam* application was contributing to suppression of reniform nematode populations in this study. The *Evangeline* Control UnTRT and TRT with *Lorsban* showed a higher number of reniform nematodes than the *Covington* and *B63* Control UnTRT and TRT with *Lorsban* in the mid-season nematode samples. In the pre-harvest nematode samples, all of the *K-Pam* *Evangeline* and *K-Pam* *Covington* treatments were above or approaching the fall threshold population of reniform nematodes while the *K-Pam* *B63* treatments were still below threshold. All varieties in the Control treatments were above the fall threshold number for reniform nematodes in the pre-harvest nematode samples. Yield results from the varietal differences study showed the *K-Pam* treatments higher than the Control treatments, in all varieties, with the exception of the Control TRT *Evangeline* treatment. Only the *K-Pam* TRT *Covington* treatment yield was significantly different from all other treatments (LSD, P=0.05). *Covington* and *Evangeline* varieties yielded more than *B63* in both the Control and *K-Pam* treatments although only the yield of Control UnTRT *Covington*, Control TRT *Evangeline*, *K-Pam* TRT *Covington* and *K-Pam* UnTRT *Covington* were significantly different from all other treatments. (L. C. Adams and R. G. Luttrell)

In 2011 USDA, ARS, Southern Insect Management Research Unit (SIMRU) and LSU AgCenter collaborated to evaluate six insecticides regimes for efficacy against sugarcane beetle in sweetpotato. A cage study was conducted at the SIMRU location in Stoneville, MS. *Beauregard* sweetpotatoes were transplanted to four row plots in the 1/8 acre field cages (14 plots per cage), treatments applied and all plots were infested with sugarcane beetles 36 days before harvest. Treatments were arranged in a RCB design and replicated four times. Sweetpotatoes were harvested from the two center rows of each plot. Yield, quality and insect damage were recorded and analyzed. Twenty-five roots per plot were chosen randomly and evaluated for insect damage after washing. Sugarcane beetle damage ranged from 1 to 33 percent in this study. Preplant

applications of *Belay* 2.13 SC, *Lorsban* 4E and *Admire Pro* resulted in significantly less damage compared to the untreated control plots. **(Larry Adams, Randall Luttrell and Tara Smith)**

During 2011 SIMRU submitted yield and quality results from six check lines and five numbered research varieties, in cooperation with researchers from Louisiana State University, North Carolina State University and Mississippi State University, to the National Sweetpotato Collaborators Group Variety Trials for the NSCG Annual Report. **(L. C. Adams, R. G. Luttrell and Chris Johnson)**

Completed the first year of a three year crop rotation project studying the effects of wireworm populations when rotating sweetpotato with conventional corn, treated and non-treated seed, and bt corn, treated and non-treated seed. Developing an accurate method to sample for wireworms in sweetpotato production is included in this project protocol. Wireworms were found sampling corn bait traps biweekly with a 24" shake box with a wire mesh bottom. Several growth stages of the wireworm larvae were collected throughout the growing season although collections were very sporadic. **(L. C. Adams and R. G. Luttrell)**

Trap, chart, summarize and report results of insect pheromone trapping of the *H. zea* (19th year) and *H. virescens* (20th year). We continue to work with SIMRU scientist in the *Bacillus thuringiensis* resistance monitoring program. The results of the long term trapping of these pests illustrate the decline of population dynamics since the introduction of transgenic crops in the Mississippi Delta. **(L. C. Adams, C. Johnson)**

Allen Research Program

A survey of loopers inhabiting soybean fields in Mississippi and Arkansas was continued during the 2011 season. Soybean fields were sampled on a weekly basis in Holmes, Sunflower, Tunica and Washington counties in MS and in Desha County, AR. Fields were sampled with a sweep net and collected larvae were placed on artificial diet and reared to adult for species identification. The majority of collections consisted of two species of loopers. The gray looper was collected from the last week of May until the last week of July. Soybean loopers were collected from the first week of July until the end of end of September. A single larva of the sharp stigma looper, *Ctenoplusia oxygramma*, was collected on July 11th. The importance of knowing the species composition of loopers present in a particular field is important due to different susceptibilities to various classes of insecticides. **(C. Allen, R. Jackson, L. Andrews, D. May)**

Reproduction and survival of tarnished plant bugs on soybean were examined in Stoneville. Once populations of tarnished plant bugs were detected, plots were sampled with a drop cloth. Samples were taken three times a week until populations of nymphs were largely diminished. For each drop cloth sample, all nymphs were collected with an aspirator, brought back to the lab and classified by instar by G. Snodgrass. Peak numbers of first instar nymphs occurred on group IV and group V soybean plots during the first week of July which coincided with the R2 stage of plant maturity. Numbers of first instar nymphs peaked at 0.79 per row foot in group IV plots and 0.96 per row foot in the group V plots. The greatest number of fifth instar nymphs collected on group IV and group V soybean plots were 0.17 and 0.125 per row foot, respectively, but these numbers were encountered on a single sample date and populations of fifth instars were 0.04 per

row foot or less. Assuming that the majority of the 5th instar nymphs developed into adults, a particular soybean field has the potential of being a significant source of tarnished plant bug adults in the landscape for a short period of time. **(C. Allen, G. Snodgrass, R. Jackson)**

Wild host plants play an important role for tarnished plant bug populations during the early spring when cultivated crops are not flowering, however, there is little information on the dispersal of tarnished plant bugs from wild hosts into cotton. Tarnished plant bugs prefer host plants during the flowering stage of plant development and utilize pollen as a nutritional resource. Pollen grains are unique and can be used to identify plant species with which an insect has had previous contact. A process called “acetolysis” was used which utilizes sulfuric acid to dissolve insect cuticle and causes little harm to the exterior surface of most pollen grains. In laboratory studies, pollen grains were recovered from 50% of the tarnished plant bugs fed pigweed up to 4 days after removal from the plant source. After 24 hours, pigweed grains were recovered from 77% of the tarnished plant bugs examined. **(C. Allen and G. Jones)**

Jackson Research Program

Tarnished plant bug immigrates into cotton fields from non-cotton hosts during late spring and early summer. Stable carbon isotope (SCI) analysis was used to characterize adult tarnished plant bugs that had developed as immatures on a C₃ or C₄ plant host. Plant material was collected from hosts of tarnished plant bug during the late spring. Both host types were identified using the SCI analysis. Analyses also showed that tarnished plant bug adults reared as immatures on various plant hosts retained a carbon isotopic signature similar to the host plant. Thus, carbon isotope ratios of tarnished plant bugs reared on C₃ plants differed from those reared on C₄ plants. The SCI method can only distinguish between C₃ and C₄ food sources. Two of the major host plants of tarnished plant bugs during the early growing season are C₄ hosts (corn and pigweed). Carbon and nitrogen isotope ratios were analyzed jointly using cluster and discriminant analyses to discriminate between adults that developed as immatures on these two C₄ hosts. Results indicated that the isotopic signature of the host plant was primarily obtained by tarnished plant bugs during the last two instars. Results from this study demonstrated the utility of carbon and nitrogen isotope ratio determination for evaluating host plant ecology of tarnished plant bugs in the mid-South. Knowledge of the primary hosts of tarnished plant bugs prior to immigrating to cotton could allow for population management/reduction of these insect populations outside of the cotton crop. Tarnished plant bug adults collected throughout the season from MS Delta cotton fields are currently being analyzed for this purpose. **(R. Jackson, G. Snodgrass, and L. Price).**

Pyrethroid insecticides are used to control bollworms in many crops; thus, selection for pyrethroid resistance within the landscape is potentially great even though there may not be much selection pressure in any single environment. A regional project was established to measure pyrethroid susceptibility in bollworm from May to September during 2007-2011 in nine states stretching from Virginia to Texas. Male moths collected from pheromone traps were tested for susceptibility to cypermethrin, a pyrethroid insecticide used historically in adult vial tests. Average survival at a discriminating dose of 5 µg/vial of cypermethrin during 2011 was 15.2%. Average survival exceeded 20% only in Louisiana (33%) and Virginia (31%). Consistent with previous years, survival was highest in most states during July. A comparison of survival during July of 2008-2011 with survival using the same methodology from July 1998-2000 showed that

survival has increased from an average of 8% to 19%. Missouri had increased susceptibility, but all other states showed reduced susceptibility for this pest. The greatest increases in resistance were found in Louisiana and Virginia. Preliminary carbon isotope analysis indicated that most of mid-summer moths developed as larvae on grasses, most likely corn. Currently, no evidence exists that supports claims of more pyrethroid resistant moths being generated in cotton (or other broadleaves) than susceptible moths. Future work will evaluate the utility of a larval vial test that will reduce the length of time necessary to determine the susceptibility of a bollworm population within a given field. **(R. Jackson, F. Musser, M. Mullen, and L. Price).**

Bt cottons have revolutionized caterpillar control, particularly for tobacco budworm. However, these transgenic cottons have never produced a high dose of toxin for control of bollworm. Even second generation Bt cottons that produce two Bt proteins often sustain economic damage from this pest. Thus, supplemental insecticide applications for bollworm control in Bt cotton are commonly made. Five field studies were conducted across the Mississippi Delta to evaluate the need for supplemental bollworm control in Bollgard II and WideStrike cottons, as well as to determine whether non-Bt cotton varieties would be competitive from a yield standpoint. Each variety was scouted independently, and insecticide applications of lambda-cyhalothrin (*Karate Z*) or chlorantraniliprole (*Coragen*) were made when a larval threshold of 4 larvae per 100 plants was met. Forty percent of field sites had very low heliothine densities, such that a larval threshold was never met, even in the non-Bt varieties. Studies with significant heliothine pressure demonstrated a yield benefit from spraying both non-Bt and Bt cottons with either insecticide. Non-Bt cottons treated with insecticides produced similar yields to Bt cottons with or without supplemental insecticide applications. These preliminary data suggest that non-Bt cottons can be produced competitively compared to Bt cottons in the mid-South and also confirm the benefit of supplemental insecticide applications to Bt cotton under significant infestation from bollworm. **(R. Jackson, D. Adams, C. Allen, and R. Luttrell)**

Luttrell Research Program

Studies on the baseline susceptibility of *H. zea* and *H. virescens* to Cry1Ac, Cry2Ab2, Cry1F and Vip3a were further summarized and prepared for publication. *H. zea* populations exhibit wide variability in response to all Bt toxins. *H. virescens* is more susceptible than *H. zea* to the cry toxins. Laboratory colonies of *H. zea* were in some cases more tolerant to Vip3a than field colonies. Ecological variables associated with ~400 field collections of these insects from 2002-2009 are being studied to determine possible associations with selection pressure. Frozen moths are also being prepared for genetic analyses to examine population structure. **(R. G. Luttrell, M. I. Ali, O.P. Perera)**

Summaries of field records, insect sampling information, crop development indices and heliothine pheromone trap records for Wildy Farms in Mississippi County, Arkansas continued in 2011. Yields on this large northeast Arkansas cotton farm showed a highly significant trend for increase during the period of Bt cotton adoption, boll weevil eradication and implementation of new crop cultural practices, especially reduced tillage systems. Comparisons of yield increases on Wildy Farms and those of similar varieties grown on the University of Arkansas Experiment Station at Keiser, Arkansas indicated higher yields on the research farm early in the study period, dramatic increased yield over the study period on Wildy farms, and higher yields in

more recent years on the large production farm. **(R. G. Luttrell, K. C. Allen, P. O'Leary, T. G. Teague)**

As a component of studies to compare performance of commercial Bt and non-Bt (conventional) cottons under different insect management systems, seven cotton varieties were exposed to extreme densities of bollworm (*H. zea*) and tobacco budworm (*H. virescens*) in large (1/8 acre) field cages. Varieties included UA48, a high-yielding early-season non-Bt cotton from F. Bourland's breeding program at the University of Arkansas; DP121, an early-season commercial non-Bt cotton; DP01912 an early-season commercial BGII (*Bollgard II*® trait from Monsanto Company that expresses Cry1Ac and Cry2Ab2 Bt toxins) cotton; PHY375, an early-season commercial WS (*Widestrike*® trait from Dow AgroScience that expresses Cry1Ac and Cry1F); MD25, a high-yielding full-season non-Bt cotton from B. Meredith's breeding program at Stoneville, Mississippi); DP174, a commercial full-season non-Bt cotton; and DP1048, a commercial full-season BGII cotton. All seven varieties were planted as plots in three separate tiers in three 1/8 acre cages. Each cage was a replicate of the experiment. Each tier within a cage included randomized plots of the seven cottons and was managed under a single insect management system. The three tiers within a cage were managed as untreated with insecticide, treated with *Karate*® (lambda-cyhalothrin) at 0.04 lb ai/acre, or treated with *Coragen*® (chlorantraniliprole) at 0.088 lb ai/acre. Within season estimates of fruit retention generally matched the variability among treatments at harvest. Significant reductions in yield were observed on all untreated non-Bt cottons (UA48, DP121, MD255, and DP174). Differences between untreated and *Karate* treated cottons were not observed on Bt cottons (DP0912, PHY375, and DP1048). *Coragen* treated UA48, DP121, MD25 and DP174 produced yields statistically similar to those of *Coragen* treated Bt cottons, and in some cases greater than those of untreated Bt cottons. Additional box mapping of plants from field plots with the same varieties and insect management approaches produced similar results. Yields from the box mapping of cage and field studies correlated with picker yields from the field plots. **(R. G. Luttrell, R. E. Jackson, K. C. Allen)**

Production fields of corn and early-maturity-group soybean growing adjacent to cotton were monitored at eight locations in the Mississippi Delta with densities of tarnished plant bugs measured at the bordering interface of each crop and at varying densities into the adjacent cotton. Immature tarnished plant bugs were found in all three crops. Densities of early-instar tarnished plant bugs were greatest in soybean. Densities of late-instar nymphs were less. Colonization patterns in cotton were monitored with insect counts and routine planting mapping. Differences among the interfaces were not obvious but additional study is required. Acreages of adjacent crops were also recorded and are being studied to determine possible landscape level influences on the colonization patterns. Large field cages were planted with corn and cotton and with soybean and cotton to study possible differences in population growth patterns. Cotton plots were plant mapped and yield was determined via a box mapping procedure. Data analyses are incomplete at this time. **(R. G. Luttrell, Chad Roberts)**

In September 2011, light traps were placed in nine crop production areas of the Mississippi Delta predominantly planted to (a) cotton, (b) corn, and (c) soybean. Three sites were sampled in each crop area. *H. zea* moths from the traps were taken to the laboratory and held as groups from each location. Reproduction was measured and cohorts of progeny were assayed by exposure to Cry1Ac and Cry2Ab2 in diet overlay experiments. Survivors of each colony from the untreated

controls and the Bt treatments were held and mass mated. Resulting progeny were assayed via topical application with cypermethrin. Variable results were obtained, but clear patterns of susceptibility associated with different crop environments were not obvious. Data are still under investigation. **(R. G. Luttrell, Chad Roberts, Kenya Dixon)**

To measure residual activity and canopy penetration of *Beauveria bassiana* sprays made to cotton for tarnished plant bug control, we collected leaves from untreated field plots and plots treated with NI8 strain of *B. bassiana* alone and in combination with novaluron. Glass slides were placed at different levels in the plant canopy, and adjacent to the leaf samples, to collect deposited spores and physically measure deposition efficiency (data incomplete at this time). All leaf samples were taken from plots two- to four-hours after treatment. Two upper-canopy leaves, two middle-canopy leaves, and two lower canopy leaves were collected from five different sample sites in each sampled plots. Untreated control, *B. bassiana*, and *B. bassiana* + novaluron treated plots were sampled. Each treatment was replicated in four large (~ one acre) plots of FM1740B2RF cotton. Mortality from *B. bassiana* was evident in the samples from the top of the plant. Cumulative mortality of TPB 7 days after exposure to the sprayed leaves indicated highest mortality from *B. bassiana* treatment on upper leaves. Numerically less, but not statistically less, mortality was observed from *B. bassiana* treated leaves in the middle of the canopy. Mortality from *B. bassiana* lower canopy leaves and leaves from all canopy levels in the *B. bassiana* + novaluron treatment was less and no greater than that of the cumulative mortality from leaves collected in the untreated plots. **(R. G. Luttrell, Kenya Dixon, Gordon Snodgrass, Ryan Jackson, Maribel Portilla)**

Perera Research Program

Assembled transcriptome of tobacco budworm (TBW), *Heliothis virescens*, was used to profile gene expression in larvae intoxicated with Bt toxins Cry1Ac and Cry2Ab2. Gene expression in the midguts from larvae of susceptible YDK strain was compared with that of highly Bt toxin tolerant CXC and KCB strains. Gene transcript expression profiles were also compared with protein expression profiles to identify midgut proteins differentially expressed in response to intoxication with Cry toxins. Two manuscripts describing the results are in preparation.

Polymorphic genetic markers were identified from *Helicoverpa zea* genomic DNA using highthroughput sequencing followed by alignment of genomic DNA sequences with expressed gene sequences. Over 10,000 genomic regions that matched expressed gene sequences contained at least one polymorphism suitable for genetic mapping studies. Backcross mapping populations of *H. zea* were obtained by mating field collected Cry1Ac and Cry2Ab tolerant insects with laboratory strains. Adults and pupae of the first (F₁) and second filial generation (F₂) progeny, respectively, of four reciprocal crosses were preserved for DNA extraction. Methods are being developed to develop linkage maps using the inheritance of the genetic markers.

Bacterial artificial chromosome containing chitin synthase A and B (CS-A and CS-B) genes of *H. zea* was identified and the nucleotide sequence was obtained. This 145,000 nucleotide genomic region revealed the genomic organization of the CS-A and B genes. A manuscript comparing the genomic organization of *H. zea* CS genes other lepidopteran species is in preparation. **(OP Perera, J.L. Jurat-Fuentes, P.D. Shirk)**

A picorna-like virus was identified and characterized from the tarnished plant bug. A publication describing morphology, genome organization, and potential routes of transmission

was made available. Two other virus genomes were identified and submitted to public databases. A publication describing the viruses is in preparation. **(OP Perera, Gordon Snodgrass)**

Collaborated with Dr. Todd Ugone in completing the genome sequence of *Beauveria bassiana* GHA strain. Illumina sequencing libraries were used to obtain over 50-fold coverage of the genome. **(OP Perera, Todd Ugone)**

Collaborated with Dr. Ceslo Omoto's group (Sao Paulo University, Brazil) in a population genetic study of tobacco budworm. A publication on the genetic structure of Brazilian tobacco budworm populations in peer review. **(OP Perera, K. L. da Silva, C. Omoto)**

Portilla Research Program

A novel bioassay for estimation of median lethal concentration (LC₅₀) and dose (LD₅₀) of the entomopathogenic fungus *Beauveria bassiana*, against tarnished plant bugs and non-target biological control agents was developed using *Lygus* artificial diet. The solidified *Lygus* diet (*Lygus* diet (Portilla *et al* 2011) + agar + inhibitors) allows insects feed and have a normal development during the infection process without manipulation. 2-days adults of *L. lineolaris* can live for over 40 days and fourth and fifth instar can reach adulthood. The diet does not need to be change during the entire insect development and helps the sporulation process on infected insects. The importance of developing this method was based on the considerable time reduction when compared using natural hosts. **(M. Portilla)**

Laboratory experiments were conducted to determine the effect of the entomopathogenic fungus, *B. bassiana* and the insect growth regulator *Diamond* on fecundity and growth inhibition of the tarnished plant bug. Adult survival was highly affected when exposed to the pathogenic fungus *B. bassiana*, which was significantly higher when compared with the untreated control and *Diamond*. Eggs daily production was significantly lower in insects sprayed with *B. bassiana*, which was noticeable from the first day of exposure. Insects exposed to *Diamond* did not show significant difference in numbers of eggs/day/cage when compared with control. A rank test for homogeneity was used for comparison of survival curves between instars, which showed no significant differences between instar survival with the water application, but showed significant differences in instars sprayed with *B. bassiana* and *Diamond*. Second instar of *L. lineolaris* was more likely to survive after fungus application, while the fifth instar was more likely to survive after *Diamond* application. **(M. Portilla, G. Snodgrass and R. Luttrell).**

Bioassay were conducted to examine the impact of the entomopathogenic fungus *B. bassiana* strain NI8 against *L. lineolaris* and non-target insects such as *Crysoperla rufilabris*, *Orius insidiosus*, *Harmonia axyridis*, jump spiders (Araneae: Salticidae), and crab spiders (Araneae: Thomisidae). Four concentrations were evaluated and the LC₅₀ was estimated for all the species except for jumping and crab spiders. Adult survival of *Lygus lineolaris* was highly affected when exposed to *B. bassiana* at 10⁹ concentration, which 100% of the population was killed by the 7-d. Only about 30% of the infected population of minute pirate bugs, lady bugs, crab and jump spiders was killed by the fungus by 10-d at 10⁹ concentration, while over 20% of the population of orius bugs and lady bugs were killed with the 10⁸ and 10⁷. Less than 10% of those populations were affected by *B. bassiana* at 10⁶. *B. bassiana* was found to be pathogenic to *C. rufilabris*, which over 70% of the population was killed with 10⁹ and over 60% with 10⁸. No

significant differences were found among these two concentrations. Egg daily production was significantly lower in adults of *C. rufilabris* sprayed with any concentration of *B. bassiana* when compared with the untreated control. The estimated LC₅₀ are as follow: 6.71 for *L. lineolaris*, 7.58 for *C. rufilabris*, 10.33 for *Harmonia axyridis*, significant regression was not obtained in Probit analysis for *O. insidiosus*. (M. portilla, G. Snodgrass and R. Luttrell)

Green house and laboratory experiments were carried out to determine the solar radiation effect on *B. bassiana* viability and infectivity to *L. lineolaris*. Foot tall plants of cotton sprayed in the laboratory with four concentration of *B. bassiana* were exposed to solar radiation for three days. Each day four plants/concentrations were placed in a cage in which *L. lineolaris* adults were released. Infection by contact of *L. lineolaris* in 0-1-2-3 day (D) solar radiation cotton plants (SRCP) after exposure to periods of time of 1-3-5- and 24 hours (H) was evaluated. 55% and 50% mortality and 47% and 32% sporulation was obtained with 10⁹ and 10⁸ concentrations respectively after 1-H of insect exposed to 0-D SRCP. The mortality and infection increased when the time period of exposure increased where 90, 85, 50, 32 and 25% mortality and 85, 77, 35, 22 and 0% sporulation was found for 10⁹, 10⁸, 10⁷, 10⁶ and control 24-H of insects exposure to the same plants. The effect of the UV light was noticeable thought out the time. No significant differences in mortality (30, 27, 27, 33, 28%) and infection (15, 15, 10, 12, 0%) were found between treatments (10⁹, 10⁸, 10⁷, 10⁶ and control, respectively) in insects exposed 1H in 3-D SRCP. However, 67 and 52% mortality and 55% and 32% infection (10⁹ and 10⁸ respectively) was obtained on insects exposed 24H to the same plants. No significant differences in mortality and sporulation were found between 10⁷ (27%, 7.5%), 10⁶ (37%, 5%) and control (32%, 0%) in plants 3D after solar radiation. (M. Portilla, G. Snodgrass, R Luttrell and T. Ramsey)

The patogenicity of *B. bassiana* on four lepidopteran noctuide (*Spodoptera frugiperda* (FAW), *Helicoverpa zea* (CEW), *Heliothis virescens* (TBW), and *Spodoptera exigua* (BAW)) was studied by direct spray and feeding on infected cotton and corn plant tissue. Immature and plants were sprayed with four concentration (10⁹, 10⁸, 10⁷, 10⁶) of *B. bassiana*. All species were more affected by consuming infected tissues than being spray except for BAW on which a very low mortality (16%) with 10⁹ was obtained and no infection was found with any concentration. CEW was more susceptible to *B. bassiana* than it was FAW or TBW. In general for all species low percentage mortality and sporulation was found and not significant differences were obtained between 10⁹ and 10⁸ concentrations. The most affected stages for the three species were second and third instar. (M. Portilla, G. Snodgrass, R. Luttrell)

Snodgrass Research Program

Resistance to acephate (*Orthene*) was determined with a glass-vial bioassay in tarnished plant bug populations from 25 locations in the Delta of AR (6), LA (4) and MS (15) in July 2011. Resistance ratios of 3.0 or larger (which means that the population would not be controlled in cotton with acephate) were found in 15 populations. Tolerance to acephate (resistance ratios of 2.25 to 2.90) was found in 9 of the populations. These results showed that resistance to acephate (which is incompletely dominant in inheritance) has remained stable since it was first found in 2005. The same 25 populations were also tested for pyrethroid resistance with a discriminating-dose bioassay. The average percent mortality found for the 25 populations was 81.0%. Mortality above 70% indicates a susceptible population, so the populations found in the Delta in

2011 were on average susceptible. In 2010, the average percent mortality was 52.2%. Pyrethroid resistance, which is recessive in its inheritance, decreased from 2010 to 2011, although the reason(s) for the decrease is unknown. **(Snodgrass and Jackson)**

Resistance to the neonicotinoid insecticides (imidacloprid and thiamethoxam) was monitored with a glass-vial bioassay in 25 populations in the Delta of AR (6), LA (4), and MS (15) in 2011. Resistance to both insecticides remained low and little change in resistance was found from 2010 through 2011. Neonicotinoid insecticides are the main class of insecticides to which tarnished plant bugs have not developed resistance. **(Snodgrass and Jackson)**

Beauveria bassiana (NI8 strain) and novaluron (*Diamond*) alone and in combination were evaluated with acephate (or dicrotophos + bifenthrin) for control of tarnished plant bugs in large (ca. 1 acre) replicated plots of cotton at Stoneville, MS in July 2011. The tarnished plant bug population in the cotton was tested and found to be highly resistant to acephate and pyrethroid insecticides. Numbers of tarnished plant bugs were above treatment thresholds in all plots when the treatments were applied (two applications 18 d apart were made). None of the treatments reduced plant bug numbers to below threshold 7 d after the first application. The novaluron + NI8 treatment was the only treatment with below threshold numbers 7 d after the second treatment application. Treatment with recommended rates of acephate (or dicrotophos + bifenthrin), or novaluron did not control the test population. The NI8 treatment had the least impact on beneficial arthropod populations, while acephate caused the greatest reduction in these populations. Novaluron at the high rate used (9 oz/acre) caused reductions in nymphs of *Geocoris punctipes* which was the most abundant beneficial arthropod present. Yield in the NI8 + novaluron treatment was the highest, but no significant differences in yield among the treatments were found. **(Snodgrass, Jackson, and Luttrell)**

Overwintering tarnished plant bug populations on pigweed, *Amaranthus spp.*, at four locations near Stoneville, MS were treated with NI8 (at a rate of one trillion spores per acre) on 7 October, 2011. Adults sampled on pigweed at four additional locations (checks) averaged 16.81 / 10-sweep sample on 4 October and 27.75 adults / 10-sweep sample on 14 October. At the four treated locations, adults averaged 21.38 / 10-sweep sample prior to treatment with NI8 and 12.81 / 10-sweep sample post-treatment on 14 October. This was a reduction in the adult population of 40.1% in the NI8 treated pigweed, while the adult population increased 65.1% in the checks. Eighty adults were collected from the checks and treated locations (20 per location) on 11 October and held individually in the laboratory for 7 d to determine mortality and if sporulation occurred in the dead adults to indicate infection by NI8. In the checks, mortality was 31.25% and none of the adults were infected with NI8. In the adults from the treated pigweed, mortality was 58.2% and 50.0% of the dead adults sporulated. The NI8 was fairly effective in reducing overwintering plant bugs with a single application to pigweed. A second non-pest mired, *Keltonia sulfurea*, was present on the pigweed in numbers as high as 52 adults and nymphs per sample. **(Snodgrass, Jackson, and Luttrell)**

A large field of tall goldenrod, *Solidago altissima*, was divided into plots (100 X 180 ft) and treatments randomly assigned to them. The treatments were a check, NI8 at one trillion spores per acre, and NI8 at the same rate with novaluron (*Diamond*) at 9 oz/ acre. Each treatment had 3 replications and the plots were sampled with a sweep net for tarnished plant bug adults and nymphs (4 samples of 10 sweeps/ replication). The contents of the sweep net were emptied into

a Ziplock bag after each sample and these were taken back to the laboratory where plant bugs along with beneficial arthropods were identified and counted. The plots were treated on 24 October and 4 November. Samples were taken on 19 and 31 October and 10 November. Additional plant bugs were taken from the plots and held to determine mortality and percent infection with NI8 on 28 October and 4 November. Data from the test is presently being analyzed. (Snodgrass, Jackson, and Luttrell)

Zhu Research Program

Survey and monitor *Orthene* and imidacloprid resistance in field populations of the tarnished plant bug. Tarnished plant bugs were collected each month (May – November) from multiple (up to 27) locations in Mississippi and Arkansas. Dose responses were obtained after *Orthene* and imidacloprid treatment. Survival rates ranged from 10% to 100% for both chemicals. Variable survival rates (10-75%) were detected in TPBs collected from May to September. Survival rates from *Orthene* treatment reached 84-100% in October and November. Survival rates from imidacloprid treatment ranged 38-99% in October and November. TPBs around cotton fields had substantially higher survival rates than the bugs collected from soybean and corn fields. (Y.C. Zhu, Y. He)

Characterize *Orthene* resistance in tarnished plant bug using biological, biochemical, and molecular approaches. Understanding resistance mechanisms is essential for insecticide resistance monitoring and management. *Orthene* toxicity (LC50s), enzyme (esterases and glutathione S-transferases) activities, gene sequences and gene expression levels were comparatively studied in *Orthene*-susceptible and -resistant TPBs. Analysis of 6,688 genes using microarray revealed 662 differentially expressed genes (2-fold), including 329 up- and 333 down-regulated genes in LLR. Twelve esterase, four cytochrome P450, and one glutathione S-transferase genes were significantly up-regulated, and no such genes were down-regulated in LLR. The results are significantly valuable in understanding the underlying mechanisms of resistance and are highly desirable for development of resistance management tactics. (Y.C. Zhu, Z. Guo)

Characterizing *Bacillus thuringiensis* resistance in the sugarcane corn borer, *Diatraea saccharalis*. Gene sequencing, real-time PCR, enzyme activities, and RNAi were conducted comparatively to characterized major Bt resistance candidate genes in Cry1Ab-susceptible and -resistant strains, including midgut aminopeptidases, cadherins, alkaline phosphatases, trypsins and chymotrypsins. (Y.C. Zhu, Y. Yang, F. Huang, R. Luttrell, J. Ottea, C. Husseneder, B.R. Leonard, C. Abel)

Analysis of Global Gene Regulation in the Cry1Ab-Resistant and -Susceptible Strains of *Diatraea saccharalis*. Microarray and real-time PCR were conducted to compare gene regulations between susceptible and resistant strains. Analysis of 7,145 cDNAs using microarray revealed 384 differentially expressed genes. Two hundred seventy-three genes were significantly up-regulated by 2-51.6-fold and 111 genes were significantly down-regulated by 2-22.6-fold in the Cry1Ab-RR strain. The large portion of metabolic or catalytic-related genes with significant up-regulations indicated a potential large increase of metabolic or catalytic activities in the Cry1Ab-RR strain. This cDNA microarray gene expression data could be used to characterize

and identify new genes that may be associated with Bt resistance in *D. saccharalis*. (**Z. Guo, Y.C. Zhu, F. Huang, R. Luttrell, R. Leonard**)

Studying interaction of proteinase inhibitors with Cry1Ac toxicity and sequencing fifteen chymotrypsin cDNAs in midgut of the tobacco budworm. Midgut proteinases are involved in Bt activation and degradation. Proteinase inhibitors may be used to control a wide range of insects and delay Bt resistance development. Proactive action to examine proteinase inhibitors for synergistic interaction with Bt toxin and cloning of proteinase cDNAs for RNAi is necessary to make transgenic cotton more versatile and durable. A sublethal dose (15 ppb) of Cry1Ac, 0.5% benzamidine, and 0.02% phenylmethylsulfonyl fluoride significantly suppressed midgut azocaseinase, tryptic, and chymotryptic activities, and resulted in reductions in larval and pupal length and mass of *Heliothis virescens*. The combination of proteinase inhibitor and Bt suppressed 20-37% more larval body mass and 26-80% more enzymatic activities than the inhibitor-only or Bt-only. To facilitate knockdown resistance-related proteinase genes, fifteen midgut chymotrypsin cDNAs were sequenced. (**Y.C. Zhu, S. West**).

2012 Research Plans

Adams Research Plans

Continue to evaluate products to suppress reniform nematodes populations in sweetpotatoes grown in the Mississippi Delta. (**L. C. Adams and R. G. Luttrell**)

Develop methods to determine spring populations of wireworms, rootworms, white grubs and sugarcane beetles in sweetpotato fields. (**L. C. Adams and R. G. Luttrell**)

Participate in the 2012 NSCG Sweetpotato variety trials. (**L. C. Adams and C. Johnson**)

Continue to monitor and report populations of *H. zea* and *H. virescens* in the Mississippi Delta through pheromone trapping. (**L. C. Adams and C. Johnson**)

Continue collaborative research with Alcorn State University scientists studying sweetpotato insect identification, sampling and damage in the Mississippi Delta. (**L. C. Adams, R. G. Luttrell**)

Expand the cooperative 2011 sugarcane beetle cage study with LSU research scientist by increasing treatments options and infestation of beetles in late season. (**L. C. Adams, R. G. Luttrell**)

Allen Research Plans

A survey of looper and stink bug species will be continued in soybean fields in the Mississippi Delta to evaluate the temporal and spatial occurrence of these insect pests (**C. Allen, R. Jackson and L. Andrews**)

An evaluation of economic injury levels for a complex of soybean insects will be conducted in sprayed and unsprayed plots (**C. Allen and R. Jackson**)

Susceptibilities of various stink bug species to commonly used insecticides will be evaluated on field collected insects from various locations within the MS Delta (**C. Allen, R. Jackson**)

The prevalence of various pollen types on or within tarnished plant bugs collected on the borders of cotton fields will continue to be examined and the practicality of using this information to quantify movement will be explored (**C. Allen and G. Jones**)

The cold tolerance of both diapausing and non-diapausing adults of tarnished plant bugs and implications on spring populations will be examined (**C. Allen, G. Snodgrass and R. Jackson**)

Jackson Research Plans

Research will continue to determine the natal hosts of tarnished plant bug adults that immigrate into cotton throughout the growing season. **(R. Jackson, G. Snodgrass, L. Price).**

Pyramided-gene, Bt field corn will be evaluated for its effects on bollworm population ecology and dynamics. Increased adoption of these Bt technologies have the potential to reduce bollworm population levels, which could also impact populations infesting cotton later in the growing season. **(R. Jackson, M. Mullen, C. Allen, R. Luttrell).**

Bollworm populations will continue to be tested for susceptibility to various Bt toxins/technologies. We will attempt to identify a relationship between laboratory assay results and field performance of these populations on Bt technologies. **(R. Jackson, M. Mullen, R. Luttrell, and C. Allen).**

Sentinel plots will again be placed throughout the MS Delta to evaluate the benefit of pyramided-gene, Bt cotton varieties for bollworm control. Economic returns based on differences between insecticide-treated and non-treated plots of the same variety will be the basis of comparison among Bt technologies. These Bt varieties will also be compared to non-Bt varieties at these sites. **(R. Jackson, D. Adams, C. Allen, and R. Luttrell).**

Luttrell Research Plans

H. zea will be collected from Bt and non-Bt corn at different latitudes in Mississippi to explore possible Bt selection as a component of crop phenological development and physiological time. Each population will be selected with additional exposure to Cry1Ac treated Bt diet. Selected and unselected progeny from each crop type will be held for subsequent observations of generation time. These data will be combined with those of a similar study conducted in Arkansas in 2009 to associate timing of corn silking with potential selection from Bt corn hybrids and resulting impacts on generation time. **(R. G. Luttrell, Kenya Dixon, Chad Roberts)**

Field cage studies will be repeated in 2012 to compare different conventional and Bt cotton varieties managed under untreated, pyrethroid, and chlorantraniliprole sprayed systems. High densities of *H. zea* and *H. virescens* from SIMRU laboratory colonies will be released into the cages during periods of peak flowering. If additional cages are available, variable densities or perhaps field collected insects from Bt and non-Bt corn will be used to infest the cages. Routine observations of insect densities and fruit retention will be recorded on plant maps. At harvest, box mapping procedures will be used to measure fruit survival as a function of fruit initiation and exposure to the different insect infestations. **(R. G. Luttrell, Chad Roberts, Ryan Jackson, Clint Allen)**

Exact experimental plans are not established at this time, but field observations of tarnished plant bugs and potential colonization of cotton from a variety of different wild and cultivated hosts will be done in 2012. Collaborations with other SIMRU entomologists interested in this major

pest problem are expected, and possible testing of sprays to limit source populations in corn and soybean are being considered. **(R. G. Luttrell, Chad Roberts, Ryan Jackson, Clint Allen)**

Field and plant assays will continue to measure deposition, persistence and canopy penetration of NI8 sprays of *B. bassiana* for tarnished plant bug control. Procedures for measuring deposition on glass surfaces will be refined before field tests are conducted. Once overall procedures and dependable numbers of laboratory bugs are available for bioassays, studies will be expanded to other crops and wild host plants. **(R. G. Luttrell, Kenya Dixon, Maribel Portilla, Ryan Jackson, Gordon Snodgrass)**

Perera Research Plans

Continue studies on the genetic variation of detoxification genes to identify loci associated with insecticide resistance in Lygus and bollworm. Single nucleotide polymorphisms identified from the transcriptomes will be used in the population genomics studies.

Complete studies on the transcriptomes of tobacco budworm, bollworm, and tarnished plant bug and prepare manuscripts.

Continue genetic marker development for bollworm to develop linkage maps.

Portilla Research Plans

Conduct bioassays to compare the virulence of nine isolates of entomopathogenic fungi against *L. lineolaris* and green lacewings or any other arthropod that shows susceptibility to *B. bassiana* NI8 strain. Five isolates from *L. lineolaris* in the Mississippi Delta including NI8 obtained by J. Leland and GS1 obtained by Gordon Snodgrass and O. Perera, three isolates from *L. lineolaris* in Arkansas, and one isolates from *L. hesperus* in California. LC₅₀s and LD₅₀s will be estimated.

Conduct field studies in order to determine effect of solar radiation on the effectiveness of *B. bassiana* infection in *L. lineolaris*. The field results will be compared with laboratory results. Field *L. lineolaris* populations and Laboratory populations will be compared.

Laboratory studies are in progress to determined resistance of *L. lineolaris* to the entomopathogenic fungus *B. bassiana*

Preliminary field studies will be conducted for life table constructions and demographic parameters estimation for *L. lineolaris* and other arthropods.

Snodgrass Research Plans

Insecticide resistance monitoring in tarnished plant bug populations in the Delta will be continued in 2012. The monitoring will determine resistance levels in plant bug populations to acephate, pyrethroids, imidicloprid, and thiamethoxam. **(Snodgrass and Jackson)**

An experiment designed to develop a tarnished plant bug colony resistant to thiamethoxam (Centric) will be continued. If 5- to 6-fold resistance is obtained, the adults will be tested in the

field or with a spray-table to evaluate what the resistance means in terms of field control. **(Snodgrass and Jackson)**

Beauveria bassiana (NI8 strain) will again be tested for tarnished plant bug control in cotton alone and in combination with novaluron (Diamond). They will also be tested in the fall and winter for control of diapausing plant bugs on wild hosts. If possible, they will be tested in corn for plant bug control when corn tassels. The effect of NI8 and novaluron on beneficial arthropods will also be evaluated on each plant host. **(Sodgrass, Jackson, and Luttrell).**

Several laboratory experiments with Dr. Perera involving tarnished plant bugs infected with viruses and bacteria will be continued. **(Snodgrass and Perera)**

Zhu Research Plans

Characterization of insecticide resistance mechanisms in the tarnished plant bug. Continue to collect tarnished plant bug populations from Mississippi, Arkansas, and Louisiana. Collected bugs will be subjected to dose response assay with spray tower and major detoxification enzyme activity assay. Representative (commonly used) insecticides for different insecticide class, such as cyfluthrin for pyrethroids, Bidrin for organophosphates, and Centric for neonicotinoids, will be used at concentrations similar to LC50 and LC95. Correlation between LC50 dose responses and enzymatic activities will be analyzed and established. The survivals from LC95 dose will be subjected to further molecular analysis. **(Zhu, Luttrell).**

Comparison of monitoring methods: glass-vial assay, spray tower assay, field caging assay, and esterase activity assay. Tarnished plant bugs will be collected from field populations with different resistance levels to an organophosphate insecticide (orthene 90WP and/or a neonicotinoid). Collected bugs will be divided into four groups. Glass-vial method will be used to treat the 1st group, spray tower method will be used to treat the 2nd group, field caging assay will be used for the 3rd group, and esterase activity assay will be conducted on the 4th group of the bugs. Resistance ratios will be obtained and regression analysis will be conducted to compare three different bioassay methods. Esterase activity ratios will be compared with the three bioassay methods. **(Zhu, Snodgrass, Jackson, and Luttrell).**

Study on neonicotinoid resistance mechanisms and association with P450 oxidase gene expression levels in cotton aphid. Esterase inhibitor (S,S,S-tributylphosphorotrithioate [DEF]), glutathione S-transferase (GST) inhibitor (diethyl maleate [DEM]), and P450 oxidase inhibitor (piperonyl butoxide [PBO]) will be used to treat both susceptible and resistant cotton aphids. Inhibitor-treated aphids will be subjected to LC50 assay with thiamethoxam. Reduced resistance ratios or synergized toxicities in thiamethoxam-resistant aphids by different inhibitors indicate different metabolic resistance mechanisms. Based on reports, P450 oxidases are potentially involved in neonicotinoid resistance. To examine which P450 gene is responsible for the resistance, cDNAs will be cloned and sequenced using RT-PCR or cDNA library sequencing. Primers will be designed and used to conduct real-time PCR to compare P450 gene expression levels between susceptible and resistant populations. **(Zhu, Gore, Luttrell).**

2011 Specific Cooperative Agreement Research Accomplishments

Project Title: Pest identification and the development of IPM systems for sweetpotato in the Mississippi Delta

Alcorn State University

Project Investigator: Frank Chukwuma

Project State Date: 8/1/2006

Agreement No.: 58-6402-6-079

ARS Investigator: Ryan Jackson

Project End Date: 7/31/2011

2011 Accomplishments:

Study conducted at Alcorn State University Extension/Research Farm located in Mound Bayou, Mississippi on a Dexter silt loam soil investigated the influence of conventional (intensive-synthetic input) and transitional (reduced-synthetic input) systems on Beauregard sweetpotato (*Ipomoea batatas*) survival, yield and quality. A randomized complete block (RCB) experiment design, with four replications of each cropping system (treatment) was used. Data analysis was by the analysis of variance, while means were separated by the least significance difference (LSD) test. Results indicated that transitional cropping system favors the production of No. 1 marketable sweet potato roots as compared to the conventional cropping system.

2012 Research Plans:

Project terminated

Project Title: Low input systems of pest control for sweetpotato in the Mississippi Delta

Alcorn State University

Project Investigator: Tahir Rashid

Project State Date: 8/1/2011

Agreement No.: 58-6402-1-614

ARS Investigator: Randy Luttrell

Project End Date: 8/31/2014

2011 Accomplishments:

Several biological compounds were extracted for toxicity evaluation against insect pests of sweetpotatoes. A preliminary study was conducted to determine the effect of a plant growth regulator on insect damage to sweetpotato storage roots. Yield and insect damage data were collected from RCBD sweetpotato field plots in Alcorn State University, Mound Bayou, MS. Treatments consisted of 4 sweetpotato varieties (Proto Rican, Beauregard, O'Henry and SC1149-19) with or without application of a plant growth regulator. Samples were weighed and insect damage compared.

2012 Research Plans:

Color traps will be designed and installed in sweetpotato fields to catch live adult beetles of wireworms to initiate lab colony for toxicity bioassays with new biological compounds. Pheromone traps will be used to detect any adult *Cylas formicarius* population in southern Mississippi's weevil quarantined areas. Effect of plant growth regulator(s) will be studied on sweetpotato yield and insect damage.

Project Title: Characterizing mechanisms of *Bacillus thuringiensis* resistance in sugarcane corn borer

Louisiana State University

Project State Date: 7/14/2006

Project Investigator: Fangneng Huang

Agreement No.: 58-6402-6-035

Project End Date: 7/14/2011

ARS Investigator: Yu Cheng Zhu

2011 Accomplishments:

This is the final report for this project. During the period of the project, laboratory bioassays have been conducted to determine the susceptibility of Bt-susceptible and -resistant strains of sugarcane borer to three different Bt Cry toxins. The resistant sugarcane borer strain demonstrated a significant level of resistance to all of the three Bt toxins examined. These results confirm the survival of the resistant strain on commercial Bt corn plants was related to Cry1Ab protein resistance and suggest that this strain have considerable value in studying Bt resistance mechanism and developing resistance management strategies for Bt corn. To date, all research experiments have been conducted and all objectives were accomplished. Data were analyzed and manuscripts were prepared, submitted or published in international journals. Major accomplishments include 1) examination of susceptibility of the sugarcane borer to different Bt toxins; 2) molecular characterization and RNA interference of three midgut aminopeptidase N isozymes from Bt-susceptible and -resistant strains; 3) comparative study of cadherin and alkaline phosphatase gene regulations between Bt-susceptible and -resistant strains; 4) Characterization and transcriptional analyses of cDNAs encoding three trypsin- and chymotrypsin-like proteinases in Bt-susceptible and -resistant strains of sugarcane borer.

The information generated from the cross-resistance study, enzymatic analysis, binding study, microarray analysis, and molecular study of Bt resistance in sugarcane borer during the last four years should provide very useful information in better understanding of evolution of Bt resistance in insects, development of new generation of Bt corn technology to manage Bt resistance in sugarcane borer. Besides several publications and presentations, one Ph.D. student successfully graduated in May, whose research was partially supported by this project. ADODR used site visit, email and telephone conferences to monitor activities of the project.

2012 Research Plans:

Project terminated

Project Title: Development of a tarnished plant bug and stink bug management system

Mississippi State University

Project Start Date: 8/22/2006

Project Investigator: Fred Musser

Agreement No.: 58-6402-6-061

Project End Date: 8/22/2011

ARS Investigator: Ryan Jackson

2011 Accomplishments:

Tarnished plant bug resistance to 3 major insecticide classes has been monitored annually since 2006 from 12 areas in central and northeastern Mississippi. Over this time resistance levels have been stable and low for pyrethroid and neonicotinoid insecticides. Resistance levels to organophosphate insecticides were stable but moderate. There was no indication that areas nearer the delta region had any more resistance than bugs collected farther from the delta.

2012 Research Plans:

Project terminated

Project Title: Bt risk assessment for Lepidopterous pests of cotton

Mississippi State University

Project State Date: 3/3/2008

Project Investigator: Fred Musser

Agreement No.: 58-6402-8-274

Project End Date: 3/2/2013

ARS Investigator: Clint Allen

2011 Accomplishments:

In cooperation with EPA, models have been developed to address changes in Bt crops being planted, new Bt events being developed and changes in Bt-crop refuge requirements being proposed. In particular, models have evaluated the impact of reduced refuges required for multi-gene corn coupled with increased selection pressure on corn earworm on the risk of developing resistance to the Bt toxins. We have begun making the user interface more accessible so that researchers can input parameters of importance to them and evaluate the impact of these parameters. A graduate student began studying the role of volunteer Bt corn on corn earworm population dynamics and resistance evolution. We are also adapting the corn earworm model for use in other insect systems to evaluate the risk of resistance development and to estimate population dynamics.

2012 Research Plans:

Modeling efforts will continue to address the risk of insects developing resistance to Bt toxins for an increasingly complex array of Bt toxins and refuge requirements available in corn and cotton. The user interface for the model will continue to be refined for broader research use. One graduate student, who began research during 2011, will continue to evaluate the role of volunteer corn emerging from former Bt-corn fields on the risk of Bt resistance development in a corn-cotton landscape. A new graduate student will begin studies on the role of weedy hosts in tarnished plant bug population dynamics. Upon completion of these field studies, data will be used to improve the accuracy and reliability of our models for corn earworm and tarnished plant bug.

Project Title: Bt risk assessment for lepidopterous pests of cotton

Mississippi State University

Project State Date: 7/1/2008

Project Investigator: Jeffery Gore

Agreement No.: 58-6402-8-313

Project End Date: 7/1/2013

ARS Investigator: Ryan Jackson

2011 Accomplishments:

Bollworm larvae were collected from Non-Bt and VT3P field corn. Pupal duration and pupal weights were determined for the parental generation. Backcrosses and reciprocal crosses were made and the offspring neonates were subjected to dose mortality bioassays on lyophilized Bollgard II cotton tissue. Male bollworm larvae collected from VT3P field corn had a longer pupal duration compared to males collected from Non-Bt field corn. Female pupal duration was not significantly different for individuals collected from non-Bt field corn and VT3P field corn. Populations collected from VT3P field corn had higher pupal weights than larvae collected from Non-Bt field corn. Progeny from females reared on VT3P field corn had a higher LC50 compared to progeny resulting from females reared on Non-Bt field corn regardless of paternal host. Based on these results, bollworms collected from VT3P field corn are healthier and more robust than those reared on non-Bt field corn. Although colonies collected from VT3P field corn had higher LC50 values on Bollgard II tissue than colonies collected from non-Bt field corn, it is not clear if the elevated LC50 is due to a resistance mechanism or increased fitness. **(B. Von Kanel, J. Gore, D. Cook, R. Jackson, A. Catchot, and F. Musser).**

An experiment was conducted to measure *Helicoverpa zea* (Boddie) survival on silks from non-Bt field corn and VT3P field corn. Fresh green silks were collected from 10 ears of VT3P field corn and non-Bt field corn on 3 dates during 2011. One hundred silks were removed from each ear and individually placed into 29.5 oz. plastic cups. A single neonate *H. zea* was placed into each cup and allowed to feed from 48 h. After 48 h, surviving larvae were transferred to new diet cups with a thin layer of meridic diet. Mortality was rated after an additional 7 days. *H. zea* survival on silks from non-Bt field corn averaged 89.0%. In contrast, *H. zea* survival averaged 39.2% on silks from VT3P field corn. This experiment demonstrates that a fairly large percentage of bollworm larvae are able to survive for at least 2 days on silks from VT3P field corn. **(J. Gore and D. Cook).**

An experiment was conducted in 2011 to evaluate the efficacy of foliar insecticide applications for *Heliothis virescens* (F.) in non-Bt cotton. Insecticides evaluated included representatives pyrethroid (bifenthrin and lambda-cyhalothrin), organophosphate (profenofos), spinosyn (spinetoram), oxadiazine (indoxacarb), and diamide (chlorantraniliprole and flubendiamide) classes of insecticides. Based on larval collections in untreated plots, 95% of the population consisted of *H. virescens*. The pyrethroids provided very little control of *H. virescens*. Surprisingly, profenofos, provided acceptable control after 2 applications. Spinetoram and indoxacarb provided marginal control after one application, but good control 5 days after the second application. The diamides provided variable levels of *H. virescens* control. In general, flubendiamide only provided marginal control. In contrast, chlorantraniliprole provided good control after 2 applications, but only marginal control with one application. These data demonstrate that *H. virescens* is very difficult to control with foliar insecticides. None of the

insecticide classes evaluated provided acceptable control with one application. **(J. Gore and D. Cook).**

An experiment was conducted to evaluate the impact of insecticide overspray's on dual toxin Bt cottons. One non-Bt cotton variety, one Widestrike cotton variety, and two Bollgard II cotton varieties were planted in a split-plot design with 4 replications. Each variety had a sprayed and unsprayed treatment. The sprayed plots were treated, as needed, with Prevathon to control lepidopteran insect pests. Overall, lepidopteran densities were low in this trial. However, the foliar overspray's reduced populations of lepidopterans and their injury in all cotton types. The cotton was planted late and was subjected to heavy frost before maturity. As a result, the plots were not harvested. These data demonstrate that lepidopteran pests can survive on and damage Bt cottons in some situations and that foliar insecticide applications could play an important role in resistance management. **(J. Gore and D. Cook).**

Multiple experimental dual gene cottons were evaluated in 2010. Plots of the experimental cottons were planted at the Delta Research and Extension Center in Stoneville Mississippi. The plots were arranged as a randomized complete block design with four replications. During 2011, the heliothine complex was primarily composed of tobacco budworm, *Heliothis virescens* (F.). Collections during the season showed that greater than 90% of the population consisted of tobacco budworm. Bollworm, *Helicoverpa zea* (Boddie), densities never exceeded 10% of the entire population. As a result, all of the Bt cottons evaluated provided good control under high population densities. Damaged bolls from tobacco budworm approached 100% in these experiments **(J. Gore and D. Cook).**

2012 Research Plans:

Experiments evaluating the impact of bollworms on yields of Bollgard II and Widestrike cotton will be continued. **(J. Gore and D. Cook)**

Collections of bollworms from Bt crops will be continued in 2012. **(J. Gore and D. Cook).**

The graduate student project evaluating the impact of Bt corn hybrids on bollworm, *Helicoverpa zea* (Boddie), population dynamics, fitness, and subsequent damage in cotton will be expanded in 2011. **(J. Gore, D. Cook, A. Catchot, and B. Von Kanel)**

An experiment that was initiated in 2010 will be continued in 2012 that examines the impact of volunteer corn on bollworm population dynamics. In this experiment, seed were collected from plots that were planted to different corn technologies. The seeds were picked up by hand after harvest to determine the Bt expression levels in volunteer corn. The corn has been planted in the greenhouse and bioassays will be conducted within the next month to measure survival levels. **(J. Gore and D. Cook)**

Experiments investigating corn earworm survival on silks from dual-gene corn hybrids will be continued in 2012. This experiment will be expanded to determine the role of cannibalism on the ability of individual larvae to complete development on dual-gene corn hybrids. **(J. Gore and D. Cook)**

Project Title: Economic analysis of Bt corn technologies and associated refuge systems

Mississippi State University

Project Start Date: 4/1/2010

Project Investigator: Steve Martin

Agreement No.: 58-6402-0-459

Project End Date: 4/1/2013

ARS Investigator: Ryan Jackson

Accomplishments:

Field studies were conducted in 2010 and 2011 with corn hybrids possessing various Bt traits across the mid-South to estimate the impact of single- and pyramided-gene Bt corn hybrids on bollworm populations, as well as to make an economic assessment of single- and pyramided-gene Bt corn/refuge systems. Single-gene Bt hybrids had little impact on bollworm populations infesting field plots, whereas pyramided-gene hybrids significantly reduced larval numbers, larval size, and the numbers of damaged kernels. Yields of corn hybrids varied over the two-year period. Data are currently being compiled to conduct an economic analysis comparing the single-gene, 50% corn refuge system with the pyramided-gene, 20% corn refuge system.

2012 Research Plans:

Field studies will again be conducted in 2012 with corn hybrids possessing various Bt traits across the mid-South to estimate the impact of single- and pyramided-gene Bt corn hybrids on bollworm populations, as well as to make an economic assessment of single- and pyramided-gene Bt corn/refuge systems. Larval infestation and damage levels, as well as yields will be recorded. A comparison of single-gene, 50% corn refuge system with the pyramided-gene, 20% corn refuge system will be made through economic analyses of 2010 and 2011 field data.

Project Title: Bt-resistance frequency detection

North Carolina State University

Project Start Date: 8/30/2006

Project Investigator: Fred Gould

Agreement No.: 58-6402-6-048

Project End Date: 3/31/2011

ARS Investigator: Ryan Jackson

Accomplishments:

Our cooperative agreement with SIMRU ended in March of 2011. During part of the time of this agreement we were funded to maintain strains of *Heliothis virescens* that were resistant to various Bt toxins. Given the lack of funds, we decided that it was important to find new home for the resistant strains.

In 2011 we searched for other labs that were willing to rear the Bt resistant strains. We have now sent strains to SIMRU, Juan Luis Jurat Fuentes, David Heckel, and to Dow Agro. We are providing our expertise to these groups as they determine the best ways to maintain the resistant strains.

2012 Research Plans:

Project terminated

2011 Publications and Presentations

Publications

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He, Y, Chen, L., Chen, J., Zhang, J., Chen, L., Shen, J., Zhu, Y.C. 2011. Electrical penetration graphic evidence that pymetrozine toxicity to the rice brown planthopper is by inhibition of phloem feeding. Pest Manag. Sci. 67: 483-491.

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Presentations

Adams, A., G. Snodgrass, J. Gore, F. Musser, D. Cook and A. Catchot. 'Efficacy of selected insecticides against tarnished plant bug' Beltwide Cotton Conferences. Atlanta, GA, Jan. 7, 2011.

Adams, L. C. and R. G. Luttrell, 2010 Product Evaluation for Reniform Nematode Suppression in Mississippi Delta Sweetpotato Production. National Sweetpotato Collaborators Group Meeting, Orange Beach, Alabama, January 22-23, 2011.

Adams, L. C. ARS Contributions to Sweetpotato Insect Research , Alcorn State University Farm Financial Management Workshop, MDCC, Moorhead, Mississippi, May 23, 2011. **(Invited)**

Adams, L. C. and R. G. Luttrell, Insecticide Application Method and Chemistry Evaluation for Sweetpotato Production in the Mississippi Delta. National Sweetpotato Collaborators Group Meeting, Orange Beach, Alabama, January 22-23, 2011.

Adams, L. C. and R. G. Luttrell. 2011 Product evaluation for reniform nematode suppression in Mississippi Delta sweetpotato production. National Sweetpotato Collaborators Group Meeting, Orange Beach, AL

Adams, L. C. and R. G. Luttrell. 2011. Insecticide application method and chemistry evaluation for sweetpotato production in the Mississippi Delta. National Sweetpotato Collaborators Group Meeting, Orange Beach, AL. (poster)

Adams, L. C. ARS Contributions to Sweetpotato Insect Research , Alcorn State University's Sweet Potato Jamboree and Fall Vegetable Field Day, September 22, 2011, Alcorn State Extension/Research Farm, Mound Bayou, Mississippi. **(Invited)**

Adams, L. C. R. G. Luttrell and C. Johnson, Insecticide Application Method and Chemistry Evaluation for Sweetpotato Production in the Mississippi Delta, 2010 Product Evaluation for Reniform Nematode Suppression in Mississippi Delta Sweetpotato Production and 2010 Evaluation of Monty's Plant Food Products to Enhance Yield for Crops Grown in the Mississippi Delta, Annual Sweetpotato Production Meeting, Calhoun County Extension Center, Pittsboro, MS, February 24, 2011.

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Jackson, R. 2011. Management of cotton bollworms in dual-gene Bt cotton: is it worth it? 2011 Row Crop Short Course, Starkville, MS. **(Invited)**

Jackson, R. 2011. Bt cotton resistance monitoring update. 38th Annual Conference of the Mississippi Agricultural Consultants Associations, Mississippi State, MS. **(Invited)**

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Jackson, R. E., K. C. Allen, and R. G. Luttrell. 2012. Comparative benefit of Bt and non-Bt cotton under different insect management strategies. Beltwide Cotton Conference, Orlando, FL.

Jackson, R., C. Allen, and R. Luttrell. 2011. Comparative benefit of Bt technologies in the Mississippi Delta. 58th Annual Conference of the Mississippi Entomological Association, Mississippi State, MS.

Jackson, R., C. Allen, and R. Luttrell. 2011. Value of transgenes in early and full season cottons for bollworm/tobacco budworm control under different insecticide spray systems. U.S. Cotton Breeder's Tour, Stoneville, MS. **(Invited)**

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Portilla, M., Snodgrass, G. and Luttrell, R. 2011. Effect of the entomopathogenic fungus, *Beauveria bassiana* and the insect growth regulator Diamond on fecundity and growth inhibition of the tarnished plant bug, *Lygus lineolaris*. Mississippi Entomological Association, Mississippi State, Mississippi. **(Poster)**

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Portilla, M., Snodgrass, G. and Luttrell, R. 2011. Susceptibility and demographic parameters of populations of fall armyworm, *Spodoptera frugiperda* to Cry1Ac and Cry1Fa proteins of *Bacillus thuringiensis*. Annual Meeting Entomological Society of America, San Juan, Puerto Rico. **(Poster)**

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Von Kanel, B., A. Catchot, F. Musser, J. Gore, R. Jackson, D. Cook and M. Caprio. Contribution of corn earworm, *Helicoverpa zea* (Boddie), to the overall population reared on VT3PRO field corn. MS Entomol. Assn. annual meeting, Miss. State Univ., MS, Oct. 25, 2011.

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Yueping, H., Y. C. Zhu, and R. G. Luttrell. 2011. Adverse influence on reproduction and potential fitness cost in survivors of Orthene-treated tarnished plant bug, *Lygus lineolaris*. Mississippi Entomological Association, Mississippi State, Mississippi. **(Poster)**

Zhu, Y. C. 2011. “Application of Sequencing and Microarray in Insecticide Resistance Research” and “Identification and Characterization of Major Pesticide Resistance Genes in *Lygus lineolaris*” Nanjing Ag Univ. Nanjing China

Zhu, Y. C. 2011. “Gene regulation and insecticide resistance mechanisms in the tarnished plant bug” Louisiana State Univ.

Zhu, Y. C. 2011. “Identify and Characterize Insecticide Resistance Genes Using Novel Techniques”. Tea research institute Chinese academy of Ag Sciences, Hangzhou, China.

Zhu, Y. C. 2011. “Move Insecticide Resistance Genes into Beneficial Insects”. Zhejiang University, Hangzhou, China.

Zhu, Y. C. 2011. “New Research Techniques for Understanding Insecticide Resistance Mechanisms” and “Move Insecticide Resistance Genes into Beneficial Insects”. Zhejiang Academy of Ag Sci. Hangzhou, China.

Zhu, Y. C., H. Yueping, and R. G. Luttrell. 2011. Acephate resistance and potential mechanisms in the tarnished plant bug. Mississippi Entomological Association, Mississippi State, Mississippi.

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Appendix A

SIMRU's 2011 STEP Employees



4th row (L to R) Julian Beamon, Dustin Picklemann, Thomas Sherman, and Corey Douglas

3rd row (L to R) Christopher Morris, Jesse King, Bailey Tubertini, D'anice Dishmon, Emily Mosow, Shelby Reister, David Liang, and Julian Henry

2nd row (L to R) Michael McCain, Jasmine Warren, Antia Cain, Cavishia Roberson, Breanna Pennington, Jana Slay, LaToyia Slay, and Chastity Scott

1st row (L to R) Nicholas Homes, Gwendolyn Lee, Jordan Tullus, and Flenadia Moore

Not pictured: Dana May and Parker Brocato