Annual Report for S-1029, Improved Methods to Combat Mosquitoes and Crop Pests in Rice Agroecosystems
Period Covered 10/2009 to 9/2010

Sharon Lawler, (splawler@ucdavis.edu), University of California-Davis
Bill Walton, (walton@ucr.edu), University of California-Riverside
Larry Godfrey, (ldgodfrey@ucdavis.edu), University of California-Davis
Luis Espino, (laespino@ucdavis.edu), University of California Extension
Mike Stout, (mstout@agcenter.lsu.edu), Louisiana State University
Natalie Hummel, (nhummel@agcenter.lsu.edu), Louisiana State University
Kelly Tindall, (tindallk@missouri.edu), University of Missouri
M. O. Way, (moway@aesrg.tamu.edu), Texas A&M University
John Bernhardt, (jbernhar@uark.edu), University of Arkansas
Gus Lorenz, (glorenz@uaex.edu), University of Arkansas
Jeff Gore, (JGore@drec.msstate.edu), Mississippi State University
Don Cook, (dc250@msstate.edu), Mississippi State University

Accomplishments: Objective 1. To advance basic and applied biological research on existing and emerging rice invertebrate pest, including mosquitoes.

Walton (CA): *Impact of sinking vs floating vegetation on mosquito control.* The consequences of sinking versus floating dried plant biomass were examined in replicate mesocosms under different flow regimes during two studies. Mosquito abundance and water quality parameters (nutrient levels, oxygen demand, and physio-chemical variables) were measured. Air-dried bulrush biomass equivalent to 15 stems/m^2 at 2.3 m high was either floated on the water surface or sunk beneath water surface. Water turnover time was either 2-3 volumes per day or approximately 0 volumes per day (essentially compensating for evaporative losses). Water quality of the supply water did not differ significantly between the spring and autumn studies. At high turnover rates, water quality did not differ significantly between the two vegetation management treatments and the water supply. At low turnover rates, water quality (nutrient levels and oxygen demand) in pools with sunk vegetation was reduced more than in pools with floating vegetation. Mosquito numbers (*Culex* spp. and *Anopheles hermsi*) in mesocosms with floating vegetation were greater than in mesocosms with sunken vegetation on most dates during spring. Sinking vegetation to enhance nitrogen removal via denitrification will enhance the effectiveness of mosquito control but, depending on water management practices, may raise the concentrations of water quality constituents in discharges that are regulated under the Clean Water Act.

Walton (CA): *Inheritance of Cry toxin resistance in Culex quinquefasciatus.* Mendelian crosses were used to study the mode of inheritance of Cry toxin resistance in a *Culex quinquefasciatus* Say colony (CqAB11A) that evolved insecticide resistance under laboratory selection. Mosquitoes were exposed to a mutant strain of *Bacillus thuringiensis* subsp. *israelensis* lacking the Cyt1Aa toxin component but expressing its three major Cry toxins, Cry4Aa, Cry4Ba, and Cry11Aa. High resistance levels were observed toward Cry toxins. F1 offspring of reciprocal crosses to a susceptible colony showed intermediate levels of resistance with no maternal effect, indicating autosomal inheritance. Dose-response data on backcross offspring deviated significantly from the monofactorial model when tested with Cry4Aa+Cry4Ba+Cry11Aa, Cry4Aa+Cry4Ba, or Cry11Aa. However, tests with Cry11Ba from *B. thuringiensis* subsp. *jegathesan* on backcross offspring fit the monofactorial model. Dominance of F1 offspring was calculated at different concentrations of Cry-toxin suspensions and, as reported for other Cry-resistant *Culex,* generally decreased as concentration increased. A subset of colony CqAB11A was reared without selection pressure for 18 generations with little change in susceptibility, indicating a

highly homozygous population. Consistent with reports for other Cry-resistant *Culex,* the data show these mosquitoes evolved insecticide resistance to *B. thuringiensis* Cry toxins at multiple loci in response to selection pressure and that cross-resistance towards Cry11Ba was conferred by one of those loci.

Hummel (LA): *Rice insect survey.* A survey was developed and distributed in 2010 in Louisiana, Texas, Missouri, Mississippi and Arkansas to describe the 2009 growing season. 184 survey sheets were processed from the following states: Louisiana (146), Texas (47), Missouri (5), Mississippi (2), and Arkansas (1). Trends from LA surveys showed rice water weevil and rice stink bug were the number one and two pests, respectively. Grasshoppers, armyworms, and chinch bugs were noted as secondary pests. Minor pests included rice leafminer, stalkborers and colaspis. The percentage of acreage that was scouted prior to treatment was 91% in LA and 100% in Texas. In 2008, in Louisiana, the most common method used to control or prevent rice water weevil was drained field (43%). In 2009, in Louisiana, the most common method used to control or prevent rice water weevil was Dermacor X-100 seed treatment (52%). In 2009, this was the only seed treatment available for use in rice.

In Louisiana, 60% of the respondents reported a low infestation, while 36% reported a moderate infestation. While, the reverse was reported in Texas, where 59% reported a moderate infestation and 31% reported a low infestation. 88% of the respondents reported that they treated for rice stink bugs in the 2009 crop season; this is an increase of 10% from the 2008 production season. Most respondents in LA reported that they treated with a single application of insecticide (47%), while in Texas the majority of respondents reported treating twice (42%). In Louisiana, the majority of respondents used a pyrethroid (Karate or Mustang) for control, followed by Malathion and Methyl 4ec. While in Texas, producers have readily adopted a new chemistry – Tenchu 20SG. 40% of respondents from Texas reported that they treated some fields with Tenchu 20SG.

Hummel (LA): *Online rice insect identification guide released in Nov 2010.* The Louisiana Online Rice Pest Identification Guide was launched in November, 2010. The web address is www.lsuagcenter.com/ricepestguide. The guide is structured as a dichotomous key. The purpose of this guide is to improve identification of arthropods (insects and mites) that damage rice in Louisiana. Once the arthropod is properly identified, you will find a link to the Louisiana pest management guide with insecticide recommendations. We have also included links to scouting videos for the rice water weevil, colaspis, and panicle rice mite. This resource is open access and applicable to the Mid-South rice production region.

Hummel (LA): *Launched Louisiana Rice Insects Wordpress blog, connected with Facebook and twitter social media tools.* The Louisiana Rice Insects blog was launched in January, 2010. The web address is www.louisianariceinsects.wordpress.com. This web 2.0 tool is used to keep stakeholders informed about rice entomology extension program activities. There are currently 57 active subscriptions to the blog, and it has exceeded 14,750 views, averaging approximately 50 views per day. Visitors from more than 115 countries have accessed the blog. The blog posts are automatically linked to my Facebook profile and twitter feed online. This has generated interest in rice production from personal friends that are not associated with agricultural production. Thus, the blog, Facebook and twitter function as a portal to educate non-agriculturally related audiences about the complexities of crop production and pest management.

Stout (LA). *Induced resistance of sugarcane borer oviposition: oviposition induced resistance to subsequent oviposition.* Attack by herbivores can change plants in ways that make them more resistant to subsequent herbivory. This phenomenon could be exploited in pest management or used as a tool to

investigate mechanisms of plant resistance. Jason Hamm continued his research on the induction of resistance by stem borer oviposition. He continued to see that sugarcane borer (SCB) oviposition induced resistance to subsequent oviposition in several varieties (Rosemont, Reiho, and Cocodrie) but not M202. The number of eggs oviposited was reduced by as much as 85%.

Stout (LA). *SCB varietal resistance.* Jaspreet Sidhu continued her investigations of various aspects of SCB biology on eight commonly grown rice varieties. Oviposition, larval weight gain, and % of larvae successfully boring into stems were found to differ significantly as a function of rice variety.

Stout (LA). *Effect of plant age on rice water weevil oviposition.* A series of greenhouse choice and no-choice experiments were conducted to characterize the relative susceptibility of various ages/stages of rice to oviposition by rice water weevils. Plants were susceptible to oviposition from the two-leaf stage to panicle differentiation, but maximum susceptibility was found at the tillering stage.

Stout (LA). *Fall armyworm research.* Simple phenolics (phenylpropanoids) in rice leaves were identified and quantified, and artificial diet studies were initiated to compare the effects of different phenolics on the growth of fall armyworms. As concentrations of caffeic acid and p-coumaric acid increased, fall armyworm weights decreased by as much as 80% and 35%, respectively. Additionally, high concentrations of cinnamic acid reduced growth more than 20%.

Stout (LA). *Predator study*. To test the hypothesis that aquatic invertebrates can reduce densities of rice water weevils, small cages were set up in plots immediately before flooding. As plots were being flooded, four treatments were set up (four cages per treatment): Treatment 1, rice was swept with a small net to remove invertebrates present in the rice; Treatment 2, aquatic invertebrates collected from an adjacent flooded rice field were added to the cages; Treatment 3, no addition or removal of invertebrates. Once rice had been flooded, 10 weevil adults were added to each cage in these three treatments and cages were covered with mesh. A fourth treatment consisted of unmanipulated rice and uncovered cages. The results were consistent with the hypothesis ($P = 0.06$) that aquatic invertebrates reduce weevil densities; however, the mechanism of reduction is unknown.

Stout (LA). *Rice stink bug chemical ecology*. Jason Hamm investigated several aspects of rice stink bug chemical ecology: 1) effect of host plant on defensive chemistry of rice stink bugs; 2) attraction of stink bugs to chemicals purportedly emitted by rice panicles in the lab and field; 3) emission of volatiles by rice panicles. When rice stink bugs were provided a choice of one of the following chemicals: methyl-salicylate, beta-caryophyllene, linalool, and (+)-limonene or air in a Y-tube olfactormeter, more rice stink bugs chose the odor stream of methyl-salicylate over air; there were no responses to any of the other chemicals.

Stout (LA). *Revision of economic thresholds for insecticide use against the rice stink bug.* Work was begun to estimate the efficiency of sweep-net sampling for rice stink bugs and preliminary data suggest that sweep netting captures on average 15% of the stink bugs present on rice plants. Additionally, work was initiated to characterize the relationship between rice stink bug density and damage to rice and to revise rice stink bug thresholds in Louisiana. Preliminary data examining the impact of stink bug feeding on different rice varieties suggest that are differences of rice stink bug preference for feeding between varieties.

Gore/Cook (MS): *Impact of Rice Stink Bug on Grain Quality and Yield.* George Awuni initiated a series of field cage experiments examining the impact of rice stink bug on grain quality and yield. In the first

experiment, rice stink bugs were caged on individual panicles at densities of one or two stink bugs per panicle at bloom, milk, and soft dough stages for 7 days. In a second experiment, multiple stink bugs were caged on rice in large field cages (6 ft. x 6 ft.). The densities included 0, 30, or 60 stink bugs per cage.

Rice stink bug did not significantly impact grain quality at the bloom and soft dough stages in these experiments. Rice stink bug significantly impacted grain quality at the milk stage. The number of damaged kernels per panicle was 22.5 and 33.4 at 1 and 2 stink bugs, respectively, per panicle during the milk stage. There was a natural infestation of stink bugs in the field where these experiments were done. This resulted in some injury at all infestation timings in the non-infested panicles. Rice stink bug significantly reduced yields at all infestation timings. The greatest yield losses were observed during the flowering stage of rice development by 57.7 for 1 stink bug per panicle and 71.7 for 2 stink bugs per panicle at the bloom stage. During the milk stage, percent yield loss averaged 29.5 and 47 for 1 and 2 stink bugs per panicle, respectively. Yield losses during the soft dough stage were similar to the milk stage and averaged 32.6 and 44.8 percent for 1 and 2 stink bugs per panicle, respectively.

Godfrey (CA). *Rice Water Weevil* - In 2009, the rice water weevil spring flight was the highest recorded since 2001. The flight in 2010 was delayed and altered by the cool, wet spring conditions. Peaks in flight activity occurred on 13 May and from 28 May to 4 June and some weevils were captured as late as July (normally 10 June is the latest flight seen). In total, ~1650 rice water weevil adults were captured which was about 30% of the 2009 total. Previous studies have shown that rice water weevil larvae primarily reduces rice grain yield by reducing the amount of tillering in the plants (instead of affecting grain weights or number of seeds per panicle). We wanted to investigate how, mechanistically and physiologically, this occurs in the rice plant; what are the factors that affect tillering in rice and how does root pruning by the larvae impact this. Developing an understanding of the manner in which the insect impacts plant productivity could be an important advancement in helping to design stable, sustainable, long-term management schemes. Several treatments were set-up with different amounts and different timing of stress from rice water weevil. Data are still being examined but the late seeding date and late-maturing rice crop (due to the cool, rainy spring and to the cooler than normal summer) inhibited the success of this study.

Godfrey (CA). *Panicle Rice Mite:* In January 2009, the panicle rice mite, *Steneotarsonemus spinki*, was found in California on the UC-Davis campus infesting rice growing in greenhouses. This invasive pest is a "Q" rated (quarantine) pest in CA. UC-Davis, in cooperation with representatives of regulatory agencies at the federal (Animal and Plant Health Inspection Service) and state (California Dept. of Food and Agriculture) levels, worked quickly to eradicate this pest. Treatment of existing rice in greenhouses followed by a rice-free period was enacted on campus to try to break the "cycle" of the mite. Rice for research purposes is again being grown on the campus using new seed handling and sanitary procedures and to-date the infestation in the UC-Davis greenhouses is non-existent. However, keeping this pest out of California is going to be an ongoing process. The California Dept. of Food and Agriculture samples a given percentage of rice fields late-season to monitor for PRM infestations. In 2010, a mite was "commonly" found and initially thought to be *Steneotarsonemus spinki* by the department's mite expert. The samples were forwarded to Ron Ochoa and he identified it as *Steneotarsonemus* sp., incidental on rice. It definitely was not *S. spinki*. The explanation was, "It is considered an incidental on rice (that is, it feeds on other, non-economic grasses). There aren't enough historical collections and there aren't enough experts to know the history of this mite in California."

Tindall (MO): *Tadpole Shrimp:* In 2010, a distribution survey was conducted to determine the where this pest occurs in rice producing areas of Missouri. After failed attempts to locate any in fields during spring,

a method to find tadpole shrimp was borrowed from individuals working in ephemeral aquatic systems. After harvest, the top 2 in of soil of an 8 in x 8 in area was collected. Low areas of the field were targeted because tadpole shrimp will congregate in areas were water remains on the field after it is drained. There was a distance of 50 to 100 ft between samples and five samples per field were collected. Tadpole shrimp eggs require a period of drying; therefore, soil was dried completely. Then soil was placed soil in a plastic container and spread to a depth no greater than one inch. Water was added as needed to containers to simulate a 2 in flood for 15 to 21 days. The containers were kept in an area that was warm and exposed to light so that the tadpole shrimp would hatch. After 2 to 3 weeks, tadpole shrimp were visible. While the methodology is effective for discovery of tadpole shrimp, current data are not sufficient to determine economic thresholds. Results of the tadpole shrimp distribution study showed they are widely distributed geographically; however, not every field within an area is infested. Additionally, most of the fields that were positive for tadpole shrimp are east of the Little River Drainage District. Tadpole shrimp are transferred from field to field via floodwaters, wind, birds and other wildlife.

Lorenz (AR): *Invasive Rice Pest Survey.* We conducted an Invasive Rice Pest Survey in cooperation with the Arkansas State Plant Board and APHIS. The survey was conducted in three parts. In south Arkansas: Ashley, Chicot, Desha, Drew, Jefferson, Lincoln, Miller and Lafayette for South American Rice Miner. This survey involved taking specimens and submitting to APHIS personnel. Mexican Rice Borer was surveyed for in Ashley, Chicot, Desha, Drew, and Lincoln Counties. Asiatic Rice Borer was surveyed in Arkansas, Clay, Craighead, Cross, Greene, Jackson, Lawrence, Lonoke, Poinsett, and Prairie County. Pheromone traps were run once every two weeks during the growing season. No positive specimens were caught in the trapping program at this time. We also participated in a webinar with APHIS on Rice Panicle Mite and helped convince APHIS to maintain Rice Panicle Mite as an invasive pest and that it should be kept on the active quarantine list.

Espino (CA): *RWW prevalence in field borders and effect on yield.* Field experiments were conducted during 2009 and 2010 on commercial rice fields in the Sacramento valley of California to validate observations regarding the prevalence of RWW immature populations around field borders and assess their impact on yield. In five locations, insecticide-treated and untreated plots were established 4.5, 30 and 60 m from one edge of the field. ANOVA showed that in most locations, RWW immature populations were higher in plots near the field's edge than in plots 60 m from the field's edge. Yields from treated and untreated plots did not differ significantly. Linear regression of RWW immature populations and rice grain yield per plot per location did not find a significant density-yield relationship in 4 locations. In one location, the density-yield relationship was significant and the slope positive. At this location, yields close to the edge of the field were higher most likely because of nitrogen application overlap rather than because of higher RWW populations. Results indicate that border applications for RWW control are appropriate; however, growers are advised to inspect their fields to confirm border populations and effects on yield.

Espino (CA): *Insects of stored rice.* A survey of several facilities that store rice was conducted using pheromone and probe traps. Grain, storage spaces, and farm bins were monitored. In grain stored in a flatbed warehouse, the most prevalent insect caught in pheromone and probe traps was the Angoumois grain moth (AGM), an internal grain feeder. The AGM appeared at the beginning of spring and number of moths captured increased during the summer until grain was fumigated. In pheromone traps located around storage bins in two mills, the AGM and lesser grain borer (LGB) were caught during spring and summer. Number of Indianmeal moths (IMM) caught was very low. In farm bins, mold feeding beetles were prevalent. Their numbers decreased as ambient temperature dropped and grain dried. AGM, LGB and IMM pheromone traps inside farm bins did not catch any insects.

Accomplishments: Objective 2. To determine the most effective control methods for rice pests while maintaining environmental quality compatible with the needs of society.

New products are now commercially available for insect control in rice: CruiserMaxx (thiamethoxam – seed treatment), Dermacor X-100 (rynaxypyr – seed treatment) and Trebon® (etophenprox). Additionally, there are other products that are promising for insect control that have driven research efforts: NipsIT INSIDE (clothianidin – seed treatment), Belay (clothianidin – foliar application), Endigo (lambda-cyhalothrin + thiamethoxam – foliar). There has been considerable effort to examine efficacy of pyrethroid alternatives for efficacy and pest spectrum. In addition to general efficacy, a concerted effort has been made to determine how these products perform under the variety of agronomic practices. Differences in production systems, pests, and pest population dynamics often require modifications in methods, yet information derived from the research intermesh to provide the best options in control methods applicable for stakeholders in all states, yet tailored for differences in each state. Lastly, efforts were directed at the impacts these new products have on non-target arthropods that utilize rice fields. As in previous years, project participants in TX, LA, MS, CA, MO and AR have demonstrated remarkable cooperation and collaboration in the evaluations of pyrethroid, neonicotinoid and anthranilic diamide insecticides for control of rice crop pests, mosquito control and non-target arthropods.

Objective 2a. Efficacy and Pest Spectrum of Biocides and Pesticides.

Stout (LA): *Effect of seed treatments on different life stages of the rice water weevil*. Srinivas Lanka conducted a series of greenhouse experiments to investigate the effects of chlorantraniliprole and thiamethoxam seed treatments on different life stages of the rice water weevil. In a series of choice and no-choice experiments, use of these seed treatments: 1) thiamethoxam resulted in adult mortality but chlorantraniliprole did not; 2) both insecticides reduced oviposition and densities of first instar and later-instar larvae. In addition, feeding by adult weevils on foliage from treated seeds resulted in reduced oviposition by these weevils even when weevils were allowed to oviposit on control plants. In other words, there was a "carry-over" effect on oviposition after feeding on non-lethal doses of these insecticides. Thus, these insecticidal seed treatments likely achieve reductions in weevil larval densities via a complex mechanism involving death of adults (for thiamethoxam only), reduced oviposition, and death of larvae.

Stout (LA): *Overall assessment of efficacy of pyrethroid alternatives.* Approximately 10 separate small-plot field experiments were conducted to assess the efficacy of neonicotinoid and anthranilic diamide insecticides against the rice water weevil. Clothianidin, thiamethoxam, and rynaxypyr continued to provide good to excellent control of the rice water weevil in drill-seeded tests, although performance of Cruiser Maxx in 2010 was not as good as in previous years. Cruiser Maxx (thiamethoxam) and Dermacor had full (Section 3) registrations in 2010; NipsIT INSIDE will have an EUP in Louisiana in 2011, with a Section 3 expected in 2012 or 2013. Dermacor X-100 (rynaxypyr) performed better in commercial fields than CruiserMaxx and pyrethroids. The most important results from our small-plot insecticide trials in 2010 were as follows:

Water-seeded tests – the application of dinotefuran granules at ~30 d post-flood reduced larval densities by more than 50% in a water-seeded test. Foliar applications of clothianidin (Belay) were slightly less effective than an application of Karate in a water-seeded test. Dermacor-treated dry seed sown into a flood effectively controlled rice water weevils.

Drill-seeded tests - Foliar applications of clothianidin (Belay) made pre-flood to drill-seeded rice were as effective as pre-flood applications of Karate in two experiments. In a drill-seeded test, addition of ProGibb to Belay appeared to increase efficacy. NipsIT INSIDE effectively controlled rice water weevils in two drill-seeded experiments. Effectiveness of Cruiser was acceptable in one trial but unacceptable in two others. Activity of Cruiser was compromised at low seeding rates (when per-seed rates were not increased to maintain per-acre rates). Activity of Dermacor at low seeding rates was also reduced, but still acceptable. Adjusting per-seed rates of Dermacor at low seeding rates to maintain per-acre seeding rates eliminated this effect of seeding rate.

Godfrey (CA): *Rice Water Weevil Management* - Studies continued to evaluate experimental insecticides versus registered standards for rice water weevil control. In summary, Dimilin®, Warrior® II, and Mustang® Max, the registered products, are all still viable products for rice water weevil control. Of these three products, Mustang Max was the least effective in 2010 but still provided effective control. Application of Warrior preflood was a very effective treatment for rice water weevil and produced results equal to or perhaps even better than the standard 3-leaf application. Mustang Max did not show equivalent efficacy with the preflood application and does not appear to fit this type of application. Trebon® (etophenprox) applied at the 3-leaf stage was effective for rice water weevil larval control; its registration in CA is "on-hold". Belay® (clothianidin) appears to have significant potential for rice water weevil management and is progressing towards registration. Belay applied preflood or as 3-leaf stage application has previously been shown to be active. In 2010, using lower rates of clothianidin, the preflood timing showed considerable weakness. The 3-leaf stage method with clothianidin was very effective in 2010 and as efficacious as any of the registered insecticides for rice water weevil control. A "rescue" treatment of clothianidin, i.e., applied at about the 5-leaf stage when the larval infestation has already began, was also shown to be effective. The control provided was in the 70% range but this is admirable given the demands placed on a product for this use. Dermacor® (rynaxypyr) efficacy on rice water weevil as a seed treatment in water-seeded rice is moderate, at best in CA. However, rynaxypyr applied preflood or at the 3-leaf stage showed promise. In both cases, the higher rate of the two rates tested was as effective as the best-performing treatments and the lower rate showed moderate activity. Dermacor registration applied either preflood or at the 3-leaf stage will not be pursued by the registrant at this time. Small plot (0.25 acre) evaluations showed efficacy (from best to worst) of Belay applied at the 3-leaf stage, Belay preflood, and Dermacor seed treatment. Given the re-evaluation of pyrethroid registrations due to possible off-site movement, it is important to continue to develop alternative active ingredients and classes of chemistry. These unregistered active ingredients have some very favorable properties in terms of toxicity to non-targets, persistence, etc.

Bernhardt (AR): *Chemicals for Rice Water Weevil Control.* Dinotefuran 3G (0.396 and 0.441 lb ai/acre) was evaluated as a possible 'rescue' treatment for rice water weevil when seed treatment or post-flood pyrethroid applications were not used or were improperly timed. Dinotefuran applied at 7 and 14 days after flood provided very good and acceptable, respectively, control of weevils and was comparable to KarateZ. Residual activity was also acceptable. Dinotefuran applied at 21 days after flood did not provide acceptable control; residual control was not tested. No significant differences were found between grain yields (lb/acre at 12% moisture). These results were better than results from previous tests where lesser rates and/or other timings were tested.

Stout (LA): *2010 Valent study.* One study which included nearly all of the options now being considered for drill-seeded rice was a study conducted for Valent. This experiment included NipsIT INSIDE, Cruiser, and Dermacor seed treatments as well as Belay and Karate foliar treatments. All treatments reduced the number of rice water weevil larvae 3 weeks after flood (WAF), with the insecticide seed treatments

and a pre-flood foliar application of Belay reducing larvae 90-99% depending on the compound, whereas a pre-flood application of Karate reduce rice water weevil by less than 80%. Dermacor was the only product to continue to provide control greater than 90% 4WAF. NipsIT INSIDE provided between 70-80% control; Cruiser and Belay provided around 60% control and Karate controlled populations by 25% compared to the control 4WAF.

Gore/Cook (MS): *Performance of Dermacor and Cruiser in the Mississippi On-Farm Variety Trial.* During 2010, entries were included in the on-farm variety trials to determine the value of insecticidal seed treatments across a range of environments (6 locations). Dermacor and Cruiser were applied to Cheniere rice seed at the recommended rates. Seed were planted at a rate of 70 lbs/A at each location. There were a total of 42 entries in the on-farm variety trial in 2010. Overall mean yields were higher with Cruiser than with Dermacor and the UTC. However, Dermacor was more consistent. Cruiser was the least stable among the three treatments in this comparison (the lower the number the higher the ranking). Based on those criteria among the 42 entries, Dermacor had the highest rating at 7. The rating for Cruiser was 22 and the rating for untreated Cheniere was 16.

Gore/Cook (MS): *Impact of Foliar Application Timing on Rice Water Weevil Control with Karate and Belay.* An experiment was conducted to evaluate foliar application timings with Karate and Belay for rice water weevil control. Treatments were: 1-day pre flood, 1-day post flood, and 7-days post flood. The foliar insecticides included Karate at 2.56 fl oz/A and Belay at 4.5 fl oz/A. Rice water weevil densities were moderate for Mississippi averaging 13 weevils per core in the non-treated. Foliar applications of Karate 1 and 7 days post flood significantly reduced rice water weevil larval densities compared to the non-treated. Additionally, Karate applied 7 days post flood reduced rice water weevil densities compared to Karate applied 1 day post flood. Foliar applications of Belay reduced rice water weevil larval densities below the non-treated at all application timings. With Belay, there were no differences in rice water weevil densities among the foliar application timings. No significant differences were observed for yields. Based on the results in this trial, Belay appears to be less sensitive to application timing compared to Karate.

Gore/Cook (MS): *Efficacy of Insecticidal Seed Treatments against Rice Water Weevil.* A series of experiments were conducted across the Mississippi Delta to determine the efficacy of insecticidal seed treatments against rice water weevil. A total of 37 trials were conducted utilizing various rates of thiamethoxam (Cruiser 5FS® or CruiserMaxx® Rice, Syngenta), chlorantraniliprole (Rynaxypyr®, Dermacor X-100®, Dupont), cyantraniliprole (Cyazypyr, DPX-HGW-86, DuPont), and clothianidin (NipsIT INSIDE ®, Valent) at different seeding rates. In general, the insecticides were used at their labeled rates and a seeding rate of 85 lbs/A. Rice water weevil densities in Mississippi were higher in 2010 than in the previous three years. Densities of rice water weevil larvae averaged 17 per core in non-treated plots across all trials. The highest value recorded in the non-treated plots was 32 larvae per core and the lowest value recorded was 4.8 larvae per core. Overall, control of rice water weevil ranged from 0-99 percent for each of the seed treatments. Mean percent control was 69.2% for Dermacor, 73.2% for Cruiser, 63% for NipsIT INSIDE, and 93.3% for DPX HGW-86. These values represent the average of >20 trials for each insecticide except HGW-86, which is the mean of only 2 trials. The mean percent control for Dermacor in those two trials was similar to HGW-86. In terms of yield, significant increases were observed compared to previous years. Cruiser and NipsIT INSIDE had yield increases of 12.8 and 12.0 bushels per acre, respectively. For Dermacor, the yield increase was higher at 23.2 bushels per acre. The two trials with HGW-86 had high weevil densities and the average yield increase was 53.3 bushels per acre.

Way (TX): *Syngenta Seed Treatments for Rice Water Weevil Control.* Aphids (bird cherry oat aphid), chinch bugs and mealybugs were found in relatively low densities on seedling rice, so no valid conclusions can be drawn regarding control of seedling pests across treatments. However, numerically, more total seedling insect pests were found in the untreated than the seed treatments. Immature rice water weevil populations were high in untreated plots on both sample dates. All treatments significantly reduced rice water weevil populations on both sample dates. None of the treatments significantly reduced number of whiteheads which is a measure of stalk borer damage. Yields were high, even in the untreated, but highest in the CruiserMaxx and EXC3925 treatments. The addition of the fungicides to thiamethoxam (the insecticidal active ingredient in Cruiser 5FS and CruiserMaxx) increased yields 390 lb/A (Cruiser 5FS vs CruiserMaxx). This difference was significant. Across all seed treatments, the average increase in yield compared to the untreated was 670 lb/A which shows the importance of controlling rice water weevil.

Way (TX): *Valent Seed Treatment Study.* Seed treatments did not affect rice stand density. Bird cherry oat aphid populations were low but all of the seed treatments significantly reduced these populations. Rice water weevil numbers on the first and second sampling dates were high in the untreated. All of the seed treatments were very effective against rice water weevil. The Belay treatment provided 81 and 97% control of rice water weevil on the first and second sampling dates, respectively even though Belay was applied late (12 days after flood). All the NipsIT INSIDE treatments produced yields significantly greater than the untreated. For instance, NipsIT INSIDE at 1.9 fl oz/cwt (seeding rate = 80 lb/A), out-yielded the untreated 684 lb/A. The Belay treatment also produced yields significantly higher than the untreated (662 lb/A). Addition of V-10212, Trilex and V-10209 did not enhance insect control or yield.

Way (TX): *Belay 2.13SC Foliar Study.* Seed treatments did not affect stand. Gibberellic acid (GA) was tank-mixed with Belay and applied 10 days after flood; this treatment led to plants being significantly taller than plants in other plots. rice water weevil populations in untreated plots were high. All Belay treatments (which were applied 10 days after flood) significantly reduced rice water weevil populations---the 3.5 fl oz/A rate provided 33% control while the 4.5 fl oz/A rate provided 64% control. The addition of GA to Belay increased the level of rice water weevil control (78-92%). This may be an anomaly, but should be further investigated. The seed treatments gave the best control (93%). Stalk borer damage, as measured by WH density, was too low and variable to draw valid conclusions. Although Belay+GA reduced rice water weevil numbers; however, it has the lowest yields of the trial. Perhaps GA applied at this time stimulated vegetative growth at the expense of reproductive development. Belay applied relatively late---10 days after flood---may be a viable option to control rice water weevil when the window of application has closed for currently labeled insecticides.

Hummel (LA): *Rice water weevil management demonstration in commercial rice fields in LA.* Ten large plot demonstrations tests were conducted on commercial farms in 7 counties in LA. Fields were managed by the producers. Field size, variety and seeding rate varied for each location. Karate, Cruiser and Dermacor were compared to a non-treated check. Rice water weevil counts in the untreated varied at each location from low to high. Overall, Dermacor X-100 provided the best level of weevil control, followed by pyrethroid and CruiserMaxx.

Lorenz (AR): *Large Block Demonstration Trials.* With the full label available now for Cruiser and Dermacor, large block trials we were conducted in several locations around the state. Data from 2010 indicated a 5 bushel yield increase in large block trials with these seed treatments compared to the untreated check.

Lorenz (AR): *Chinch Bug Efficacy Trial.* An efficacy trial was conducted with currently labeled and potential products for control of chinch bugs in rice. Standards (pyrethroids) appeared to provide the best level of control but it appears high rates are needed to achieve acceptable levels of control.

Lorenz (AR): *Insecticide Rates*. Experiments were conducted at three locations to evaluate seed treatments on Clearfield and Hybrid varieties to confirm that the same response seen with these rice varieties as in conventional varieties. The seed treatments performed better than an application of Karate and reduced numbers of rice water weevil by 46-68% compared to the control. However, the impact of the seed treatments had minor effect on yield. The best rice water weevil control (68% control) was achieved at a rate of 9 fl oz/cwt of Dermacor but the yield was 2 bu/A less than the control plot, a 1% decrease in yield. The best yield came from plots treated with Dermacor at a rate of 3 fl oz/cwt (9 bu/A increase in yield); however that treatment reduced rice water weevil populations by 52%.

Lorenz (AR): *Summary of 3 years of yield data.* To determine the value of the seed treatments data from the last 3 years were examined to determine yield impact. The summary indicated that in all 61 trials with Cruiser at the labeled rate (3.3 oz/ cwt), there was an average yield increase of 6.0 bushels/ acre with an 75% chance of a positive net return (above the cost of the seed treatment). In 67 trials with Dermacor, there was an average yield increase of 6.0 bu/ A with a 75% chance of a positive net return. In 51 trials with NipsIT INSIDE, there was an average yield increase of 5.0 bu/ A with a positive net return 75% of the time. In addition to insect control, seed treatments increased plant vigor, stand and growth which lead to an overall more productive production system. Trials indicate excellent control of rice water weevil with all these products although Dermacor may have a slight edge over Cruiser and NipsIT INSIDE. However, for GC control both Cruiser and NipsIT INSIDE are better than Dermacor. Undoubtedly the seed treatments appear to be the best way to control both pests and are better than foliar applications of pyrethroids.

Gore/Cook (MS): *Rice Stink Bug Control with Malathion + Gamma-cyhalothrin Applied ULV.* Large strip-plot experiments were conducted to evaluate the efficacy of Fyfanon Plus ULV on rice stink bug control in rice. Fyfanon Plus ULV (a premix of the organophosphate, malathion, plus the pyrethroid, gamma-cyhalothrin) was applied ultra-low volume by air at a rate of 9 fl. oz. per acre. The total application volume was 1 quart per acre applied in modified vegetable oil. Rice stink bug control was compared with a standard application of Karate applied by air at 2.56 fl. oz. per acre and a total mix volume of 5 gallons per acre. Rice stink bug densities were measured at various timings after application by taking 10 sets of 10 sweeps per plot. In both of these experiments, Fyfanon Plus ULV provided control of rice stink bug similar to that observed with Karate.

Stout (LA): *Evaluate alternative insecticides for stink bug management.* Research is ongoing to compare the efficacy and residual activity of dinotefuran and clothianidin with the efficacy and residual activity of pyrethroids. Preliminary evidence from several states indicates that dinotefuran and clothianidin (both neonicotinoids) are as effective as pyrethroids, and may actually have longer residual activities. In Louisiana, 3 small plot efficacy studies were conducted and no evidence for longer residuals was seen. A Greenhouse study attempted to compare residuals of Karate vs. Tenchu, but no reliable data obtained because there was no mortality in the Karate treatment.

Way (TX) *Efficacy of Endigo ZC against Rice Stink Bugs* – Endigo ZC was evaluated for control of rice stink bug and performed as well as Tenchu 20SG. The company (Syngenta) has been asked to consider submitting a rice label. If submitted and approved, rice farmers would have another excellent rice stink

bug insecticide---another tool to increase market competition and bring down the cost of rice stink bug control.

Way (TX): *Dermacor X-100 Water-Seeded Study.* In a water-seeded study examining the effectiveness of Dermacor X-100, 3d after emergence of rice through water, a large numbers of uprooted rice seedlings were seen in untreated and Karate Z-treated plots. Uprooted seedlings (floaters) were collected from all plots in the experiment were processed. *Tropisternus lateralis* (Coleoptera: Hyrdophillidae) adults were recovered while recording the number of uprooted seedlings. The adults feed on plant material and detritus while larvae are predaceous. *T. lateralis* is responsible for uprooting rice seedlings in water-seeded situations via foraging and/or reproductive activities. Numbers of uprooted seedlings were significantly greater in untreated and Karate-Z treated plots than in plots planted with Dermacor X-100-treated seed. An average of more than 800 floaters were recovered in untreated and Karate-Z-treated plots compared to 41 and 20 in plots planted with seed treated with Dermacor X-100 at the lowest and middle/highest rates, respectively. Based on seeding rates and number of seeds per pound, we surmised that uprooted seedlings accounted for approximately 26% of the number of seeds planted. These data suggest Dermacor X-100 protected seed from *T. lateralis* uprooting activities, probably by killing these adult beetles. We speculate that an application of Karate-Z should reduce the amount of uprooted seedlings; however, Karate-Z was applied 3 days after rice emerged through water, after uprooting of seedlings already had occurred.

Although Dermacor X-100 reduced rice water weevil numbers on the first sample date, the numbers were not significantly different from the untreated plots. Karate-Z applied 3 days after emergence through water, provided 87% control. On the second sample date, none of the treatments reduced rice water weevil numbers significantly. White head counts (a measure of stalk borer damage) were not significantly different among the treatments, although numbers were less in Dermacor X-100 plots than in the untreated plots. Yields were significantly higher in all treatments compared to the untreated. For instance, yields from rice treated with the 2.0 fl oz/cwt rate of Dermacor X-100 was more than 1800 lb/A than the untreated rice, which was probably a result of partial rice water weevil and stalk borer control, and better stands.

In conclusion, data show Dermacor X-100 applied at the rates in this experiment to dry seed in a water-seeded, continuous flood system did not effectively control rice water weevil, but may have other benefits controlling potential seedling pests, such as *T. lateralis.* Further research is needed to better determine efficacy of Dermacor X-100 against *T. lateralis* and other seed/seedling pests of water-seeded rice, such as tadpole shrimp and rice seed midges. Application of Dermacor X-100 to sprouted rice seed is another possibility for future research.

Godfrey (CA). *Tadpole Shrimp.* Nine treatments were evaluated in 2010 for tadpole shrimp mortality and protection of rice seedling stands. Trebon, copper sulfate, Warrior preflood and post-flood and Dermacor preflood produced the most tadpole shrimp mortality. Trebon again showed good performance in terms of protection of seedlings (stands); however, Belay, Dermacor, and Warrior all applied preflood were equally effective.

Way (TX): *Tenchu 20SG and Endigo ZC Study.* This experiment evaluated the contact activity of the treatment insecticides against long-horned grasshopper (*Conocephalus fasciatus*) (test insects were sprayed directly). No mortality was observed in the untreated. All untreated insects were active and found at the top of the tubes. Tenchu 20SG provided excellent control---almost 100% mortality. The lone survivor was lethargic and on the sand surface, not on the panicles. The Endigo ZC treatment

provided 35% mortality, but all survivors were lethargic and on the sand surface or on the panicles---none were at the top of the tubes which was characteristic of the untreated long-horned grasshoppers. In short, all surviving insects insecticide were probably "functionally" dead

Objective 2b. Impact on Non-target Organisms.

Rice has been touted as one of the most environmentally friendly crops because of the ecosystem services provided. Rice serves as an alternative to natural wetlands, which have diminished over the past 100 years. Aquatic invertebrates, i.e., mosquitoes and other arthropods that pose no threat to rice, are an important component of the ecosystem as they serve as a food source for many animals that use these artificial wetlands or, in the case of mosquitoes, may cause public health risks. Since there are many new alternatives to pyrethroids, it is important to determine the impacts these pesticides have on the arthropod community in rice.

Tindall (MO): Pest control in rice often involves the use of pyrethroid insecticides that have a negative impact on a broad spectrum of aquatic organisms. The new seed treatments present opportunities to control pests of rice, but the impact on the non-targets that inhabit rice fields is largely unknown. Therefore, the impact of the seed treatments rynaxypyr (Dermacor X-100, 3 years of data) and thiamethoxam (Cruiser, 3 years of data), clothianidin (NipsIT INSIDE, 1 year of data) and foliar applications, pyrethroid, lambda cyhalothrin (Karate Z, two years of data) and clothianidin (Belay, 1 year of data) were examined in large field plots. All samples but those collected at four weeks after flood from 2010 have been processed. Preliminary analysis of data suggest that the most significant result of this data set is that the samples taken at 4 weeks after permanent flood are more diverse than samples taken earlier in the season. However, there are trends that an application of Karate creates the least diverse community of insects of all treatments. The insect communities in plots treated with insecticide seed treatments appear to be more similar to the untreated plots of rice than plots treated with Karate. More analyses of data are necessary to elucidate additional differences.

Godfrey (CA): *Non-Target Organisms:* Nine insecticide treatments (and an untreated) were compared in terms of their effects on populations of non-target invertebrates and their potential to upset naturally-occurring mosquito management. Data from 2009 are completely summarized and results for 2010 are still in progress. Mosquito populations were fairly high in 2009 (the highest we have seen in this study) and data on mosquito larvae were collected weekly for 9 weeks. Four preflood applications were evaluated in 2009 – Warrior and Belay as preflood broadcast applications, and DPX-HGW86 and Dermacor as seed treatments. Belay preflood appeared to cause the greatest reduction in populations of aquatic insects and other aquatic animals (mostly other invertebrates). For instance, at 13 to 36 DAT, Belay reduced insect levels by an average of ~50% and there were also reductions later in the season. There was some indication that all the preflood treatments increased numbers of mosquitoes, but there were no definite (consistent) trends. Dimilin, Warrior, Belay, and Trebon were evaluated with 3-leaf stage applications. At 10 DAT, all four products significantly reduced aquatic insect levels and three of the four affected other aquatic animal levels. At 16 and 23 DAT, these reductions generally persisted but at lower levels. Warrior, Dimilin and Belay appeared to have the potential to increase populations of mosquitoes when applied at the 3-leaf stage timing. Trebon did not exhibit this same effect. Warrior was evaluated as a representative material that could be applied against armyworms mid- to late-season. At 1 week after application, this treatment was very damaging to populations of aquatic insects and other aquatic animals (a ~90% reduction in both cases). The numbers equilibrated somewhat thereafter so the seasonal average showed only a 25% reduction. Warrior is very toxic to mosquito

larvae (this class of chemistry is used for mosquito control), thus the data showed significant reductions of mosquito numbers for 5 weeks after application.

Stout (LA): *Compatibility of pyrethroid alternatives with crawfish production*. Crawfish were placed in paddies 1 d after flooding in the following treatments: 1) control; 2) NipsIT INSIDE (seed treatment), 3) Belay (pre-flood); 4) Dinotefuran granules (after crawfish placement); 5) Karate (after crawfish placement); and 6) Dermacor (seed treatment). Mortality of crawfish was 100% in Karate-treated plots, but mortality in other treatments was not significantly different from untreated control.

Lawler (CA): In 2010 we conducted at study in collaboration with Dr. Keith Miles of USGS. We performed a set of laboratory studies testing the effects of two mosquito larvicides on fairy shrimp. We tested whether BTI (a bacterial product) and methoprene (an insect juvenile hormone mimic) are suitable mosquito control agents in habitats containing endangered fairy shrimp. Laboratory tests were conducted with a surrogate species, *Streptocephalus sirindhornae*, which is commercially available. This was because the endemic species of interest was scarce in the archived soil samples we had been given to study. Results showed that Bti is likely to be safe for fairy shrimp at levels used in mosquito control; there were no detectable differences in the survival of fairy shrimp between treated and control laboratory microcosms. However, fairy shrimp treated with methoprene showed significantly poorer survival than those in controls. Both materials killed larval mosquitoes as expected.

Objective 2c. Impact of Agronomic Pracitices.

Gore/Cook (MS): *Effect of Planting Date on rice water weevil.* An experiment was conducted in Mississippi to determine the impact of planting date on rice water weevil control with Dermacor and Cruiser. Cheniere rice seed was treated with Dermacor at 2.5 fl oz/cwt and Cruiser at 3.3 fl oz/cwt. The seed were planted at 75 lbs seed per acre. Treatments included 5 planting times; early April, late April, early May, late May, and June. Overall, yields were higher at the first 2 planting dates compared to later planting dates. The early May and late May planting dates had the lowest yields. This was most likely due to excessively high temperatures (>100^0 F) during the flowering stages of rice development. At the first planting date, yields of the seed treatments were 4 to 5 bushels higher than the untreated. At all other planting dates, yield increases for the seed treatments ranged from 9 to 13 bushels over the untreated. Both of the seed treatments provided a significant benefit regardless of planting date. The greatest benefit was observed for late April through June planting dates.

Stout (LA): *Seeding rate study*. A seeding rate study was conducted to determine if efficacies of Cruiser and Dermacor were reduced at low seeding rates when per-seed rates were not adjusted to maintain constant per-acre insecticide rates. Intended treatment rates were 130-135 g ai per 100 kg seed for Cruiser and 2 fl oz per 100 lbs seed for Dermacor. Seeding rates were 30, 60, and 90 lbs seed per acre. Results indicated that activities were compromised at low seeding rates, with the effect more pronounced for Cruiser.

Gore/Cook (MS): *Impact of Insecticidal Seed Treatments on Rice Water Weevil Control in Hybrid Rice.* Experiments were conducted at two locations to determine the optimum rates of Cruiser and Dermacor on hybrid rice at low seeding rates. Cruiser was applied to hybrid rice seed at 3.3, 6.6, 9.9, and 13.2 fl oz/cwt. Dermacor was applied at 2, 3.25, 4.75, and 6 fl oz/cwt. All plots were planted at 25 lbs seed per acre. At one of the locations, rice water weevil densities averaged 25.3 weevils per core in the untreated plots. In this situation, the two lower rates of Cruiser (3.3 and 6.6 fl oz/cwt) and Dermacor (2.0 and 3.25 fl oz/cwt) did not significantly reduce larval densities below that in the untreated. The

higher two rates of Cruiser (9.9 and 13.2 fl oz/cwt) and Dermacor (4.75 and 6.0 fl oz/cwt) significantly reduced rice water weevil larval densities below that in the untreated. At the second location, rice water weevil densities were lower, averaging 4.8 larvae per core in the untreated. Where rice water weevil pressure was lower, all rates of both Cruiser and Dermacor significantly reduced larval densities compared to that in the untreated and there were no significant differences in grain yields among all of the treatments. Based on these data, both of these seed treatments will provide adequate control of rice water weevil when larval densities are low (<5/core). Under more significant weevil pressure, the currently labeled rate of Cruiser (3.3 fl oz/cwt) did not provide adequate control of rice water weevil at a seeding rate of 25 lbs per acre. At this seeding rate, the recommended rate of Dermacor (6.0 fl oz/cwt) provided adequate control of rice water weevil and significantly higher yields than the untreated plots. Therefore, the general recommendation in Mississippi is to use Dermacor at 5 to 6 fl oz/cwt on hybrid rice where seeding rates are extremely low.

Way (TX): *Cruiser 5FS Seeding Rate Study.* Rice plant stands reflected seeding rates---the highest, middle and lowest seeding rates produced stands significantly different from one another. Seed treatments did not affect rice stands. Populations of rice water weevil were high in control plots on both sampling dates. For both sampling dates, all seed treatments, regardless of seeding rate, significantly reduced rice water weevil numbers relative to corresponding control treatments. Plots planted with treated seed produced significantly fewer rice water weevil at the 50 and 75 lb/A seeding rate compared to the 25 lb/A seeding rate. For the first sampling date, plots planted with treated seed at 25, 50 and 75 lb/A provided 81, 91 and 95% control, respectively. For the second sampling date, plots planted with treated seed at 25, 50 and 75 lb/A provided 68, 86 and 92% control, respectively. Data suggest when rice seed is treated with Cruiser 5FS at 3.3 fl oz/cwt, rice water weevil control may be compromised at a low seeding rate of 25 lb/A. WH counts were relatively low and not significantly different among the treatments which suggests Cruiser 5FS did not control stalk borers. At the 25 lb/A seeding rate, the difference in yield between treated and control plots was not significant, but the numerical difference was large---616 lb/A. At the 50 lb/A seeding rate, the difference in yield between treated and control plots was significant---876 lb/A. Likewise, at the 75 lb/A seeding rate, the difference in yield between treated and control plots was significant---807 lb/A.

Way (TX): *Dermacor X-100 Seeding Rate Study.* Dermacor X-100 was applied to rice at rate of 1.75 fl oz/cwt seed, regardless of seeding rate. Rice stand counts reflected the desired seeding rates and seed treatments did not affect rice stands. Rice water weevil populations were high in untreated plots on both sample dates. Rice water weevil populations were not significantly different among Dermacor X-100 treatments, regardless of seeding rate. All Dermacor X-100 treatments provided excellent control of rice water weevil. All Dermacor X-100 treatments also significantly reduced the number of WHs which is strong evidence that Dermacor X-100 provided good control of stalk borers, primarily Mexican rice borer. As seeding rate increased, yields increased in untreated and Dermacor X-100-treated plots. These results are unexpected. However, rice water weevil populations in untreated plots increased as seeding rate increased which also is unexpected---usually rice water weevil populations are higher in fields and plots with low rice stands. However, yield response to all Dermacor X-100 treatments was excellent and increased with seeding rate. For instance, at the 60, 90 and 120 lb/A seeding rates, yield increases over the corresponding untreated controls was 888, 933 and 1100 lb/A, respectively.

Bernhardt (AR): *Impacts of CruiserMaxx in both Conventional and Hybrid Production Systems.* The efficacy of seed treatment with thiamethoxam (CruiserMaxx or Cruiser 5 FS) at 3.3 oz of product per 100 lb of seed was tested for rice water weevil control in a conventional rice variety and a hybrid variety. Conventional rice was planted at the rates of 45, 67.5 and 90 lb/acre and 20, 30 and 40 lb/acre for the

hybrid rice. Analysis for a difference in weevil density between treated and untreated and between varieties was significant. Seeding rate was not significant and there were no significant interactions. The percent control with 3.3 oz of Cruiser was less in the hybrid than in the conventional variety. Analysis of yields indicated no difference between treated and non-treated. The yield differences between varieties and seeding rates were significant and there were no significant interactions.

Lorenz (AR): *Seeding Rates.* Experiments were conducted to test the labeled rate of the insecticide seed treatments across seeding rates commonly used by Arkansas producers to insure that, even at low seeding rates these products would continue to deliver the same level of control, vigor, and increased yields. Seeding rates were 60, 90 and 120 lbs per acre; all seed treatments regardless of seeding rate effectively reduced rice water weevil larval numbers. At a of seeding rate 50 lbs/A, rice water weevil control ranged from 18% (both NipsIT INSIDE and Cruiser) to 36% (Dermacor) and yield increases ranged from 1.2% increase (Dermacor) to 5.3 (NipsIT INSIDE). At the 60 lbs/A seeding rate, rice water weevil control ranged from 33% (NipsIT INSIDE) to 75% (Cruiser) and yield increases ranged from 0.5% (both Cruiser and Dermacor) and 7.3% (NipsIT INSIDE). At the 70 lbs/A seeding rate, rice water weevil control ranged from 25% (Cruiser) to 58% (Dermacor) and yield decreased compared to the untreated plots for all treatments (-1.1% [NipsIT INSIDE] to -6.6% [Dermacor]).

Godfrey (CA). *Cultivar Response*. Resistant cultivars are an important way to manage pests and developing a rice variety that would not be feed upon and/or damaged by rice water weevil has been a goal. Some success was made in this area by RES breeders but the program has been curtailed in recent years; this slow success for breeding against rice water weevil has also been experienced in other states as well. However, developing lines that the insect will not preferentially infest and cultivars that can be fed upon but the plant exhibits traits that allow it to withstand the feeding and still produce an unaffected yield are also viable types of plant resistance. In this project, the response of commonly-grown California rice cultivars to rice water weevil in terms of 1) severity of infestation and 2) yield loss upon infestation was examined utilizing only M-202. In controlled ring studies with four varieties, the yield loss was highest in M-202, about 1/3 as high in S-102 and L-206, and Calmati-202 was most lightly infested with rice water weevil among the four varieties and did not suffer any yield loss. In field studies with 12 varieties, the medium grain varieties typically suffer the highest yield loss from rice water weevil and M-202 and M-205 upheld this trend (up to a 10% loss per each rice water weevil larva feeding on the roots). M-401 was the most heavily infested of the 12 varieties evaluated and did suffer a significant yield loss but the high yield capacity of this variety largely compensated for this loss. Conversely, M-206 was infested at a moderate level but did not show much yield loss from rice water weevil; similarly, L-206, M-104, and Calamylow-201 did not have any measurable yield loss from rice water weevil in spite of infestation levels twice that thought to cause a yield loss (based on data collected on M-202).

Objective 3. To develop strategies to maintain the effectiveness of current pest control techniques.
Project participants in MO, TX, LA, MS and AR demonstrated exceptionable collaboration in the evaluations of a pyrethroid insecticide, lambda cyhalothrin (Karate Z) for development of resistance in a common rice pest, the rice stink bug. Additionally, several new compounds were examined for efficacy (and discussed in Section 2a) that, if labeled for commercial rice production, will provide additional options for pest control in rice.

All mid-southern states: *Lambda-cyhalothrin Resistance Monitoring with Rice Stink Bug.* Rice stink bugs (rice stink bug) feed on grass hosts, including crops like wheat, sorghum, and corn. As a result, bugs are exposed to insecticides applied for other pests. Some rice production areas in the mid-south have experienced rice stink bug problems that are more severe than others. For instance in areas of Texas,

rice may be sprayed as many as six times a year, whereas, Missouri and other states average one application or less annually. High use and exposure in multiple crops are likely to lead to the development of resistance in rice stink bug. There are concerns, especially in these high use areas, that pyrethroids are not as efficacious now as when first used In 2009, a multi-state project was initiated to determine LC_{50}'s for rice stink bug exposed to lambda-cyhalothrin in four mid-southern rice producing states and compare current data to baseline data collected in 2001 and 2002 in Louisiana.

All mid-southern rice producing states participated in this objective. Rice stink bug adults were subjected to the adult vial test with the compound lambda-cyhalothrin (the active ingredient of Karate Z). All vials were rolled in Missouri and shipped to each state for use on rice stink bug populations in each state. Adults were exposed to insecticide for four hours and data were compared to baseline data collected in Louisiana in 2001 and 2001. In 2009, pyrethroid resistance in the rice stink bug was documented in Texas. These data were important to secure a Section 18 label for Tenchu 20SG in Texas. Results from 2010 showed the LC50s to be lower than 2009, but the trend remained that rice stink bug in Texas have higher LC50s than any other rice producing area in the midsouth. Specifically, the LC50 values (the higher the value, the harder to kill) for Round Mott populations were 10.5, 3.3, 11.2 and 4.1 times higher than those for Louisiana, Missouri, Mississippi and Arkansas, respectively. For Ganado populations the LC50 values were 9.1, 2.9, 9.7 and 3.5 times higher than those for the above states, respectively.

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