MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 17-2017 (YEAR 2)
FINAL REPORT

Title: Kudzu Bug Management in Soybeans

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EXECUTIVE SUMMARY

Kudzu bug has become established throughout Mississippi and will likely be a common pest in soybean production regions near kudzu.

The results of this research suggest that early season management of kudzu bug is not likely to be routinely needed. Yields are not impacted by densities up to 3 kudzu bugs/plant during early vegetative stages and kudzu bugs do not readily establish in early-planted beans.

This research documents that a neonicotinoid seed treatment does not control this pest, so growers cannot rely on this strategy for managing kudzu bug.

This research documents that several foliar insecticides provide good efficacy against adults and nymphs.

Natural biological control from *Beauveria bassiana* appears to be important and has suppressed late-season populations during the last two years, but no other biological control agents are contributing to kudzu bug suppression in Mississippi.

As a result of this research, fewer early-season insecticide applications should be applied to soybean to control this pest.

Growers and consultants are more aware of the expected population dynamics and relatively low damage potential of kudzu bug. Furthermore, the chemical control options have been evaluated so growers/consultants can choose a product that fits their situation.

Background

Kudzu bug, *Megacopta cribraria*, was first reported in the U.S. near Atlanta, GA during 2009 and has since become a major pest in Georgia and the Carolinas. It has spread from Louisiana to Delaware. It was first observed in Mississippi during 2012 and is now found throughout the state, often at high densities. Based on the rapid increase in density observed in Southeastern states, it is possible that kudzu bug will become an annual pest in Mississippi soybean.

The kudzu bug overwinters as an adult in protected cracks and crevices in homes, trees and leaf litter. In spring, adults migrate to host plants such as kudzu and wisteria to feed and oviposit. After one generation has passed, a second migration event happens, and this is typically when soybeans become

infested in the Southeast. The kudzu bug reproduces prolifically in soybeans, building up large populations. They feed on the stems of the soybean plant, removing sugars from the plant. Yield losses from untreated plots have been as much as 47% and have averaged 18%. From these trials, a threshold of 1 nymph/sweep has been established. Following the second generation, the kudzu bug seeks out overwintering sites.

Mississippi growers often plant soybeans during April, and plants in these planting are in early vegetative stages during the spring migration. The yield risk from kudzu bugs feeding on soybeans at this time is unknown, so insecticides are being applied early in the season without research to guide them. Early season insecticide applications can have negative consequences on the overall system, so it is important to only apply insecticides when required. Another option may be the use of seed treatments for early-season management of this pest, but these have not been evaluated. Some soybeans are also planted during June. These late-planted beans may still be in vegetative stages when the second dispersal occurs. As with early-seeded soybeans, we have minimal knowledge about the best management practices to address kudzu bug infestations in vegetative soybeans.

During the last two years, *Beauveria bassiana* has emerged as a critical biological control agent for kudzu bug. This fungus has eliminated numerous populations when they were getting near the point of needing to be controlled, so we need to conserve this natural biological control agent. Most soybean fields are routinely sprayed with a fungicide during R3-R4 stages, a time when kudzu bugs can also be growing. It is unknown if one or more of our common fungicides have any impact on growth of *Beauveria bassiana*, but it is plausible to expect that fungal growth would be inhibited by the application of a fungicide. Therefore, we will explore this possibility so growers can know all the likely impacts before making a fungicide application.

Objectives

1. Develop action thresholds for kudzu bug during vegetative growth stages.
2. Evaluate the impact of fungicides on *Beauveria bassiana* growth.
3. Evaluate seed treatment efficacy against early season kudzu bug.
4. Evaluate foliar insecticide efficacy on kudzu bug.

Report of Activity

Objective 1: Develop vegetative stage threshold

Complete results of research conducted on this objective can be found in Chapter 2 of the M.S. thesis written by William McRight. The following is an abbreviated version extracted and condensed from the thesis.

Methods. Maturity group 5 soybeans were planted at the MSU research farm during April and June, 2016 using standard practices with 8 seeds/row ft. on 38-in.-wide rows. Kudzu bugs were collected from kudzu and placed in 6 ft x 6 ft cages covering two rows of soybeans to create an infestation by first generation adults. Insect densities of 0, 1, 3, 5, and 10 insects/plant were infested at VC, V2, and V4 growth stages of the soybeans. Cages were kept on the plants for 21 days. Measurements of kudzu bug density, plant height, leaf area index, and plant growth stage were recorded beginning one week after

infestation. Soybean measurements continued to be taken every two weeks throughout the growing season. Plants were harvested at maturity to evaluate which components of yield were impacted by the infestation.

Soybean plots were planted again in 2017, but due to extremely low populations of *M. cribraria*, it was not possible to collect enough kudzu bugs to conduct the trial in 2017.

Results. For an unknown reason, nearly all kudzu bugs died in both V2 infestations. Therefore, data are only shown for VC and V4 infestations. Within both growth stages, there were no differences in the plant growth measurements between uninfested and infested treatments. From the VC infestation, no infestation level averaged more than 50% of the soybean plants infested with kudzu bugs and the percentage of plants infested varied with infestation level. Insects also clumped after the V4 infestation, so that the highest percentage of infested plants at any infestation level was 56% and the percentage of plants infested varied with infestation level.

In both the VC and V4 infestations, there was no impact on soybean yield. Although there are data showing the damaging effects of kudzu bug on reproductive stage soybean, densities up to 3 kudzu bugs/plant on vegetative stages were not damaging. Kudzu bugs seem to prefer reproductive stage soybean to vegetative stages, so densities greater than 3 kudzu bugs/plant are not likely, making economic damage from kudzu bug on vegetative stage soybean rare.

Objective 2. Evaluate the impact of fungicides on *Beauveria bassiana* growth.

Following submission of our grant proposal, we found that a colleague at Clemson had already made good progress in examining this area, so we did not pursue this objective. Instead, we conducted a bi-weekly survey of kudzu bug egg parasitism and adult, egg, and nymph densities of kudzu bug in kudzu and soybean in Northeastern Mississippi to improve our understanding of kudzu bug movement and population dynamics. The complete report of this objective is Chapter 4 in William McRight's thesis.

Methods. A survey was conducted in the North-Central and North-East regions of Mississippi from April through October 2017. A standard 15 in. sweep net was used to sample wild kudzu patches and commercial soybean fields for populations of *M. cribraria.* Also, leaves from both kudzu and soybean were sampled for egg masses. At each location, four sets of ten sweeps were taken and the number of kudzu bug adults and nymphs in each set of sweeps was recorded.

Fifty leaves were sampled by observing the underside of each leaf at each location for egg masses. All collecting dates were separated into fifteen-day intervals representing the early and late part of each month. Approximately 15 locations of kudzu and 10 soybean locations were sampled during each fifteen-day interval. While the same general regions were sampled all year long, specific locations changed as needed so potential hosts could be sampled. Each leaf containing an egg mass was collected and placed in a 100 mm diameter x 15 mm petri dish where the eggs were allowed to hatch inside a growth chamber maintained at 80°F with 70 % relative humidity and 16:8 hour light to dark photoperiod. Throughout the survey, eggs were held in the growth chamber and observed daily for parasitoid emergence.

Results.

Population Dynamics in Kudzu

During the sampling periods from early April through early June, adult kudzu bugs in kudzu averaged less than 3 insects/40 sweeps. In the four sampling periods from late June through early August, the populations in kudzu increased and adult kudzu bugs averaged between 5.5 and 15.2 insects/40 sweeps with the highest average recorded in early August. The population of adults continued to increase through late September when the density of adults averaged over 50/40 sweeps and then declined.

No nymphs were found in kudzu during April; however, some egg masses were collected during this time. The average number of nymphs slowly increased from early May through early July, but never exceeded 7/40 sweeps. Nymph densities increased during late July when they averaged 84/40 sweeps. During both sampling periods in August, nymphs averaged about 57/40 sweeps. Kudzu bug nymph densities began to decrease during early September, and no nymphs were found by early October.

Throughout the survey, egg mass collections were few, likely due to them being difficult to find in the dense foliage of the kudzu and the small size of the egg masses. However, egg masses were collected during all but 2 sampling periods from early April through early August.

Population Dynamics in Soybean

In soybean, the population densities of *M. cribraria* were more variable among fields within a week than in kudzu, likely due to insecticide applications. The survey of soybean began in late June with adult populations averaging 3.3/40 sweeps. From late June through early September, average adult densities were between 3 and 7/40 sweeps. Densities increased to 21/40 sweeps in late September as nymphs molted into adults. Part of this increased density could also be a result of aggregation into unharvested fields as early-planted soybean fields were being harvested at this time. No nymphs were found in late June or early July soybean even though they were found in kudzu at this time. The first nymphs were found in soybean in late July and peaked in early August at 9/25 sweeps. No nymphs were found in soybean after early September. Egg masses were found in soybean only during early June and early August. Although we began the soybean survey in late June when at least 50% of the soybean crop was already in reproductive stages, late-planted fields with vegetative stage soybean seemed to have fewer kudzu bugs than soybean in reproductive stages during the same week.

Natural Enemies

Beauveria bassiana was first observed infecting kudzu bug beginning in late August. From late August until the survey was concluded, *B. bassiana* was found infecting kudzu bug at every sampling location of both kudzu and soybean in which kudzu bugs were found. The abundance of mycelia appeared to vary among locations, but was never absent. We were unable to confirm the previous documentation of parasitism of kudzu bug eggs in Mississippi with this survey. No eggs collected during the survey were parasitized. No other natural enemies were observed during the survey in kudzu. Numerous generalist predators were found in soybean, but their impact on kudzu bug is unknown.

Objective 3: Evaluate seed treatment efficacy against early season kudzu bug

Complete results of research conducted on this objective can be found in Chapter 3 of the M.S. thesis written by William McRight. The following is an abbreviated version extracted and condensed from the thesis.

Methods. Three seed treatments along with an untreated control were planted in replicated small plots at the Delta Research and Extension Center in Stoneville, MS. The trial took place twice during 2016. Each planting date consisted of three insecticide seed treatments (imidacloprid 0.78g a.i./kg of seed, clothianidin 0.5g a.i./kg of seed , thiamethoxam 0.5g a.i /kg of seed) along with non-treated soybean. Seeds were planted in each plot at a density of 29 seed/row meter.

Ten cages (20.32 cm diameter X 30.48 cm in height) each covering a soybean plant were infested with two adult kudzu bugs when the plants reached VC (vegetative cotyledon), V1 (first trifoliate), and V2 (second trifoliate) growth stages. The insects were left to feed on the plants for 48 hours. After this time, the cages were removed from the plants to evaluate mortality. Each treatment was replicated four times.

During 2017, trials were conducted in Stoneville, Mississippi at the Delta Research and Extension and Center and in Starkville, Mississippi at the R.R. Foil Plant and Research Station. In Stoneville, the trial was conducted using a randomized complete block design, and in Starkville the trial was conducted using a completely randomized design. Each planting location consisted of the same insecticide seed treatments used 2016. In Stoneville, Asgrow 4632 variety seed were planted on 5 July 2017 at a density of 29 seed/row meter. In Starkville, Asgrow 5335 variety seed was planted on 26 June 2017 at the same density. Laboratory bioassays were utilized at both locations to test insecticide seed treatment efficacy. Soybean plants were allowed to grow in the field until the plants reached VC growth stage. Ten individual plants from each plot were then cut from the plot and a 2.5-cm-long stem along with both cotyledons was placed into a petri dish. Two adult kudzu bugs were placed into the petri dish and allowed to feed on the plant tissue for 24 hrs. After 24 hrs, kudzu bugs were rated for mortality. This test was repeated using stem samples at V1 and V2 growth stages in Stoneville and V1 growth stage in Starkville to determine duration of the efficacy of the seed treatments.

Results. During 2016, there were no significant interactions between planting date and seed treatment or plant growth stage and seed treatment on insect mortality. Seed treatment was a significant factor on kudzu bug mortality when data were pooled across both planting dates and all rating dates. While thiamethoxam seed treatment resulted in higher mortality, average mortality was only 14% higher than the untreated check (48% vs. 34%).

During the 2017 growing season, there were no interactions between locations, growth stages, and seed treatments, so data were pooled across both locations and growth stages. No seed treatment provided higher mortality than the untreated control in 2017. Therefore, based on our findings, seed treatments are not an effective management option for controlling kudzu bug in vegetative stage soybean.

Objective 4: Evaluate foliar insecticide efficacy

Complete results of research conducted on this objective can be found in Chapter 3 of the M.S. thesis written by William McRight. The following is an abbreviated version extracted and condensed from the thesis.

Methods. The efficacy of foliar insecticides against kudzu bug adults and nymphs was tested at the R.R. Foil Plant Science and Research Center in Starkville, MS during 2016 and 2017. The insecticides tested were those that were labeled for use in soybean. In both years, experiments were designed as a randomized complete block with four replications with six insecticide treatments and an untreated control plot. The plots were four rows wide with a row spacing of 96.5 cm and plot length of 9.1 m. Insecticides were applied at 10 GPA and 65 P.S.I. with TeeJet TX6 hollow cone spray tips.

The soybeans were at the R3 growth stage when the application was made. One 9-cm-diameter piece of filter paper was placed into each 100-mm-diameter x 15-mm-diameter petri dish and then dampened with water to insure the soybean tissue did not become dry. Leaf and petiole samples from each plot were collected at 1 hr, 1 day, 3 days, 5 days, 7 days, and 10 days after insecticide application. A single leaflet of a trifoliate and the base of the petiole, 2.5 cm long, randomly selected from the upper plant canopy of each plot was individually placed in ten petri dishes along with two adult or two nymph (3rd instar) kudzu bugs. Kudzu bugs used in the trial were collected from commercially grown soybean fields within 24 hrs of the start of the assay. The petri dishes were sealed with Parafilm M® All-Purpose Laboratory Film to retain moisture and prevent escape and placed in a growth chamber at 80˚F with 70 % relative humidity and 16:8 hour light to dark photoperiod. Each infested petri dish was rated after 24 hrs and mortality was recorded. During the 2016 growing season, the assay was performed 1 hr and 1 day after spraying. Adult kudzu bug populations crashed after this, so kudzu bugs could not be collected at 3, 5, and 7 days after application. Each insect in a petri dish was recorded as either dead or alive. Data were corrected for control mortality using Abbott's formula.

Results. During the 2016 growing season, there was no difference in efficacy between 1hr and 1 day; therefore, the means over both ratings are presented. Mortality ranged from 61-100%. All 6 insecticide treatments provided some mortality. Clothianidin at 1.1 oz./acre, bifenthrin at 0.8 oz./acre, bifenthrin at 1.6 oz./acre, and acephate at 12 oz/acre caused the highest mortality and were not significantly different from each other.

During the 2017 growing season, all treatments in assays conducted 1 hr after application caused at least 58% mortality. Clothianidin, acephate, and the high rate of bifenthrin caused greater mortality than dimethoate and were not different from each other. Lambda-cyhalothrin and the low rate of bifenthrin were not significantly different from dimethoate or clothianidin, acephate, or the high rate of bifenthrin. At 1 day after application, all treatments still provided at least 66% mortality and were not different from each other. Data collected at 3 days after application were removed from the analysis due to high control mortality. The high mortality is believed to be due to excessive moisture in the petri dishes from the wetting of the filter paper.

Clothianidin and acephate were the only two chemicals to provide at least 15% mortality 6 days after application; therefore, those chemicals were the only two that were tested against the untreated control 14 days after application. Mortality in the acephate and clothianidin treatments were not significantly different at 14 days after application and were both less than 20%. Throughout the trial, clothianidin and acephate provided as good or higher mortality than all other insecticides.

Similar to the adult kudzu bug trial, a trial was conducted on kudzu bug nymphs during 2017. In this trial, assays 1hr after application resulted in all insecticide treatments causing greater than 40% mortality with dimethoate being the only treatment that was less effective than the best treatments. At 1 day after

application, all treatments caused at least 40% mortality and were not significantly different from each other. Data for the nymph trial at 3 days after application were removed from analysis due to high control mortality. Between five and six days after insecticide application, a 10-cm rainfall event occurred. Seven days after application, only lambda-cyhalothrin and the low rate of bifenthrin provided mortality higher than 10%. Due to low mortality among all treatments at 7 days after application, no treatments were tested at 14 days after application. No previous efficacy trials on kudzu bug nymphs have been reported.

Impact and Benefits to Mississippi Soybean Producers

Kudzu bug has become established throughout Mississippi and will likely be a common pest in soybean production regions near kudzu. The results of this research suggest that early season management of kudzu bug is not likely to be routinely needed. Yields are not impacted by densities up to 3 kudzu bugs/plant during early vegetative stages and kudzu bugs do not readily establish in early-planted beans. Furthermore, we have documented that a neonicotinoid seed treatment does not control this pest, so growers cannot rely on this strategy for managing kudzu bug. Fortunately, we have documented that several foliar insecticides provide good efficacy against adults and nymphs. Natural biological control from *Beauveria bassiana* appears to be important and has suppressed late-season populations during the last two years, but no other biological control agents are contributing to kudzu bug suppression in Mississippi. As a result of this research, fewer early-season insecticide applications should be applied to soybean to control this pest. Growers and consultants are more aware of the expected population dynamics and relatively low damage potential of kudzu bug. Furthermore, the chemical control options have been evaluated so they can choose a product that fits their situation.

End Products

Publications.

McRight, W. M. 2018. Evaluation of kudzu bug as a pest in Mississippi soybean production systems. M.S. thesis. Mississippi State University.

McRight, B., F. Musser, A. Catchot, N. Bateman, J. Gore and D. Cook. 2017. Kudzu bug: a new pest in Mississippi soybeans? Pp. 690-694. *In:* Proc. Beltwide Cotton Conferences, Dallas, TX, Jan.4-6, 2017. National Cotton Council, Memphis TN.

Presentations.

McRight, B., F. Musser, A. Catchot, D. Cook and J. Gore. Biocontrol of *Megacopta cribraria* eggs in Mississippi. Entomol. Soc. of America meeting, Denver, CO, Nov. 6, 2017.

McRight, B., F. Musser, A. Catchot, D. Cook and J. Gore. Population dynamics of *Megacopta cribraria* in Mississippi. MS Entomol. Assn. annual meeting, Mississippi State, MS, Oct. 16, 2017.

McRight, B. A. Catchot, F. Musser, J. Gore, D. Cook and N. Bateman. Kudzu bug: A new pest in Mississippi soybean? SEB- Entomol. Soc. of America meeting, Memphis, TN, Mar. 13, 2017.

McRight, B. F. Musser, A. Catchot, J. Gore, D. Cook and N. Bateman. Kudzu bug: A new pest in Mississippi soybean? Future of Agriculture Graduate Student Competition, Mississippi State, MS. Feb. 9, 2017.

McRight, B., F. Musser, A. Catchot J. Gore and D. Cook. Kudzu bug: a new pest of soybeans? Beltwide Cotton Conferences. Dallas, TX, Jan. 5, 2017.

McRight, B., F. Musser, A. Catchot and N. Bateman. Kudzu bug: a new pest in Mississippi soybeans? MS Entomol. Assn. annual meeting, Mississippi State, MS, Oct. 17, 2016.

In addition to these presentations and publications, aspects of this research have been incorporated into extension presentations given by Angus Catchot at numerous venues. The insecticide and threshold research results are incorporated into the 2018 Mississippi State University Extension Service Insect Control Guide (Publ. 2471).