MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 58-2017 (YEAR 1)
FINAL REPORT

TITLE Redbanded Stink Bugs: An Immediate Threat to Miss. Soybean Producers

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EXECUTIVE SUMMARY

Since at least the 1960's, the RBSB has been known in the United States. In 2000, small numbers of the pest were reported in Louisiana, and in 2002 they reached treatable levels there. Now, for many soybean fields in Louisiana, after an initial insecticide treatment has been applied, RBSB's are the most common stink bug. Only in the past few years has RBSB been found in Mississippi, and generally they have been restricted to the southern Delta. In 2009, RBSB was the primary cause for an increase in number of insecticide applications for stink bugs on soybean acres in Mississippi. In 2017, RBSB had successfully overwintered in Miss., and ditchbank surveys indicated high numbers of adults and nymphs present as early as March. Populations increased on wild hosts, moved to soybean fields in early June, and persisted throughout the growing season. The pest was found at treatable numbers statewide. The research reported here was conducted in 2017, and is the first to evaluate how RBSB affects soybean in Miss., and what measures may be needed to manage this pest.

RBSB was successfully controlled with insecticide applications applied either weekly or at threshold (4 RBSB bugs/25 sweeps) at R6 and later; however, final seed damage was not different among timing treatments. These results suggest that significant damage to seed is occurring earlier than R6, the full seed stage.

Insecticide tank mixtures provided the most consistent control of RBSB, with the tank mix of bifenthrin + acephate performing the best.

At all test locations, the weekly spray treatment, though likely not sustainable, resulted in the greatest seed yield.

Based on the trials conducted in 2017, the current recommended threshold of 4 bugs/sweep remains the standard for Miss. growers.

Results from these studies indicate that RBSB populations that persist through the seed development stages can be catastrophic, especially to seed quality that will result in heavy dockage at the elevator.

Results from these studies indicate the importance of aggressively treating RBSB from R4 through R6 to avoid significant delays in maturity.

Finally, these results indicate that further research is needed to determine what RBSBs are doing during their field presence that increases the certain and significant seed damage that is associated with that presence.

INTRODUCTION

Redbanded stink bug (RBSB) is a neotropical pentatomid that can be found from the southern United States to Argentina, and is among the top stink bug pests of soybean in Brazil. Since the late 1970's, it has begun to replace the southern green stink bug as the principle stink bug pest of soybeans in portions of Brazil.

Since at least the 1960's, the RBSB has been known in the United States, and since then it has been reported in several states including South Carolina, Florida, Georgia, and New Mexico. In the early 1980's, this pest was a major part of the stink bug complex in Georgia and Florida. However, it is rarely encountered in these states today.

In 2000, small numbers of the pest were reported in Louisiana, and in 2002 they reached treatable levels there. Now, for many soybean fields in Louisiana, after an initial insecticide treatment has been applied, RBSB's are the most common stink bug.

Only in the past few years has RBSB been found in Mississippi, and generally they have been restricted to the southern delta. In 2009, RBSB was the primary cause for an increase in number of insecticide applications for stink bugs on soybean acres in Mississippi.

In 2017, RBSB had successfully overwintered in Miss., and ditchbank surveys indicated high numbers of adults and nymphs present as early as March. Populations increased on wild hosts, moved to soybean fields in early June, and persisted throughout the growing season. The pest was found at treatable numbers statewide.

EXTENSION OBJECTIVES

Objective 1: Determine in-field damage potential of redbanded stink bugs in Miss. producer fields (large plot)

Three fields that were approximately 5 miles west of Anguilla, MS were used to conduct on-farm large plot damage potential assessments during late reproductive stages of soybean. Fields were identified to evaluate damage potential from R6 to R8 growth stages by comparing current economic thresholds of 4 RBSB/25 sweeps to automatic weekly sprays.
Treatments were:

1. Untreated Check
2. Beginning at R6, all plots sprayed weekly until R8
3. Treated at 4 RBSB/25 sweeps

Plot size was 75 ft wide by 200 ft. long and replicated 4 times. At R8 growth stage, 5 plants were removed and all pods were opened and examined for stink bug damage.

RESULTS—EXTENSION OBJECTIVE 1

Sprays of Bifenthrin (6.4 oz/acre) + Acephate (0.75 lb/acre) that were applied either weekly or at threshold successfully reduced RBSB numbers at all three locations. There was no difference in final seed damage among the treatments.

Location	Treatment	Percent Damaged Seed
Site 1	Untreated Check	44.23 a
Site 1	Weekly Spray Starting at R6	33.20 a
Site 1	Threshold (4 RBSB/100 Sweeps)	24.00 a
Site 2	Untreated Check	42.59 a
Site 2	Weekly Spray Starting at R6	52.23 a
Site 2	Threshold (4 RBSB/100 Sweeps)	50.05 a
Site 3	Untreated Check	15.40 a
Site 3	Weekly Spray Starting at R6	14.58 a
Site 3	Threshold (4 RBSB/100 Sweeps)	15.55 a
Means within a column and site with the same letter do not differ significantly at P = 0.05		

Objective 2: Determine influence of insecticide termination timings on yield and seed quality for redbanded stink bugs

Three additional fields were utilized approximately 5 miles west of Anguilla, MS to conduct on-farm large plot damage potential assessments during late reproductive stages. Fields were identified to evaluate damage potential and treatment termination timing from R6 growth stage to R8 comparing various termination timings in late stage reproductive soybean.

Treatments were:

1. Untreated Check
2. R6 single insecticide application
3. Treated one week after R6
4. Treated two weeks after R6
5. Treated three weeks after R6
6. Weekly automatic starting at R6
7. Treated at 4 RBSB/25 sweeps

Plot size was 75 ft wide by 200 ft. long and replicated 4 times. At R8 growth stage 5 plants were removed and all pods were opened and examined for stink bug damage.

RESULTS—EXTENSION OBJECTIVE 2

Location	Treatment	Percent Damaged Seed
Site 1	Untreated Check	29.83 a
Site 1	R6 single insecticide application	27.80 a
Site 1	Treated one week after R6	24.13 a
Site 1	Treated two weeks after R6	27.43 a
Site 1	Treated 3 weeks after R6	26.97 a
Site 1	Weekly Automatic starting at R6	19.70 a
Site 1	Threshold (4 RBSB/100 Sweeps)	37.80 a
Site 2	Untreated Check	36.63 a
Site 2	R6 single insecticide application	40.38 a
Site 2	Treated one week after R6	34.75 a
Site 2	Treated two weeks after R6	37.83 a
Site 2	Treated 3 weeks after R6	38.80 a
Site 2	Weekly Automatic starting at R6	34.30 a
Site 2	Threshold (4 RBSB/100 Sweeps)	37.88 a
Site 3	Untreated Check	22.75 a
Site 3	R6 single insecticide application	8.33 a
Site 3	Treated one week after R6	23.08 a
Site 3	Treated two weeks after R6	14.50 a
Site 3	Treated 3 weeks after R6	21.10 a
Site 3	Weekly Automatic starting at R6	13.83 a
Site 3	Threshold (4 RBSB/100 Sweeps)	12.55 a
Means within a column and site with the same letter do not differ significantly at P = 0.05		

Additional Late Reproductive Stage Damage Potential Assessment

Late-season damage potential from RBSB was evaluated in a controlled setting in small plot cages in Starkville, MS in 2017. RBSB's were caged in 6 ft x 6 ft mesh cages at the R6.5 growth stage with 0, 12, 24, and 48 RBSB adults released in each cage. Damage was evaluated at R8 by removing 5 consecutive plants and hand shelling and counting stink bug-damaged seed at R8. Results are shown in the below table.

Treatment	Final Percent Damaged Seed	Yield—bu/acre
0 RBSB	31.64 a	36.50 a
12 RBSB	23.67 a	36.40 a
24 RBSB	32.20 a	36.30 a
48 RBSB	20.67 a	35.00 a
Means within a column and site with the same letter do not differ significantly at P = 0.05		

OVERALL RESULTS OF LATE SEASON DAMAGE POTENTIAL (OBJECTIVES 1 AND 2)

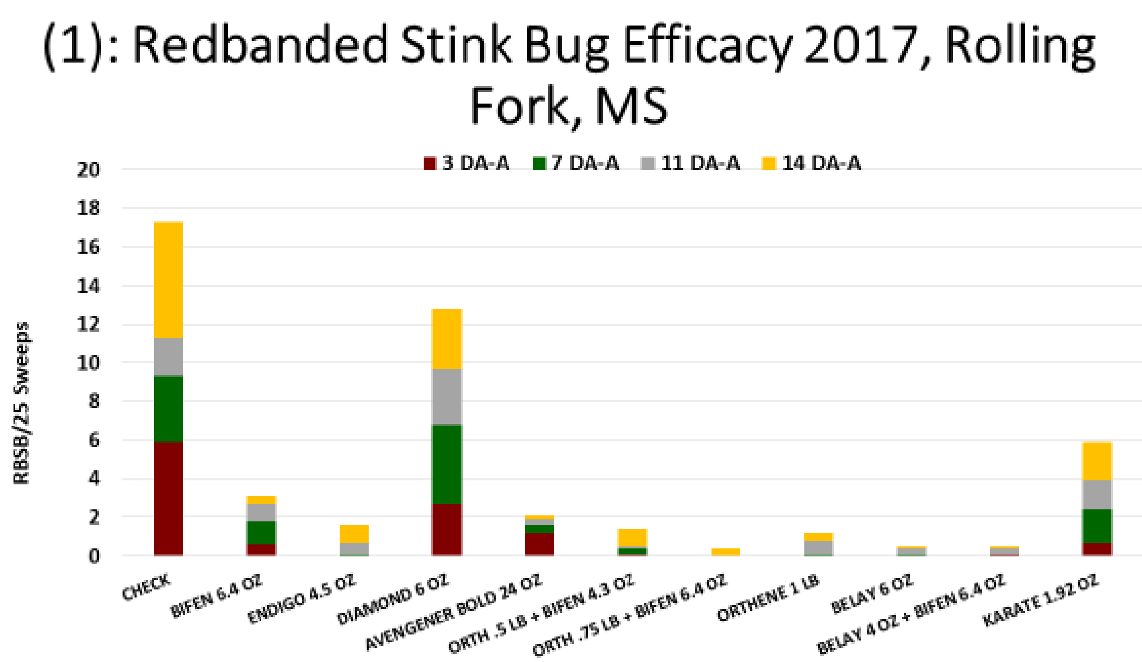
RBSB were successfully controlled with insecticide applications either applied automatically or at threshold; however, damage was not significantly affected in any test by making applications at or after R6 growth stage. In the additional cage study, releasing RBSB at various levels at the R6.5 growth stage did not significantly affect yield or damage levels regardless of infestation numbers.

These data suggest that applications of insecticides after the R6 growth stage will not likely impact damage to soybeans or yield caused by RBSB. However, it is important to note that data from other universities have shown damage can be caused after the R6 growth stage, but these findings seem to be highly correlated with adverse weather conditions. This could be due to the introduction of secondary pathogen(s) causing seed decay.

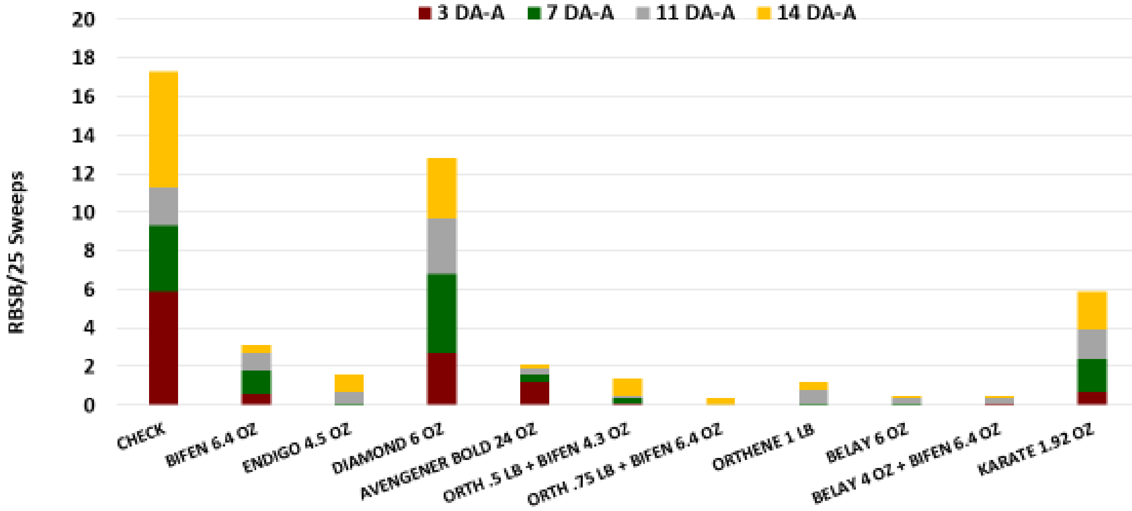
These data allowed for modification of existing recommendations in the 2018 Insect Control Guide for Agronomic Crops publication to further refine termination points for RBSB. It should also be noted that these test sites did in fact in some cases have high levels of damage despite weekly sprays in some treatments. This is likely due to low levels of RBSB that persisted in the field prior to testing. These data suggest that most damage is occurring beginning at the R5 growth stages rather than after full seed stage.

Objective 3: Determine insecticidal efficacy of insecticides to control redbanded stink bugs in Miss.

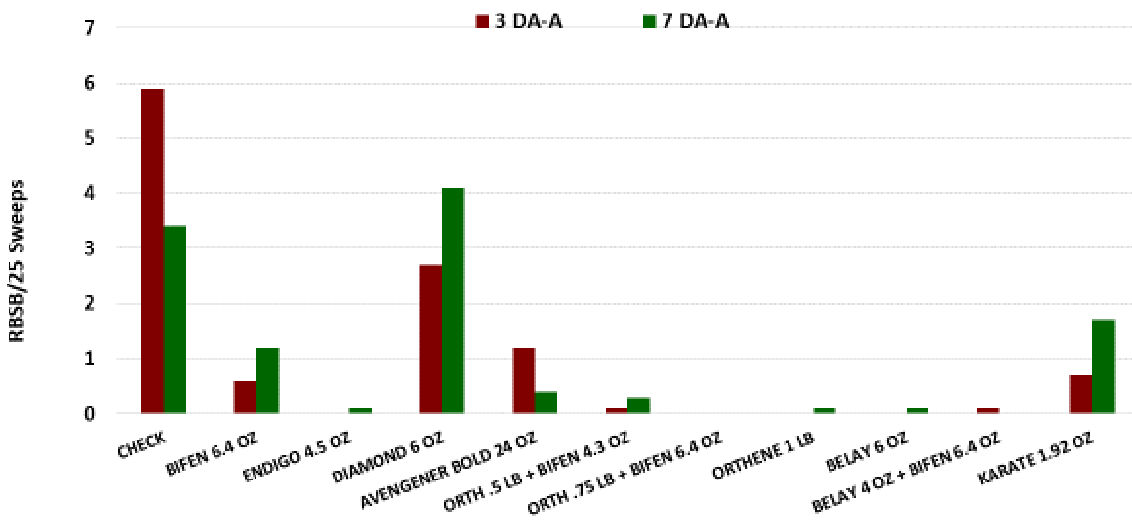
Various test were conducted on producer fields and MSU research farms in 2017 to determine insecticide efficacy against RBSB. All tests were sprayed with a high clearance sprayer calibrated to deliver 10 GPA with TX6 hollow cone nozzles at 65 psi.



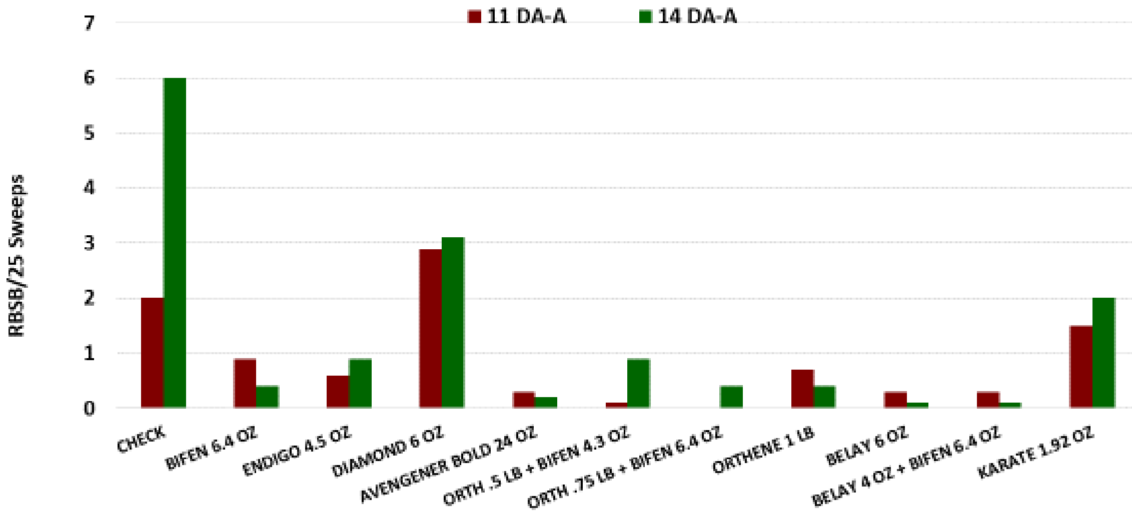
(1): Redbanded Stink Bug Efficacy 2017, Rolling Fork, MS



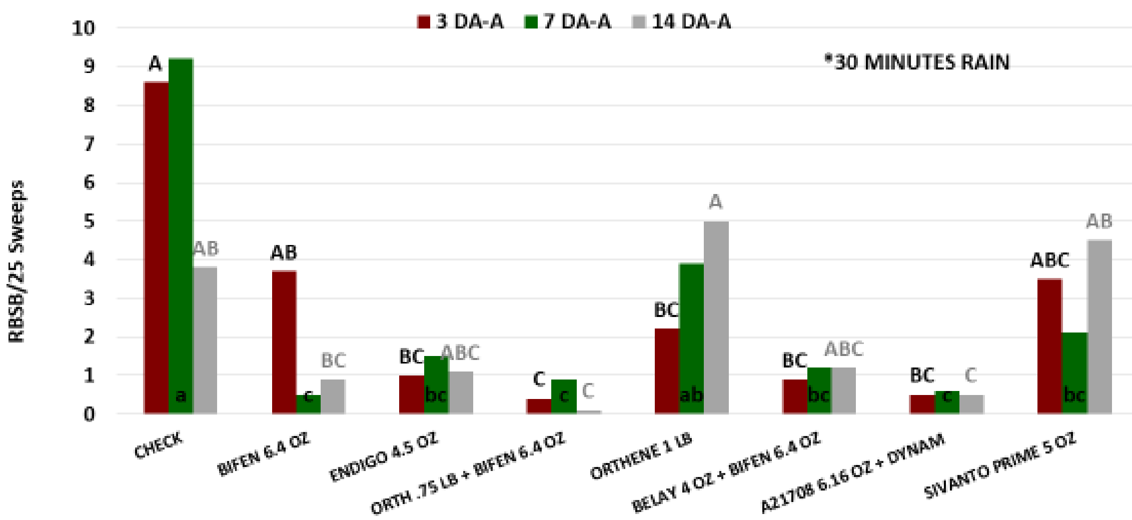
(1): Redbanded Stink Bug Efficacy 2017, Rolling Fork, MS

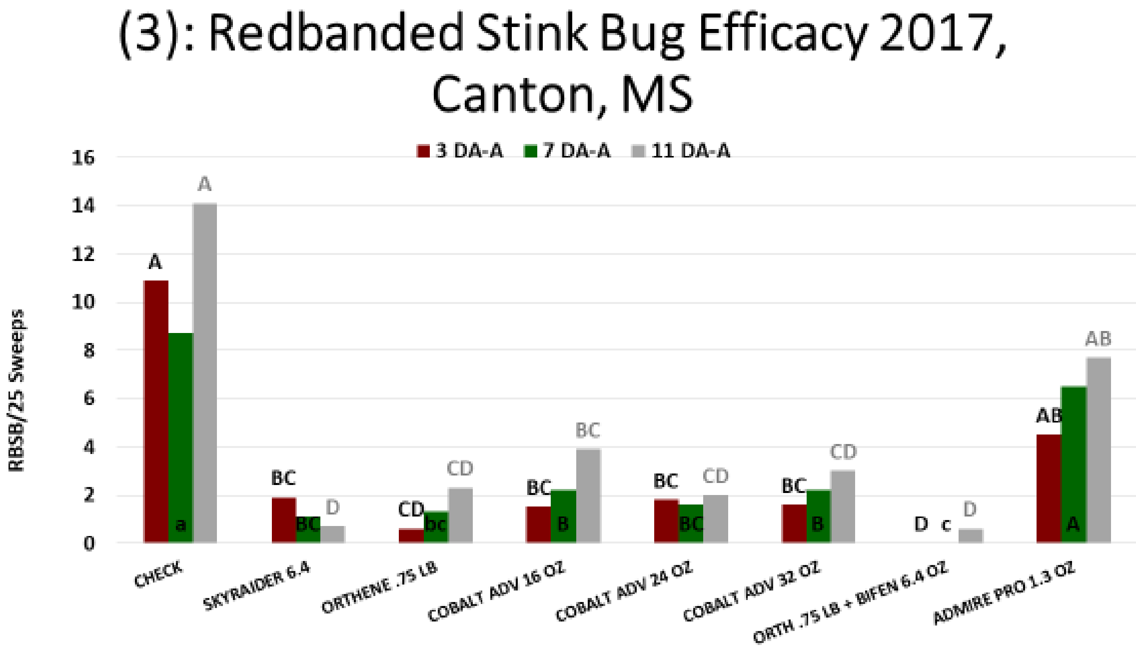


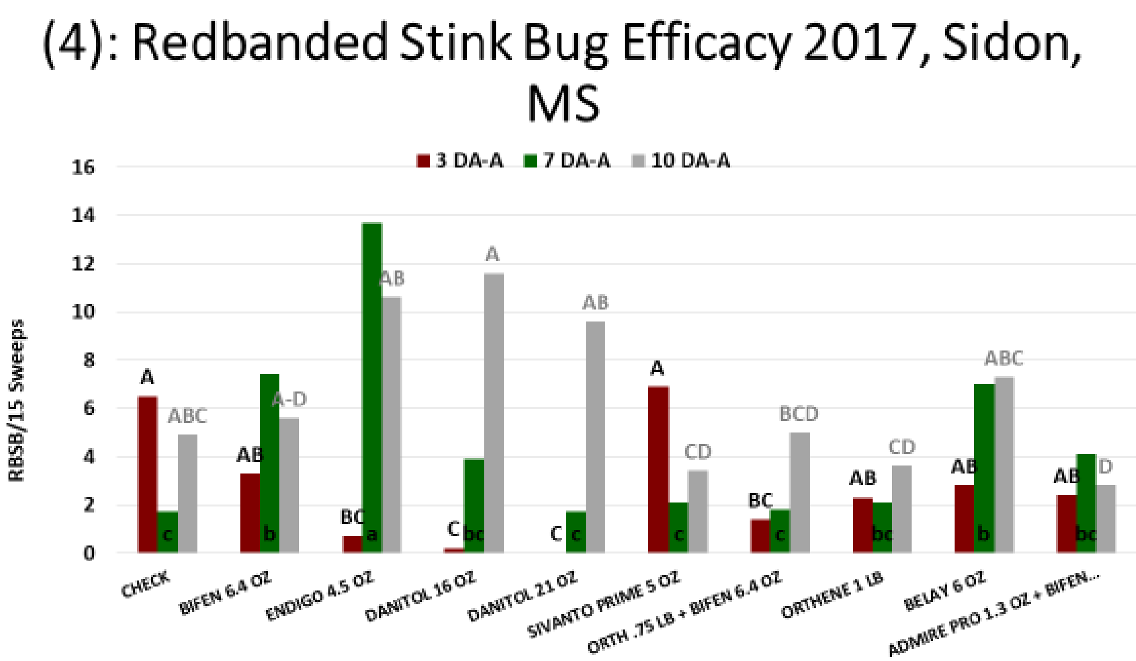
(1): Redbanded Stink Bug Efficacy 2017, Rolling Fork, MS



(2): Redbanded Stink Bug Efficacy 2017, Canton, MS




(3): Redbanded Stink Bug Efficacy 2017, Canton, MS
3 DA-A
7 DA-A
11 DA-A
RBSB/25 Sweeps
CHECK
SKYRAIDER 6.4
ORTHENE .75 LB
COBALT ADV 16 OZ
COBALT ADV 24 OZ
COBALT ADV 32 OZ
ORTH .75 LB + BIFEN 6.4 OZ
ADMIRE PRO 1.3 OZ


(4): Redbanded Stink Bug Efficacy 2017, Sidon, MS
3 DA-A
7 DA-A
10 DA-A
RBSB/15 Sweeps
CHECK
BIFEN 6.4 OZ
ENDIGO 4.5 OZ
DANITOL 16 OZ
DANITOL 21 OZ
SIVANTO PRIME 5 OZ
ORTH .75 LB + BIFEN 6.4 OZ
ORTHENE 1 LB
BELAY 6 OZ
ADMIRE PRO 1.3 OZ + BIFEN...

RESULTS—EXTENSION OBJECTIVE 3

Many products provide some level of control of RBSB in soybean; however, tank mixtures provided the most consistent control, with the tank mix of acephate and bifenthrin being the best.

Additional Evaluations of Threshold Validation at Sidon, Miss.

Studies were also initiated to refine/validate treatment thresholds for RBSB. Threshold levels evaluated included 2, 4, 6, 9, 12, and 16 bugs per 25 sweeps, plus a non-treated control and an automatic weekly application treatment.

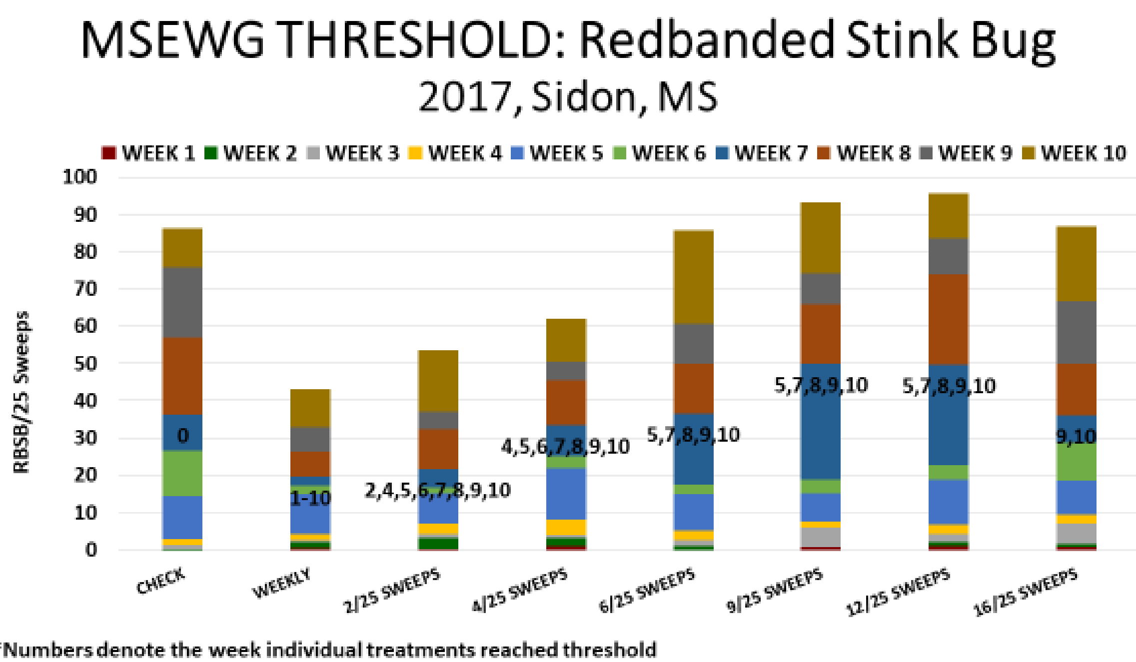


Figure 1. Evaluation of treatment thresholds for RBSB at indicated locations. Growth stages following sampling dates in legend are for the weekly application treatment. The number below the treatments on the x axis indicates the number of insecticide applications for that treatment.

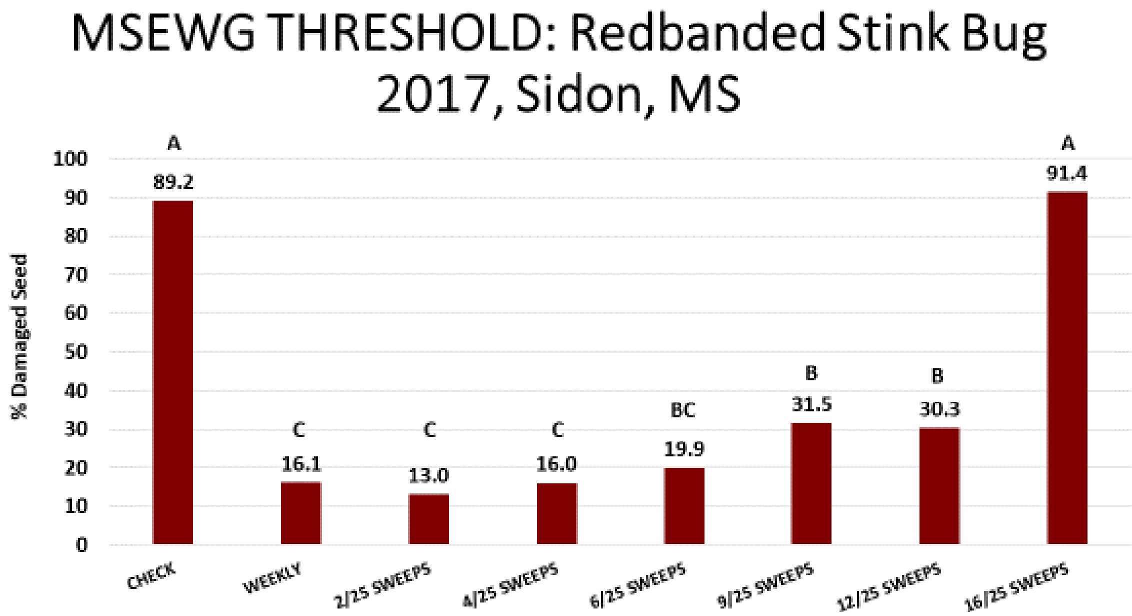


Figure 2. Impact of RBSB thresholds on percent stink bug-damaged seed.

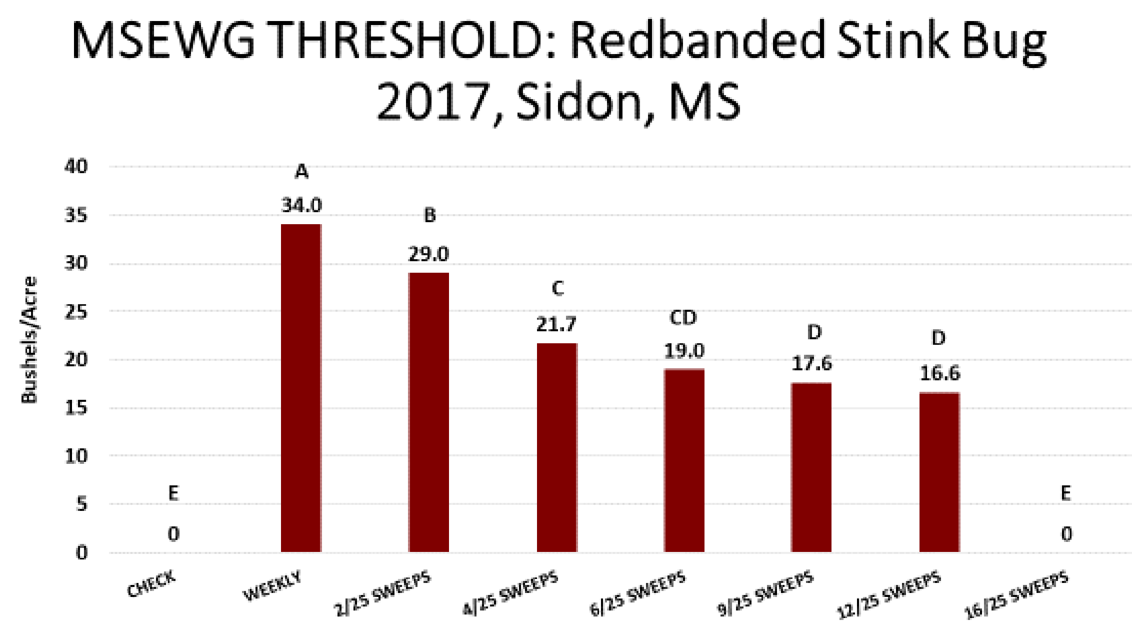


Figure 3. Impact of RBSB treatment thresholds on soybean yield.

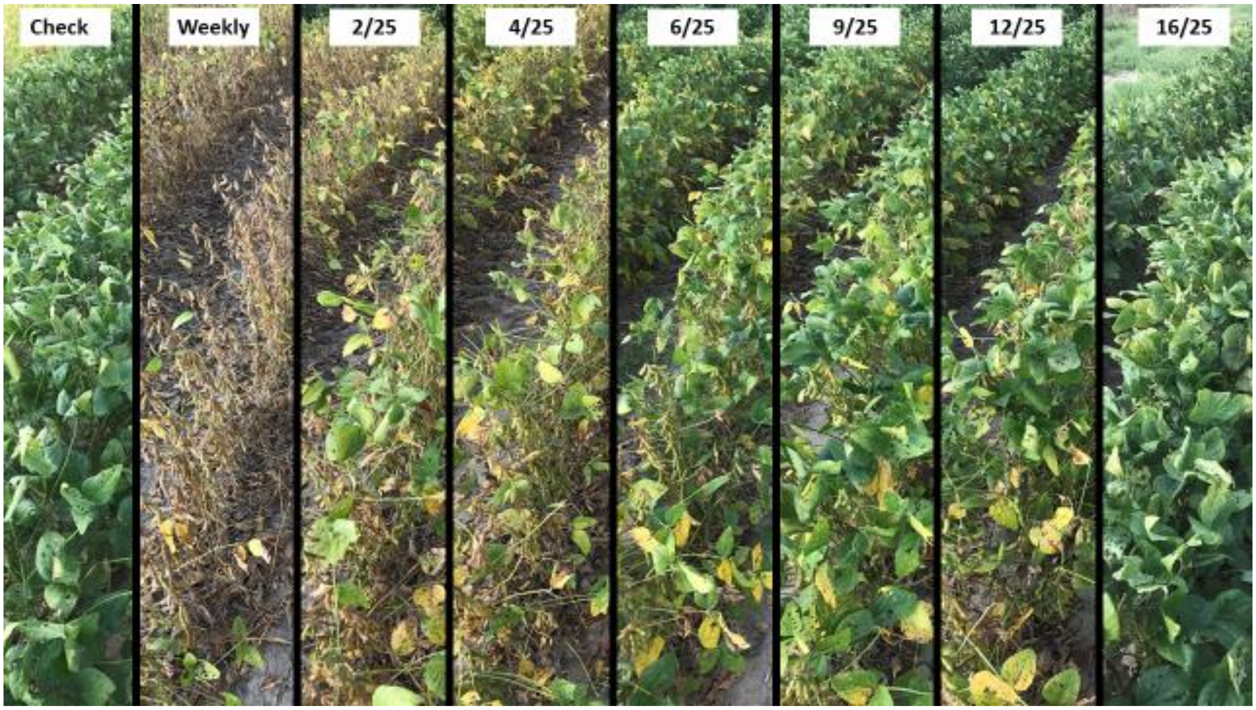


Figure 4. Impact of RBSB on soybean maturity at various sweep net thresholds/25 sweeps

Additional Evaluations of Threshold Validation at Stoneville, Miss.

Studies were also conducted at Stoneville, Miss. to refine/validate treatment thresholds for RBSB. Threshold levels evaluated included 2, 4, 6, 9, 12, and 16 redbanded stink bugs per 25 sweeps, a non-treated control, and an automatic weekly application treatment.

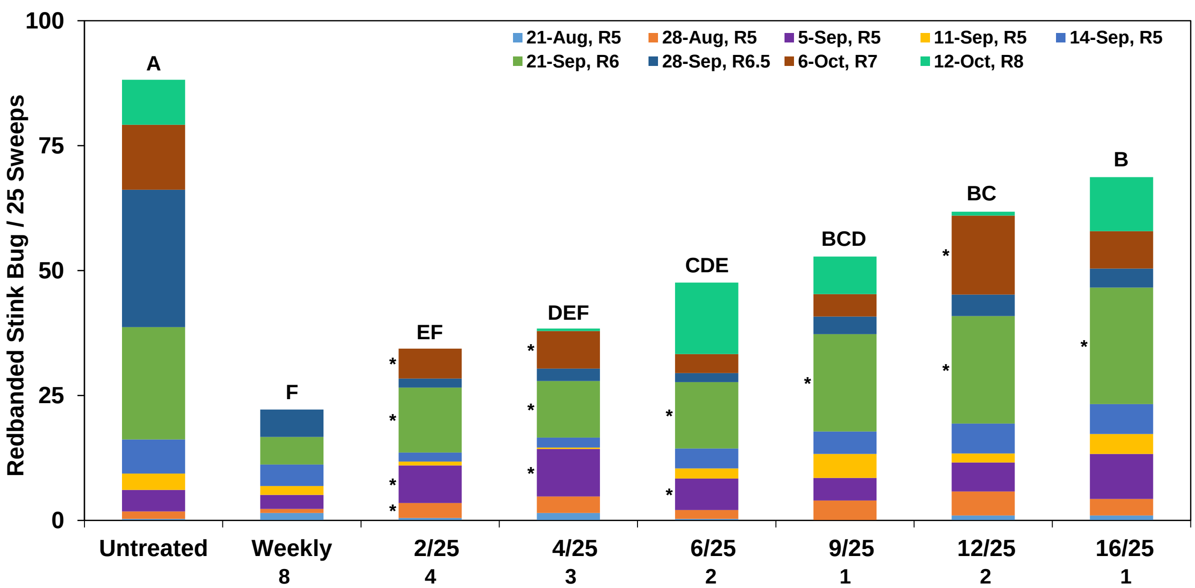


Figure 1. Evaluation of treatment thresholds for RBSB at Stoneville, Miss. Growth stages following sampling dates in legend are for the weekly application treatment. The number below the treatments on the x axis indicates the number of insecticides applications for that treatment.

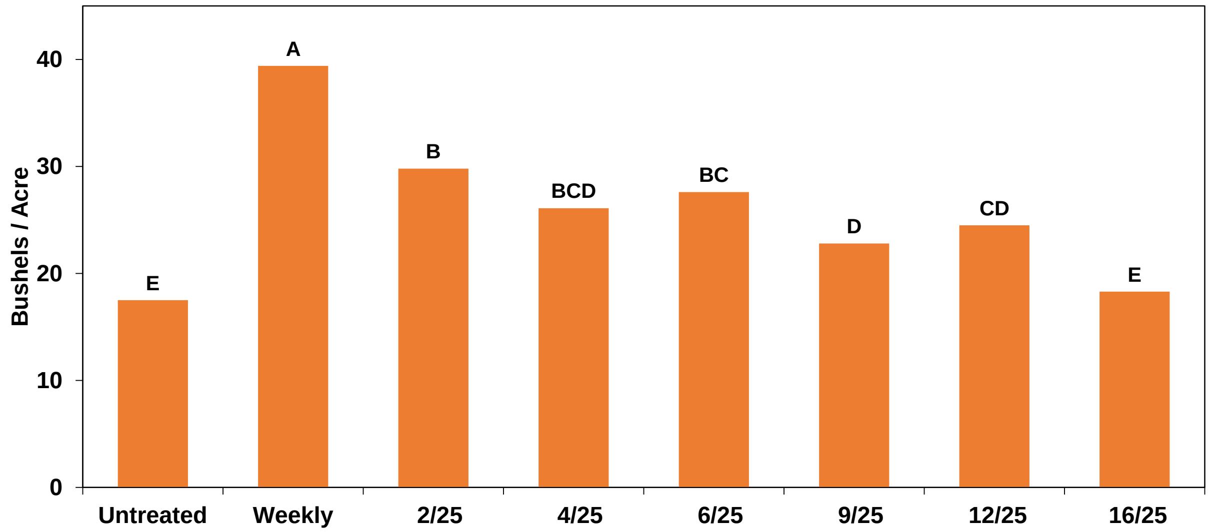


Figure 2. Impact of RBSB treatment thresholds on soybean yield.

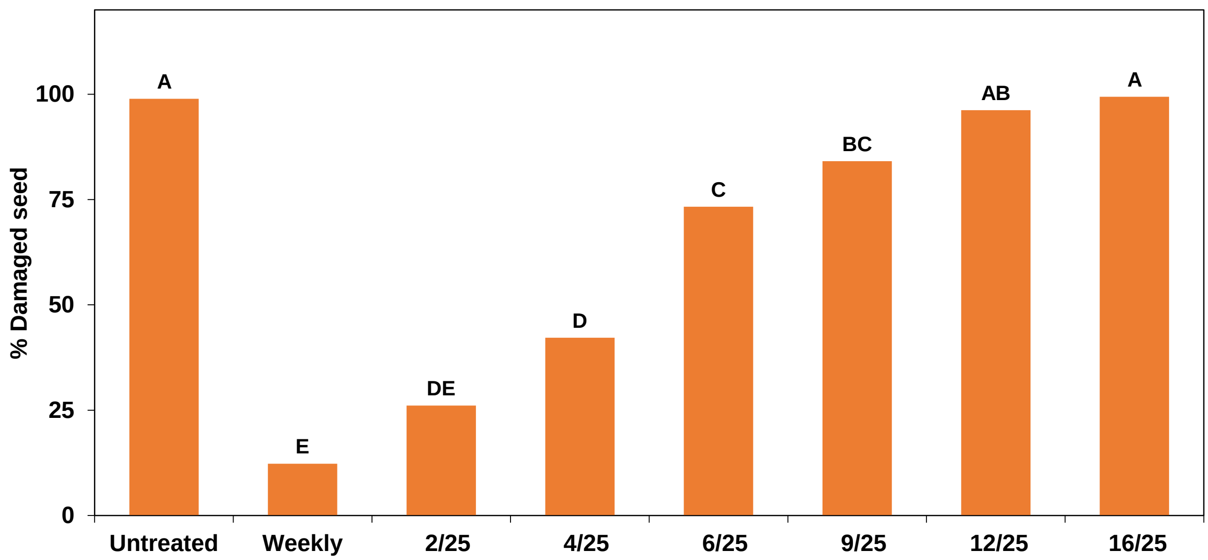


Figure 3. Impact of RBSB thresholds on percent stink bug-damaged seed.

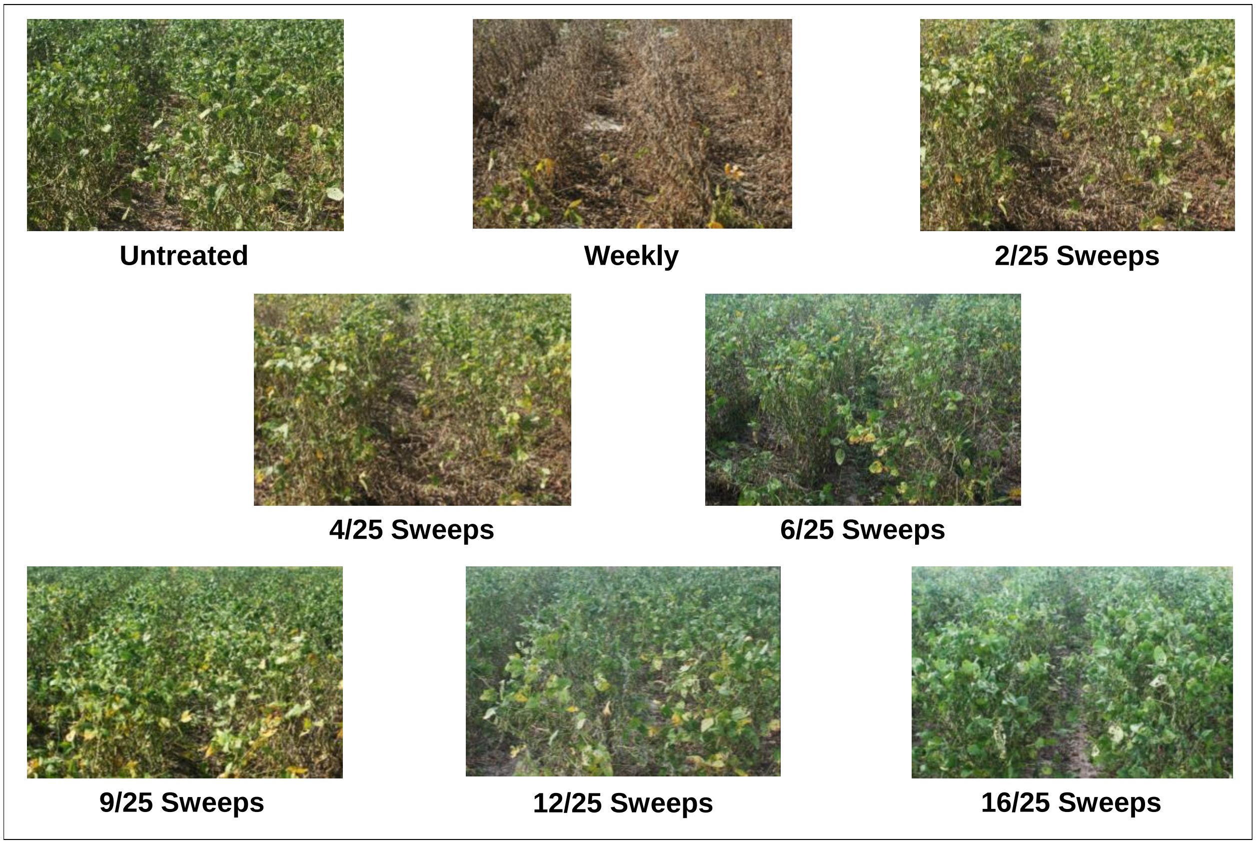


Figure 4. Impact of RBSB on soybean maturity.

SUMMARY OF TREATMENT THRESHOLD VALIDATION FOR RBSB

Threshold validation trials were conducted in soybean plantings that were made in mid-to late June at Sidon and Stoneville, Miss. Selected fields had very high populations of RBSB. At both locations, the weekly spray treatment resulted in greater yield than any of the threshold treatments.

Among threshold treatments at the Sidon location, the 2/25 sweep threshold resulted in greater yield than the 4/25 sweep threshold (current threshold), but it did not differ significantly from the 4 or 6/sweep at Stoneville. Based on these two trials, we feel that weekly sprays are not sustainable, plus pressure at these sites was much greater than would normally be expected in producer fields. This resulted in the decision to maintain the 4/sweeps as the standard recommendation for growers in Mississippi.

Under heavy pressure as seen in these studies, damage potential from RBSB can result in nearly 100% seed damage and render all seed unmarketable. These results indicated that populations that persist through the seed development stages can be catastrophic.

High populations of RBSB that occur through the early reproductive stages in contrast to objectives 1 and 2 (late infestations past R6) can significantly delay crop maturity. This was witnessed in many later-planted producer fields as well. It is imperative to treat RBSB aggressively from R4-R5.9 to avoid maturity delays and high levels of damaged seed.

RESEARCH OBJECTIVES

Objective 1: Establish a colony of RBSB at the MSU Insect Rearing Center. Having a colony of RBSB readily available will give researchers a reliable supply of insects to conduct laboratory and field experiments on a sporadically occurring but economically damaging soybean pest.

Redbanded stink bugs were collected from soybean fields and brought into the laboratory at various times during 2017. Numerous diets and environmental conditions were tested to optimize rearing conditions. The selection of ingredients was based on various papers in the scientific literature that reported rearing RBSB.

Results—Objective 1

Diet ingredients offered various mixtures of green beans, peanuts, soybeans, whole soybean plants, and various berries. Regardless of food offered, few eggs were laid, fewer eggs hatched, and no nymphs were able to complete development to adult. Since there was not success with a whole soybean plant (R4-R5 stage), we concluded that perhaps the environmental conditions were not suitable. Increasing humidity seemed to improve survival, but we were still unable to get a complete generation of development. Over the winter we have made adjustments to our rearing facility to try to maintain a higher humidity for trials in 2018.

Objective 2: Compare the feeding rates of adult and immature RBSB to adult and immature southern green stink bug. By comparing redbanded stink bug to southern green stink bug in laboratory trials, we will begin to develop a basis for setting the threshold for RBSB where it is most appropriate during various reproductive growth stages of soybean. Field trials (not in this proposal) will be designed in future years to validate the lab-based threshold results obtained here.

Field-collected southern green and redbanded stink bugs and lab-reared southern green stink bug adults and large nymphs were placed in petri dishes with soybean seed for 3 days to compare puncture rates and associated damage. Since Objective 1 was not successful, lab-reared RBSB were not available.

Soybean pods (R6 growth stage) were hand-harvested from insect-protected field plots and hand-shelled. Seed were surface-sterilized in sodium hypochlorite, rinsed with distilled water, and allowed to air-dry before being placed in a petri dish with stink bugs. After 3 days of feeding, stink bug mortality was noted and the number of visible punctures using a dissecting microsocope were counted.

Results—Objective 2

Although every effort was made to obtain seed free of stink bug damage, the uninfested controls still had nearly 20% damaged seed. Redbanded stink bug nymphs had high mortality and caused no more damage than the control, so the environment was apparently not suitable for this population (Table 1). Overall, there were no differences among the three populations, or between large nymphs and adults. These results are not consistent with field observations, so further research is needed to determine what RBSBs are doing in the field that increases the damage per stink bug typically observed.

Table 1. Stink bug mortality and feeding damage from stink bugs.					
Species	Insect stage	% Mortality	% Damaged Seed	Punctures / Dish	Punctures / Live Stink Bug
RedBanded	Adult	5 ± 5	49 ± 8	7.1 ± 1.2	3.8 ± 0.6
	Large Nymph	55 ± 16	24 ± 6	2.0 ± 0.4	1.6 ± 0.3
Southern Green-Field	Adult	15 ± 11	40 ± 8	6.4 ± 2.0	3.6 ± 1.0
	Large Nymph	25 ± 8	43 ± 7	6.5 ± 1.3	4.9 ± 1.3
Southern Green- Lab	Adult	5 ± 5	43 ± 6	6.1 ± 1.4	3.2 ± 0.7
	Large Nymph	10 ± 7	53 ± 7	5.8 ± 0.8	3.3 ± 0.4
Control		-	18 ± 4	2.0 ± 0.5	-

Objective 3: Compare insecticide tolerances of redbanded stink bug to southern green stink bugs. This lab-based objective complements the field efficacy trial planned in the MSU-ES component.

A trial was conducted 21 Sept, 2017 with field-collected redbanded and southern green stink bugs. Soybean plots were sprayed with the highest recommended rates of 4 insecticides plus an unsprayed control (Table 2). Soybean pods were collected from the upper portion of plants (to maximize coverage) after 24 hr and brought to the laboratory. Two pods were placed in a petri dish with 2 stink bugs of the same species and age. Mortality was assessed after 48 hr. Third and fifth instar nymphs and adult stink bugs were tested. Unfortunately, sufficient 3rd instar RBSBs were not available, so that species-stage combination was not included in the trial. A total of 15 dishes (30 insects) were tested on each compound. Data were analyzed to evaluate the impact of the insecticides on mortality and whether or not that changed for each species and/or growth stage.

Results—Objective 3

Overall, mortality was highest for smaller nymphs, then large nymphs, and lowest for adults. There was no overall difference in mortality between redbanded and southern green stink bugs, but the same treatments were not equally effective on both species. Endigo was most effective for control of southern green stink bugs, while Belay was best for controlling redbanded stink bugs (Table 2). In this trial, Orthene performed poorly against both species.

Table 2. Treatments and percent stink bug mortality after 48 hr exposure.						
Insecticide	Rate / ac	Redbanded Stink Bug		Southern Green Stink Bug		
		5th Instar	Adult	3rd Instar	5th Instar	Adult
Endigo ZC	4.5 fl. oz.	40 ± 8.7ab	30 ± 8.2bc	77 ± 8.3a	73 ± 8.3a	57 ± 9.6a
Brigade 2EC	6.4 fl. oz.	30 ± 8.2bc	40 ± 10.0ab	50 ± 10.9b	40 ± 10.0b	30 ± 8.2b
Belay 2.13	6.0 fl. oz.	60 ± 7.2a	57 ± 10.8a	30 ± 6.5b	37 ± 9.1b	20 ± 6.5bc
Orthene 90S	1.1 lb	17 ± 8.0c	10 ± 5.3cd	30 ± 8.2b	3 ± 3.3c	10 ± 5.3c
Untreated Control		13 ± 5.9c	0 ± 0.0d	7 ± 4.5c	0 ± 0.0c	7 ± 4.5c