BOLL INJURY CAUSED BY LEAFFOOTED BUG IN LATE-SEASON COTTON

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Abstract

Leaffooted bug, *Leptoglossus phyllopus* (L.) (Hemiptera: Coreidae), has been observed in large numbers on cotton late season in south Texas and elsewhere in U.S., but reports of economic damage to cotton are sporadic. As an initial look at cotton-leaffooted bug interactions, field-collected leaffooted bugs were caged on cotton to characterize boll injury and examine within-plant distribution of boll injury within the context of its late-season occurrence. Boll injury type and symptomology of cotton boll rot observed on leaffooted bug-infested bolls were similar to that previously documented for stink bugs. There was more boll injury to the relatively younger bolls in the middle branch section of the plant (1.28 boll injury average based on a 0 to 4 injury scale) than on bolls in lower branches, which was most obvious at the one leaffooted bug per plant infestation rate cotton boll rot generally followed the same pattern: higher frequency of boll rot symptoms on bolls in the middle branches (average of 30%). The next year under more severe water-stress conditions, the amount of boll injury and cotton boll rot was marginally lower, and about the same in middle and lower branches. Despite boll injury and rot at levels known to affect yield, there were no yield differences detected in the late-season cotton caged in these experiments. Overall, leaffooted bug injured bolls, and data supported it as a suspect vector of cotton boll rot. Yet, yield loss was not detected using late season cotton that coincided when leaffooted bug has been observed in commercial fields. We propose that risk of yield impact is low when leaffooted bug movement into cotton is first detected late season. Should leaffooted bug occur earlier in cotton development, risk to yield likely increases, and further study would help evaluated the degree of risk across boll age and cotton development. Please note that a journal articles of the same name is scheduled to appear in Crop Protection in 2019. The contribution here is the form of a pre-print of the following web version in the journal Crop Protection: https://doi.org/10.1016/j.cropro.2019.02.003 .

Introduction

Cotton boll injury due to insect feeding has increased substantially during the last two decades in the southern United States of America (USA), including Texas (Luttrell et al. 2015). A complex of stink bugs and plant bugs (Hemiptera: Pentatomidae and Miridae, respectively) cause boll injury which results in lint staining and degradation, seed loss and boll abscission (Greene et al. 2001, Brewer et al. 2012). Loss can be greatly magnified when bacterial boll rot is introduced during probing and feeding activity (Medrano et al. 2009, 2015, 2016). The southern green stink bug, *Nezara viridula* (L.), green stink bug, *Acrosternum hilare* (Say), brown stink bug, *Euschistus servus* (Say) (Hemiptera: Pentatomidae), and verde plant bug, *Creontiades signatus* Distant (Hemiptera: Miridae) are known to cause economic damage of this type (McPerson and McPherson 2000, Greene et al. 2006, Glover et al. 2019).

Leaffooted bug, *Leptoglossus phyllopus* (L.) (Hemiptera: Coreidae), has been observed in large numbers on late-season cotton matured to about 5 nodes above first white flower on fruiting position one from the main stem (NAWF, Kerby et al. 2010) in south Texas (MJB and JPG, pers. obs.) and elsewhere in the southern USA (Greene et al. 2006). Similar to stink bugs and plant bugs, leaffooted bug probes bolls with piercing-sucking mouthparts (Esquivel 2015). But reports of its economic damage to cotton are sporadic, and it is not listed as one of the main sucking bug boll-feeders in outreach publications (Greene et al. 2006, Vyavhare et al. 2018). Based on past experiences with stink bugs and plant bugs, this may be due to less abundance of leaffooted bug in cotton, occurrence at a time when cotton bolls are older and less susceptible to leaffooted bug feeding, or boll response to leaffooted bug feeding that is less injurious than feeding by other boll-feeders.

In general, boll injury by stink bugs and the verde plant bug has been well documented, and management guidance is available for a mixed species complex and selected individual species of stink bugs and plant bugs (Greene et al. 2001, Brewer et al. 2013ab, Glover et al. 2019). The yield-insect density relationships are often sufficently robust and similar across species that pest management decision-making can be pursued comprehensively across species (Glover et al. 2019). As an initial look at cotton-leaffooted bug interactions, leaffooted bug was caged on cotton to characterize symptoms and distribution of boll injury within the cotton plant and within the context of the insect's late-season occurrence. These data were used to assess potential and reported economic pest status of leaffooted bug on cotton, and whether more intensive research was warranted to assess risk to cotton yield.

Materials and Methods

Insect Collection and Pre-Infestation Cotton Management

In three experiments in 2013 and 2014 at the Texas A&M AgriLife Research and Extension Center in Corpus Christi, TX, adult leaffooted bugs were released into caged cotton for a seven-day period. Field-collected adult leaffooted bugs were used for infesting cages covering the upper half of the plant of late-season cotton (an initial partial plant experiment) in 2013 and whole cotton plants (whole plant experiments conducted both years). The leaffooted bugs were collected on maturing seed heads of sorghum from Nueces and San Patricio Counties, Texas. They were collected by hand in 2013 and by using a modified leaf blower that displaced insects from vegetation and blew them into an inflatable sock in 2014 (Beerwinkle et al. 1997). Only healthy adults were used for infesting the caged cotton after a 24h fasting period.

Cotton used in caging was selected for uniformity from a ≈0.4 ha field planted to Phytogen 499 WRF (Dow AgroSciences, Indianapolis. IN). Planting occurred first week in May on 91-m rows and 96-cm row centers at a rate of ≈77,800 seeds per ha (31,500 seed per acre). The region experienced extreme drought (188 mm and 274 mm of rainfall from May 15 to August 1 in 2013 and 2014, respectively), which is about one-quarter to one-third of the average long-term rainfall for this period, and about one-third of the needed rainfall for optimal yield for the region (Morgan 2018). Rainfall estimates were acquired from the Corpus Christi airport weather station located ca. 6.75 km from the experiment (National Weather Service 2017). Likely due to water stress, irregular patterns of fruiting were observed: <10% boll retention was seen on the upper branches and a high majority of bolls were found on fruiting positions one and two of the middle and lower branch sections (Fig. 1). Thiamethoxam insecticide (Centric, Syngenta Crop Protection, Greensboro, NC) was applied weekly to the field where the experiments were conducted at a rate of 87.6 g per ha with a tractor-mounted sprayer during flowering and before caging. The insecticide was used to control plant bugs and aphids which were detected in the plots and may proliferate once cotton was caged. Insecticide application was stopped when leaffooted bug were first detected about the third week of bloom (ca. July 20), which was two weeks before starting the cage experiments. Other agronomic practices were normal for the region (Morgan 2018).

Plant Cage Experimental Design and Insect Infestation

An experimental unit consisted of groups of four cotton plants which were enclosed by large organza fabric cages (152 by 122 cm, ~240-micron mesh, JoAnn's Fabrics, Hudson, OH) draped over the cotton foliage. Late-season cotton was used, with plant development at about 5 NAWF. This advanced cotton growth stage coincided when leaffooted bugs were available in sufficient numbers for infesting caged cotton. For the partial plant experiment in 2013, the cages covered the upper half of the plant starting at node 11 which corresponded to reproductive branch six (Fig. 1), and the cage bottoms were tied to the main stem. For the whole plant experiments, the fabric entirely covered the four plants and extra fabric at the base of the plants was covered by soil. The partial plant experiment exposed leaffooted bugs to a range of boll ages up ca. 21 days in age in the middle (B6-10) and upper (B11-15) branches, and the whole plant experiments presented a greater array of boll ages from new bolls at pink flower on upper branches to about 33 days in age on the bottom branches. Boll age was estimated using the standard of three days of growth between branches and six days of growth between fruiting positions along a branch (Ritchie et al. 2004).

Two days before leaffooted bug infestation, plants were sprayed to run-off with pyrethrins, a very short-residual U.V.-sensitive insecticide (0.02% by volume, Bonide products, Oriskany, NY) to remove aphids and other small insects that may contaminate the caged cotton. The cotton was then covered with the fabric cages and infested with leaffooted bug the next day. Cages were infested with leaffooted bug adults for seven days at rates of 0 (control), 0.5, and 1 adult per plant for the 2013 whole plant experiment. For the 2013 partial plant experiment and the 2014 whole plant experiment, the infestation rates were 0 and 1 adult per plant. The infestation treatment was set out as a physical randomized complete block, with 8 (2013 partial plant), 5 (2013 whole plant), and 6 (2014 whole plant) replications, depending on the number of leaffooted bug available. Two cages were not infested at the high rate for the 2014 whole plant experiment due to shortage of leaffooted bugs. A seven day infestation period was chosen to reflect a commercial field where insects might go undetected during weekly scouting. Leaffooted bugs were active in the cages based on periodic visual inspection during the seven-day infestation.

All caged treatments were treated with thiamethoxam at end of day seven post-infestation and again on day 14 to eliminate remnant treatment insects including nymphs emerging from eggs laid by the adults. Experimental cages remained in place until harvest, allowing bolls to mature (>90% of harvestable bolls were open) and any cotton boll rot suspected to be introduced by leaffooted bug to express symptoms. In previous experiments caging verde plant bug on cotton in the same field setting, yield data were not affected by caging (Brewer et al. 2013a). Also, yield taken from four uncaged groups of plants monitored during the 2013 whole plant experiment was similar to yield taken from uninfested caged plants, except the period of boll opening in caged plants was extended by about a week. Therefore, caging effects on yield weight were assumed negligible for these experiments.

Boll Injury and Yield Measurements

At harvest, cages were uncovered, and each of the four plants from a cage were mapped using PMAPplus to record boll injury and cotton boll rot by fruiting position and branch (Anderson et al. 2018). Reproductive or sympodial branches were counted in order from bottom to top of the plant beginning with the first reproductive (sympodial) branch. Reproductive branches were consistently found at or above the fifth node. Specifically, bottom branches (B1-5) corresponded to nodes 6-10, middle branches (B6-10) corresponded to nodes 11-15, and upper branches (B11-15) corresponding to nodes 16-20 (Fig. 1). Fruiting positions on reproductive branches were counted in order from the nearest position to the main stem outward (Anderson et al. 2018). Boll injury and cotton boll rot data were taken on all open bolls (i.e. physislogically-matured bolls with dehiscent carpel walls) and green bolls (once cracked and fully dried in a commerical dryer). Symptoms were photographed on a representative group of green and open bolls from extra infested and uninfested caged cotton. Observations were the presence of external and internal punctures, internal galls and warts on the carpel wall, seed deterioration, and presence of symptoms of cotton boll rot (Medrano et al. 2009).

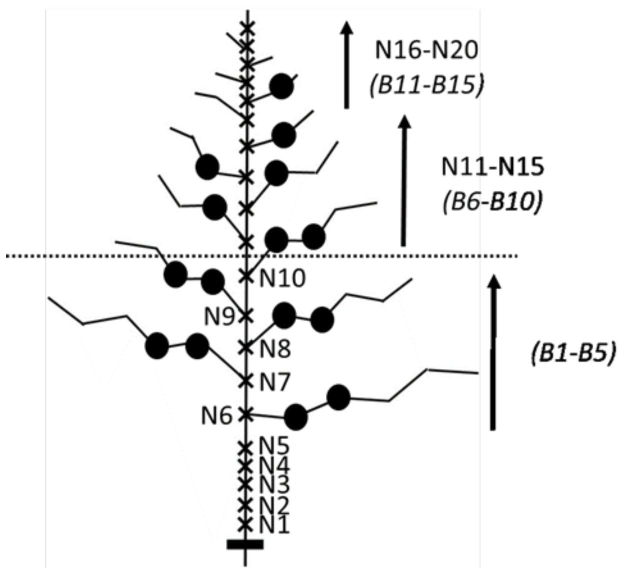

Figure 1. Diagram of a cotton plant illustrating the main stem (vertical line), branches (broken lines radiating outward from the main stem), fruting postions (lines breaks along the branches), and bolls (filled-in circles). All bolls were exposed to leaffooted bug infestation in the whole plant cage experiments in 2013 and 2014. Only bolls above the dotted line were exposed to leaffooted bug in the partial cage experiment of 2013. Bolls were mainly found on the first two fruiting positions from the main stem on the bottom branches (B1-B5 corresponding to nodes N6-N10) and middle branches (B6-B10 corresponding to nodes N11-N15), and boll retention was <10% on the upper branches (B11-B15 corresponding to nodes N16-N20) during the droughty conditions of the experiments.

For 2013 and 2014 whole plant experiments, data were separated by branch sections (Fig. 1). Boll retention was <10% on upper branches (B11-15) and variable on other branches due to drought conditions; therefore, boll retention data were excluded, and other data were restricted to bottom branches (B1-5) and middle branches (B6-10).

Boll injury was rated using a boll injury scale ranging from 0 (representing no locule injury), 1 to 3 (representing a progression of seed and lint degradation occurring in one to three locules, respectively), and 4 (representing severe degradation of seed and lint in all locules) (Brewer et al. 2013a). Bolls were scored for presence or absence of cotton boll rot visually by thoroughly inspecting the lint for symptoms (Medrano et al. 2009). For the 2013 whole plant experiment, yield data were estimated by cotton lint weights. Bolls from the four plants per cage were collected and separated for the bottom and middle bottom branches. To obtain lint weight, seed cotton was ginned by hand using a 10-saw laboratory cotton gin (Continental Eagle Crop., Prattville, AL). Yield data were recorded as grams of lint per branch section per plant. Yield data were not taken in 2014 because of extreme water-limiting conditions.

Data Analysis

Analysis of variance (ANOVA implemented in the procedure Proc GLM) for a split plot experimental design was used for the two whole plant experiments, where the infestation treatment was considered the main plot factor and the two branch sections were considered the split factor (Neter et al. 1985, Littell et al. 1991). For the 2013 partial plant experiment, the data were comparable to the middle branch data of the whole plant experiments. The analysis defaulted to the field layout of the infestation treatment in a randomized complete block of the infestation factor. Tukey's means separation test available in the Proc GLM procedure (Littell et al. 1991) was conducted for the 2013 whole cage experiment with three infestations rates, slicing data by branch section when the interaction was significant. Linearity of the measures across the infestations rates was also considered by using contrast statements available in the procedure. Given the wide variation in cotton boll rot encountered, cotton boll rot proportion data were transformed by the arcsine square-root transformation before analysis to compensate for potential deviation from normality (Neter et al. 1985). Backtransformed data converted to percent of bolls with cotton boll rot were presented for ease of interpretation.

Results and Discussion

Description of Boll Injury

Feeding punctures isolated on bolls exposed to leaffooted bug caused warts and galls on the inner carpel wall (Fig. 2), as has been seen on bolls fed upon by several stink bug species (Medrano et al. 2009, 2016). Similarly, lint and seed degradation and symptoms of cotton boll rot occurred in bolls infested with leaffooted bugs (Fig. 2), as documented for stink bugs and verde plant bug (Medrano et al. 2009, 2016, Brewer et al. 2012). Overall, boll injury type and symptoms of cotton boll rot were observed in both green bolls and fully matured open bolls infested with leaffooted bug and were similar in appearance to those caused by stink bugs and verde plant bug.

Boll Injury Severity, Cotton Boll Rot, and Yield

In the initial partial plant experiment, infested bolls had significantly greater boll injury (1.9 $\pm$ 0.45 on a 0 to 4 injury scale), than occurred on uninfested bolls (0.23 $\pm$ 0.12) (Tables 1 and 2). Cotton boll rot levels in the infested plants were relatively high (26.5 $\pm$ 9.5%), but frequency of boll rot symptoms did not significantly differ from that in the uninfested plants (6.2 $\pm$ 4.1%), likely because of the high variability of this measure (Tables 1 and 2). For both whole plant experiments, boll injury and cotton boll rot were higher on bolls of the infested plants than the uninfested plants (Tables 1 and 2), which verified the findings of the partial plant experiment. Some boll injury and cotton boll rot were observed in uninfested plants of the partial plant experiment in 2013, while boll injury and cotton boll rot were not detected in uninfested plants in 2014 and were very low in 2013 in the whole plant experiments (Table 2).

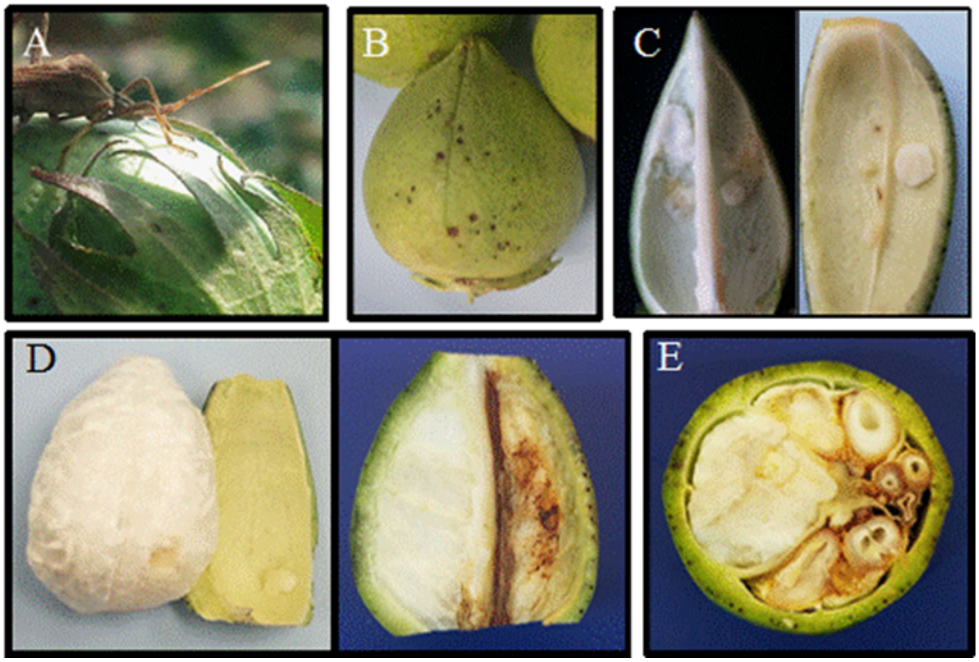

Fig. 2. External and internal effects of feeding on field-grown cotton bolls caged with leaffooted bug, *Leptoglossus phyllopus* (L.) (Hemiptera: Coreidae). Leaffooted bug feeding on a young green boll (A), feeding punctures on the external carpel wall (B), inner carpel injury in the form of warts, galls, and puncture marks (C), lint injury with no (left) and positive (right) visual symptoms of cotton boll rot (D), and advanced lint injury and cotton boll rot development visible two weeks after infestation with leaffooted bug (E).

Introducing leaffooted bug onto whole plants provided comparison across a wider array of boll ages on the middle and lower branch sections. In the 2013 whole plant experiment, there was more boll injury in the middle branches, which was most obvious at the one leaffooted bug per plant infestation rate (1.28 $\pm$ 0.25) than in the bottom branches (0.50 $\pm$ 0.13) (infestation by branch interaction was significant, Tables 1 and 2). Cotton boll rot generally followed this pattern of higher boll rot on bolls in the middle branches (29.4 $\pm$ 7.9%) than in the lower branches (9.18 $\pm$ 2.12%), although the resolution of the infestation by branch interaction was marginal (P = 0.082, Table 1). In this experiment using three infestations rates, means separation followed the general pattern of higher boll injury and boll rot as infestation increased for the bolls in the middle branches but not in the lower branches (Table 2). This pattern was also confirmed using contrast statements that tested for linearity. In contrast in 2014 when water-stress was more severe, the amount of boll injury and cotton boll rot were similar in the middle and bottom branches (branch main effect not significant, Tables 1 and 2), and no infestation by branch interaction was detected (Table 1).

Yield data were available from the 2013 whole plant experiment, where the greatest differences in boll injury and cotton boll rot were detected across the leaffooted bug infestation rates and between the middle and bottom branches. Yield was not affected by infestation rates or the interaction with branch (Table 1). Bottom branches contributed to a much greater portion of the yield than the middle branches, regardless of infestation rate (Table 2). Completely and partially hard-locked carpels (i.e., a boll carpel section with lint not or partially visible, respectively) were observed primarily on small bolls in middle and upper branches in the leaffooted bug infested cages. Although lint from the partially hard-locked bolls was recovered through our process of hand collection and ginning, their small size likely contributed little to yield. When Brewer et al. (2013a) conducted a similar caging study with verde plant bug, yield differences across similar infestation rates were detected when infesting cotton during mid-bloom but not during late-bloom when plant development was about 10 to 12 NAWF. In the current study, cotton was infested with leaffooted bug even later in cotton development (ca. 5 NAWF). In future experimentation infesting cotton earlier in development, lint from larger partially hard-locked bolls may be classified as non-harvestable (by machine harvest) and discounted from yield as done by Willrich et al. (2004).

Table 1. ANOVA *F* test results of the leaffooted bug infestation treatment (Infest) on middle branches (2013 partial plant experiment) and on bottom and middle branches (2013 and 2014 whole plant experiment).

	2013 partial plant			2013 whole plant			2014 whole plant		
Factor	*F*	df	*P*	*F*	df	*P*	*F*	df	*P*
Boll injury									
Infest [a]	15.14	1, 7	0.0006	9.42	2, 7	0.010	33.69	1, 4	0.004
Branch [b]				12.59	1, 11	0.005	0.64	1, 9	0.64
Infest*Branch				5.18	2, 11	0.026	0.77	1, 9	0.40
Cotton boll rot									
Infest	3.31	1, 7	0.11	17.23	2, 7	0.0020	122.0	1, 4	0.0004
Branch				7.01	1, 11	0.023	1.38	1, 9	0.27
Infest*Branch				3.16	2, 11	0.082	1.65	1, 9	0.231
Yield									
Infest				0.95	2, 7	0.431			
Branch				314.3	1, 11	< 0.0001			
Infest*Branch				0.63	2, 11	0.55			

Data were boll injury and cotton boll rot (all experiments) and yield (2013 whole plant experiment only).

[a] Infestation rate (Infest): 0, 0.5, and 1 insect per plant (2013 whole plant) and 0 and 1 insects per plant (2013 partial plant and 2014 whole plant) experiments.

[b] Branch: Boll retention was <10% on upper branches (B11-15) and highly variable on other branches due to drought conditions; therefore, boll retention data were excluded and other data were restricted to bottom branches (B1-5) and middle branches (B6-10). For the 2013 partial plant experiment, the data were comparable to the middle branch data of the whole plant experiments.

Table 2. Boll injury, cotton boll rot, and yield across the bottom and middle branches of cotton plants infested with leaffooted bug in three caging experiments.

		Infestation rate [b]		
Experiment [a]	Branch [a]	0	0.5	1
Boll injury (0 to 4 scale)				
2013 partial	B6-10	0.23 ± 0.12 (8) *		1.92 ± 0.45 (8) *
2013 whole	B6-10	0.14 ± 0.06 (5) a	0.64 ± 0.14 (5) ab	1.28 ± 0.25 (4) b
2013 whole	B1-5	0.16 ± 0.04 (5) a	0.34 ± 0.12 (5) a	0.50 ± 0.13 (4) a
2014 whole	B6-10	0.00 ± 0.00 (6) *		1.06 ± 0.30 (5) *
2014 whole	B1-5	0.00 ± 0.00 (6) *		1.24 ± 0.12 (5) *
Cotton boll rot (%)				
2013 partial	B6-10	6.25 ± 4.09 (8) NS		26.49 ± 9.51 (8) NS
2013 whole	B6-10	2.22 ± 2.22 (5) a	11.10 ± 1.89 (5) b	29.38 ± 7.95 (4) b
2013 whole	B1-5	2.04 ± 1.45 (5) a	5.06 ± 1.52 (5) a	9.18 ± 2.12 (4) a
2014 whole	B6-10	0.00 ± 0.00 (6) *		21.23 ± 5.47 (5) *
2014 whole	B1-5	0.00 ± 0.00 (6) *		25.12 ± 1.87 (5) *
Yield (g)				
2013 whole	B6-10	47.2 ± 4.89 (5) **	36.6 ± 3.61 (5) **	30.0 ± 2.89 (4) **
2013 whole	B1-5	114.4 ± 7.25 (5) **	113.2 ± 4.51 (5) **	107.3 ± 8.63 (5) **

Data were boll injury on a 0 (no injury) to 4 (severe lint degradation in all locules) scale and % cotton boll rot (all experiments) and yield (2013 whole plant experiment only). Mean ± SEM followed by replication number in parentheses. Tukey's means separation test was conducted for the 2013 whole cage experiment with three infestations rates, slicing data by branch section (means differing across infestation rates were indicated by different letters). When two infestation rates were used, a '*' and '**' indicate significant differences of the infestation and branch main effect, respectively. NS indicated no differences detected (see Table 1).

[a] For 2013 and 2014 whole plant experiments, data were separated by bottom branches (B1-5) and middle branches (B6-10). For the 2013 partial plant experiment, the data were comparable to the middle branch data of the whole plant experiments (designated as B6-10) because of low boll retention on the upper branches.

[b] Infestation rate: 0, 0.5, and 1 insect per plant (2013 whole) and 0 and 1 insects per plant (2013 partial and 2014 whole) plant experiments.

Cotton-Leaffooted Bug Interaction and Economic Perspectives

From a plant-insect interaction viewpoint, the leaffooted bug is as large or larger than stink bug species and much larger than verde plant bug that feed on cotton bolls. Esquivel (2015) has shown that mouthpart size is relevant to the ability of stink bugs to penetrate the carpel wall of the boll. Younger bolls (less than seven days old) had thinner more pliable carpel walls which were more susceptible to stink bug injury, and susceptibility varied by the mouthpart size of the different species (Esquivel 2015). For verde plant bug, bolls less than seven days old were injured more than older bolls, and large squares were also injured (Brewer et al. 2012). Compared to stink bugs and verde plant bug, leaffooted bug appeared to have the ability to injure larger bolls, although they may have preferred younger bolls or younger bolls were more susceptible to feeding-induced injury. In our study, there was more boll injury in the middle branches where average boll age was younger, than on the lower branches where average boll age was older (2013 whole plant experiment, Table 2). Differences in boll injury across branch sections were, however, not seen in 2014. Under the severe water-limiting conditions in 2014, boll integrity and leaffooted bug feeding may have been affected, complicating comparison of results to the previous year. Regardless, boll injury and cotton boll rot were seen both years on the bottom branches where boll age was as high as 33 days old at the time of infestation on positions one and two. Plant water stress may also be relevant to boll susceptibility (Glover et al. 2019). Additional experiments examining boll age susceptibility under water stressed and non-stressed conditions (Brewer et al. 2012, Glover et al. 2019), observing internal boll injury (Medrano et al. 2009), and measuring mouthparts and carpel wall thickness (Esquivel 2015) would better delineate the ability of leaffooted bug to penetrate the carpel wall as affected by boll age, size, and health.

Medrano et al. (2009) showed the capability of stink bugs to introduce cotton boll rot-causing bacteria. Cotton boll rot symptoms from bolls infested with stink bugs (Medrano et al. 2009, 2016, Glover et al. 2019) and verde plant bug (Brewer et al. 2013a) were similar to those observed in this experiment using leaffooted bug (Fig. 2). Combined with the cotton boll rot frequency differences detected across the leaffooted bug infestation rates (Tables 1 and 2), the data supported leaffooted bug as a suspect vector of cotton boll rot. Isolation of cotton boll rot-causing pathogens and transmission studies with leaffooted bug would verify causation of the disease and leaffooted bug as a vector (Medrano et al. 2009).

From an economic viewpoint, the stink bug complex and verde plant bug have the ability to cause cotton boll injury and economic damage (Greene et al. 2001, Brewer et al. 2013a, Glover et al. 2019), and introduce cotton boll rot-causing bacteria which magnifies the damage (Medrano et al. 2009, 2015, 2016). They can appear seasonally by mid-bloom when smaller bolls are present which will contribute to yield. Here, leaffooted bug was shown to injure bolls similarly and to be a suspect vector of cotton boll rot. Yet, there was no indication of yield loss caused by leaffooted bug using late-season cotton matured to about 5 NAWF when new fruit set was not expected to reach maturity before harvest (Table 1 and 2, Fig. 2). Although boll injury was observed on bolls in both middle and bottom branches, a high majority of bolls were likely sufficiently mature to reduce the severity of the injury and consequences to yield. Infestation intensity was also limited to no more than two levels not exceeding one bug per plant.

Management for boll-feeding species such as stink bugs and plant bugs focuses on a combination of first detection and inspecting young bolls for internal boll injury (Greene et al. 2001, Brewer et al. 2013b). First detection of leaffooted bug moving into cotton is very relevant to management given its traditional late-season arrival in cotton. We propose that the risk of yield impact is low when movement into cotton is detected late season when cotton development is at or approaching 5 NAWF, at least under the plant water stress conditions and infestation levels experienced in the experiments reported here. Our findings are consistent with reports of sporadic economic damage and the lack of recognition of leaffooted bug as a principle boll-feeding pest (Greene et al. 2006, Vyavhare et al. 2018), even though leaffooted bug is able to injure bolls and likely introduce cotton boll rot. Further field experimentation using cotton earlier in development across a wider range of infestations and under contrasting water availability would complement the experiments noted above on boll susceptibility and interaction with cotton boll rot. Together, they would increase our understanding of cotton-leaffooted bug interaction and the need for management, especially should leaffooted bug appears earlier in cotton development than commonly observed in south Texas and elsewhere at this time.

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