COTTON BOLL ABSCISSION INFLUENCED BY TARNISHED PLANT BUG FEEDING

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Abstract

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), is becoming a significant late-season pest in Louisiana cotton. The effects of TPB density and boll age on boll abscission were studied during 1997-1998. TPB adults were caged on bolls classed according to heat units (HU) accumulated. Boll abscission was recorded at 72 hours after infestation (HAI), 7 days after infestation (DAI) and at harvest. Significant differences in boll abscission between TPB infestation levels $\geq$ 2 TPB/boll and infestation levels $\leq$ 1 TPB/boll were observed at 72 HAI and 7 DAI. At 72 HAI and 7 DAI, cotton bolls that had accumulated $\leq$ 265 HU or 11.7 days beyond anthesis had higher boll abscission rates than that for the non-infested control. At harvest, boll abscission rates for the infested bolls remained higher from the non-infested controls until bolls accumulated approximately 300 HU or 13.3 days beyond anthesis.

Introduction

Tarnished plant bugs (TPB) can produce significant adverse affects on the growth and development of the cotton plant. TPB have been shown to cause excessive branching, swollen nodes, shortened internodes, deformed leaves (Hanney et al. 1977), and non-fertile squares (Scales and Furr 1968). Hanney et al. (1977) also found significant reductions in plant height and plant weight from TPB injury. Early season TPB infestations can reduce the number of fruiting forms, delay fruiting and crop maturity, and limit yield (Scales and Furr 1968, Tugwell et al. 1976, Hanney et al. 1977, Scott et al. 1985). Managing economic infestations of TPB can result in cotton plants with a higher fruit load, earlier maturity, and a higher yield (Scott et al. 1985, Snodgrass 1994).

Previous TPB research has concentrated on plant injury during the pre-flowering stages of development. The cotton plant is most susceptible to yield losses from TPB injury between the 4-6 true leaf stage through early squaring (Scales and Furr 1968). The most significant injury caused by the TPB is the result of feeding on young squares, which causes them to abscise from the plant (Pack and Tugwell 1976, Cleveland 1982, Layton 1995). TPB feeding results in a characteristic necrosis of the anthers and atrophy of the pollen sacs (Pack and Tugwell 1976). TPB feeding on squares during the early season can result in significant yield losses. Tugwell et al. (1976) documented that economic TPB infestations during the fourth week of squaring reduced total yield by 60%. TPB feeding on pre-flowering cotton can delay crop maturity in addition to reducing seedcotton yield (Scales and Furr 1968, Tugwell et al. 1976, Hanney et al. 1977, Layton 1995). TPB infestations occurring before the second week of squaring significantly increased plants with aborted terminals (Tugwell et al. 1976). These injured plants typically develop more vegetative branches and produce fewer fruiting sites from the loss of apical dominance. However, Hanney et al. (1977) documented that pre-flowering TPB feeding caused no significant affect on several yield variables including lint weight, seed weight, percent lint, boll weight, and seed per boll.

Until recently, few studies have examined the effects of TPB injury on cotton plants during the flowering and post-flowering stages of plant development. The effects of TPB injury on flowers and bolls have been considered relatively unimportant (Tugwell et al. 1976). The TPB has generally been considered an early season pest, and low levels of injury observed on bolls were due to lower TPB populations during the late-season. Tugwell et al. (1976) observed a 1-10% yield reduction from TPB injury to cotton bolls. However, boll and plant maturity was not considered a factor in that study. Pack and Tugwell (1976) reported TPB caged on 2-day old bolls significantly increased boll abscission and reduced seed cotton yield and seed quality. The objective of these experiments are to define the period of cotton boll susceptibility to TPB feeding by examining the effects of TPB density and boll maturity on cotton boll abscission.

Materials and Methods

All experiments were conducted at the Macon Ridge location of the Northeast Research Station (Louisiana State University Agricultural Center) near Winnsboro, LA. These studies were on transgenic *Bacillus thuringiensis*, var. *kurstaki* cotton variety (NuCOTN 33^{B}, Delta & Pine Land Co., Scott, MS) containing the Bollgardâ (Monsanto Co., St. Louis, MO) gene. The test area consisted of 16 rows by 76.2 m and was managed according to agronomic practices recommended by the Louisiana Cooperative Extension Service.

TPB Collections and Colony Maintenance

TPB adults were collected from cotton and native hosts in northeast Louisiana using a standard 15-inch diameter sweep net. The native hosts included *Coreopsis* spp. *Erigeron* spp., *Rumex* spp., and *Aster* spp. Insects were held in a 0.457 m^3 wire mesh cage in the laboratory for 24 h to reduce mortality from physical injury and disease. TPB were fed washed green beans, *Phaseolus vulgaris* (L.), and a 10% sugar water solution to maintain the health of the

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insects in the laboratory. The insects were placed into 20 ml glass vials and transported to the field in a chilled ice cooler to eliminate TPB mortality from heat stress.

Boll Infestation Procedures

Cotton plants were monitored bi-weekly until the first week of flowering. First position white flowers (flower located on the first fruiting node of a fruiting branch attached to the main-stem of the plant) were marked with a yellow "snap on tag" (A. M. Leonard, Inc. Piqua, Ohio) placed on the fruiting branch between the peduncle of the flower and the main-stem of the plant. The date of anthesis was recorded on the tag in permanent ink to ascertain the boll's age at the time of infestation. Boll age was calculated using heat unit (HU) accumulation beginning at anthesis as described by Bagwell and Tugwell (1992). HU were calculated as:

$$\frac{\text{(Maximum daily temperature + Minimum daily temperature)}}{2} \text{ (-) } 60^{0}\text{F=HU}$$

TPB infestation procedures were similar to that used by Adamczyk et al. (1997) for caging lepidopteran larvae on cotton bolls. Two TPB adults were placed into 15 cm x 11.5 cm nylon mesh (no. 280) bags and then caged on an individual boll. The opening of the bag was tightly closed around the peduncle of the boll with a drawstring. The date of the infestation was also recorded on the snap-on -tag for each individual boll. TPB were caged on each boll for 72 h, after which time the bags and insects were removed. The control bolls had bags placed on them containing no TPB. Multiple first position bolls were used on individual plants, however, bolls were selected at similar fruiting positions on adjacent plants to compare boll abscission in the control treatments to that in the infested bolls.

Tarnished Plant Bug Density

Infestation levels consisted of 0, 1, 2, or 3 TPB adults on a boll. TPB were placed on pink flowers (1-day old bolls, 21.5-28.5 HU) and allowed to feed for 72 h. The number of abscised bolls at 72 h after infestation (HAI), 7 d after infestation (DAI) and at harvest were recorded. All harvestable bolls were individually collected and seedcotton weights recorded to determine yields. Fiber quality data were also evaluated when sufficient lint (> 5 g) was available. Each infestation level was replicated 4 times between July 20 and July 30 during 1997 and again in 1998. Ten bolls were used for each infestation level in each replication. The data were analyzed with ANOVA procedures, and means separated with Fisher's Protected LSD (SAS Institute 1996).

Boll Maturity and TPB Injury

Cotton bolls at selected levels of HU accumulation beyond anthesis were infested with 2 TPB adults for 72 h. TPB infestations began at white flower (0 HU), and continued on bolls that had accumulated up to 487 HU. A total of 59 HU were used during 1997 and 1998. The sample size for each HU ranged from 9 – 85 flowers and/or bolls. At 72 HAI, the cages and TPB were removed. The number of abscised bolls were recorded at 72 HAI, 7 DAI, and at-harvest. Fiber quality data were also evaluated if sufficient lint (> 5 g) was available. Data were analyzed with simple regression procedures to determine the relationships between boll age and selected variables for the infested and control bolls (SAS Institute 1996).

Results and Discussion

Tarnished Plant Bug Density on Individual Bolls

There were no year and infestation density interactions for boll abscission at 72 hours after infestation (HAI) ($\underline{F}$=2.38, $\underline{df}$=3, $\underline{P}$=0.1037) or for boll abscission rates at-harvest ($\underline{F}$=144.79, $\underline{df}$=3, $\underline{P}$=0.4934). Therefore the data for both years was combined and analyzed as a single set of data.

Significant differences among density levels were observed for boll abscission at 72 HAI ($\underline{F}$=8.73, $\underline{df}$=18, $\underline{P}$=0.001), and at-harvest ($\underline{F}$=5.46, $\underline{df}$=18, $\underline{P}$=0.001) (Table 1). Boll abscission was significantly different among all infestation densities at 72 HAI and ranged from 35.0 % to 73.8% boll abscission for the infested bolls. All infestation densities produced significantly higher boll abscission compared to that for the non-infested bolls. A significant difference in boll abscission was also observed when comparing infestation levels of 1 TPB/boll to 2 or 3 TPB/boll at-harvest. However, no significant differences were observed between the non-infested and 1 TPB/boll treatment as well as between the 2 and 3 TPB/boll treatments. Boll abscission ranged from 58.8 % to 91.3 % in the infested plots at-harvest. The difference in boll abscission at-harvest compared to that at 72 HAI was the result of natural boll abscission during the growing season. The difference in boll abscission between the non-infested and 1 TPB/boll treatment at 72 HAI illustrates the sensitivity of 1-day old bolls to TPB injury. No difference between these two treatments at-harvest indicates many of the bolls that abscised at 72 HAI in the 1 TPB/boll treatment would probably have naturally abscised from the plant. A significant difference in boll abscission was observed between 2 and 3 TPB/boll at the 72 HAI period, but not at-harvest. This is likely due to the longer time interval between the boll infestation and the actual rating. Only infestations $\geq$ 2 TPB/boll resulted in significant boll abscission at 72 HAI and at-harvest.

Boll Maturity and Tarnished Plant Bug Injury

All data from the 1997 and 1998 growing seasons were combined to increase total sample size for a more accurate analysis.

A polynomial regression ($\underline{r}^2$=0.6946, $\underline{F}$=63.69, df=2, $\underline{P}$<0.001) was found to best describe the relationship between boll maturity and boll abscission for the infested bolls at 72 HAI (Fig. 1). Boll abscission for the non-infested bolls at 72 HAI appeared to have a linear relationship ($\underline{r}^2$=0.2158, $\underline{F}$=15.69, df=1, $\underline{P}$<0.001) with boll maturity. A higher incidence of boll abscission was observed in the infested bolls compared to the non-infested bolls until approximately 265 heat units (HU) or 11.7 days after anthesis.

At 7 DAI, a polynomial regression equation also best described boll maturity and boll abscission for both the infested ($\underline{r}^2$=0.7767, $\underline{F}$=97.43, $\underline{df}$=2, $\underline{P}$< 0.001) and non-infested bolls ($\underline{r}^2$=0.4258, $\underline{F}$=20.77, $\underline{df}$=2, $\underline{P}$< 0.001) (Fig. 2). Boll abscission appeared higher in the infested bolls compared to the non-infested bolls until approximately 265 HU or 11.7 days after anthesis.

Data for the infested ($\underline{r}^2$=0.8155, $\underline{F}$=123.78, $\underline{df}$=2, $\underline{P}$<0.001) and non-infested ($\underline{r}^2$=0.4187, $\underline{F}$=20.17, $\underline{df}$=2, $\underline{P}$<0.001) bolls was best described by a polynomial regression at-harvest (Fig. 3). Boll abscission rates appeared to be higher for the infested bolls compared to that in the non-infested bolls until approximately 300 HU or 13.3 days after anthesis. Data collected at-harvest was more variable than for the 72 HAI and 7 DAI evaluation intervals. Cotton plants will normally shed 30-50% of bolls between anthesis and harvest (Guinn 1982). An increase in natural boll abscission was observed during the growing season for both the infested and non-infested bolls. Boll abscission data collected at 72 HAI and 7 DAI were very close to the time of initial infestation and should represent the greatest effect of TPB induced boll abscission. The time period from the 7 DAI to harvest ranged from 40 - 84 days and allowed numerous factors in the environment to effect natural boll abscission. Boll abscission rates in the non-infested bolls were generally below 50% for bolls with < 100 HU, which is in the expected range for natural boll abscission in cotton fields (Kennedy et al. 1991, Stewart and Sterling 1988, Guinn 1986).

The abscission of bolls that had accumulated $\geq$ 300 HU was also recorded. The abscission of these older bolls was minimal but indicates that some older bolls (275 - 410 HU) will abscise when exposed to severe stress. The cause of abscission in these bolls was not identified because of the difficulty in finding the exact boll that had abscised. In some instances, the cause of abscission was attributed to larval feeding by lepidopteran pests or cotton plant diseases.

Bolls that have accumulated $\geq$ 300 HU probably will not abscise due to TPB injury. At boll abscission levels $\leq$ 20%, there is very little change in the regression line for the infested bolls and non-infested bolls. This level coincides with the accumulation of approximately 202 HU and is similar to first position boll abscission rates reported by Kerby and Buxton (1980). It appears that the TPB cannot sufficiently penetrate the carpal wall of a boll to result in the abscission of a boll that has accumulated $\geq$ 300 HU. Although sufficient injury may not be inflicted to cause boll abscission, damage to the lint and seed may still occur.

The data collected during 1997-98 is extremely important in the establishment of future thresholds for the control of late-season TPB populations.

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Table 1. Boll Abscission Rates for Selected Tarnished Plant Bug Densities on Caged Individual Bolls.

	Percent Abscised Bolls ± S. E.	
Tarnished plant bug/boll	72 HAI[1]	Harvest
0	10.0 ± 6.2 d	50.0 ± 7.3 b
1	35.0 ± 7.3 c	58.8 ± 5.2 b
2	56.3 ± 5.9 b	83.8 ± 3.8 a
3	73.8 ± 9.0 a	91.3 ± 3.9 a
P>F	0.0001	0.0001

Means followed by same letter do not significantly differ (P= 0.05, Fisher's Protected LSD)

[1] Hours after infestation.

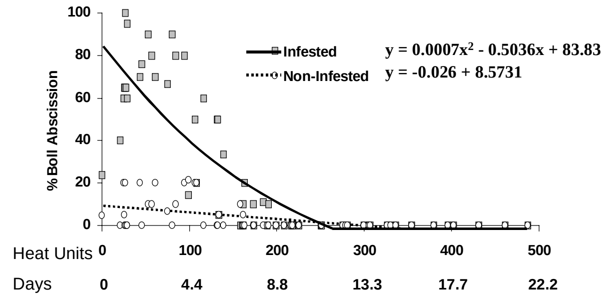

Figure 1. Effects of Boll Maturity on Tarnished Plant Bug Induced Boll Abscission at 72 Hours After Infestation (2 Adult Tarnished Plant Bugs / Boll)

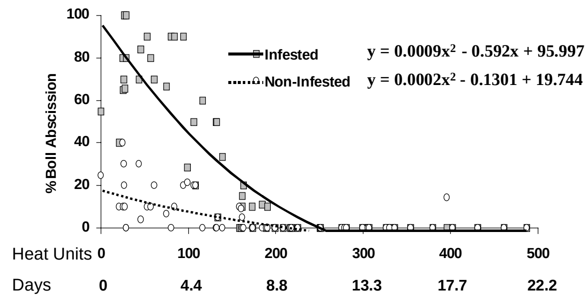

Figure 2. Effects of Boll Maturity on Tarnished Plant Bug Induced Boll Abscission at 7 DAI (2 Adult Tarnished Plant Bugs / Boll)

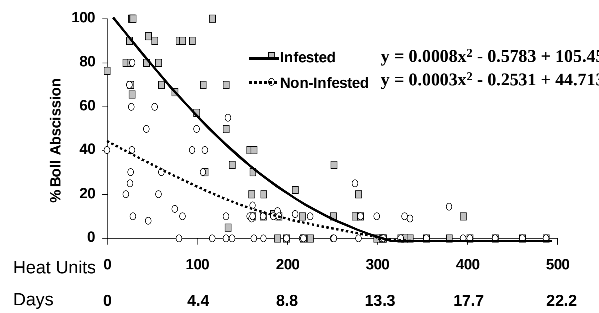

Figure 3. Effects of Boll Maturity on Tarnished Plant Bug Damage (2 Tarnished Plants Bugs / Boll at Harvest)