GLANDLESS COTTON IN NEW MEXICO: BEET ARMYWORM, *SPODOPTERA EXIGUA* AND BOLLWORM, *HELICOVERPA ZEA* DEVELOPMENT AND FIELD DAMAGE

Jane Breen Pierce
Patricia E. Monk
Andrew Garnett
Robert Flynn
John Idowu
New Mexico State University
Las Cruces, NM

Abstract

Cotton glands produce gossypol, a natural defense against insect pests. Glandless cotton varieties are available, but losses from pests have prevented commercial development. Some areas of New Mexico have somewhat lower insect pressure, with high predation and desiccation, suppressing pest populations. With appropriate management and monitoring of insect pests, growers could potentially produce glandless varieties as a niche crop with greatly added seed value. In 2011-2013, field and field to lab trials were conducted on a New Mexico State University farm to determine susceptibility to lepidopterous pests.

Bollworm and beet armyworm survival was 2-6 times higher at pupation on glandless cotton in 2013. Among survivors, beet armyworm fourth-instar larval weights and pupal weights were not significantly different on glandless or glanded cotton in 2012. However, those on glandless leaves required 4 less days to reach pupation. Bollworm fourth instar larvae were 69% heavier, pupae were 16% heavier on glandless cotton squares, and pupated in 9 fewer days compared to those on glanded cotton. Survival was not affected by nitrogen although there were some impacts on development.

Glandless cotton had twice as many damaged squares within 2012 and 2013, but no difference in 2011. The numbers of damaged squares were not affected by nitrogen levels. Results in 2013 were similar to 2012. However, in 2013 monitoring of each instar indicated that beet armyworm was significantly more likely to molt into a sixth instar when feeding on conventional rather than glandless cotton. This delay in development allowed beet armyworm to compensate for slower weight gain and pupate at weights similar to those fed on glanded cotton despite being significantly smaller at 14 days. Glandless cotton is more susceptible to insect injury, but will likely be manageable as a valuable niche crop.

Introduction

Cotton has glands that produce natural toxins, primarily gossypol, that provide resistance to insects. Cottonseed is high in protein, and could be a value added product but it also contains 1% gossypol, and only ruminant animals can digest it well. Glandless, gossypol-free varieties of cotton, show promise in utilizing cotton seed as a protein source in food products increasing seed value for growers. (Jenkins et. al. 1966, Bottger et. al. 1964, Lukefahr et. al. 1966). However, both laboratory and field trials showed greater larval growth of cotton bollworm and tobacco budworm on glandless cotton. (Lukefahr et. al. 1966). Diet containing gossypol fed to beet armyworm and bollworm reduced 10 day larval weights and increased the number of days required for pupation (Bottger, et. al. 1966). Glandless cotton was not considered a viable option in much of the cotton belt due to losses from pests. Lower insect pest pressure in New Mexico might allow commercialization of glandless cotton as a niche crop. Beneficial insect populations are also high in New Mexico, and could help control the higher populations of insect pests. Bt cotton has also reduced the prevalence of once key insect pests.

Plants with high nitrogen levels have shown increased insect damage in many crops (Mattson 1980). Beet armyworm and bollworm preferred to oviposit on cotton containing higher N (Chen et. al. 2008, Pierce et. al. 2001). The objective of this trial was to determine differences in field damage and lab evaluations of survival and development on glandless and glanded cotton, and if differences in nitrogen would affect these responses.

Material and Methods

Field plots of glandless Acala-GLS and glanded Acala1517-08 were 100 feet long by four rows wide and replicated four times. One day before nitrogen fertilization, 40 petioles were collected and continued once a week to determine nitrate levels throughout the trial period. Field to laboratory bioassays were also conducted using field collected squares and leaves to determine effects on survival, development and feeding preference. At the initiation of the field to lab bioassay, squares were randomly sampled daily from field plots and examined for bollworm damage. Whole plants were sampled to determine beet armyworm infestations. Laboratory reared first instar cotton bollworm and beet armyworm were fed glandless or glanded cotton squares or leaves at both high and low nitrogen levels, and maintained until adult emergence. Ten first instar bollworm (*Helicoverpa zea*) and beet armyworm (*Spodoptera exigua*) were fed glandless or susceptible cotton squares or leaves from the field in petri dishes with 30 dishes per trial. After 48 hours, each dish was reduced to one larva which was fed daily, weighed at fifth and sixth instar and maintained until adult emergence.

Results

Beet Armyworm and Bollworm Field Damage

Despite similar rates of infestation by beet armyworm with 98% of all plants infested, defoliation rates were very high only in glandless cotton in 2011. In 2012 and 2013, there was no beet armyworm pressure and no damage was noted. However in 2013, as in 2012, glandless plants had more than twice as many damaged squares from bollworm as glanded plants with 6% and 3% mean damage in glandless and glanded plots (Figure 1). High nitrogen plots did not have more damaged squares than low nitrogen plots in 2013 as in 2012. (Garnett et. al. 2013)

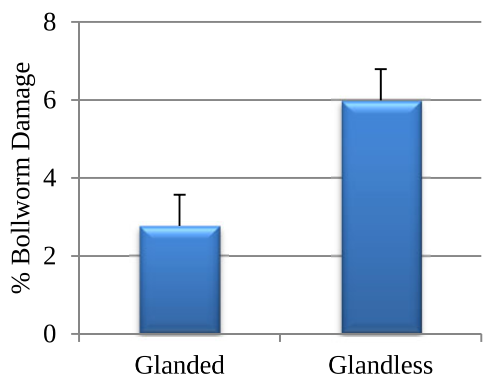

Figure 1. Percent damaged squares in glanded and glandless cotton from bollworm.

Feeding Preference for Glandless Cotton by Beet Armyworm and Cotton Bollworm

Beet armyworm preferred feeding on glandless cotton with twice as many feeding on glandless cotton after 48 hours (63 vs 32%). There was no significant preference for glandless cotton by 1st-2nd instar bollworm larvae with 56% vs 44% feeding on glandless and glanded cotton squares.

Development of Beet Armyworm and Bollworm on Glandless Cotton

As in 2012, there was no difference in 1st-2nd instar survival of beet armyworm or bollworm after 48 hours. Beet armyworm had 69 and 72% survival on glanded and glandless cotton respectively. Bollworm larvae had 63% survival on both glanded and glandless cotton (Garnett et al. 2013). However, ultimately beet armyworm and bollworm survived at higher rates and developed faster on glandless cotton. At 10 and 14 days larvae on glandless cotton were more than 3 times heavier. Weights at 5th and 6th instar were less dramatically different because larvae on glanded cotton fed 3 days longer and most affected, smaller larvae did not survive to pupation. Almost 3 times more beet armyworm fed glandless cotton molted to a sixth instar before pupating suggesting that this is a means of adding the additional weight necessary to successfully pupate (Table 1).

Table 1. Development on glandless vs. glanded cotton 2013.

Insect	Host Plant	5th Instar Wt.	6th Instar Wt	Pupal Wt
		mg (s.e.)	mg (s.e.)	mg (s.e.)
Beet armyworm	glanded	38 (2)	97 (8)	83 (3)
	glandless	71(4)	115 (11)	88 (2)
Bollworm	glanded	52 (8)	203 (22)	98 (-)
	glandless	78 (4)	238 (5)	275 (3)

Impact of Nitrogen

Beet armyworm and bollworm larvae reared on glandless cotton leaves or squares had 2-3 times higher survival to pupation compared to those fed on glanded cotton (Figures 2 & 3). Survival was not significantly affected by nitrate levels.

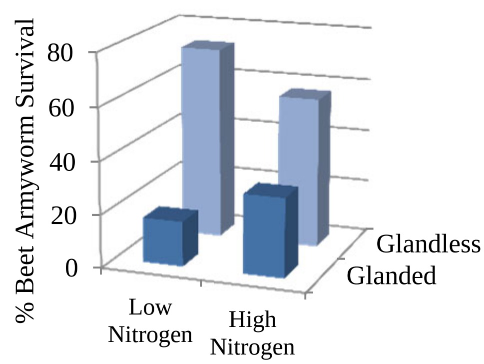

Figure 2. Percent beet armyworm survival on low and high N glanded and glandless leaves.

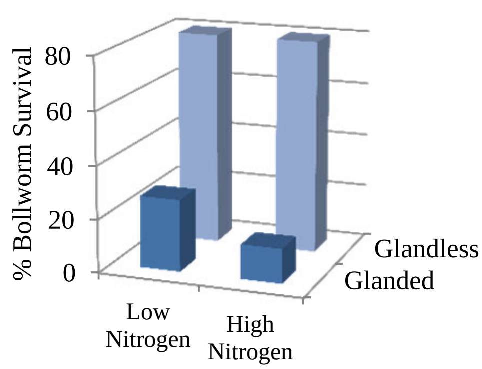

Figure 3. Percent bollworm survival on low and high N glanded and glandless squares.

Glanded/Glandless Predators

A number of predators were more prevalent in glanded rather than glandless cotton, particularly, early season (Figure 4). Ladybugs and spiders, in particular, were more abundant in glanded cotton.

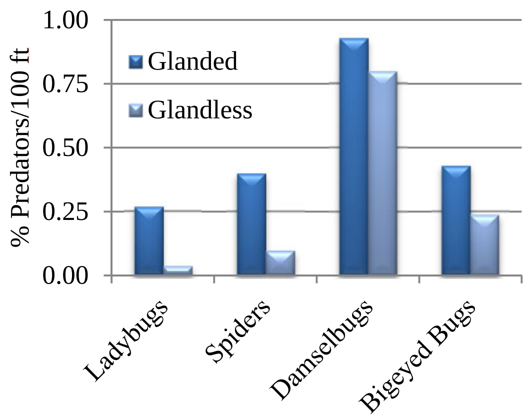

Figure 4. Percent predators per 100ft in glanded and glandless cotton.

Conclusion

Glandless cotton is more susceptible to injury by insect pests, but the higher value of glandless cottonseed likely compensates for that risk. Beet armyworm damage in field plots was significantly higher in glandless compared to glanded cotton in 2011, but not in 2012 or 2013. Bollworm square losses were 2-4 times higher in glandless cotton plots in 2012-2013, but were not correlated with yield losses. Larvae feeding on glanded cotton compensated to a degree for the low quality of the host plant by feeding longer and often with an additional molt to sixth instar. However, survival to pupation was still 2-6 times higher in larvae fed glandless cotton. Field and lab data suggests that glandless cotton will require close monitoring but that development of insect pest management strategies can make it a viable option.

Acknowledgement

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