GLANDLESS COTTON IN NEW MEXICO: IMPACT OF NITROGEN ON GOSSYPOL ASSOCIATED RESISTANCE TO COTTON BOLLWORM AND BEET ARMYWORM

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Abstract

Cotton glands produce gossypol, a natural defense against insect pests. Glandless cotton varieties have been developed but were rejected as a commercial crop in many areas due to losses from pests. New Mexico has lower insect pressure than most of the cotton belt, and could potentially produce glandless varieties as a niche crop with added seed value. In 2012, field trials were conducted on a New Mexico State University farm to evaluate the influence of nitrogen and glandless cotton on cotton bollworm and beet armyworm survival and development in field and lab trials.

Field petiole nitrate levels were 1573-1765 ppm N in low nitrogen treatment plots and 5211-6243 ppm N in high nitrogen treatment plots when a field to lab bioassay was initiated. Survival was not affected by nitrogen levels in the first 48 hours in early instar larvae. Survival to pupation also was not affected by nitrogen level. Beet armyworm fourth instar larvae were 30% larger and required two less days to reach pupation on high N cotton. Bollworm pupal weights were 9% larger on high N cotton but there was no significant difference in fourth instar larval weights or days to pupation

Effects of glandless cotton were more notable. Although there was no difference up to 48 hours, bollworm and beet armyworm survival was 5-10 times higher at pupation on glandless cotton. Beet armyworm fourth instar larval weights and pupal weights were not different on glandless or glanded cotton. 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. Bollworm larvae also developed 43% faster on glandless cotton pupating in 21 days vs. 30 on glanded cotton.

Field square damage was significantly higher in glandless plots compared to glanded plots. Glandless plots had twice as many damaged squares with 6% damaged squares compared to 3% damaged squares in glanded plots. The number of damaged squares were not affected by N levels.

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 and Patana 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. Three times more cotton aphids were found on cotton containing higher N (Godfrey and Hutmacher 1997). 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 survival and development on glandless and glanded cotton, and if differences in nitrogen would affect these responses.

Materials 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 sampled daily from field plots and examined for damage by insects. 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 pupation. Ten first instar bollworm or beet armyworm larvae were fed leaves or squares of glanded or glandless cotton from high or low N plots. After 48 hours the number of larvae were recorded and reduced to one larvae per dish which was maintained until adult emergence. Data collected included weight of 4^{th} instars and pupae, days to 4^{th} instar and pupation and survival.

Results

At 48 hours, 55-61% early instar bollworm larvae survived after feeding on high and low N treatments of glanded and glandless cotton squares. At 48 hours, 81% of beet armyworm larvae survived in all nitrogen and glanded/glandless treatments (Table 1).

Table 1. Percent Survival of Early Instar Larvae by Gossypol Content.

Insect	48 Hour Feeding			48 Hour Feeding		
	Glanded		Glandless	Low N		High N
Bollworm	55%		60%	55%		61%
P>t		0.13			0.067	
Beet armyworm	81%		81%	81%		81%
P>t		0.72			0.72	

Nitrogen Effects:
Bollworm pupal weights were 9.6% heavier on high N compared to low N but fourth instar larval weights and days to pupation were not significantly different (Table 2). Beet armyworm fourth instar larvae were 30% heavier on low N compared to high N but, there were no significant differences in pupal weights. Beet armyworm feeding on low N leaves developed significantly faster. Those on glandless cotton pupated in 21 days vs. a mean 23 days on glanded cotton, 9% faster (Table 2).

Table 2. Impact of Nitrogen on Development of Bollworm and Beet Armyworm

Insect	Nitrogen	4th Instar Wt. (mg)	Pupal Wt. (mg)	Pupation Days	Insect	Treatment	4th Instar Wt. (mg)	Pupal Wt. (mg)	Pupation Days
Bollworm	Low	71	301	25	Beet Armyworm	Low	51	75	21
	High	72	330	26		High	39	68	23
	T	-0.15	2.67	1.2		T	-2.18	-1.01	3.37
	P>t	0.88	0.01*	0.23		*P*>t	0.03*	0.32	0.002*

Effects of Glandless Cotton:
Fourth instar bollworm larvae were 69% larger on glandless cotton squares compared to those fed glanded cotton. Pupae were over 16% larger on glandless cotton. Bollworms feeding on glandless cotton developed faster pupating on average 9 days faster than those on glandless cotton (Table 3). Beet armyworm fourth instar larval and pupal weights were not affected. Development time was once again reduced, with beet armyworm pupating 4 days sooner on glandless cotton (Table 3).

Table 3. Development of Bollworm and Beet Armyworm on Glanded and Glandless Cotton

Insect	Treatment	4th Instar Wt. (mg)	Pupal Wt. (mg)	Pupation Days	Insect	Treatment	4th Instar Wt. (mg)	Pupal Wt. (mg)	Pupation Days
Bollworm	Glanded	53	291	30	Beet Armyworm	Glanded	43	71	24
	Glandless	90	339	21		Glandless	47	74	20
	T	-2.83	-2.63	10.42		T	-0.72	-0.34	2.65
	P>t	0.0006*	0.01*	<0.0001*		*P*>t	0.48	0.74	0.012*

Cotton bollworm and beet armyworm survival to pupation was not significantly affected by N level (Figures 1 & 2). However, survival was 5-11 times higher in glandless compared to glanded cotton. Beet armyworm had 51% and 10% survival on glandless and glanded cotton squares respectively (chi^2=19.3 P<0.001). Bollworm had 85% and 8% survival to pupation on glandless and glanded cotton leaves respectively (chi^2 = 45.3 P<0.001).

Field square damage was not significantly different by high or low N (t = -1.12, P< 0.27). However, there were significantly more damaged squares in glandless cotton, with 5% damaged squares compared to 2% in glanded plots (t = -3.49, P < 0.0007).

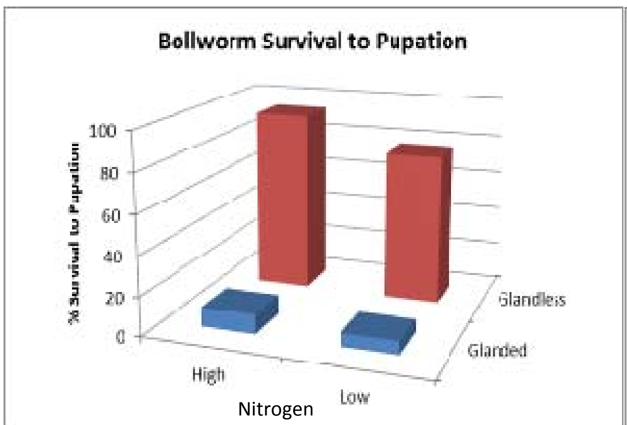

Figure 1. Bollworm percent survival to pupation.

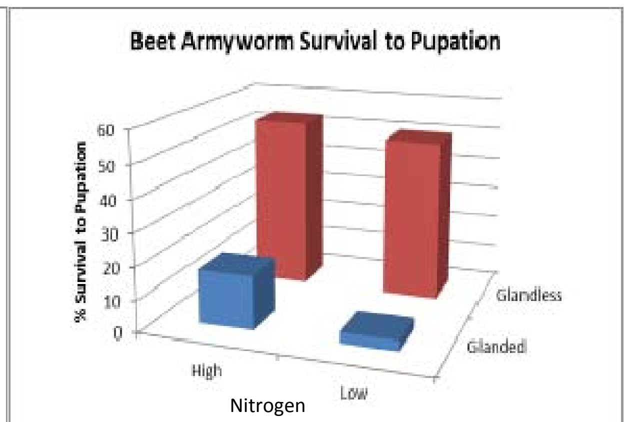

Figure 2. Beet armyworm percent survival to pupation.

Conclusion

The difference in survival to pupation in two insect pests is the most significant concern. Bollworm and beet armyworm survival on glandless cotton was ten times and five times higher than on glanded cotton.

A shorter development time, 25-43% faster in beet armyworm and bollworm respectively, is also a significant concern. It suggests that populations could increase in the field more rapidly, and allow more opportunity for these pests to avoid predation.

Glandless cotton was more susceptible to both bollworm and beet armyworm damage. Damage to squares from field collected squares was significantly higher in glandless plots, confirming the potential for greater field damage in glandless cotton. However, square damage in the glandless plots was late season, and not likely to cause yield losses (Pierce et. al. 2007).

Natural controls for insect pests in New Mexico are high. Predation rates are often over 80% and control from desiccation is also high. There is potential for losses, particularly if glandless cotton is managed no differently than glanded cotton. However, management practices can help maintain pests at subeconomic thresholds. Planting Bt cotton nearby and earlier than glandless cotton will likely help protect glandless cotton. Glandless cotton can be planted in areas near alfalfa to benefit from beneficial predator populations (Pierce et. al. 2011). These and other strategies can be investigated to determine the best pest management practices to develop glandless cotton into a niche product for New Mexico. Savings from the lack of a tech fee for bollworm would also allow growers to budget for rescue treatments if necessary.

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