1826 Yield compensation from simulated bollworm injury in New Mexico

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Cotton plants very effectively compensated for square losses primarily by retaining squares or bolls that would otherwise have been shed. In 2003, plots with 4 squares removed once had 1% yield loss and averaged 95 bolls/m, 10% less than the 105 bolls/m in the control plots. Plots with 8 squares removed/plant over two weeks produced 85-95 bolls/m, 10-18% less than control plots. Lint yields were 10-16% less than control plots. The loss of 8 bolls/plant resulted in 66-79 bolls/m, 25-37% less than the control plot. Compensation was nonetheless evident since these plots would have produced 58% fewer bolls than uninjured plots with no compensation. Yields were consistent with the number of bolls, 29-33% less lint than control plots. Control plots produced 1899kg/Ha compared to 1265-1348 in boll removal plots. Cotton compensated primarily by retaining bolls that otherwize would have been shed. At times, cotton compensated by producing more lint per boll. Lint weight per lock was significantly higher in plots injured 8/4. These plots had only 1% yield loss despite losing 4 squares/plant and despite having 10% fewer bolls/m at season end. Cotton overcompensated for the loss of 4 squares/plant on 8/15 producing 0.47 g/lock, 12% higher than the 0.42 g/lock from the check plots. Lint yields were 1820kg/Ha in the injured plot, not significantly different from the 1775kg/Ha in the undisturbed plots.

KEYWORDS: Compensation, Cotton, Insect, *Helicoverpa zea*, Losses, Pest,Yield

INTRODUCTION

Management decisions regarding crop inputs are often difficult. Real and immediate costs for control must be weighed against estimates of yield losses and crop value. In New Mexico, cotton bollworm, *Helicoverpa zea* (Boddie), is a late-season pest injuring the crop when the value of susceptible squares and bolls is relatively low. Good estimates of the ultimate yield value of the susceptible squares or bolls are essential to determine if insecticide applications are justified.

The value of mid-late season squares diminishes rapidly making the return on insecticide inputs questionable. Further complicating the issue, crop value for economic thresholds in cotton sometimes assume a worst-case scenario where boll value is determined from undisturbed plants. The value of missed squares or small bolls is not equal to harvestable bolls from undisturbed plants. Cotton has a known ability to compensate for insect injury to fruiting structures. Resources that would have been directed toward development of fruit can be redirected. On the other hand, late season injury may allow little time for compensation. Also very late season, if squares are unavailable, bollworms will infest small bolls in which the plant has a higher investment. These issues justified field tests to specifically address potential compensation for insect injury to mid-late-season cotton in New Mexico.

MATERIALS AND METHODS

In 2002-2006, field trials were conducted in Artesia and Las Cruces, New Mexico to evaluate compensation from heavy mid-late-season bollworm injury. Manual removal of fruiting structures produces essentially the same crop response as damage by pests, so squares and

bolls were removed manually (Brook et. al. 1992). Treatments were designed to mimic extremely heavy bollworm injury by removing 4-8 susceptible bolls or squares at 1-2 time points per treatment in 2002-2003.

Small squares were removed August 1 and 15 in 2002. Small bolls were removed late August 29 and September 12. COTMAN data was collected in control plots. Plots were three meters with six replicates in randomized blocks. Yields were determined by removing all plants from each plot. Seed cotton was hand picked then sorted by node and position for each plot. Lint quality was determined for each node and position.

Small squares were removed once August 4 in 2003. Small squares were removed twice over two weeks beginning August 1 and 15. Eight small bolls were removed beginning August 28 and September 11. COTMAN data was collected in control plots. Plots were three meters with six replicates in randomized blocks. Yields were determined by removing all plants from each plot. Seed cotton was hand picked then sorted by node and position for each plot and ginned separately. Lint quality was also determined for each node and position.

In 2004-2005, compensation trials were also conducted with larger plots, 9 meters long in randomized blocks. Squares or bolls were removed once a week for two weeks late-season. A total of eight squares or bolls were removed from each plant twice as many as the 2002-2003 trials. Yields were determined by hand picking all plots without regard to node or position. Seed cotton was ginned and quality determined from this pooled yield per plot.

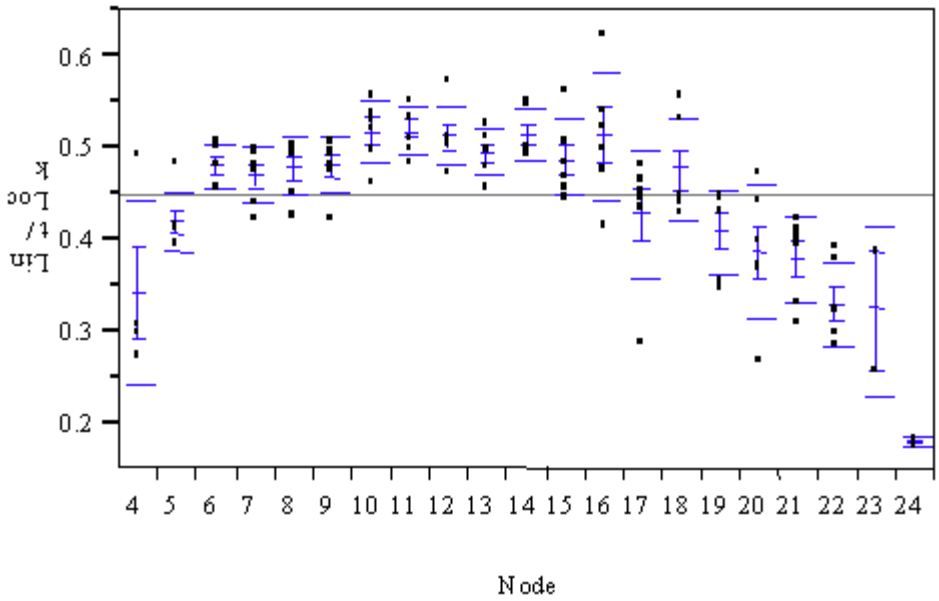
RESULTS

In 2002 and 2003, all plots exhibited at least some compensation for injury. The primary means of compensation was by retaining more squares and bolls, but sometimes also by producing more lint per boll. Higher boll retention is evidenced by a harvestable boll number greater than what would be expected when the number of removed squares or bolls are subtracted from the harvestable boll number in the undisturbed plot.

In the 2002 test, both undisturbed and square removal plots had 95-98 bolls/m, despite removal of 3 squares per meter (Table 1). Lint yields from square removal plots were similar to those from uninjured plots and ranged from 1658-1820kg/Ha. The highest yield, 1820kg/Ha, was from one of the treatment plots with squares removed 8/15, from the 17-21st nodes. In those same plots mean lint weight per lock and boll was 12% higher than uninjured plants. The difference in boll weight was particularly notable in very late bolls, nodes 19-22 where the injured plants' bolls had 20% more lint than control bolls. (Figures 1 and 2)

Injury from loss of bolls is, not surprisingly, more difficult to compensate. Yield was somewhat compensated in plots with bolls removed 8/29. Lint yields were 9.9% lower than undisturbed plots. Those injured plots had 90 bolls/m, only 10% fewer than undisturbed plots despite losing 4 bolls per plant. The final plant population was 8.04 plants/m. Without compensation, injured plots would have produced 98.8-(4 x 8.04)=66.6 bolls/m or 33% less than undisturbed plots. Plants with small bolls removed 9/12 had no yield compensation. These plots averaged only 1232kg/Ha, 31% less lint than undisturbed plots. The number of bolls was also significantly fewer with 69 bolls/m, 30% less than the 98.4 bolls per meter in undisturbed plots. This 69 bolls was consistent with the number, 67 predicted to be left at harvest, if plants did not compensate.

Overcompensation with yields higher than undisturbed plots was made possible by adding higher lint weight per lock, to increased square or boll retention. Mean lint weight per boll and per lock was 12% higher for plants with squares removed 8/15 compared to undisturbed plants (Table 1). Undisturbed and all other treated plots had approximately 0.5 g lint/lock in nodes 10-16, but less lint in earlier and later nodes. (Figure 1) Overcompensating plants had high lint weights per lock in all but the last two nodes, 21st and-22nd. (Figure 2)



In the 2003 test, plots with squares removed once had 95 bolls/m, 10% less than the check plots. With no compensation these plots should have produced only 75 bolls/m due to the removal of 30.2 squares per foot. (Table 2). These relatively low injury plots had lint yields similar to the control plots with 1876kg/Ha, only 1% less than the 1899kg/Ha in the uninjured plots. As in 2002, there was some evidence of compensation apart from greater boll or square retention. Part of this yield compensation was due to larger bolls. These injured plots had significantly higher lint weight per lock, 0.44g/lock vs 0.43 in the check plots and 0.42-0.43 in all other injured plots.

Removal of 4 squares twice beginning 8/1 and 8/15 produced 95 and 85 bolls/m, 10 and 18% less than control plots. Still this final boll load was much greater than the 46 bolls/m that would have been expected without compensation. Removal of 8 squares/plant in plots with 7.5 plants/m should have produced a yield loss of 60.1 bolls/m or a 58% loss compared to the 105 bolls/m in the control plots if there was no compensation. Neither of the 8 square removal treatments resulted in significant lint yield losses/hectare which ranged from 10-16%. The August 1 injury plots produced 1705kg/Ha, a 10% loss compared to the control plots. The August 15 plots produced 1590kg/Ha a 16% loss compared to control plots. The earlier injury may have allowed more time for compensation through greater retention of squares and bolls since the August 1 plots had 95 bolls/m compared to 85 bolls/m in the later injured August 15 plots.

Injury from loss of bolls is, not surprisingly, more difficult to compensate. Plots with boll injury had 29-33% yield losses with 1265-1348kg/Ha. These plots also had with 66-79 bolls per meter, 25-37% boll losses compared to the 105 bolls/m in the control plots. Despite the

high losses and very late damage date there was still some compensation since without compensation these injured plots would have produced 105-66 bolls/m or only 46 bolls per meter, a 58% loss.

The larger plot tests which were hand-picked but not separated by node and position had yield losses ranging from 23-57%. (Figure 3) Plots that had a total of eight squares removed /plant July 16-23 produced an average 1214kg/Ha. Plants that had squares removed July 29-August 5 produced 1160kg/Ha. These yields were significantly lower, 23% and 26% respectively than the undisturbed plots, which produced 1571kg/Ha. Plots with eight bolls removed Aug 18- Sept 9, and Sept 23 produced 803kg/Ha and 669kg/Ha respectively, 49% and 57% less than control plots.

CONCLUSION

Yield compensation was variable and dependent on intensity of injury, reproductive organ injured (square or boll) and time of injury. Compensation was primarily accomplished by greater retention of remaining squares or bolls. Some compensation was accomplished in one treatment by producing heavier bolls. Late-season removal of four squares per plant did not have a significant impact on yield. Loss of eight squares per plant may be enough to impact yield. Although the 10-16% loss was not significant in small plots tests reported here, larger plot tests in 2004 did result in significant losses (Pierce et al 2006, 2007). Similar injury at an earlier time point in 2004 (July 16 and 29) resulted in greater yield losses 23-26%. Removal of eight bolls per plant, very late-season, did produce high yield losses (29-33%) albeit still less loss than would be expected without plant compensation.

Effective compensation was evident with relatively high rates of injury, but persistent high levels of injury can prevent the plant from completely compensating for losses. Plants are more likely to compensate for square losses than boll losses in which the plant has invested more resources.

Studies in other states have examined the effect of square loss on cotton yield with responses ranging from slight yield increases to dramatic decreases (Sadras 1995). In Louisiana, Homan (1996) indicated that up to 19% first-position square shed at first flower did not result in a yield loss. Square losses above 19% did produce a significant yield loss. In the San Joaquin Valley, Montez and Goodell (1994) found that light to moderate losses of early squares had higher yields than control plots. Very severe losses of squares resulted in some yield loss. Our trials are consistent with results of these earlier studies. However, our focus was on late season injury with bolls or squares of lower value. Three years of testing has indicated that late season square losses would have to be in excess of 4 squares/plant or 30 squares/meter. This is close to 100% of available 1/3 grown squares at a given time point late-season. Yield losses are not incurred from late-season square injury unless the loss is both heavy and persistent. Boll losses are more significant. However, cotton displays an impressive ability to compensate at least partially for even very late-season boll losses.

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**Table 1. Yield Compensation after Square/Boll Removal from Acala 1517-99*

in 2002

Square/Boll Removal Date	Reproductive organs lost/plant	Bolls/Row Meter	Lint Wt/Lock (grams)	# kg lint/Ha
Untreated	none	98.4a	0.42a	1775a
8/1	4 squares	95.1b	0.41a	1658ab
8/15	4 squares	98.8a	0.47b	1820a
8/29	4 bolls	89.9ab	0.43a	1599ab
9/12	4 bolls	68.9b	0.44a	1232b

***Means across rows followed by different letters are significantly different by Tukey's Comparison**

Table 2. Yield Compensation after Square/Boll Removal from Acala1517-99 in 2003, Artesia, NM.*

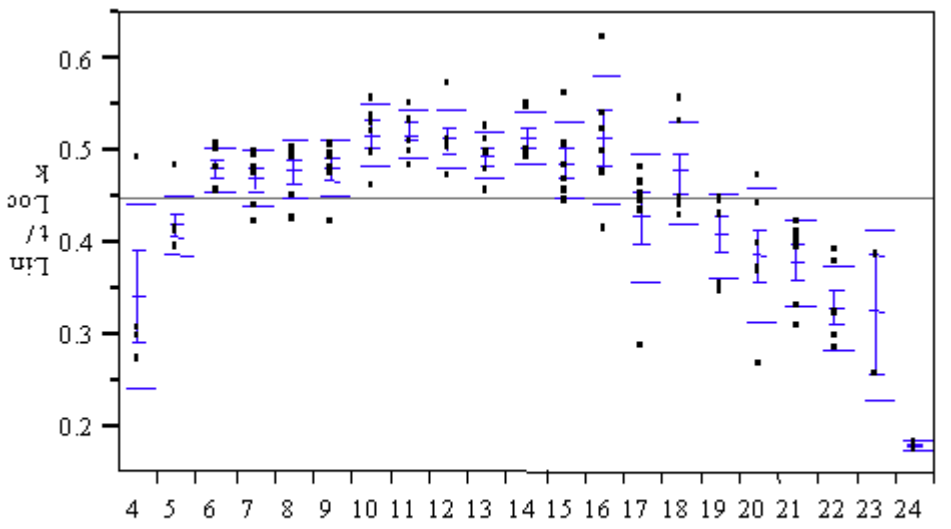
Square/Boll Removal Date	Reproductive Organs Lost/Plant	Bolls/Row Meter	% Loss	Lint Wt/Lock (grams)	# Locks/Boll	Lint (Kg/Ha)	% Loss
Untreated	None	105a	(0)	0.43a	3.9a	1899a	(0)
8/1	8 Squares	95ab	(10)	0.43a	3.9a	1705a	(10)
8/4	4 Squares	95ab	(10)	0.44b	3.9a	1876a	(1)
8/15	8 Squares	85b	(18)	0.43a	4.0a	1590ab	(16)
8/28	8 Bolls	66c	(37)	0.42a	3.9a	1265b	(33)
9/11	8 Bolls	79bc	(25)	0.42a	3.9a	1348b	(29)

***Means across rows followed by different letters are significantly different by Tukey's Comparison**

Figure 1. Lint weight per lock by node in undisturbed Acala 1517-99 compensation test in 2002.

Figure 2. Lint weight per lock by node in plots with four squares removed 8/15/02 from Acala 1517-99.

Figure 3. Lint (lb/A) of cotton with eight squares or bolls removed over two weeks in 2004.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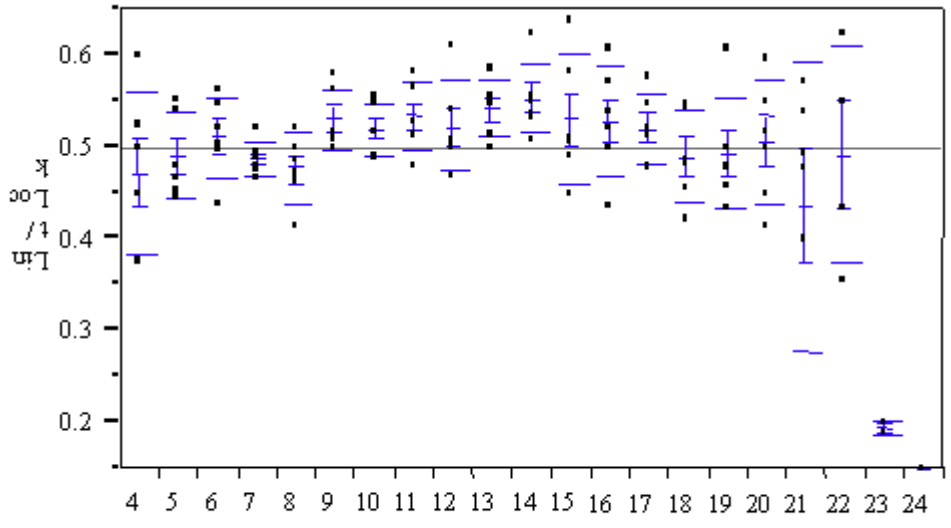
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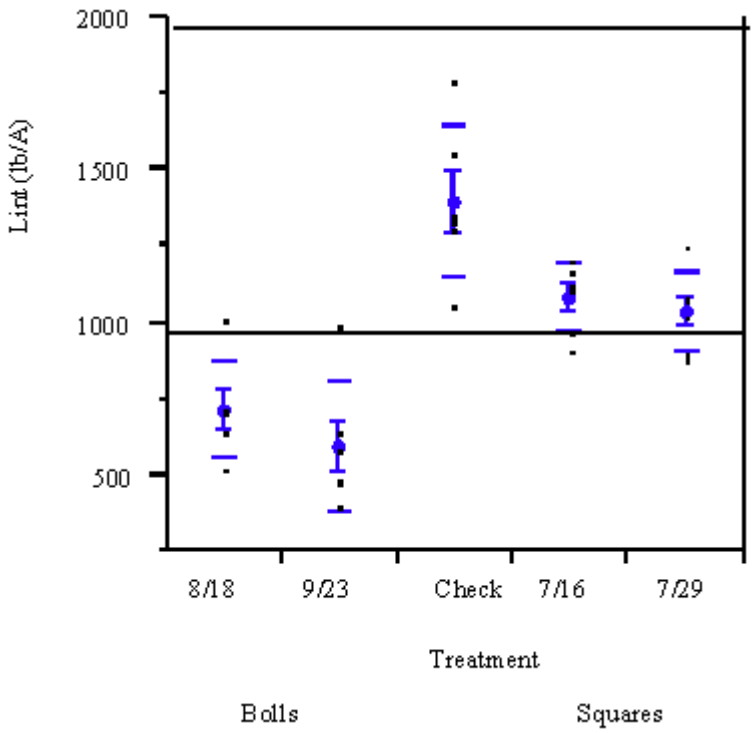
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