HELIOTHIS DAMAGE THRESHOLDS IN RELATION TO COTTON BOLL WEIGHT

Frank Bordelon and Gerald Myers
The Department of Agronomy
Louisiana State University
B. Roger Leonard
Macon Ridge Research Station
Louisiana State University

Abstract

Within the last ten years, there has been a large increase in the number of commercial cotton cultivars, *Gossypiun hirsutum* L., available for production. Most cotton cultivars available in the past were similar morphologically and the more recently developed cultivars set bolls at a different time period than older cultivars. Breeders have inadvertently been selecting plant types with smaller bolls and with fewer and smaller seed per boll. Due to the inverse relationship existing between number of bolls per plant and boll weight, the objective of the research was to determine if the economic injury level could be varied based on boll weight for Tobacco Bud Worms (TBW) (*Heliothis virescen* Fabricius) and Boll Worms (BW) (*Heliothis zea* Boddie). The experiment was conducted at the Macon Ridge Research Station, in 1995, comparing six cotton varieties; Stoneville LA 887 (STV LA887), Stoneville 132 (STV 132), Chembred 830 (CB 830), Hartz 1215 (H1215), Delta and Pine Land 5409 (DPL 5409), and Delta and Pine Land (DPL 5415). The experimental design was a split plot with three replications: main plot = insecticide treatment, control and untreated; split plot = varieties. For the control insecticide treatment, all economically important insects were controlled all season until 40% open boll was achieved. For the untreated insecticide treatment all economicily important insects were controlled through out the season. When the crop reached mid-bloom for untreated insecticide treatment, control of TBW/BW was discontinued to inflict mature fruit damage. Results from the analysis of variance showed main plot effects, seed cotton yield, predicted seed cotton yield, lint yield, predicted lint yield, open bolls per 2 meter, bolls per acre, and total bolls open at 90% maturity were significant at alpha =.05. Results from the analysis of variance showed split plot effects, seed cotton yield, boll weight, and total bolls open at 90% maturity were significant at alpha =.05. Numerically , the medium (STV 132 and H1215) and heavy (STV LA887 and CB 830) boll weight varieties had higher seed cotton yields, open bolls per 2 meters, and predicted seed cotton yield than the light boll weight varieties (DPL 5415 and DPL 5409). The lighter boll weight varieties also had a higher number of worm damaged bolls per 2 meters than did the heavier boll weight varieties. The regression analysis indicated when boll weight was regressed against seed cotton yield, it had a positive relationship to yield; $y = 16.22 + 238.2x_1$, $R^2 = .15$, C.V. =26.5. The full model of seed cotton yield = open bolls per 2 meters + boll weight + worm damaged open bolls per 2 meters had a fit of $R^2 = .75$, and C.V. = 15, ($y = -756 + 154.77x_1 + 139.05x_2 + -11.28x_3$).

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:943-947 (1997)
National Cotton Council, Memphis TN

Introduction

Within the last ten years, there has been a large increase in the number of commercial cotton cultivars, *Gossypium hirsutum* L., available for production. In the 1984 Louisiana State Cotton Variety Trials, there were only 16 cotton varieties tested with no separation of maturity groups. In 1995, 38 cotton varieties were tested in two maturity groups.

Wells et. al., 1984, concluded that in the development of the more modern cultivars, breeders have inadvertently been selecting plant types with smaller bolls with fewer and smaller seed per boll. This has increased lint percentage and the number of bolls per land area. More recent cultivars transition earlier from vegetative to reproductive growth than older cultivars, Jenkins et. al., 1990. Jenkins et. al., 1990, found newer cultivars have a better coordination of assimilator capacity with reproductive sink activity and concentrate more reproductive development during the time of maximal leaf area with bolls setting at a different time period than older cultivars.

In this study, we are primarily interested in late season damage, specifically boll damage. In recently years, due to the build up of chemical insecticide resistance in the Tobacco Bud Worm (TBW), (*Heliothis virescen* Fabricicus.), and Boll Worm (BW) ,(*Heliothis zea* Boddie) wild populations, late season insect pressure of TBW/BW has become extremely critical. Guinn et. al., 1985, showed while TBW/BW usually do not destroy the whole boll, their damage allows diseases such as boll rot to set in or causes the plant to cut off assimilates to the boll, thereby arresting boll development. This damage will prevent mechanical separation of the seed cotton from the boll, thus reducing total seed cotton yield. Jenkins et. al., 1986, cites a study in 1970 by Kincade, in which TBW/BW damage was simulated through the hand removal of squares and its effects on yield. Early season hand removal of squares did not have a significant effect on yield, but mid- to late season removal did have significant effects on yield. In contrast, Jenkins et. al., 1986, found the artificial infestation of cotton plants with TBW larvae early in the season had profound effect on yield and maturity than did the late season infestations. The loss of mature fruiting structures will decrease yield, but the loss of squares may simply increase maturity time without decreasing yield, Ungar et. al., 1987. Cotton also over produces fruiting sites and physiologically adjust the final number of mature fruiting structures in response to the environment, McCarty et. al., 1986. This is not compensation but rather a modification of a plant's natural fruiting pattern response to environmental conditions, such as weather or insect populations in a cotton field, McCarty et. al., 1986. A predetermined boll load and the allocation of assimilates to retained fruiting structures reduces the ability of cotton to compensate for insect damage, Hearn et.al., 1979, Constable et. al., 1991, Kletter et. al., 1982, Jenkins et. al., 1986. Cotton plants may also compensate for yield loss by increasing boll weight and micronaire, Brook et. al., 1992. It has been noted that square removal initially leaded to a decrease in the flowering rate, and this may further slow down the ability for the plant to compensate, Ungar et. al., 1987.

In Louisiana, the current recommendation for the control of TBW/BW is to begin control measures, usually insecticide applications, when squares are at least one third developed and 5 live TBW/BW larvae plus eggs per 100 plants are present. Once control measures have been initiated, insect counts are continued until the crop is terminated, regardless of cultivar, to monitor insect populations and to determine the need for additional insecticide applications(13).

Many of the recently developed cultivars have a wide range of boll weights, (4-7 grams of seed cotton/boll), and typically have an inverse relationship between boll weight and the number of bolls per plant; the heavier the boll, the fewer bolls per plant, Kletter et. al., 1982, Wells et. al., 1984. The TBW/BW will typically attack a boll, and penetrates it where they are protected from insecticide applications and predation. Plants with lower boll weights will generally induce TBW/BW to move more often from fruiting structure to fruiting structure, increasing the worms exposure to predation and insecticide applications, Wilson et. al., 1980. Jenkins et. al.,1990, found that the rate of boll set and the number of bolls per plant both influence how well the plant tolerates TBW pressure. The objective of this study was to determine if the economic threshold levels for TBW/BW can be varied based on boll weight and if plants with smaller boll weights will be able to sustain less yield loss than plants with heavier boll weights due to TBW/BW damage.

Materials and Methods

The research project involved the comparison of six different genotypes of cotton, Stoneville LA 887 (STV LA887), Chembred 830 (CB 830), Delta and Pine Land 5415 (DPL 5415), Delta and Pine Land 5409 (DPL 5409), Stoneville 132 (STV 132), and Hartz 1215 (H1215), with each genotype having a different seed cotton boll weight, and two insecticide treatments: untreated = control of TBW/BW to be discontinued at approximately mid-bloom; control = control TBW/BW through out the season until about 40% open boll, when bolls are considered to be safe from predation. All other economically important insects were controlled as per Louisiana Agricultural Experiment Station Extension (LAESE) recommendations to insure that the effects of the TBW/BW damage would not be confounded by other insect damage. The heavy boll weight varieties used in this experiment are STV LA887 and CB 830, (5.6-6.5 grams/seed cotton/boll), the medium weight varieties are STV 132 and H1215, (4.8-5.5 grams/seed cotton/boll), and the light varieties are DPL 5409 and DPL 5415 , (4.0-4.7 grams/seed cotton/boll).

The experiment was conducted at the Macon Ridge Research Station, on a Gigger Silt Loam in Winnsborro, Louisiana in 1995. The experiment was planted on June 6, 1995, with 3.3 lbs. Temick 15G in furrow. Plots were four rows wide, planted on 38 inch centers, and fifty feet in length. Four row border rows were planted between insecticide treatments to reduce the effect of insecticide drift and to impede the migration of TBW/BW larvae from row to row. The experiment was planted later than recommended by LAESE to insure a heavy population of TBW/BW at mid-bloom.

The experimental design used was a split plot with three replications. The main plot were insecticide treatments and varieties were the split plot. The experiment was grown under furrow irrigation to insure continued growth and reduce drought stress that typically occurs in this environment. Once insecticide applications for TBW/BW were discontinued in the no spray treatment, weekly insect counts were made in all plots. This was achieved by pulling 50 squares (bolls late season) from the two outside rows of all plots, scoring them for insect presence and damage, and inspecting 10 terminals per plot for TBW/BW eggs and larvae to monitor insect populations within each plot. Insect counting was continued until the TBW/BW insecticide control plots reached 40% open boll. Boll weevil and tarnish plant bug damage was noted. All fertilization and agronomic practices were carried out as per LAESE recommendations.

Boll samples were collected by hand harvesting 50 bolls from the two center harvest rows before machine harvest to obtain yield components, ie. boll weight, seed index, lint weight per boll, and lint percentage. Random one meter sections of each harvest row had all fruiting forms removed and inspected for damage. Fruiting forms were separated into the following categories: open bolls (OB), worm damaged open bolls (WDOB), weevil damaged open bolls (WEDOB), green bolls (GB), worm damaged green bolls (WDGB), weevil damaged green bolls (WEDGB), immature bolls (IB), and rotten bolls (RB). All values represent 2 meters of row area. This allowed for attribution of yield and yield loss due to predation, maturity estimations, estimations of compensation rate, and delay of maturity. The two center rows were machine harvested to obtain plot weight and seed cotton yield on October 25, 1995.

All data was subjected to analysis of variance, contrast, and regression analysis. All insect count data was transformed by square root plus 0.5, ($\sqrt{x}$ +0.5), to achieve common variance. Average insect counts, average worm damage fruiting forms (AV_WDS), average weevil damage fruiting form (AV_WEDS), average live larvae in fruiting forms (AV_WSQ), and average weevil in fruiting form (AV_WESQ) are represented by 3 collection dates; Aug. 22, Aug 29, and Sept. 12. The addition of 0.5 to the variable before transformation was necessary due to some the value of some data points were 0. All data obtained from strip samples were also subjected to square root transformation to achieve common variance. Open bolls did not require the addition of 0.5, because no 0 data points existed. Bolls per acre were calculated by: seed cotton yield lbs. x bolls sample lbs. x 50 x 132. Due to maturity differences and the inability to allow both treatments and all varieties to go to full maturity, two variables were created to adjust for maturity. Total bolls open at 90% maturity (T_B_90) were calculated by adding open bolls and green bolls and adjusting to 90% of that figure. Ninety percent maturity was chosen because not all bolls will open and this gives a more actual figure of production. Predicted seed cotton yield was calculated by: T_B_90 x boll weight of each plot/ lbs. x 2000 the conversion factor for 2 meter area of one acre. Values given from these variables have not been converted back natural form.

Fiber analysis was conducted by use of a High Volume Instrument (HVI) at the Louisiana State University Cotton Fiber Testing Lab.

Results

Results from the analysis of variance showed for the variables GB, WDGB, WEDGB, IB, and RB that there were no statistically significant main or split plot effects.

Results from the analysis of variance showed main plot effects were statistically significant at alpha =.05 for the variables: seed cotton yield, predicted seed cotton yield, lint yield, predicted lint yield, open bolls , worm damaged bolls, bolls per acre and T_B_90. Mean analysis by the Tukey Method, numerically ranked the control treatment having the highest values, except for worm damaged open bolls, Tables 1-3. Results from analysis of variance showed split plot effects were statistically significant at alpha =.05 for seed cotton yield, predicted lint yield, boll weight, and T_B_90. Mean analysis commonly ranked the medium boll weight varieties the highest, the heavy boll weight varieties in the middle of the grouping, and the lighter boll weight varieties the lowest. The variable, boll weight, was ranked in the order they were predicted to by yield trail data, Table 4-7.

All variables were regressed individually against seed cotton yield, then in combinations leading to the full model of seed cotton yield = boll weight + open boll + worm damaged open bolls. Models are as follows: seed cotton yield = boll weight; $y = 16.22 + 238.2x_1$, with R^2 =.15, and C.V. =26.5. Seed cotton yield = open boll; $y = -284.5 + 177.34x_1$, with R^2 =.69, and C.V. =16.03. Seed cotton yield = worm damage open bolls; $y = 1634.3 + -147.3x_1$, with R^2 =.32, and C.V =23.79. Seed cotton yield = boll weight + open bolls; $y = -923.74 + 138x_1 + 167.05x_2$, with R^2 =.74 and C.V. =14.9. Seed cotton yield = boll weight + worm damaged open bolls; $y = 557.78 + 200x_1 + -136x_2$, with R^2 =.42 and C.V. =22.2. Seed cotton yield = boll weight + open bolls + worm damaged bolls; $y = -756 + 139.05x_1 + 154.8x_2 + -24.81x_3$, with R^2 =.75 and C.V. =15.

Results from the contrast analysis confirmed some of the results of the analysis of variance and regression analysis, Tables 8-10. When single degree of freedom contrasts were constructed by grouping the varieties to their according to their boll weight classification, for the variables T_B_90, predicted seed cotton yield, boll weight, and predicted lint yield, the contrast of heavy boll weight varieties versus medium boll weight varieties were statically significant. The contrast of heavy boll weight varieties versus light boll weight varieties, seed cotton yield, lint yield, and boll weight were statistically significant. In the final contrast of medium boll weight varieties versus light boll weight varieties, seed cotton yield, predicted seed cotton yield, lint yield, predicted lint yield, boll weight, open bolls , worm damaged open bolls, bolls per acre, and T_B_90, were statistically significant.

Conclusion

Preliminary results have shown that TBW/BW economic injury levels should possibly be altered based in accordance to a variety's boll weight.

No statistically significant main plot effects for boll weight existed, which signifies that yield compensation was avoided through increase in boll weight, Brooks et. al., 1992. Most of the results derived form this work has shown there are differences among boll weight classes, but most of the results are going against what has been cited in other work, Wilson et. al., 1980 and Culp et. al., 1975. Regression analysis demonstrated that boll weight had a positive relationship with seed cotton yield in all models and other literature indicated there would be a negative relationship, Wilson et. al., 1980, Culp et. al., 1975. Results from the contrast analysis indicated that for the variables seed cotton yield, lint yield, open bolls, and bolls per acre there was no statistical differences between varieties of heavy versus medium boll weight varieties, but there were statistical differences for the contrasts of medium versus light boll weight varieties for the same variables, Table 8-10. There were also statistical differences for the contrasts of heavy versus light boll weight varieties for the variables seed cotton yield, lint yield, and boll weight. This indicated that the heavy and medium boll weight varieties were more tolerant of TBW/BW pressure than light boll weight varieties.

When contrasts were made on variables that had been altered, T_B_90, predicted seed cotton yield, predicted lint yield, to adjust for maturity variation between varieties, the medium boll weight varieties did statistically differed from heavy boll weight varieties, when previously compared to unadjusted variables. When heavy boll weight varieties were compared to light boll weight varieties they did not statistically separate as well as when compared to unadjusted variables. This is a possible indication there may be a bell shape curve distribution as to how well varieties do with increase of TBW/BW pressure.

All results and conclusions drawn are based on one years data and single location. The experiment was repeated in 1996 at the same location to confirm the results of 1995.

References

A.B. Hearn and P.M. Room. 1979. Analysis of Crop Development for Cotton Pest Management. Protection Ecology, 1(1978/1979) 265-277

T.W. Culp and D.C. Harrell. 1975. Influence of Lint Percentage, Boll Size, and Seed Size on Lint Yield of Upland Cotton with High Fiber Strength. Crop Science 15:741-746.

L.T. Wilson and A.P. Gutierrez. Fruit Predation submodel: *Heliothis* Larvae Feeding Upon Cotton Fruiting Structures. 1980. Hilgardia Vol.48 No. 2, 24-36.

K.D. Brook, A.B. Hearn, and C.F Kelly. 1992. Response of Cotton, *Gossypium hirsutum* L., to Damage by insect Pests in Australia: Manual Simulation of Damage. Journal of Economic Entomology. Vol. 85, no. 4 1368-1377.

G.A. Constable. 1991. Mapping the Production and Survival of Fruit on Field Grown Cotton. Agronomy Journal 83:374-378.

Elazar Kletter and Daniel Wallach. 1982. Effects of Fruiting form Removal on Cotton Reproductive Development. Field Crop Research 5:69-84.

Gene Guinn. 1985. Fruiting of Cotton. III. Nutritional Stress and Cutout. Crop Science 25:981-985.

E.D. Ungar, D. Wallach, and E. Kletter. 1987. Cotton Response to Bud and Boll Removal. Agronomy Journal 79:491-497.

Johnnie N. Jenkins, W.L. Parrott, J.C. McCarty, and Lee Dearing. 1986. Performance of Cottons when Infested with Tobacco Budworm. Crop Science 26:93-95.

J.C. McCarty, Jr., J.N. Jenkins, and W.L. Parrott. 1986. Yield Rsponse of Two Cotton Cultivars to Tobacco Budworm Infestation. Crop Science 26:136-138.

Randy Wells and William R. Meredith, Jr.. 1984. Comparative Growth of Obsolete and Modern Cotton Culivars. III. Relationship of Yield to Observed Growth Characteristics. Crop Science 24:868-872.

Johnnie N. Jenkins, J.C. McCarty, Jr., and W.L. Parrott. 1990. Effectiveness of Fruiting Sites in Cotton: Yield. Crop Science 30:365-369

Louisiana State University Agricultural Experiment Stations. 1996. Cotton Insect Control Guide. Publication 1083.

Table 1. Means for Main Plot Treatment (Insect Control) of Data Collected at Harvest, October 25, 1995 Winnsborro.

Means	Seed Cotton Yield lbs./acre	Predicted Seed Cotton Yield lbs./acre	Lint Yield lbs./acre
Control	1441a	324.01a	555a
Untreated	1094b	239.98b	421b

Alpha =.05

Table 2. Means for Main Plot Treatment (Insect Control) of Data Collected During the Year and at Harvest, October 25, 1995 Winnsborro.

Means	Predicted Lint Yield lbs./acre	Boll Wt.	Open Boll (no.m-1)	Worm Damage Open Boll (no.m-1)
Control	124.5a	5.3a	9.6a	1.49b
Untreated	92.3b	5.2a	7.9b	3.49a

Alpha =.05

Table 3. Means for Split Plot Treatment(Variety's) of Data Collected at Harvest , October 25, 1996 Winnsborro.

Means	AV_WSQ (no. m-1)	Bolls per Acre	Total Bolls at 90% Maturity (no. m-1)
Control	1.4a	124154a	13.96a
Untreate d	1.5a	94611b	10.32b

Alpha =.05

Table 4. Means for Split Plot Treatment(Variety's) of Data Collected at Harvest , October 25, 1996 Winnsborro.

Means	Seed Cotton Yield lbs./acre	Predicted Seed Cotton Yield lbs./acre	Lint Yield lbs./acre
STV LA887	1304.6ab	298.36a	526.7a
CB 830	1423.4ab	275.18a	500.13a
STV 132	1441a	298.75a	569.32a
HZ 1215	1355.2ab	317.8a	531.6a
DPL 5409	1194.6ab	257.18a	459.0a
DPL 5415	886.6b	244.72a	341.0a

Alpha =.05

Table 5. Means for Split Plot Treatment(Variety's) of Data Collected at Harvest , October 25, 1996 Winnsborro.

Means	Predicted Lint Yield lbs./acre	Boll Weight	Open Boll (no. m-1)
STV LA887	119.13a	5.98a	8.15a
CB 830	96.57a	5.82ab	9.78a
STV 132	117.87a	5.34bc	9.50a
HZ 1215	124.68a	5.11cd	9.40a
DPL 5409	98.31a	4.71d	8.49a
DPL 5415	93.55a	4.57d	7.73a

Alpha =.05

Table 6. Means for Split Plot Treatment(Variety's) of Data Collected and During the Year and at Harvest ,October 25, 1996 Winnsborro.

Means	Worm Damaged Open Bolls (no. m-1)	AV_WSQ
STV LA887	2.75a	1.30a
CB 830	2.08a	1.42a
STV 132	2.16a	1.46a
HZ 1215	2.14a	1.44a
DPL 5409	3.31a	1.34a
DPL 5415	2.52a	1.59a

Alpha =.05

Table 7. Means for Split Plot Treatment(Variety's) of Data Collected at Harvest , October 25, 1996 Winnsborro.

Means	Bolls per Acre	Total Bolls Open at 90% Maturity (no. m-1)
STV LA887	99440a	11.28ab
CB 830	111655a	10.75b
STV 132	122887a	4.412.67ab
HZ 1215	119762a	14.06a
DPL 5409	115296a	12.3ab
DPL 5415	87256a	11.99ab

Alpha =.05

Table 8. Contrast Analysis for Data Collected at Harvest on October 25, 1995, Winnsborro. All Values Presented Represent Mean Squares.

Source	df	Seed Cotton Yield lbs./acre	Predicted Seed Cotton Yield lbs./acre	Lint Yield lbs./acre
Heavy vs. Medium	1	6976.86	1220857^	8238.4
Heavy vs. Light	1	627525.4*	143530.7	76715.7*
Medium vs. Light	1	766837.5**	2201598.4*	135234.1**

^ = Significant at alpha =.10
* = Significant at alpha =.05
** = Significant at alpha =.01

Table 9. Contrast Analysis for Data Collected at Harvest on October 25, 1995, Winnsborro. All Values Presented Represent Mean Squares.

Source	df	Predicted Lint Yield lbs./acre	Boll Weight	Open Boll (no. m-1)
Heavy vs. Medium	1	287109.7*	2.7608**	3.2267
Heavy vs. Light	1	11397.1	9.5130**	2.1780
Medium vs. Light	1	412912.7**	2.0242**	10.7067^

^ = Significant at alpha =.10
* = Significant at alpha =.05
** = Significant at alpha =.01

Table 10. Contrast Analysis for Data Collected at Harvest on October 25, 1995, Winnsborro.

Source	df	Worm Damaged Open Bolls (no. m-1)	Bolls per Acre	Total Bolls Open at 90% Maturity (no. m-1)
Heavy vs. Medium	1	.4108	1493479534	5346.14**
Heavy vs. Light	1	1.5	109482390	1033.6
Medium vs. Light	1	3.481*	2411688597^	1678.35^

^ = Significant at alpha =.10
* = Significant at alpha =.05
** = Significant at alpha =.01