EFFICACY OF EARLY INSECTICIDES AND THEIR EFFECT ON YIELD AND MATURITY OF Bt COTTON

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Abstract

Little is known about effects of early season insecticides in Bt cotton *Gossypium hirsutum* L. Field studies were established in a commercial, cotton production system in the Mississippi Delta in 1997 to examine the effects of various insecticide treatments on insect populations. Sampling of plant growth, squaring rates, date of node above white flower 5 (NAWF5), and lint cotton yields was done to determine if early season insect feeding affected these plant variables. Intense sampling allowed for an accurate description of the insect populations in the field during the physiological development of fruiting branches below node 10. This allowed for an examination of insecticide efficacy, and the calculation of insect day data for the period when the first fruiting branches were initiated. Measurements of plant anatomy and maturity stages allowed for the quantification of plant damage done by insect populations by regressing insect days on plant measurements. Differences among insecticide treatments were measured through insect numbers and plant damage. Regression of yellowstriped armyworm, *Spodoptera ornithogalli* (Guenée), days on terminal damage is shown to be significant and positive. Regression of both yellowstriped armyworm and tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), days produced significant negative regressions. Regression using two independent variables (armyworm days and *Lygus* days) was shown to be significant and negative when regressed on percent square set of cotton with 10 mainstem nodes.

Introduction

Insecticide management and defining the early season stages of cotton have become a topic of interest in cotton production systems in the Mississippi Delta. In particular, the control of tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), during this early stage of growth in cotton is critical. As transgenic varieties become utilized more in production systems, early fruit loss will be one parameter in the system that will have to be investigated to quantify these effects on "earliness" as it relates to harvest delay and yield.

Parvin et al. (1987) described "earliness" as a complete season-long management of production systems that should decrease the time between planting and harvesting. Automatic insecticide applications made to cotton shortly after emergence are often recommended and considered necessary in their contribution towards "earliness." Rosenheim (1985) defined early season pest populations as those populations occurring on pre-squaring cotton or seedlings up to the sixth node.

How we manage insect populations will determine the long-term consistency of transgenic Bt varieties. Pests such as the tarnished plant bug, boll weevil, *Anthonomous grandis* (Boheman), and stink bugs, *Nezara viridula* (L.), *Acrosternum hilare* (Say), *Euschistus servus* (Say), may increase as primary pests in transgenic Bt cotton.

Tarnished plant bugs and cotton fleahoppers, *Pseudatomoscelis seriatus* (Reuter), occur primarily during early season. Tarnished plant bugs can destroy meristematic tissue in developing plant terminals (Leigh et al., 1988). An accumulation of feeding periods from tarnished plant bug can lead to damaged plant terminals and subsequently lead to aborted square positions or low square retention during early cotton development. The effects of cumulative feeding patterns have been described as an adequate indicator of pest infestation levels in crop production systems (Ruppel, 1983; Morrill and Wrona, 1987; Harris et al., 1992). Insect populations do not always relate to actual feeding, although plant damage does (Goodell et al., 1992). A cumulative index such as insect days explains the presence of insect pest in cotton over time.

Phelps et al. (1996a) reported a positive regression of heliothine larvae days on terminal damage and a negative regression of tarnished plant bug days on percent square set on 'Sure-grow 125' cotton as it developed first fruiting sites. Andrews et al. (1997) reported the relationships between tarnished plant bug and percent square set on 'NuCOTN 33^{B}.'

Beneficial arthropod populations often initially increase during mid-late June (Smith et al. 1983). Early fruit loss can occur before this period if adequate control with insecticides is not achieved. The negative effect of early season insecticides on beneficial insects can be offset, if the insecticide treatments are timed to precede this initial increase in the population. Researchers (Green et al., 1995) indicate a significant decrease in beneficial species when pyrethroid insecticides were applied to early developing cotton during mid-late June.

Turnipseed et al. (1995) noted a one-week delay in harvest maturity when mechanical induced square removal was implemented for four weeks, although this resulted in no yield loss. Phelps et al. (1996b) noted a delay in harvest maturity when mechanical induced square removal was implemented for 2, 3, and 4 weeks. These removal periods delayed harvest maturity from 2 - 14 days, respectively. Effective and timely insecticide applications are essential to prevent insect damage in cotton systems, and early fruit

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retention is essential to high production yields. Jenkins et al. (1995) determined the relative value of fruit on both early and full season cultivars. Averaging 'DES 119' with 'Deltapine Acala 90,' approximately $347.00/acre can be accounted for on nodes 5 through 10. This study reports the effects of early season insecticide treatments on control, duration of control, and yield characteristics of cotton.

Materials and Methods

Five commercially sold insecticides were evaluated for effectiveness in control and length of control against early season insects of cotton. In addition, their effects on plant parameters and yield were also measured. A cotton production system was selected in Washington County, adjacent to Deer Creek, near Stoneville, MS. Cotton variety 'NuCOTN 33[B]' was planted on thirty-inch row patterns on 6 May 1997, on a Bosket very fine sandy loam soil. Temik at 5 lb/A was applied in-furrow at planting. An acceptable stand had emerged at approximately 50.5 DD60's from the initial planting date. The original design of the study was a randomized complete block design with seven treatments four blocks, which included five insecticide treatments, one untreated check, and one plot where treatments were to be administered when pest populations reached published thresholds. Plots of the insecticide treatments ran the length of the field, which was approximately 1000 feet and contained twenty 30-inch rows. The five insecticide treatments contained four replications and the untreated check plots contained eight replications. The untreated check plots were 300 feet long followed by the insecticide treatment for the remainder of the field. Failure of insect populations in the as needed treatments to reach threshold levels resulted in a six treatment randomized complete block design with two untreated checks in each block.

Visual and sweep net sampling procedures were initiated on 4 June 1997, and continued at two day intervals through 20 June 1997. Insect sampling consisted of 50 sweeps with a 15 inch sweep net and visual examination of 25 cotton plants per plot. Plant terminals were visually examined for insect damage to terminals, Heliothine eggs, and lepidopterous larvae. Insects collected in the sweep net were anesthetized with ether and placed in a kill bucket containing a cotton wick soaked with ethyl acetate. Sweep net samples were transported to the laboratory where insects were identified and counted the same day as sampling procedures took place.

Insecticide treatments were applied with a tractor mounted hydraulic pump system, delivering 8 gpa. Insecticide treatments were initiated on 5 June 1997, at the 4.58 leaf stage of the cotton plant. Insecticide treatments included: Baythroid 2 EC at 0.033 lb ai/A, Decis 1.5 EC at 0.025 lb ai/A, Orthene 90 S at 0.33 lb ai/A, Karate 1 EC at 0.033 lb ai/A and Fury 1.5 EC at 0.0375 lb ai/A.

Insect days (ID) were calculated for the sample period 4-20 June for tarnished plant bug *Lygus lineolaris* (Palisot de Beauvois), yellowstriped armyworms *Spodoptera ornithogalli* (Guenée), threecornered alfalfa hoppers *Spissistilus festinus* (Say), spotted cucumber beetle *Diabrotica undecimpunctata* (Barber), and all species of leafhoppers collectively according to Harris et al. (1992).

Samples for node above white flower (NAWF) were taken on 21, 28 July and 8 August. Yields were obtained weekly by hand harvesting fully opened bolls on a thirty foot segment of row on 2, 9, 16, 23 September. On 23 September all opened bolls were harvested as well as all remaining green, unopened bolls. These green bolls were allowed to open after being harvested and considered yield on 30 September. Cotton was air dried and ginned on a ten-saw laboratory micro-gin.

Delay was measured by calculating the Julian day on which each plot reached NAWF5 (5 nodes above white flower); and 50, 60, 70, and 80 percent of its yield as open bolls. The day when each plot reached various maturity stages were calculated by linear extrapolation from one weekly sample to the next. Yield measurements were calculated as pounds of lint per acre and because only fully open bolls were picked at each harvest date, percent of total yield could be calculated for any date between 2 Sept and 30 Sept. All insect, maturity stage, and yield sampling was conducted on the same planter row for every sample date. Several different rows in the middle of the plot were utilized to prevent plant injury but the same row was used on any given sample date. All samples were taken approximately 200 feet from the edge of the field.

Analysis of variance was accomplished using Proc. Mixed (SAS 6.10 for Windows 1991 - 1994) to accommodate unequal numbers of replications. Least significant differences were used to determine the probability of treatment mean differences. Regression analysis was performed to examine the linear relation between plant measurements and early season insect populations from the twenty-eight plots. Treatment effects on these trends were examined using F-tests for common slopes. Linear regressions were conducted with Proc. GLM (SAS 6.10 for Windows 1991 - 1994).

Results and Discussion

Cotton in the test averaged 4.58 mainstem nodes per plant on 4 June (one day prior to insecticide applications). Insect sampling ceased on 20 June, at which time plants averaging 9.88 mainstem nodes were mapped. Plants in the untreated check were numerically shorter than the Fury treated plants on 5 of the last 6 sample dates (Table 1). On 12 and 14 June, plants from the untreated check were different ($P \leq 0.1$) from the Fury treated cotton. Orthene treated plants were numerically shorter than the plants from the untreated check in samples taken from 4-8 June. Orthene treated cotton had numerically more mainstem nodes on all sample dates after 8 June and had more mainstem nodes on 14 and 18 June ($P \leq 0.01$ and $P \leq 0.1$, respectively). Orthene had more mainstem nodes ($P \leq 0.1$) than cotton treated with Decis on 14 June.

Sweep net sampling revealed low tarnished plant bug populations for the period 4-10 June. Plant mainstem node averaged 4.34-6.29 nodes during this period. The efficiency of sampling small plants and the application of insecticide both contributed to the low plant bug population early in the sample period, but there is no way to determine how much each factor affected plant bug captures. All insecticide treatments were different ($P \leq 0.1$) from the untreated check on 12 June (Table 2). On 14 June, 10 DAT, (days after treatment) fewer plant bugs were captured from the Karate and Baythroid plots than Decis, Fury, and untreated check plots ($P \leq 0.1$). Fewer tarnished plant bugs were observed on 16 June in all pyrethroid treatments than were from the Orthene treated cotton ($P \leq 0.05$). Higher numbers of tarnished plant bugs were observed in the untreated check than were in Decis and Karate treatments ($P \leq 0.1$) on 16 June. On 18 and 20 June, the tarnished plant bug population increased, but variation within plots also increased, as no differences were observed on these dates. In spite of these increases, average numbers of tarnished plant bugs were below thresholds noted in extension service publications (Anon. 1997). When the tarnished plant bug data were accumulated over time (ID), similar trends were observed (Table 3). All pyrethroid treatments accumulated lower levels of *Lygus* days than did the untreated check ($P \leq 0.1$), with the exception of the Fury treatment on 20 June. In addition, Orthene treated cotton had accumulated less *Lygus* days than Baythroid for the period of 16 through 20 June ($P \leq 0.1$). All tarnished plant bugs in sweep net samples were adults. Seven hundred plants were examined on each sample date. No tarnished plant bug nymphs were observed in these whole plant examinations. It is assumed that the plantbugs sampled were moving into the field from surrounding vegetation.

No effort was made to record the age of the armyworm larvae collected from the sweep net samples. An attempt was made to identify by family, all arthropods in the sweep net samples, which could be separated by visual identification. Insects as small and fragile as first instar armyworms were not observed, and no larvae larger than third instar were found. No differences were observed on any sample date, with respect to yellowstriped armyworm control (Table 4). Yellowstriped armyworms were observed 4 June, although no yellowstriped armyworms were observed 6 June in any of the 28 plots. Since the untreated plots were 50 feet wide and 300 feet long, this absence of yellowstriped armyworms makes drift from the insecticide treatments the suspect as to the reason for their absence. Yellowstriped armyworms were observed in the untreated check from 8-14 June. No yellowstriped armyworms were observed in any treatment after 14 June. Damage sustained from yellowstriped armyworms occurred from second or third instar yellowstriped armyworms before 14 June. This damage occurred within 9 days, between 5 and 14 June, when the last yellowstriped armyworm was observed. All insecticide treatments were different than the untreated check, with respect to yellowstriped armyworm days (Table 5) on 10 ($P \leq 0.1$), 12, and 14 June ($P \leq 0.05$).

Damaged terminals were observed in treatments on all sample dates, and most differences ($P \leq 0.1$) occurred between insecticide treatments and the untreated check (Table 6). Fury treated cotton had a higher percentage of damaged terminals than did Orthene treated cotton on 6 June, and Baythroid, Decis, or Karate treated cotton on 12 June ($P \leq 0.1$).

All pyrethroid treatments on 10 June had lower mean numbers of leafhoppers than the untreated check ($P \leq 0.01$) (Table 7). All pyrethroid treatments except Fury had fewer leafhoppers than the untreated check ($P \leq 0.05$), 7 DAT. Fury and Orthene treated cotton had more ($P \leq 0.05$) leafhoppers on 18 June than did Karate treated cotton. The leafhopper data also show decreases of total insects sampled the day after insecticide treatments were applied. The untreated check also showed a numeric decrease. Suppositions for this decrease could be drift or interference with insects moving into the plots because they were killed in the treated plots adjacent to the untreated plots.

No differences between any of the insecticide treatments were noted, with respect to three cornered alfalfa hoppers (Table 8). Insect day data were calculated for three cornered alfalfa hopper data, but no differences were detected on any sample date.

Treatment differences occurred, with respect to spotted cucumber beetle on 20 June. Karate treated cotton had more spotted cucumber beetles than Orthene treated cotton ($P \leq 0.05$), the untreated check, or Baythroid treated cotton ($P \leq 0.1$) (Table 9). Insect day data were calculated for twelve spotted cucumber beetles, although no differences occurred on any of the sample dates.

More beneficial arthropods were observed in the untreated check than at least one treated plot ($P \leq 0.1$) on 4 of the sample dates. The differences observed were not consistent from one sample date to the next (Table 10).

Heliothine eggs were observed on two sample dates (Table 11). Eggs were not observed under magnification. These eggs were assumed to be heliothine eggs, because of their creamy appearance, the placement on the plant, and either *Heliothis virescens* (F.) or *Helicoverpa zea* (Boddie) or both species of moths were observed in the field on these dates. On 18 June, more heliothine eggs were observed in Baythroid treated cotton than in Decis ($P \leq 0.05$), Orthene, Fury treated cotton or the untreated check ($P \leq 0.01$). On this same date, Karate treated cotton had more heliothine eggs than Orthene ($P \leq 0.1$), Fury ($P \leq 0.05$) treated cotton or the untreated check ($P \leq 0.05$). The fate of these eggs is not known since the only variables recorded from the plants on 20 June were variables associated with plant maps. One can only speculate the reason for the differences among these treatments. Two possible reasons for the higher eggs counts would be that the plants were more attractive to the adult moths or these plots had fewer beneficial arthropods feeding on the eggs. A combination of both of these factors certainly cannot be ruled out.

No differences were detected between any treatment with respect to mainstem node of first fruiting site or average number of fruiting sites per plant (Table 12). All insecticide treated cotton fruited lower numerically, and had more fruiting sites than did cotton in the untreated check. Plants averaged more squares in Karate ($P \leq 0.05$), Baythroid, and Orthene ($P \leq 0.1$) treated cotton than the untreated cotton. All insecticide treatments provided a higher percentage of fruit set ($P \leq 0.1$), than did untreated cotton. Orthene treated cotton retained a higher percent of their fruit than did cotton treated with Fury ($P \leq 0.1$).

Decis treated cotton reached NAWF5, two days before the Fury treated cotton ($P \leq 0.1$). It should be noted that cotton treated with Baythroid and Karate reached NAWF5 the same day as cotton treated with Decis, but are not different than the Fury treated cotton (Table 13). This occurs because fractions of days are not presented in the table and the Decis treated cotton reached NAWF5 a fraction of a day earlier than did the Baythroid or Karate plots. No differences existed in the time to reach 50, 60, 70, and 80% of total lint from open bolls (Table 13). Baythroid and Decis treated cotton were numerically earlier, by one day, when 50% of the lint was in open bolls. These data are consistent with NAWF5 data. Boll openers and defoliant were applied to all plots on 13 September. This application caused boll opening to occur quickly and plots quickly and uniformly yielded 60, 70, and 80 percent of their lint in open bolls.

Orthene treated cotton yielded more lint cotton ($P \leq 0.05$) on 16 September than did Baythroid treated cotton (Table 14). The untreated check and cotton treated with Decis yielded more lint cotton ($P \leq 0.1$) on 30 September. Table 15 displays the differences in accumulated lint cotton yields for each harvest date. More lint cotton ($P \leq 0.1$) was harvested from the cotton treated with Fury than cotton treated with Baythroid, Decis or the untreated check. Orthene treated cotton had produced more lint cotton ($P \leq 0.1$) than the cotton treated with Baythroid or the untreated cotton. When lint cotton was accumulated over all harvest dates, cotton from the Baythroid treatment had produced less lint cotton than all other treatments and Fury treated cotton had produced more lint cotton than all other treatments, except Orthene treated cotton.

Dependent and independent variables used in linear regression are noted in Table 16. These variables were chosen to examine the relationships between early season insects and measured plant parameter variables. Three regressions were statistically significant ($P \leq 0.05$). The test for common slopes between treatments with all independent variables was examined and the variable by treatment interaction was never significant ($P > 0.05$).

The regression of yellow stripped armyworm days on percent damaged terminals was significant on three sample dates. The dates were 12, 14, and 16 June. On 14 June, the last yellowstriped armyworm was sampled from the plots and on that same date these two variables produced the most significant regression. The equation is:

% Damaged Terminals = 0.57 (±0.140) armyworm days + 1.59 (±0.51)
F=15.71, df=1, 27, P=0.0006,

where values within parenthesis denote the standard error of the slope and intercept.

Phelps et al. (1996) reported a correlation between *Heliothis* days and percent damaged terminals with a slope of 0.15, using a whole plant examination as the sample method.

Percent square set was not regressed on itself, but was used as a dependent and independent variable. This square set was measured on 20 June when the plants contained approximately ten nodes. Significant regressions were produced when *Lygus* days and yellowstriped armyworms days were regressed on percent square set. However, the interaction was not significant between these two insect variables. Therefore, a linear regression using two independent variables was calculated. The equation is:

% Square Set = -0.225(±0.12) *Lygus* days - 1.47(±0.48) armyworm days + 88.41 (±2.91)
F=11.17, df=2, 25, P = 0.0003.

This equation is plotted in Figure 1 showing the data points and trend line for yellow stripped armyworm days corrected for *Lygus* days, as well as data points and trend line for *Lygus* days corrected for yellowstriped armyworm days. Andrews et al. (1997) reported the slope and regression of *Lygus* days on percent square set for combined data taken in 1995 and 1996 to be – 0.23.

Summary

This study was designed to be multifaceted. The data collection was intense, and the data analysis was extensive. The most important aspects of this study are the data and the methods to quantitatively study damage done by insects to cotton at what seems to be a very sensitive period in its development. The study will provide useful information for the improvement of treatment thresholds for early season

insects as well as the creation of multiple pest thresholds in Bt cotton. Before thresholds can be improved, there must be agreement as to how much terminal and square damage can be tolerated at each stage of plant maturity. The amount of damage tolerated during this period will depend upon the length of the growing season. Growing seasons will continue to change from one year to the next and from south to north in the Cotton Belt. Until such research information is available, cotton producers will set their own standards as to how much damage can be tolerated during the early part of the growing season. These data demonstrate that insecticides applied when cotton had produced only 5 nodes caused differences in yields. The data collected during early season on plant measurements as well as insect populations do not explain why these differences occurred. These data do show the efficacy in terms of control as well as duration of control for several insecticides, which may help producers with insecticide selection for early season insect control.

References

Anonymous. 1997. Cotton Insect Control Guide 1997. Cooperative Extension Service, Mississippi State University. Pub. No. 343.

Andrews, G.L., C.W. Bednarz, J.B. Phelps and J.T. Ruscoe. 1997. The relationship of insects on cotton plant fruiting characteristics during the first nodes of fruiting. Proceedings Beltwide Cotton Conferences. 1158-1160.

Goodell, P.B., T.A. Kerby, J.A. Young, and R.E. Plant. 1992. Plant based measurements for Lygus bug management decisions in cotton. Proceedings Beltwide Cotton Conferences. 769-770.

Greene, J.K., G.S. McCutcheon, S.G. Turnipseed, and M.J. Sullivan. 1995. The impact of beneficial arthropod on cotton insects in South Carolina with and without early season control of the tobacco budworm. Proceedings Beltwide Cotton Conferences. 850-853.

Harris, F.A., G.L. Andrews, D.F. Caillavet, and R.E. Furr, Jr. 1992. Cotton aphid effect on yield, quality, and economics of cotton. Proceedings Beltwide Cotton Conferences. 652-656.

Jenkins, J.N., and J.C. McCarty, Jr. Useful tools in managing cotton production: End of season plant maps. MAFES/MSU Bulletin 1024. pp. 8.

Leigh, T.F., T.A. Kerby, and P.F. Wynholds. 1988. Cotton square damage by the plant bug, Lygus hesperus (Hemiptera:Heteroptera:Miridae), and abscission rates. J. Econ. Entomol. 81(5): 1328-1337.

Morrill, W.L. and A. Wrona. 1987. Feeding intensity as a factor in insect-day calculations. J. Agric. Entomol. 4(3):213-215.

Parvin, D.W., Jr., J.W. Smith and F.T. Cooke, Jr. 1987. Cotton harvesting in the Midsouth at it relates to shorter season production systems. Proceedings Beltwide Cotton Conferences. 78-81.

Parvin, D.W., Jr. The value of earliness, revisited. 1992. Proceedings Beltwide Cotton Conferences. 760-761.

Phelps, J.B., J.T. Ruscoe, and G.L. Andrews. 1996. The effects of early season insect control on fruiting characteristics of cotton. Proceedings Beltwide Cotton Conferences. 956-957.

Phelps, J.B., J.T. Ruscoe, and W.H. McCarty. 1996. Cotton development following early square removal. Proceedings Beltwide Cotton Conferences. 1412-1413.

Rosenheim, J.A. 1985. Cotton aphid (Aphis Gossypii) on early season cotton: The anatomy of a non-pest. Proceedings Beltwide Cotton Conferences. 998-1003.

Ruppel, R.F. 1983. Cumulative insect-days as an index of crop protection. J. Econ. Entomol. 76:375-377.

SAS System for Microsoft Windows. Release 6.10. 1991-1994. SAS Institute, Cary, NC.

Smith, J. W., W. A. Dickerson, and W. P. Scott. 1983. Sampling Arthropods in Cotton, Chapter 12. In Cotton Insect Management with Special Reference to the Boll Weevil. R. L. Ridgeway, E. P. Lloyd. and W. H. Cross editors. USDA Agriculture Handbook No. 589.

Turnipseed, S. G., J.E. Mann, M.J. Sullivan, and J.A. Durant. 1995. Loss of early season fruiting sites. Should we re-examine as pest management strategies change?? Proceedings Beltwide Cotton Conferences. 821-823.

Table 1. Treatment means of mainstem nodes at each sample date.

June	**4**	**6**	**8**	**10**	**12**
Treatment					
Baythroid	4.23	4.77	5.44	6.28	6.80
Decis	4.34	4.80	5.28	6.35	6.90
Orthene	4.27	4.82	5.35	6.44	6.77
Karate	4.42	4.75	5.49	6.32	6.89
Check	4.38	4.88	5.40	6.15	6.72 F#
Fury	4.44	4.79	5.38	6.22	6.97

Table 1. cont.

June	**14**	**16**	**18**	**20**
Treatment				
Baythroid	7.61	8.23	9.14	9.80
Decis	7.40 Ox	8.10	9.01	10.03
Orthene	7.85 C*	8.27	9.18 C#	9.83
Karate	7.59	8.21	9.12	9.96
Check	7.42 F#	8.12	8.91	9.80
Fury	7.70	8.07	9.25	9.87

Table 2. Treatment means of tarnished plant bugs per 100 sweeps on indicated sample dates.

June Treatment	4	6	8	10	12
Baythroid	0.00	0.00	0.00	0.00	0.25 Cx
Decis	0.50	0.00	0.00	0.50	0.25 Cx
Orthene	0.00	0.50	0.00	0.00	0.50 C#
Karate	0.50	0.00	0.00	0.50	0.50 C#
Check	0.25	0.75	0.50	0.00	1.25
Fury	0.00	0.00	0.50	0.00	0.00 C*

Table 2. cont.

June Treatment	14	16	18	20
Baythroid	0.00 Cx D#	1.50 Ox	2.0	1.50
Decis	2.50	1.00 O*	2.5	4.50
Orthene	2.00	5.00 K*	2.0	2.00
Karate	0.00 Cx D#	1.00 Cx	3.0	5.00
Check	3.00	3.25 D#	3.5	3.75
Fury	2.50 B# K#	1.50 Ox	5.0	2.50

Table 3. Treatment means of accumulated *Lygus* days on indicated sample dates.

June Treatment	6	8	10	12
Baythroid	0.00	0.00	0.00	0.75 Cx
Decis	0.50	0.50	1.25	2.25 C#
Orthene	0.75	1.00	1.00	2.50 C#
Karate	0.50	0.50	1.25	3.00
Check	1.25	2.38	2.62	6.38
Fury	0.00	0.75	1.00	1.00 Cx

Table 3. cont.

June Treatment	14	16	18	20
Baythroid	1.00 Cx	3.25 Ox	7.00 Ox	10.25 O#
Decis	5.50 C#	8.00 Cx	12.25 Cx	20.25 C#
Orthene	6.00 C#	14.50	20.00	24.00
Karate	3.50 Cx	5.00 C*	10.00 C*	19.00 C#
Check	12.12	18.50 B*	25.38 B*	32.00 B*
Fury	4.75 Cx	8.25 C#	16.50 C#	22.75

Table 4. Treatment means of yellowstriped armyworms per 100 sweeps on indicated sample dates.

June Treatment	4	6	8	10	12	14	16
Baythroid	0.5	0.0	0.0	0.00	0.00	0.00	0.0
Decis	0.5	0.0	0.0	0.00	0.00	0.00	0.0
Orthene	0.0	0.0	0.0	0.00	0.00	0.00	0.0
Karate	0.0	0.0	0.0	0.00	0.00	0.00	0.0
Check	0.5	0.0	0.5	0.25	0.25	0.38	0.0
Fury	0.5	0.0	0.0	0.00	0.00	0.00	0.0

Table 5. Treatment means of accumulated Armyworm days on indicated sample dates.

June Treatment	4	6	8
Baythroid	0.5	0.75	0.75
Decis	0.5	0.75	0.75
Orthene	0.0	0.00	0.00 C#
Karate	0.0	0.00	0.00 C#
Check	0.5	0.75	1.50
Fury	0.5	0.75	0.75

Table 5. cont

June Treatment	10	12	14
Baythroid	0.75 C#	0.75 Cx	0.75 Cx
Decis	0.75 C#	0.75 Cx	0.75 Cx
Orthene	0.00 Cx	0.00 C*	0.00 C*
Karate	0.00 Cx	0.00 C*	0.00 C*
Check	2.50	3.50	4.88
Fury	0.75 C#	0.75 Cx	0.75 Cx

Table 6. Treatment means of percent damaged terminals on indicated sample dates.

June Treatment	4	6	8	10
Baythroid	2.0	3.0	3.0 Cx	2.0 C#
Decis	2.0	4.0	3.0 Cx	3.0
Orthene	2.0	1.0 F#	5.0	1.0 Cx
Karate	2.0	2.0	2.0 C*	3.0
Check	3.5	3.0	8.0	6.5
Fury	0.0 C#	7.0	5.0	3.0

Table 6. cont.

June Treatment	12	14	16	18
Baythroid	0.00 C* F*	0.25 Cx	3.0	1.0 Cx
Decis	0.50 Cx F#	0.50 C#	3.0	5.0
Orthene	0.75 C#	0.00 C*	1.0 Cx	4.0
Karate	0.50 Cx F#	0.25 Cx	2.0 C#	2.0 Cx
Check	1.75	1.25	6.0	7.5
Fury	1.50	0.75	5.0	3.0 C#

Table 7. Treatment means of leaf hoppers per 100 sweeps on indicated sample dates.

June Treatment	4	6	8	10	12
Baythroid	0.50	0.50	0.50	0.250 C*	0.250 Cx
Decis	1.00	0.00	0.00	0.250 C*	0.250 Cx
Orthene	1.00	0.50	0.00	1.000	0.750
Karate	2.00	0.00	0.00	0.000 C*	0.250 Cx
Check	1.75	0.75	1.00	1.875	1.75
Fury	1.50	0.00	0.50	0.00 C*	1.50

Table 7. cont.

June Treatment	14	16	18	20
Baythroid	2.00	2.00	4.0	2.00
Decis	1.75	3.50	4.0	1.50
Orthene	1.00	2.50	6.0 Kx	4.00
Karate	1.50	2.00	1.0	3.50
Check	2.50	2.75	3.5	3.25
Fury	3.00	2.00	5.5 Kx	3.50

Table 8. Treatment means of three cornered alfalfa hoppers per 100 sweeps on indicated sample dates.

June Treatment	4	6	8	10	12
Baythroid	0.50	0.00	0.00	0.0	0.00
Decis	0.00	0.00	0.00	0.0	0.25
Orthene	0.00	0.00	0.00	0.0	0.00
Karate	0.00	0.00	0.00	0.0	0.00
Check	0.25	0.25	0.25	0.0	0.00
Fury	0.00	0.00	0.00	0.0	0.00

Table 8. cont.

June	14	16	18	20
Treatment				
Baythroid	0.25	0.50	1.00	2.00
Decis	0.50	1.50	0.50	1.50
Orthene	0.25	0.50	0.50	4.00
Karate	0.25	0.50	0.00	3.50
Check	0.50	0.75	0.75	3.25
Fury	0.25	0.25	1.00	3.50

Table 9. Treatment means of twelve spotted cucumber beetles per 100 sweeps on indicated sample dates.

June	4	6	8	10	12
Treatment					
Baythroid	0.50	0.0	0.0	0.0	1.00
Decis	0.00	0.0	0.0	0.5	1.00
Orthene	0.50	0.0	0.5	0.5	1.00
Karate	0.50	0.0	0.0	0.5	0.00
Check	0.25	0.0	0.5	0.0	0.25
Fury	0.00	0.0	0.0	0.5	0.50

Table 9. cont.

June	14	16	18	20
Treatment				
Baythroid	0.5	0.5	0.50	1.0 K#
Decis	1.0	0.5	0.00	1.5
Orthene	1.5	0.0	1.00	0.5 Kx
Karate	0.0	0.5	0.50	3.5 C#
Check	1.0	0.5	0.25	1.5
Fury	1.5	0.0	1.00	2.5

Table 10. Treatment means of beneficial arthropods per 100 sweeps on indicated sample dates.

June	4	6	8	10	12
Treatment					
Baythroid	1.0	0.00	1.0	0.0 Dx	1.0
Decis	1.0	0.00	1.0	3.5 O#	1.0
Orthene	0.0	1.00	0.0 Cx	0.5	2.0
Karate	0.5	0.00	0.5 C#	1.0	2.5
Check	1.5	0.75	2.5	2.5 B#	3.0
Fury	1.5	0.75	1.0	1.0	0.0 C#

Table 10. cont.

June	14	16	18	20
Treatment				
Baythroid	3.50	3.50	3.5	4.0
Decis	3.50	4.00 F#	3.0	5.5
Orthene	2.00	1.50 Cx	0.5 Fx	4.0
Karate	1.50	2.00	1.5 Fx	2.5
Check	2.75	4.75	3.5	3.0
Fury	2.00	1.00 Cx	6.0	2.5

Table 11. Treatment means of Heliothine eggs per 100 plants on indicated sample dates.

June	16	18
Treatment		
Baythroid	1.0	9.0 Dx O* C* F*
Decis	1.0	2.0
Orthene	2.0	1.0
Karate	1.0	6.0 O# Cx Fx
Check	1.5	1.5
Fury	2.0	1.0

Table 12. Treatment means of plant data sampled on 20-June.

Treatment	Node of First Fruit	Fruiting Sites/Plant	Squares/ Plant	Percent Square Set
Baythroid	6.07	5.94	5.21 C#	87.1 C*
Decis	6.33	5.38	4.52	82.8 Cx
Orthene	6.31	5.38	4.79 C#	88.6 C* F#
Karate	6.22	5.78	4.95 Cx	85.5 C*
Check	6.38	5.12	3.64	70.9
Fury	6.29	5.40	4.31	79.45 C#

Table 13. Mean day on which plots treated with indicated insecticide reached NAWF5 and the indicated percent of total lint yield picked from open bolls.

Treatment	NAWF5	50%	60%	70%	80%
Baythroid	7/30	9/12	9/16	9/18	9/21
Decis	7/30 F#	9/12	9/15	9/18	9/21
Orthene	7/31	9/13	9/15	9/18	9/21
Karate	7/30	9/13	9/16	9/18	9/20
Check	8/1	9/13	9/16	9/18	9/21
Fury	8/1	9/13	9/16	9/18	9/21

Table 14. Treatment means of pounds of lint cotton per acre picked on indicated harvest dates.

Date	8/26	9/2	9/9	9/16	9/23	9/30
Treatment						
Baythroid	56	132	296	270 Ox	373	45
Decis	55	162	293	299	370	76 O#
Orthene	54	134	331	334	408	26 C#
Karate	63	143	301	313	395	38
Check	56	133	292	294	395	72
Fury	64	149	331	311	421	53

Table 15. Treatment means of pounds of lint cotton per acre picked and accumulated at the indicated harvest dates.

Date	8/26	9/2	9/9
Treatment			
Baythroid	56	188	484
Decis	55	217	510
Orthene	54	188	518
Karate	63	205	506
Check	56	189	481
Fury	64	213	545

Table 15. cont.

Date	9/16	9/23	9/30
Treatment			
Baythroid	754	1126 Ox F*	1171 F*
Decis	809	1179 F#	1255 B# F#
Orthene	852	1260 C#	1287 Bx
Karate	819	1214	1253 B# F#
Check	775	1170 Fx	1242 B# Fx
Fury	856	1277	1330

Table 16. Dependent and independent variables used in regression to examine relationships.

Dependent Variables	**Independent Variables**
Percent Square Set	*Lygus* Days
% Damaged Terminals	Armyworm Days
Day of Node above White Bloom 5	Alfalfa hopper Days
Day of 50% open bolls	Leaf hopper Days
Day of 60% open bolls	Cucumber beetle Days
Day of 70% open bolls	Percent Square Set
Day of 80% open bolls	
Total lint cotton	

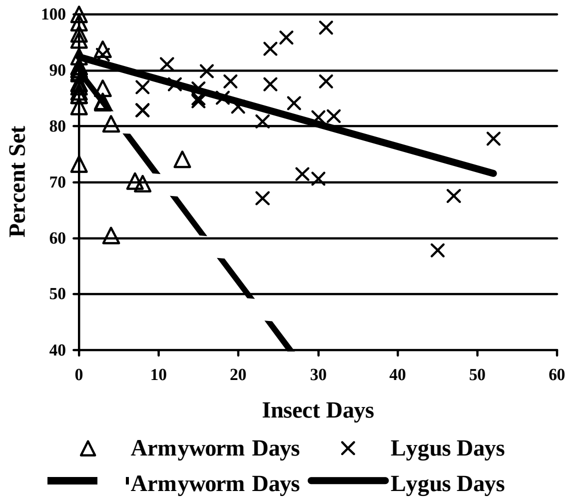

Figure 1. Graph of the linear regression (Percent Set= - 0.225 *Lygus* days- 1.47 Armyworm days +88.41) of two independent variables (*Lygus* days and Armyworm days) on percent square set on ten node cotton.