THE INTERACTION OF NITROGEN FERTILIZATION AND INSECT POPULATIONS

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Abstract

Fields test during 1998 and 1999 were conducted to study the interaction of nitrogen fertilization and insect control decisions. Insect data and plant data were collected from replicated plots treated with 90, 120, 150, 180, and 210 lbs. of nitrogen per acre. No results clearly indicate that increasing nitrogen fertilization increases numbers of insects. Four of the plots exceeded heliothine treatment thresholds only one time in the 2 years. The only treatment, which did not exceed treatment thresholds, was the plots fertilized with 150 lbs. per acre nitrogen. Statistically there were no differences in the heliothine larval data. Delay caused by nitrogen fertilization caused one extra boll weevil insecticide to be applied in 1998 to plots fertilized with 150 lbs. of nitrogen per acre or higher. Dollars returned above specified costs were not different in any treatment fertilized at or above 120-lb. nitrogen per acre.

Introduction

The interaction of nitrogen fertilization and insect populations has been discussed in the scientific literature on several occasions. Nitrogen fertilization has been shown to affect number, (Isley 1946 and Ratchford et al. 1989), and insecticide susceptibility, (McKenzie et al. 1995) of the cotton aphid, *Aphis gossypii* Glover, on cotton. Leigh (1970) reported differences of, *Lygus hesperus* Knight, *Geocoris pallens* Stal., and *Tetranychus pacificus* McGregor. These differences did not always correlate with the various rates of nitrogen. These authors implied that cotton growers could reduce the threat from insect pest by optimizing their irrigation and fertilization practices. Beckham (1970) showed differences in boll weevil, *Anthonomous grandis* (Boheman) and cotton aphid populations by varying nitrogen rates ranging from 0 to 120 lbs. per acre. The boll weevil differences were not correlated to nitrogen fertilization but aphids increased with the increased rates of nitrogen fertilizer. Fletcher (1941) showed bollworm larval numbers were correlated to moisture content of the growing tips of cotton plants.

In conversations with cotton producers and field consultants, the phrase “too much nitrogen causes insect problems” was and is common. This test was designed to gather information on the effects of nitrogen fertilization on insect populations and to determine if these insect populations had an effect on the economic return of the cotton crop.

Materials and Methods

A 19-acre field rented by the Delta Research and Extension Center was chosen for this test. The field was planted with corn in the 1997 season. The field was composed of three soil types and was land formed so that it could be irrigated. Approximately, the upper half of the field was classified as Dundee silt clay loam. The lower third of the field was classified as Forestdale silt clay loam. Between these two soil types was a streak of Dowling soils (Morris et al. 1961).

The field was bedded in the fall and rebedded in the spring of 1998 to 40 inch rows. The field was divided into 20 plots. Each plot was 16, rows wide and varied from approximately 500 to 600 feet long because the field was not square. On 1April, 5 nitrogen treatments of an aqueous mixture of urea and ammonium nitrate (32% UAN) were applied to the plots in a randomized complete block design. The treatments were either 90, 120, 150, 180, or 210 lbs. nitrogen per acre.

On 5 May, the entire field was planted with Stoneville 474 cottonseed with 3.5 lbs. Temik 15G applied in furrow. On 3 June, when the cotton had 5 true leaves a broadcast rate of 2.13 oz per acre Baythroid 2 was applied in a 20-inch spray band. On 5 June, methyl parathion 4E at a rate of 0.5 pints per acre was applied by air to the entire field. On 12 June Baythroid 2 plus Provado 1.6 F were applied at the broadcast rates of 2.13 and 3.75 oz per acre, respectively, in a 20 inch spray band.

Beginning 16 June, all plots were scouted twice a week (generally on Monday and Thursday). Ten terminals were examined in each plot for bollworm eggs, bollworm larvae, and all developmental stages of plant bugs. As the terminals were being examined, 10 squares were also examined for boll weevil damage, bollworm damage, bollworm larvae, and plant bugs of all ages.

Aphids and beet armyworms, *Spodoptera exigua* (Hubner), were sampled as needed. Aphid infestation estimates were done from leaf samples. Ten leaves attached to the fourth node below the terminal leaf were placed into sealed plastic bags, placed on ice, returned to the laboratory, and examined for aphids. Counts from each leaf were recorded and the average number of aphids per leaf was calculated. Beet

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armyworm population estimates were done by counting the number of hits (leaf damage caused by the feeding of first instar armyworms as they hatch from their egg mass) on 100 feet of row.

At the proper time, 10 plants in each plot with a white bloom in the first fruiting position from the mainstem terminal were selected. The number of nodes between the white bloom and the terminal (NAWF, Oosterhuis et al. 1993) of the plant was counted. Later in the growing season, 10 plants in each plot with a cracked boll in the first fruiting from the mainstem were selected. The number of mainstem nodes above the cracked boll (Oosterhuis et al. 1993) to the last harvestable boll (NACB) was counted. On 2 September, plots fertilized with 90,120, 150, and 180 lbs. per acre nitrogen were defoliated. Defoliant was applied on 11 September to the plots receiving 210 lbs. of nitrogen fertilizer. This application was washed off by rain and reapplied on 16 September. On 17 September, the middle four rows of plots receiving 90, 120, 150 and 180 lbs. of nitrogen per acre were harvested with a two-row picker. The seed cotton was then dumped into a boll buggy equipped with electronic scales, and the seed cotton weights were recorded. The plot length of each plot was measured to determine the acreage picked. On 2 October all sixteen rows of all plots were harvested and the seed cotton was weighed as described above. This was the first harvest for the plots receiving 210 lbs. of nitrogen and the second harvest for the other treatments. After the harvest on 2 October, no further harvesting was considered economically feasible.

The same field was utilized for the experiment in 1999. On 20 April, all plots received the same nitrogen fertilizer rates that they had received in 1998. On the same day, the field was planted with DPL 33B cottonseed. An in-furrow application of 3.5 lbs. of Temik 15G per acre was applied at planting. On 21 May, Karate was applied at the broadcast rate of 2 oz per acre in a 20-inch spray band. On 4 June, Baythroid 2 plus Provado 1.6 were applied by air at the rate of 2 oz and 3.76 oz per acre respectively. Sampling was the same as 1998, except 10 additional blooms per plot was examined for bollworms and plantbugs. Plots were all defoliated on 8 September. The plots treated with 90 and 120 lbs. per acre nitrogen were harvested on 16 September and the plots treated with 150, 180 and 210 lbs. of nitrogen were harvested on 19-Sept. The harvest methods were similar to 1998 but no second harvest was done and only the four middle rows of the plots were harvested from all plots.

Insecticides were applied to each nitrogen treatment when insects reached threshold numbers (Layton, 1998-1999). Dates when each plot reached Node Above White Flower 5 (NAWF5) and Node Above Cracked Boll 4 (NACB4) were determined by linear extrapolation between two sample dates. Analysis of variance was accomplished using PROC. ANOV (SAS 7.0 for Windows 1999).

Results and Discussion

Tables 1, 2, and 3 show the insect data that were used to make insecticide application decisions for both years. Table 1 shows the bollworm data that led to the aerial application of Decis at a rate of 2.56 oz per acre 16 July 1998. Aerial application was necessary because wet soils prevented ground application. The threshold was 4 lavae per 100 terminals (Layton 1998). This threshold was reached on 14 July in the 90, 180, and 210 lb. per acre treatments (Table 1). Ground application was not an option because of wet soil. From these data, the decision was made to treat the field by air and charge only the treatments that had met threshold requirements with the cost of the application. Before the application was made on 16 July, a second sample was taken. At this time, only the plots treated with 120 lb. per acre nitrogen exceeded the threshold. The plane was in the air at this point and the application was made to all plots. So, all treatments except plot fertilized with 150 lb. per acre nitrogen were charged with the cost of the application. The objective to manage each treatment independently was a good idea in theory but practically it was achieved only as weather, labor, and equipment allowed.

Table 2 shows the boll weevil data that led to the aerial application of 1.5 pints of Malathion 57EC on 21 August 1998. The boll weevil samples on 13 August showed boll weevil counts in four of the plots to be above the 10% damage square threshold. Based on NAWF counts all plots were past cutout NAWF5 and one had already accumulated 350 heat units (DD60). At this point bolls are considered safe from boll weevil attack (Layton 1998) and the weevils were mostly damaging squares at this point. The decision was made to wait until the next sample date and see how many plots would be considered terminated at the next sample date. The next sample date indicated that all plots were above 50% weevil damage. The decision to apply the malathion by air was made to suppress the entire weevil population in all plots. The cost of the application was only applied to the 150, 180 and 210 lb. per acre nitrogen plots. They had not accumulated the 350 heat units needed for termination of insecticide applications on 19 August when the sample was taken. The plots treated with 150 lbs. of nitrogen had accumulated sufficient heat units for termination on 20 August but the application was requested on 19 August. The damage counts indicated that it was more than likely that threshold numbers were present before the 19 August.

Table 3 shows aphid data that triggered the aerial application of 4 oz of Provado 1.6F on 28 June 1999. This aphid population had established itself in the field in one week. Field observation the previous week showed populations of

1or more winged adults per leaf and small aphids were present around the adults. After the sample on the 24 June (Table 3), spot checks on 26 June showed aphid populations to be over 50 per leaf.

The only statistical differences that were found in the 2 years of data where insects exceeded treatment threshold (Tables 1, 2, and 3) were heliothine eggs on 14 July. These differences do not totally correlate with nitrogen rates in all cases, even though the highest numerical egg counts are in the 180 or 210 lb. per acre nitrogen treatments on both 14 and 16 July.

Tables 4 and 5 show data of various insect populations, none of which required control with insecticides. The aphid population shown on 27 July 1998 resulted from the insecticide application of Decis on 16 July. This population was not sprayed since many of the leaves examined had dead aphids on them, which appeared to have been killed by a fungus. The aphid population was gone within the week of the sample. No differences in aphids per leaf are seen among the nitrogen rates.

Hits (leaf damage where egg masses hatched) of a low population of beet armyworms were counted in 1998. No statistical differences are seen among the nitrogen treatments, but plots fertilized with 210 lb. of nitrogen per acre treatment had numerically the highest count. Similar data were recorded for a low population of spider mites, *Tetranychus urticae* (Knoch) and *Tetranychus cinnabarinus* (Boisduval) in 1999. No statistical differences were noted in mites per square inch, but the highest number of mites were found in the 210 lb. per acre nitrogen treatments. There were no statistical differences among the means of low numbers of bandedwinged whiteflies, *Trialeurodes abutilonea* (Haldeman). The plots fertilized with the three highest nitrogen rates had numerically more whiteflies than did plots fertilized with 90 and 120 lbs. of nitrogen per acre.

Average plant bug counts (nymphs plus adults) made from the first scouting date to the date of cutout showed statistical differences among nitrogen treatments both years (Tables 4 and 5). More plant bugs were sampled in 1998 on the three high nitrogen treatments than the two lowest nitrogen treatments. However, in 1999 the three treatments with the lowest nitrogen rates had higher numbers of plant bugs than did the 180 and 210 lb. per acre nitrogen treatments.

Tables 6 and 7 contain plant physiological data that could impact insect control costs. This was seen in 1998, when plots fertilized with 150, 180, and 210 lbs. of nitrogen per acre, required one more application for boll weevils than the plots fertilized with 90 and 120 lbs. of nitrogen per acre. In both years, the plots fertilized with the 3 highest rates of nitrogen reached cutout (NAWF5) significantly later (3-6 days) than did the plots fertilized with the 2 lower rates. In 1999, plots fertilized with 90 lbs. of nitrogen per acre reached cutout significantly (6 days) earlier than did the plot treated with 120 lbs. of nitrogen. Delays due to nitrogen treatments are similar in the insecticide termination data (NAWF5+350 DD60's) as is seen in the cutout data.

There were differences in the dates when the nitrogen treatments were ready to defoliate [node above cracked boll 4 (NACB4), McCarty et al. 1998]. In 1998 defoliation date were 4 days later for the 210 lb. per acre treatment than was the 90 lb. per acre treatment. The difference between these same two treatments in 1999 was 16 days. The 90 and 210 lb. nitrogen rates would be considered rates that are excessively low and excessively high for these soils. Differences between the 120 and 180 lb. per acre nitrogen treatments were 3 days (no statistical difference) in 1998 and 6 days (statistically different) in 1999. These two treatments would be considered closer to the commonly used nitrogen fertility rates.

In both years lint cotton yields numerically increased with each additional 30 lb. increase in nitrogen fertilization except for the 210 lb. per acre treatment in 1999 (Tables 9, 11). In 1998 specified costs numerically increased with the highest two nitrogen treatments. This was not true of the costs of insecticide in 1999 when boll weevil eradication eliminated some possible late applications (Tables 8, 10). Boll weevil eradication may reduce the risk of extra insect cost due to delayed cotton crops.

In 1998 there was $25.82 difference (not significant at the 0.05 level of probability) between the 120 lb. nitrogen per acre treatment (treatment with highest returns above specified costs) and the 150 lb. treatment (treatment with lowest returns) (Table 9). In 1999 there was $108.75 difference (significant at the 0.05 level of probability) between the 90 and 180 lb. nitrogen per acre treatments. These treatments had with the lowest and the highest dollar returns above specified costs respectively (Table 9).

Averaged over both years, treatments fertilized with 120 lbs. or more of nitrogen per acre all had significantly higher returns above specified costs (Table 12). Numerically plots fertilized with 180 lbs. nitrogen per acre gave the highest returns above specified costs.

Conclusions

Every weather year will vary the results of this test, and if this test is moved to other soil types results will differ. For the two years this test was conducted, nitrogen fertilization did not sufficiently alter insect populations enough to affect decisions to apply insecticides. In one instance, the delay caused additional insecticide applications to be applied to the plots fertilized with higher nitrogen rates.

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Table 1. Average percent eggs and heliothine larvae in terminals of cotton plants in plots treatment with the indicated nitrogen fertilization rates on indicated dates in 1998. [1]

Treatment Lbs. N/Acre	% eggs 14 July	% larvae 14 July	% eggs 16 July	% larvae 16 July
90	3.12 b	10.0 a	2.50 a	2.5 a
120	3.75 ab	2.50 a	2.50 a	5.0 a
150	3.12 b	2.50 a	1.88 a	0.0 a
180	9.38 a	5.00 a	4.38 a	2.5 a
210	4.38 ab	10.0 a	5.00 a	0.0 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.

Table 2. Average percent boll weevil damaged squares from plots fertilized with indicated amounts of nitrogen indicated dates in 1998. [1]

Treatment Lbs. N/Acre	Boll Weevil Damaged Squares 13 August	Boll Weevil Damaged Squares 19 August
90	2.5 a	60.0 a
120	12.5 a	55.0 a
150	17.5 a	60.0 a
180	12.5 a	62.5 a
210	12.5 a	72.5 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.

Table 3. Average number of aphids per leaf sampled form 40 leaves per treatment on the indicated date in 1999. [1]

Treatment Lbs. N/Acre	Aphids per leaf 24 June
90	25 a
120	33 a
150	24 a
180	28 a
210	35 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.

Table 4. Average number of insects counted on the indicate dates in 1998 [1]

Treatment Lbs. N/Acre	Aphidsper leaf 27 July	Hits of Beet Armyworms per 100 row feet 31 July	Plant bug average per 100 terminals and squares 16 June-27 July
90	38 a	0.75 a	0.50 bc
120	25 a	0.50 a	0.25 c
150	43 a	0.75 a	1.50 ab
180	43 a	0.75 a	2.25 a
210	38 a	1.50 a	1.50 ab

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.

Table 5. Average number of insects counted on the indicate dates in 1999. [1]

Treatment Lbs. N/Acre	Whiteflies per square inch 13 Aug	Mites per square inch 13 Aug	Plant bug average per 100 terminals and squares 1999 11 June-22 July
90	0.62 a	1.10 a	2.08 a
120	0.30 a	0.72 a	1.88 ab
150	4.58 a	1.10 a	1.67 ab
180	1.00 a	1.40 a	0.62 ab
210	0.95 a	1.50 a	0.21 b

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.

Table 6. The average date plots with different nitrogen treatments reached the indicated physiological stage of growth in 1998. [1]

Treatment Lbs. N/Acre	Date of Node Above White Flower 5	Date of Node Above White Flower 5 + 350 DD60's	Date of Node Above Cracked Boll 4
90	27 July b	12 August b	29 August c[2]
120	30 July b	15 August b	29 August bc
150	3 August a	20 August a	1 September abc
180	4 August a	21 August a	1 September ab
210	5 August a	22 August a	2 September a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.
[2]Apparent differences between the same date arise from averaging four plots producing fractions of days.

Table 7. The average date plots treated with different rates of nitrogen fertilizer reached the indicated physiological stage of growth in 1999. [1]

Treatment Lbs. N/Acre	Date of Node Above White Flower 5	Date of Node Above White Flower 5 +350 DD60's	Date of Node Above Cracked Boll 4
90	22 July c	4 August c	23 August c
120	28 July b	11 August b	3 September b[2]
150	2 August a	17 August a	4 September ab
180	5 August a	21 August a	9 September a
210	5 August a	20 August a	8 September a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.
[2]Apparent differences between the same date arise from averaging four plots producing fractions of days.

Table 8. Specified costs[3] per acre for each nitrogen treatment in 1998.

Treatment Lbs. N/Acre	Cost/acre Nitrogen	Cost/acre Insects	Cost/acre Defoliation
90	$19.51	$39.02	$11.92
120	$26.02	$39.02	$11.92
150	$32.52	$38.51	$11.92
180	$39.03	$49.33	$11.92
210	$45.53	$49.33	$22.43

[3]Lee et al. 1997.

Table 9. Average yield and dollars returned from plots receiving different nitrogen fertilization treatments in 1998. [1]

Treatment Lbs. N/Acre	Lbs. Lint /acre	Gross Returns /acre[4]	Returns Minus Specified Costs
90	730 c	$462.49 c	$401.79 a
120	787 ab	$498.73 ab	$419.62 a
150	752 bc	$476.75 bc	$393.80 a
180	806 a	$510.74 a	$410.46 a
210	828 a	$524.68 a	$407.39 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.
[4] Cotton price. $0.62/lb. Anonymous 1999.

Table 10. Specified costs[5] subtracted from the average gross dollars per acre return for each nitrogen treatment in 1999.

Treatment Lbs. N/Acre	Cost/acre Nitrogen	Cost/acre Insects	Cost/acre Defoliation
90	$16.96	$83.98	$14.39
120	$22.61	$83.98	$14.39
150	$28.27	$83.98	$14.39
180	$33.92	$83.98	$14.39
210	$39.57	$83.98	$14.39

[5]Lee et al. 1998.

Table 11. Average yield and dollars returned from plots receiving different nitrogen fertilization treatments in 1999. [1]

Treatment Lbs. N/Acre	Lbs. Lint /acre	Gross Returns /acre[6]	Returns Minus Specified Costs
90	1168 b	$583.96 b	$468.64 b
120	1284 ab	$641.87 ab	$520.89 ab
150	1388 a	$693.80 a	$567.17 a
180	1420 a	$709.67 a	$577.39 a
210	1367 a	$683.52 a	$545.58 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.
[6]Cotton price $0.50/lb. (estimated) Cooke 1999.

Table 12. Two year averages of yield and dollars returned receiving different nitrogen fertilization treatments in 1998 and 1999. [1]

Treatment Lbs. N/Acre	Lbs. Lint /acre	Gross Returns /acre	Returns Minus Specified Costs
90	949 c	$518.12 c	$430.11 b
120	1035 b	$564.79 b	$465.82 a
150	1070 ab	$580.01 ab	$475.22 a
180	1112 a	$604.57 ab	$488.29 a
210	1097 ab	$598.31 a	$470.69 a

[1]Means followed by the same letter are not significantly different at the 0.05 level of probability.