THE EFFECTS OF N AND IRRIGATION ON TERMINATION OF INSECT CONTROL

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Abstract

Replicated experiments were conducted in 2000 and 2001 in the same cotton field to examine the effects of irrigation and nitrogen (N) rates on the time required to terminate insecticide applications. In both years irrigation increased days to reach insecticide termination. In the year 2000, irrigation increased returns above the specified costs of irrigation and insect control but in 2001 irrigation dramatically decreased returns above the insect and irrigation costs. Only in 2001 was N measured. In 2001 increased N decreased returns above the cost of N and insect control numerically under both irrigated and non-irrigated conditions but were significantly different at the P=0.05 level of probability in irrigated plots fertilized with 180 lb/A N.

Introduction

In 1993-1996 studies indicated that Node above White Flower Five (NAWF5)+ 350 DD60's is a reliable indicator of when insect control can be terminated (Harris et al. 1997). The number of main-stem nodes from the white flower in the first fruiting position to the terminal is defined by Harris et al. (1997) as nodes above white flower (NAWF). NAWF5 is the point where the NAWF value of the average plant is 5 and the crop is said to be at physiological cutout (Harris et al. 1997). NAWF5 plus 350 heat units (DD 60's) is considered to be the time when the cotton crop is safe from insects such as boll weevil, Anthonomous grandis (Boheman), cotton bollworm, Helicoverpa zea (Boddie), tobacco budworm, Heliothis virescens (Fabricus), and tarnished plant bugs, Lygus lineolaris (Palisot de Bearvois). Past research (Andrews et al. 2000) shows that under irrigated conditions 120 lb/A rates of N fertilization caused cotton to cutout 8 days sooner than 180 lb/A rates of N. These studies were initiated to examine the effect of irrigation in the growing season of 2000 and the interaction between N and irrigation in the 2001 growing season on termination of insect control.

Materials and Methods

A 19-acre field of the Tribbett Satellite Farm of the Delta Research and Extension Center was utilized for the study in both 2000 and 2001. The upper half of the field has been 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 soil (Morris et al. 1961). Insect and NAWF data were taken on the upper half of the field where the predominant soil is Dundee silt clay loam but whole plots were harvested for yield data.

Experimental Design and Treatments - 2000 Test

Sure-Grow 747® cotton variety was planted on the test site in the year 2000, i.e. 320-rows (1067-ft) wide by 509- to 594-ft long. The test site was tilled and hipped into 40-in rows in the fall of 1999 and planted on 24 Apr. The experiment consisted of two treatments (1) Irrigated, and (2) Non-irrigated. Treatments were arranged in a completely randomized design replicated 10 times. Each plot was 16 rows wide and extended the full length of the field (i.e. plot length ranged from 509- to 594-ft). Irrigated plots received three furrow irrigations in the 2000-growing season. Each irrigation event cost $12.60 for a total cost of $37.50 for irrigation (Anon. 1999).

Plots were scouted twice weekly to estimate insect populations. Two early season applications of insecticide were applied to one half of the field. These applications were part of a multi-year study and should have no impact on the effect of irrigation on termination of insecticides since equal number of plots were used for the early season treatments. Insect control maintenance over the whole experiment was achieved with a single aerial application on 9 Aug of Karate® (cyhalothrin) 0.033 lb ai/A plus Orthene® (acephate) 0.5 lb ai/A. The decision for this application was based on scouting data for 27 Jul. The cost of $14.75 (Anon. 1999) for insecticide and application applied only to plots that reached NAWF5 plus 350 DD60's after 27 Jul.

Yield was obtained by mechanically picking whole plots with a commercial harvester and dumping the seed cotton into a weighing boll buggy. The length of each plot was measured and per acre seed cotton yield was calculated. Lint turnout was set at 30.3 percent for all plots (Personnel communication 2000, USDA Ginning Laboratory, Stoneville, MS) and used to calculate lint yield per acre. Price of cotton used to calculate returns, was $0.505/lb for 2000 (Anon. 2001a). Analysis of variance and mean separation was accomplished by using PROC ANOV (SAS 8.0 for Windows 1999).

Experimental Design and Treatments - 2001 Test

Stoneville BXN 47® cotton variety was planted on the same, but smaller portion of the test site in the year 2001, i.e. 288 rows (960-ft) wide by 516- to 594-ft long. The site was prepared in the fall of 2000 by subsoil tillage and hipping into 40-in rows. The experiment was arranged in a split-plot, randomized-complete-block design replicated 6 times. Two main plot variables were (1) Irrigated, and (2) Non-irrigated. Sub-plot variables were three nitrogen (N) rates, (1) 120 lb N/A , (2) 150 lb N/A, and (3) 180 lb N/A. Nitrogen rates were achieved by applying a urea-ammonium nitrate aqueous solution by "knife-application" to both sides of the row at a rate of 120 lb N/A prior to planting. Additional N was applied as sidedress application at pin-head square stage of crop development at rates of 0, 30, and 60 lb N/A to achieve the final rates of 120, 150, and 180 lb N/A. Main plots were 24 rows wide and sub-plots were 8 rows wide. Plot length was the entire length of the field and ranged from 516- to 594-ft long.

Three replications received the two early season insecticide applications and three did not, similar to the way the test was done in 2000 as part of the a multi-year study. Plots were scouted twice weekly to estimate insect populations. Four applications of insecticides were needed after first bloom. The insecticide and application costs (Anon. 2000) were:

1. Provado® (imidacloprid) 0.047 lb ai/A costing $14.75 for plant bugs
2. Steward® (indoxacarb) 0.104 lb ai/A costing $15.41 for plant bugs and bollworms
3. Decis® (deltamethrin) 0.025 lb ai/A plus Centric® (thiamethoxam) 0.047 lb ai/A costing $22.19 for plant bugs and bollworms
4. Orthene® 97 (acephate) 1.067 lb ai/A costing $11.95 for plant bugs and bollworms.

The entire field was sprayed at each application. The cost of the application was applied only to plots that had not reached NAWF5 plus 350 DD60's when scouting data were collected to base the need for application.

Whole plots were picked and yields recorded similar to the 2000 test. Lint percent was determined by ginning samples through the USDA Ginning Laboratory micro-gin using standard machine sequence and two lint cleaners (Personnel communication 2001. USDA Ginning Laboratory, Stoneville, MS.). Lint yields were then calculated using the lint percent obtained. The cost for N in each treatment was $40.22 for 120 lb/A, $54.34 for 150 lb/A, and 63.04 for 180 lb/A (Anon. 2000). Analysis of variance was accomplished by using PROC MIXED (SAS 8.0 for Windows 1999).). Cotton price was set at $0.54/lb (Anon. 2001b) for 2001.

NAWF Data 2000 and 2001

NAWF was counted on ten plants from each plot starting in mid-July and weekly thereafter until the average NAWF of sampled plants in each plot was 10 in 2000 and 6 in 2001. Linear extrapolation was used to determine the date when (NAWF5) occurred for each plot. Dates were converted to Julian dates for analysis and fractions of dates were rounded to the next highest date.

Soil Moisture Measurements

Soil water potential sensors (Watermark model 200SS) were installed as stations on 2 irrigated rows ¼ and ¾ the width of the field. At each station, the watermark sensors were placed at 5 depths from 6 to 30 inches deep. On two rows where water mark stations were located, four stations were uniformly located down the row, being equal distance between the first and last station and the row ends and equal distance between stations within the row. Irrigations were triggered when the easily available water had been removed from each depth monitored down to 30 inches of the four watermark stations located in the predominate soil type which in this situation was the upper half of the field (Dundee silty clay loam soil). Average soil water potential reading of 60 centibars or greater were used to indicate when the easily available water had been removed. In both years, irrigation did not occur until after first bloom.

Results and Discussion

Delay due to irrigation was a variable in 2000 and 2001. Data in Table 1 show the dates when the average plot reached NAWF5. Irrigation caused a 9-day delay in NAWF5 in 2000 and a 23-day delay in 2001. In Table 2 the number of days required to accumulate 350 DD60's (DREC Weather GIS Data Center) after cutout is shown. By subtracting data in Tables 1 and 2 it can be noted that irrigation caused a delay in NAWF5 and NAWF5+350DD60's of 9 days for both plant stages in 2000 but delays of 23 and 26 days respectively in 2001. The hot dry season of 2000 caused the plant to cutout quickly. In only 15 days, the average plant had accumulated 350 DD60's for the non-irrigated and the irrigated plots. Subtraction of data in Table 2 from data in Table 1, a 16-day time interval to accumulate the 350 heat units in the non-irrigated plots and a 19-day period to accumulated 350 heat units in the irrigated plots is obtained from the 2001 data. Cooler weather in late August added an extra 3 days to the time of insect control.

The additional time required for the irrigated plots to reach the point where insect control could be terminated added $8.86 and $21.06 to the cost of production in 2000 and 2001 growing seasons, respectively (Table 3). In Table 4, the cost of irrigation is added to the insect control cost for irrigated plots. Table 5 shows data for the average of lint cotton yield from irrigated and non-irrigated plots. Average lint turnout from irrigated cotton was 35 % and from non-irrigated cotton was 38 % in 2001. The 2000 growing season was extremely dry. The 2001 growing season was normal until August and September, these months were abnormally wet and had low solar radiation. The combination of thick plant stands (5.5 plants per foot of row) and the wet conditions set up plant competition and boll rot in 2001. These factors produced a 214-lb/A lint-yield loss in the irrigated plots. The two years may represent the extremes of dry and wet years.

Data in Table 6 gives the bottom line for the two years with reference to irrigation. Returns to irrigation for the combined years are -$147.98/A.

In 2001, N fertilization was included as a variable. Data in Table 7 show that N significantly increased time to NAWF5 at the 150-lb/A N rates but was not different at the 180-lb/A rates where the cotton was not irrigated. Under non-irrigated conditions, the increased time required to reach cutout reversed. There was not a significant increase between the 120-lb/A rates and the 150 lb/A N rate. However, there was a 9-day significant increase in time required to reach cutout between the 120 and 180 lb/A N rates. The time difference between 120 and 180-lb/A N rates increased to 13 days to reach NAWF5+350DD60's (Table 8). Table 9 shows the change in yields among N rates. There was no significant difference in yields in the non-irrigated plots fertilized with 120, 150, and 180 lb/A N. There was a significant 87-lb lint/A decrease in yield at the 180-lb/A N rates in the irrigated plots.

The cost of insect control due to N was not significantly different within the irrigated or non-irrigated plots (Table 10). When the cost of N is added to the insect control costs, significant differences in costs are seen in all plots except the non-irrigated 150 and 180 lb/A N rates and the irrigated 120 lb/A N rate (Table 11).

In Table 12, returns due to N above the specified costs of N fertilization and insect control was not significantly different in non-irrigated plots but decreased numerically as N rates increased. The returns from plots fertilized with 180-lb/A N were significantly different from the 120 and 150 lb/A N rates in plots that were irrigated. As in the non-irrigated plots, returns decreased as N increase but seem to decrease at a greater rate.

Conclusions

Weather and location will cause the effects of irrigation and N to vary but these data are good examples of the interactions of one input on other inputs and associated costs. Irrigation increased the time needed for insect control. In 2001, the irrigation increased insect control costs $21.06 while and additional 60 lbs N/A increased insect control costs $1.71 and $1.99 under non-irrigated and irrigated conditions respectively.

Because of high plant populations in the 2001 experiment, and excessive rainfall and cloudiness in late August and early September 2001, the experiment may have endured a near worse case weather scenario that year to produce negative effects of both irrigation and N.

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Table 1. Date when NAWF5 occurred in the irrigated and non-irrigated plots and the days increase to cutout in the 2000 and 2001 growing season.

	Day of Node Above White Flower 5 (NAWF5)		Increase in days to cut out	
Irrigation	**2000**	**2001**	**2000**	**2001**
NO	15-July	21-July		
YES	24-July	13-August	9**	23**

**Indicates increase was significant at the 0.01 level of probability.

Table 2. Date when NAWF5 +350DD50's occurred in the irrigated and non-irrigated plots and the days of insects control increase in the 2000 and 2001 growing season.

	Day of Node Above White Flower 5 +350DD60's		Increase in days of insect protection	
Irrigation	**2000**	**2001**	**2000**	**2001**
NO	30-July	6-August		
YES	8-August	1-Sept	9**	26**

**Indicates increase was significant at the 0.01 level of probability.

Table 3. Insect control costs in the irrigated and non-irrigated plots and the portion of insect control costs attributed to irrigation in the 2000 and 2001 growing season.

	Cost of Insect Control After Bloom		Insect Control Costs attributed to Irrigation	
Irrigation	**2000**	**2001**	**2000**	**2001**
NO	$4.42	$42.36		
YES	$13.28	$63.42	$8.86**	$21.06**

**Indicates increase was significant at the 0.01 level of probability.

Table 4. Costs of insect control and irrigation of the irrigated and insect control for non-irrigated plots and the additional costs attributed to irrigation in the 2000 and 2001 growing season.

	Specified Costs (Insect Control and Irrigation)		Difference in Specified Costs	
Irrigation	**2000**	**2001**	**2000**	**2001**
NO	$4.42	$42.36		
YES	$51.08	$101.22	$46.66**	$58.85**

**Indicates increase was significant at the 0.01 level of probability.

Table 5. Lint cotton yields 2000 and 2001 growing season.

	Yield (lb lint/A)		Lb lint/A increase from Irrigation	
Irrigation	**2000**	**2001**	**2000**	**2001**
NO	578.6	884.0		
YES	716.4	669.2	137.9**	-214.8**

**Indicates increase was significant at the 0.01 level of probability.

Table 6. Returns above costs of insect control and irrigation from lint yields in 2000 and 2001.

Irrigation	Returns above Specified Costs (Insect Control and Irrigation) 2000	2001	Difference in Returns 2000	2001
NO	$321.12	$382.47		
YES	$348.00	$207.61	$26.88**	-$174.86**

**Indicates increase was significant at the 0.01 level of probability.

Table 7. Date when NAWF5 occurred in plots fertilized with 120, 150, and 180 lb of N that were irrigated and non-irrigated and the days increase to cutout due to N in 2001.

Irrigation	Lb N	Node Above White Flower 5 (NAWF5)	Days increase to cutout due to N rates above 120 lb/A
NO	120	18-July a[1]	0
	150	25-July b	7
	180	19-July ab	1
YES	120	9-August c	0
	150	12-August c	2
	180	18-August d	9

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

Table 8. Date when NAWF5 plus 350 DD60's occurred in plots fertilized with 120, 150, and 180 lb of N that were irrigated and non-irrigated and the days increase in insect control due to N in 2001.

Irrigation	Lb N	Node Above White Flower 5 (NAWF5) + 350DD60's	Days of increased insect control due to N rates above 120 lb/A
NO	120	31-July a[1]	0
	150	8-August b	8
	180	2-August ab	2
YES	120	4-August c	0
	150	27-August c	3
	180	5-September d	13

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

Table 9. Lint cotton yields from plots fertilized with 120, 150, and 180 lb of N that were irrigated and non-irrigated and change in yield due to N in 2001.

Irrigation	Lb N	Yield (lb lint/A)	Change in yield due to N rates above 120 Lb
NO	120	887.4a[1]	0.0
	150	903.3a	15.9
	180	861.3a	-26.1
YES	120	701.15b	0.0
	150	692.3b	-8.8
	180	614.1c	-87.0

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

Table 10. Specified costs (insect control) and change in specified costs due to N above 120 lb/A among irrigate and non-irrigated plots in 2001.

Irrigation	Lb N	Costs of insect control	Increase in costs due to increase in N
NO	120	$39.33 a[1]	$0.00
	150	$46.72 a	$7.40
	180	$41.04 a	$1.71
YES	120	$62.09 b	$ 0.00
	150	$64.08 b	$1.99
	180	$64.08 b	$1.99

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

Table 11. Specified costs (insect control and N) and change in specified costs due to N rates above 120 lb/A among irrigated and non-irrigated plots in 2001.

Irrigation	Lb N	Costs of insect control and N	Increase in costs due to increase in N above 120 lb/A
NO	120	$79.54 a[1]	$0.00
	150	$101.07 b	$21.52
	180	$104.08 b	$24.53
YES	120	$102.31 b	$0.00
	150	$118.42 c	$16.11
	180	$127.12 d	$24.81

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

Table 12. Returns above specified costs (insect control and N) and change in returns due to N rates above 120 lb/A among irrigated and non-irrigated plots in 2001.

Irrigation	Lb N	Returns above costs of N and insect control	Change in returns due to increase in N above 120 lb/A
NO	120	$399.66 a[1]	$0.00
	150	$386.71 a	-$12.94
	180	$361.04 a	-$38.62
YES	120	$238.51 b	$ 0.00
	150	$217.62 b	-$20.89
	180	$166.69 c	-$71.82

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