FORMULATING DECISION SUPPORT FACTORS FOR VARIABLE RATE NITROGEN FERTILIZATION

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Abstract

A field study was conducted in 1998 on an alluvial-derived field in Bolivar county, MS to determine the effects of variable rate N fertilization on cotton growth and lint yield. Two variable rate sidedress treatments were compared to a constant fertilizer N check of 40 lb N/A. The first variable rate treatment was based solely on soil available N differences throughout the field, while the second treatment was based on these same available N differences but with additional adjustment factors for differences in field elevation, wetness, and % clay. Both of the variable rate treatments ranged from 15.2 - 62.0 lb N applied per acre. Plant height was not significantly affected by either variable rate treatment. Overall the variable rate prescription based on available N alone did not increase lint yield, while the prescription based on multiple factors did result in a significant lint yield increase, especially in those areas of the field where less fertilizer N was applied.

Introduction

Because soil N levels constantly fluctuate, current fertilizer N recommendations are based on yield potentials and long-term rate-response studies on varied soil types. Up to now farmers have not had the necessary tools to adequately deal with infield variations due to soil type or topography. With small fields this problem may not be significant, but with large, alluvial -derived soils in the Mississippi Delta, there can be significant textural and elevation differences that require differing amounts of fertilizer N. The capability to vary N rates in these fields could potentially help farmers to optimize their fertilizer N distribution/usage by better matching N rate with texture. The minimization of within field plant height differences could also increase the effectiveness of pesticide applications and decrease the need for plant growth regulators. Consequently, the objective of the present study was to formulate and test decision support factors for variable N fertilization in cotton by determining the effects of variable rate N fertilization on cotton growth and lint yield.

Materials and Methods

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A field study was conducted in 1998 on an alluvial-derived field in Bolivar county containing at least six different soil types. Elevation differences in the field were determined using LIDAR flown from a helicopter. Drier and wetter areas in the field were determined using images of bare soil flyovers obtained in 1997 and 1998. In May 1998, before applying any fertilizer N, 72 acres were mapped on a one-acre grid and soil samples were taken at each location in increments down to three feet to determine available soil N and texture. The samples were extracted using 1 M KCl and analyzed for NH_4^+ and NO_3^- using an autoanalyzer. Differences in available soil N ranged from 21 to 93 lb N/A as shown in Figure 1. Two weeks after planting 60 lb N/A was applied to the entire field. At first flower three sidedress N treatments were randomly assigned to eight row plots in each of four transects located in the mapped area of the field. The 32% UAN-solution treatments were as follows: <u>Control</u> **-** constant fertilizer N check of 40 lb N/A; <u>Variable Rate 1</u> **-** based on available soil N differences in the field; and <u>Variable Rate 2</u> **-** based on available soil N with adjustment factors for elevation, wetness, and % clay.

To develop the variable rate 1 prescription, the available soil N at each of the 72 sampling locations was graphed and N levels between them were interpolated. As illustrated in Table 1, as available soil N increased in the field, the sidedress N application prescription decreased. The same logic was used to formulate the variable rate 2 prescription except that adjustment factors were added to account for variability in elevation, wetness, and clay content. The elevation data was divided into nine categories with the lowest receiving 30% and the next two higher elevations receiving 60 and 90%, respectively, of the sidedress N rate. These areas were mostly drainage ditches that historically produce low cotton yields. The wetness data interpolated from the bare soil imagery was divided into three categories with the drier and wetter areas receiving 75% of the sidedress N rate and the remaining area receiving 100%. The drier areas were suspected to be sandier, while the wetter areas were suspected to be lower and more poorly drained. The last adjustment factor, clay content in the upper six inches of the soil profile, was divided into four categories that adjusted the available N prescription as follows: 0 to 7% clay = 85%of sidedress N rate; 7 to 14% clay = 100% of sidedress N rate; 14 to 25% clay = 115% of sidedress N rate; and >25% clay = 130% of sidedress N rate. All three adjustment factors were multiplied into the available N prescription to derive a final variable rate 2 prescription. Both the variable rate 1 and 2 prescriptions were designed to change every three meters in the field, if the decision support parameter dictated it.

The N applicator that was used was designed by Bell Industries in Inverness, MS and consisted of a liquid band applicator coupled to two different controllers. The first maintained field position and prescription data information, while the second received the data, adjusted a solenoid valve on the applicator accordingly, and sent flowmeter data back to the first controller. Plant height measurements were taken throughout the growing season to determine the effects of variable rate N applications on cotton growth. At maturity, four of the eight rows from each plot area were harvested on a one acre grid using a four row picker and a weigh wagon. Representative seed cotton samples were ginned from each plot area to determine lint yields.

Results and Discussion

Sidedress N application data was analyzed to determine how accurately the N applicator applied the two variable rate prescriptions. Two application maps were constructed, a target, which was based on the sidedress prescriptions, and an actual, which was based on the flowmeter data collected by the applicator controller and sent back to the position controller. The average difference across the field between what was supposed to be applied and what was actually applied was exactly one gallon of UAN solution per acre or 3.5 lb N/A. The actual range of the variable sidedress treatments was 15.2 to 60.0 lb N/A compared to the constant fertilizer control rate of 40 lb N/A.

In order to make the statistical analysis of the sidedress treatments more meaningful, data from similarly treated areas across the field were grouped into three classification groups. The Less N group included those areas of the field that had more than 3.5 lb N/A less than the control, or less than 36.5 lb N/A applied. The Equal N group included those areas that were within 3.5 lb N/A more or less than the control rate of 40 lb N/A applied. Lastly, the Greater N group included those areas that had more than 3.5 lb N/A more than the control, or greater than 43.5 lb N/A applied. Within each of these classification groups, the variable rate 1 and 2 treatments were compared to the control treatment that corresponded with their individual locations in the field.

Table 2 shows the average N applied in the field by classification grouping and by the overall average of all locations. In the Less N group, the variable rate 1 and 2 treatments applied 11.3 and 9.7 lb N/A, respectively, less than their corresponding controls. Likewise, in the Greater N group, the variable rate 1 and 2 treatments applied 7.6 and 9.4 lb N/A, respectively, more than their corresponding controls. In terms of the overall average N applied, the variable rate treatments were basically the same or a little greater than the control. Variable rate N, therefore, redistributed fertilizer N but did not decrease the total amount of fertilizer applied for the whole field.

Table 3 shows the average plant height measured in the field at cutout, both by classification grouping and by overall average of all locations. Variable rate treatments were expected to be a little shorter than their corresponding control in areas where less N was applied and a little taller than their control in areas where more N was applied. In actuality, however, no significant differences were seen between any plant height measurements taken after the sidedress treatment was applied, either in the groupings or overall. The best explanation for these results can be seen by examining the plant height differences as they appear in the field before the sidedress treatments were applied at first flower. With the range being 15 to 51 cm, it appears that much of the spatial variability that is seen in late season plant height might actually be attributed to growth that occurred early in the growing season. N adjustments at sidedress did little to alter these preexisting height differences.

The last and perhaps most important parameter that was measured was lint yield. Table 4 shows the average lint yield by classification grouping and by overall averages of all locations. In those areas of the field where less N was applied compared to the control, variable rate 1 was not significantly different than the control, while variable rate 2 outyielded the control by 88 lb lint/A. In areas where basically the same amount of fertilizer was applied, there were no significant differences between either variable rate treatment and their corresponding control. Lastly, in those areas where greater N was applied, the control outyielded the variable rate 1 by 83 lb lint/A, while the variable rate 2 outyielded the control by 39 lb lint/A. Overall, the variable rate 1 yielded significantly lower than the control, while the variable rate 2 treatment yielded significantly greater than the control.

Conclusions

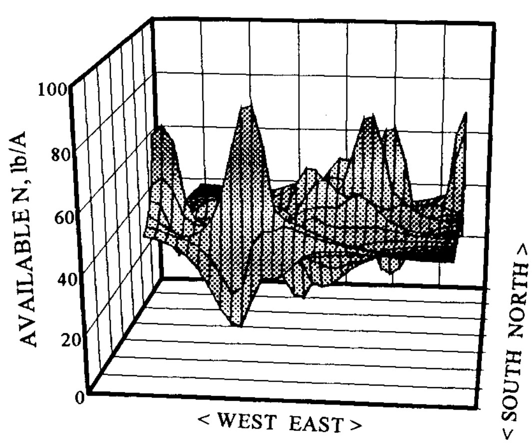

Figure 1. Spatial variability in soil available N in the three foot profile.

Because 1998 was the first year of this variable rate N experiment, the following conclusions are considered by the authors to be "preliminary": variable rate N in cotton is plausible when field variability warrants its use; efforts to use variable rate N to minimize spatial variability in plant height need to occur before sidedress; and lastly, variable rate nitrogen can result in significant lint yield increases when multi-factor prescriptions are utilized.

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Table 1. Variable rate 1 prescription logic.

Available Soil N, lb N/A	Sidedress N Rate, lb N/A
21-30	60
31-40	50
41-50	40
51-60	30
61-70	20
71-95	10

Table 2. Average N rate applied in lb N/A for each classification group and the overall average.

	Less N	Equal N	Greater N	Average
VR1	28.8	39.9	47.7	40.1b
Control	40.1	40.1	40.1	40.1b
VR2	30.4	40.1	49.5	41.9a
Control	40.1	40.1	40.1	LSD (0.1) = 1.76

Table 3. Average plant height at cutout in cm for each classification group and the overall average.

	Less N	Equal N	Greater N	Average
VR1	93.7	91.8	97.4	94.4a
Control	93.3	93.8	98.5	95.4a
Significance	NS	NS	NS	
VR2	93.6	92.7	98.5	95.4a
Control	92.6	90.2	102.1	LSD (0.1) = 2.35
Significance	NS	NS	NS	

Table 4. Average lint yield in lb lint/A for each classification group and the overall average.

	Less N	Equal N	Greater N	Average
VR1	933	954	839	909c
Control	957	951	921	942b
Significance	NS	NS	**	
VR2	1024	933	972	972a
Control	935	959	933	LSD (0.1) = 27
Significance	**	NS	†	

†,** Significant at the 0.1 and 0.01 probability levels, respectively.