COTTON RESPONSE TO MULTIPLE SPLIT APPLICATIONS OF NITROGEN

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Abstract

A 4-year study to evaluate and further define nitrogen (N) management for cotton utilizing multiple split applications was initiated in 1991 on a Dundee silt loam at the Delta Research and Extension Center. Four N rates (60, 90, 120, and 150 lb N/A) and six N application systems involving combinations of preplant (PP), pin-head square (PH), and/or early bloom (EB) applications were evaluated. Lint yields were quite different between years yet the responses were similar (no year by treatment interaction). In three of four years, there was no significant yield response to N rates above 90 lb/A. Of the application systems evaluated, the PP50-PH50 system produced the highest yields averaged over N rates followed closely by the PP100 and PP25-PH50-EB25 systems. The lowest yields occurred with the PP25-PH25-EB50 system where only 25% of the total N was applied prior to initial fruit set and development. There was no effect of application systems on second harvest yields, only on first harvest and total yield. Multiple split N applications at both pin-head square and early bloom did not increase yields above those obtained with a single split application at pin-head square. Data indicated that having sufficient N available during vegetative growth and early reproductive growth was the most important consideration in timing.

Introduction

Nitrogen nutrition of cotton and other crops has been studied for many years. Most of the non-symbiotic agronomic crops utilized ammonium and/or nitrate N to sustain normal metabolic processes. Adequate levels of plant available N are required for vegetative and reproductive growth. Imbalances, deficiencies, or even excesses may result in delayed fruiting, cause either reduced or excessive vegetative growth, and delay maturity in crops such as cotton. For most crops, timely N applications hastens maturity (1). Timely N application near the critical need time (fruit development for cotton) results in more efficient use of available N.

Several researchers (2, 6, 8, 9, 10) have demonstrated the effects of different N sources and the effects of application scheduling on cotton production. Early research in the Mississippi Delta (8, 9, 10) with full season cultivars showed no significant advantage to split applications. The most economic yields were obtained when all N was applied prior to planting. Studies in the early 1980's (2) at Stoneville demonstrated a slight decrease in yields with split applications when the sidedress N was applied at pin-head square. Later work by researchers in the Mississippi Delta (3, 4, 5, 6) found a significant lint yield response to delayed sidedress N applications on a Dundee very fine sandy loam. The increase ranged from 5.5 to 10.1% and averaged 7.5% over a 4-year period. The delay in application was from pin-head square to early- to mid-bloom. The greatest yield increases (average 31%) were measured at the second harvest with no apparent delay in maturity. Researchers attributed the yield increase to late-season N which was needed for development of bolls located at the higher positions..

Most of the research at Stoneville in the mid- to late-1980's used application systems involving 50% of the total N applied prior to planting with the remaining 50% applied between pin-head square and mid-bloom. Varying the preplant/sidedress ratio (7) showed little variation as long as at least 25% of the total N was applied at early bloom. However, little research is available on the fast-fruiting, early-maturing new cultivars with respect to N management. With this in mind, a 4-year study was initiated in 1991 at the Delta Research and Extension Center to evaluate multiple split N applications. The objective of this research was to evaluate the interaction effects of N rates and multiple split N application systems.

Materials and Methods

A 4-year field study was initiated in 1991 on a Dundee very fine sandy loam (Aeric Ochraqualfs) to evaluate the interaction of N rates (60, 90, 120, and 150 lb N/A) and application timing at preplant (PP), pin-head square (PH), and early bloom (EB). Soil test levels of phosphorus and potassium were adequate for optimum yields. The six application systems included: a) 100% of total N applied preplant (PP100); b) 50% of total N applied preplant plus 50% of total N applied at pin-head square (PP50-PH50); c) 50% PP plus 50% of total N applied at early bloom (PP50-EB50); d) 50% PP plus 25% PH plus 25% EB (PP50-PH25-EB25); e) 25% PP plus 50% PH plus 25% EB (PP25-PH50-EB25); and f) 25% PP plus 25% PH plus 50% EB (PP25-PH25-EB50). The 24 treatments (4x6 factorial) were arranged in a randomized complete block design (RCB) with four replications. The N was band-applied as urea-ammonium nitrate solution (UAN, 32% N) to both sides of the row (10 inches from the drill) with a 'John Blue' liquid fertilizer applicator. Preplant N was applied (April 9 to 24) into prepared beds which were re-hipped following application. The sidedress N was applied 10 inches to either side of the row with the same equipment as described for preplant N. Cotton ('DES-119)') was planted between April 27 and May 17 depending upon the year.

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Emergence occurred within 5 to 7 days. All conventional cultural practices including herbicide application, cultivation, irrigation, insecticide application, and defoliation were maintained uniformly across all treatments throughout the growing season.

After defoliation, the two center rows of each 4-row plot were harvested with a two-row spindle picker adapted for plot harvest. Two harvests were made in October of each year. A subsample was taken from each plot for use in determining lint yield. All results were analyzed statistically using analysis of variance procedures (Statistical Analysis Systems, SAS). Main effect means for N rates and application systems were calculated if the interaction was not significant. A combined analysis over all four years was also included to evaluate the overall effect of the N management system. Where appropriate, means averaged across years have been calculated and are presented in the tables with the appropriate statistics.

Results and Discussion

Analysis of variance for individual years of the 4-year study indicated no significant interaction between N rate and application system. Seedcotton yields (data not included) were measured each year of the study with lint yields calculated from subsamples collected at the time of harvest. Increasing N rates have been shown in other studies to decrease lint percent. Therefore, it is more appropriate to look at summaries of lint yields. Main effect means for 1991 are summarized in Table 1 for each harvest. Lint yields increased with increasing N rates up to 120 lb N/A. There was no additional lint yield increase above 120 lb N/A. The averaged total lint yields were 1267, 1349, 1427, and 1428 lb/A for the 60, 90, 120, 150 lb N/A rates, respectively. In 1991, there was no significant difference between any of the six application systems. The yields ranged from 1323 to 1397 lb lint/A. Lint yields for the PP25-PH25-EB50 were 4.8% and 5.3% lower than the PP100 and PP50-PH50 systems, respectively.

Lint yields from 1992 are summarized in Table 2. Overall yields in 1992 (1021 lb Lint/A) were down 25% compared to 1991 (1368 lb lint/A). At the first harvest, lint yields were not significantly increased with N rates above 90 lb N/A. At the second harvest there was some lint response up to 120 lb N/A. The total lint yields were 902, 1040, 1085, and 1059 lb/A for the 60, 90, 120, and 150 lb N/A rates, respectively. There was no difference between application systems with respect to total lint yields. The PP25-PH25-EB50 system was 3.1% and 8.9% lower when averaged over N rates compared to the PP100 and PP50-PH50 systems, respectively.

Yields were lower overall in 1993 compared to previous years (Table 3). Average lint yield across N rates and application systems was down to 544 lb lint/A, a 47% decrease compared to 1992 and 60% compared to 1991. As reported in 1992, there was no significant lint yield increase above 90 lb N/A with yields ranging from 489 lb/A for the 60 lb N/A treatment to 586 ll lint/A for the 90 lb N/A system. With lower yields, one would likely expect less response to increasing N rates. In 1993, there were significant differences between the application systems. The highest total lint yield (596 lb lint/A) was obtained with the PP100 system followed by PP50-PH50 (574 lb lint/A) and the PP25-PH50-EB25 system (552 lb lint/A). The lowest yield occurred when 50% of the total N was not applied until early bloom (PP50-EB50 and PP25-PH25-EB50). Reduced yields in 1993 were the result of drought stress during July and August. With sidedress N applications delayed until early bloom, irrigation and/or rainfall become important for moving the sidedressed N into the root system. With limited moisture, the plant has little chance for complete utilization of the applied N.

In 1994 lint yields were higher than those observed in 1993 but lower than either 1991 or 1992. The yields are summarized in Table 4. Lint yield increased with increasing N rates up to 90 lb N/A with no additional lint increase as N rates were increased to 120 and 150 lb N/A. Lint yields ranged from 713 to 797 lb/A. There was no significant difference between application systems with respect to total lint yield.

The 4-year summary of lint yields are included in Table 5 (interaction effects) and Table 6 (main effects). There was no significant year by treatment (N rate and application system) interaction for either first harvest lint yields or total lint yields. The year by treatment interaction was significant for second harvest lint yields so interaction effects have been included in Table 5. In this study as with other agronomic studies with cotton, the long-term effects of using a particular production system are of importance to the producer. With this in mind, it becomes appropriate to evaluate the main effects over time. The summary of these results are included in Table 6. Averaged across years and application systems, lint yields were 843, 938, 965, and 954 lb/A for the 60, 90, 120, and 150 lb N/A rates, respectively. There was no significant increase in lint yields with N rates above 90 lb N/A for both first harvest and total harvest. Lint yields were significantly higher for second harvest at the higher N rates. On the Dundee silt loams and sandy loams, MCES recommendations call for 90 to 100 lb N/A in most years and are supported by these data.

The effects of multiple split applications are also included in Table 6. The highest average yield was achieved with the PP50-PH50 system (962 lb lint/A) followed closely by the PP100 and PP25-PH50-EB25 systems (946 lb lint/A). The lowest yield (886 lb lint/A) was found with the PP25-PH25-EB50 system which reduced yields by 7.9% compared to the PP50-PH50 system. The application systems had no significant effect on second harvest yields as shown in Table 6. There was little effect of application on maturity as measured by the percent first harvest. Increasing N rates did tend to delay maturity slightly.

In summary, increasing N rates did not significantly increase lint yields when rates exceeded current recommended levels. Multiple split applications of nitrogen at both pin-head square and early bloom did not significantly increase yields above those obtained with a single split application at pin-head square. With irrigation and higher yields, split applications may have some advantage. However, with limited water, split N applications or delaying the N applications may result in somewhat lower yields. By adding the cost of additional trips across the field, it becomes more difficult to recommend multiple split applications. Having sufficient N available during vegetative growth and early reproductive growth is most important.

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Table 1. Main effect lint yield from multiple split applications of nitrogen. 1991. MAFES - DREC

Main Effect	First Harvest	Second Harvest	Total Harvest
	---------- (lb lint/A) ----------		
N Rate (lb/A)			
60	1229c	38b	1267c
90	1300b	49ab	1349b
120	1378a	49ab	1427a
150	1364a	64a	1428a
LSD(0.05)	58**	15*	57**
Application Schedule			
PP100	1341	49	1390
PP50-PH50	1345	52	1397
PP50-EB50	1287	51	1338
PP50-PH25-EB25	1322	44	1366
PP25-PH50-EB25	1339	53	1392
PP25-PH25-EB50	1272	51	1323
LSD(0.05)	72ns	18ns	69ns

LSD's are also provided for mean comparisons at the 5% level (** = <0.01, * = 0.01 - 0.05, ns = not significant).

Table 2. Main effect lint yields from multiple split applications of nitrogen. 1992. MAFES - DREC

Main Effect	First Harvest	Second Harvest	Total Harvest
	---------- (lb lint/A) ----------		
N Rate (lb/A)			
60	826b	76c	902b
90	941a	100b	1040a
120	965a	120a	1085a
150	939a	120a	1059a
LSD(0.05)	68**	13**	76**
Application Schedule			
PP100	923	96ab	1019
PP50-PH50	969	114a	1083
PP50-EB50	902	101ab	1003
PP50-PH25-EB25	898	94b	992
PP25-PH50-EB25	933	114a	1047
PP25-PH25-EB50	882	104ab	987
LSD(0.05)	83ns	16*	93ns

LSD's are also provided for mean comparisons at the 5% level (** = <0.01, * = 0.01 - 0.05, ns = not significant).

Table 3. Main effect lint yield from multiple split applications of nitrogen. 1993. MAFES - DREC

Main Effect	First Harvest	Second Harvest	Total Harvest
	- - - - - - - - - - (lb lint/A) - - - - - - - - - -		
N Rate (lb/A)			
60	451b	38b	489b
90	539a	48a	586a
120	504a	48a	552a
150	500a	49a	549a
LSD(0.05)	44**	5**	48**
Application Schedule			
PP100	546a	50a	596a
PP50-PH50	525ab	50a	574ab
PP50-EB50	474bc	42b	516c
PP50-PH25-EB25	482bc	42b	524bc
PP25-PH50-EB25	504abc	48a	552abc
PP25-PH25-EB50	461c	41b	502c
LSD(0.05)	54*	6**	57*

LSD's are also provided for mean comparisons at the 5% level
(** = <0.01, * = 0.01 - 0.05, ns = not significant).

Table 4. Main effect lint yields from multiple split applications of nitrogen. 1994. MAFES - DREC

Main Effect	First Harvest	Second Harvest	Total Harvest
	- - - - - - - - - - (lb lint/A) - - - - - - - - - -		
N Rate (lb/A)			
60	687b	26b	713b
90	743a	32a	775a
120	766a	31a	797a
150	746a	32a	778a
LSD(0.05)	46**	3**	48**
Application Schedule			
PP100	749	31ab	780
PP50-PH50	758	34a	792
PP50-EB50	726	29b	756
PP50-PH25-EB25	713	28b	741
PP25-PH50-EB25	761	31a	792
PP25-PH25-EB50	704	28b	732
LSD(0.05)	56ns	4*	59ns

LSD's are also provided for mean comparisons at the 5% level
(** = <0.01, * = 0.01 - 0.05, ns = not significant).

Table 5. Lint yield from multiple split applications of nitrogen. 1991 - 1994. MAFES - DREC

Application Schedule	Nitrogen Rate, lb N/A			
	60	90	120	150
	- - - - - - - - - - (lb lint/A) - - - - - - - - - -			
First Harvest				
PP100	793ghi	886a-g	978a	901a-f
PP50-PH50	819e-i	954ab	918a-d	905a-f
PP50-EB50	760i	863b-h	851c-i	915a-f
PP50-PH25-EB25	856b-i	866b-h	846c-i	847c-i
PP25-PH50-EB25	792ghi	897a-f	917a-e	931abc
PP25-PH25-EB50	768hi	818f-i	908a-f	826d-i
LSD(0.05)		99 **		
Second Harvest				
PP100	39i	57b-h	73abc	57b-h
PP50-PH50	49f-i	71a-d	67a-e	64b-f
PP50-EB50	45ghi	53e-i	52e-i	74ab
PP50-PH25-EB25	48f-i	51e-i	54d-i	56c-h
PP25-PH50-EB25	43hi	57b-h	64b-f	84a
PP25-PH25-EB50	44hi	55d-i	64b-f	63b-g
LSD(0.05)		17 **		
Total Harvest				
PP100	832gh	943a-f	1052a	958a-e
PP50-PH50	868e-h	1025ab	985abc	969a-e
PP50-EB50	805h	915b-h	903c-h	989abc
PP50-PH25-EB25	904c-h	916b-g	900c-h	903c-h
PP25-PH50-EB25	835fgh	954a-e	981a-d	1015ab
PP25-PH25-EB50	812gh	872d-h	972a-e	888c-h
LSD(0.05)		110 **		

LSD's are also provided for mean comparisons at the 5% level
(** = <0.01, * = 0.01 - 0.05, ns = not significant).

Table 6 Main effect lint yield from multiple split applications of nitrogen. 1991 - 1994. MAFES - DREC

Main Effect	First Harvest	Second Harvest	Total Harvest
	- - - - - - - - - - (lb lint/A) - - - - - - - - - -		
N Rate (lb/A)			
60	798b	45c	843b
90	880a	57b	938a
120	903a	62ab	965a
150	887a	66a	954a
LSD(0.05)	40**	7**	45**
Application Schedule			
PP100	890ab	56	946ab
PP50-PH50	899a	63	962a
PP50-EB50	847bc	56	903bc
PP50-PH25-EB25	853abc	52	906bc
PP25-PH50-EB25	884ab	62	946ab
PP25-PH25-EB50	830c	56	886c
LSD(0.05)	49*	9ns	55*

LSD's are also provided for mean comparisons at the 5% level (** = <0.01, * = 0.01 - 0.05, ns = not significant).