Nitrogen Management Experiments For Upland Cotton, 2000

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Abstract

Two field experiments were conducted in Arizona in 2000 at two locations (Maricopa and Marana). The Maricopa experiment has been conducted for nine consecutive seasons; the Marana site was initiated in 1994. The purposes of the experiments were to validate and refine nitrogen (N) fertilization recommendations for Upland cotton. The experiments each utilized N management tools such as pre-season soil tests for NO_3^--N, in-season plant tissue testing (petioles) for N fertility status, and crop monitoring to ascertain crop fruiting patterns and crop N needs. At each location, treatments varied from a conservative to a more aggressive approach of N management. Results at each location revealed a strong relationship between the crop fruit retention levels and N needs for the crop. This pattern was further reflected in final yield analysis as a response to the N fertilization regimes used. The higher, more aggressive, N application regimes did not benefit yields at any location. In 2000, fruit retention levels were good and crop vigor was not excessive. The more conservative, feedback approach to N management provided optimum yields at both locations.

Introduction

The management of fertilizer nitrogen (N) is a very important component of any cotton (Gossypium spp.) production program in Arizona. Water, and N are normally the most limiting inputs to successful cotton production in most desert soils. It is important for farmers to use fertilizer N efficiently to maintain optimum return in yield for the amount of fertilizer N provided. Also, from an environmental standpoint, it is important to manage fertilizer N so that downward movement of NO_3^--N in the soil profile, can be minimized.

For cotton production systems in the desert Southwest, there are several N management tools available to manage fertilizer N inputs efficiently in terms of economic, agronomic, and environmental concerns. Nitrogen management tools include: residual soil NO_3^--N levels from preseason soil samples, inputs of NO_3^--N through irrigation water, petiole samples taken in-season for NO_3^--N analysis, fruit load and growth pattern measurements of the crop in terms of N needs, and the use of split applications of fertilizer N through the course of the season (Silvertooth and Doerge, 1990).

Recommendations from University of Arizona Cooperative Extension personnel concerning N management in cotton usually include the aforementioned tools. Fertilizer N applications based purely on conjecture or guesswork are discouraged. The two field experiments conducted in 1998 serve as an extension of consecutive experiments from 1989 through 1998 (Silvertooth et al., 1990; Silvertooth et al., 1991b; Silvertooth et al., 1992; Silvertooth et al., 1993; Silvertooth et al., 1994; Silvertooth et al., 1995; Silvertooth and Norton, 1996; Silvertooth and Norton, 1997; Silvertooth and Norton, 1998; Silvertooth and Norton, 1999, and Silvertooth and Norton, 2000) to develop and refine guidelines for recommendations concerning the integration of N management tools to improve overall efficiency for the grower. Objectives for these experiments are: 1) to compare several fertilizer N management strategies for cotton in terms of N fertility status of the crop, and yield; and 2) develop refinements in the fertilizer N recommendations associated with in-season N fertility assessments using cotton petiole analysis and fruit load development.

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Materials and Methods

Field experiments were conducted in 2000 at the University of Arizona Maricopa Agricultural Center (MAC) and the Marana Agricultural Center (MAR).

Upland cotton (G. hirsutum L., var. DP 33b) was dry-planted and watered-up on a Casa Grande sandy loam on 5 April at Maricopa. The experimental structure was a randomized complete block design with four replications. The N treatments are outlined in Table 1. Plots were eight, 40 inch rows wide and extended the full length of the irrigation run (600 ft.). At Marana, Upland cotton (var. DP 33b), was planted into moisture on Pima clay loam soil on 5 April in plots which were eight, 40 inch rows wide and 600 ft. in length, with N treatments (Table 1) arranged in a randomized complete block design with four replications. All pest control and irrigation management practices were carried out on optimum, an as-needed basis at each location.

Soil samples were collected preseason to a depth of two feet at each location, to which soil nitrate-N analyses were performed.

Basic plant measurements were carried out within each plot on a regular 14-day interval for the entire season. These measurements included plant heights, number of mainstem nodes per plant, flower numbers per 167 $ft.^2$ area, and the number of nodes above the top white flower to the terminal (NAWF). Plant mapping was performed on each distinct treatment (variety and N treatment) at 14-day intervals during the course of the season. Results from the plant mapping provide information concerning the percent total fruit retention (sum of positions one and two on each fruiting branch) for each treatment, a record of the general vegetative/reproductive balance maintained by the various treatments over time, and maturity progress.

The N fertilization regimes utilized at each location are outlined in Tables 2 and 3 for Maricopa and Marana, respectively. Final irrigations and harvest dates were 4 August and 18 October at Maricopa and 9 August and 4 October at Marana.

Lint yields were obtained for each treatment by harvesting the entire center four rows of each plot with a two row mechanical picker. Seedcotton subsamples were collected for ginning, from which lint turnout estimates were made. Fertilizer N use efficiency (FUE) estimates were made consistent with the methods outlined by Norton and Silvertooth, (1998) and Navarro et al. (1997). Results were analyzed statistically in accordance to procedures outlined by Steel and Torrie (1980) and the SAS Institute (SAS, 1990).

Results

Fruit retention (FR) and height to node ratio (HNR), and petiole analysis results are presented for all locations, varieties, and treatments in Figures 1 and 2. Lint yield results are presented in Table 4.

Maricopa

Fruit retention levels, plant vigor estimates (height to node ratios, HNR) developed from the plant mapping data, and petiole NO_3^--N concentrations are shown in Fig. 1 for the DP (NuCOTN) 33b. Early season low plant vigor resulted in low HNRs (Fig. 1). Fruit retention levels were high in the early stages of the season, but declined prior to early bloom due to a fleahopper infestation and damage to small squares. Following control measures for the fleahopper population, FR increased after early bloom (~1500 HUAP). A substantial boll load, which would indicate a strong N sink and a high N demand, developed mid-season for this crop. Visual symptoms of N deficiency were not apparent in the check plots at any time in the season. The FR and HNR patterns were similar for all treatments.

Yield data is shown in Table 4. Significant differences were detected among the N treatments with the feedback treatment (treatment 3) providing the highest overall yield. Treatment 3 resulted in a very conservative approach to N fertilization (100 lbs. N/acre total) and was not significantly different in yield than the more aggressive N application regime of treatment 4 (200 lbs. N/acre total). Treatment 1 (check) was significantly lower in yield than treatments 3 and 4. The yield results in relation to the N fertilization schemes employed are generally consistent with several of the previous seasons.

Micronaire has been a point of interest in the Arizona cotton industry in recent years. Most often micronaire is not affected by N fertilization regimes in this project. However, in 2000 at MAC (Table 4) a slightly higher micronaire result was experienced with the highest N rate (200 lbs. N/acre, Treatment 4). This was attributed to a slight delay

in maturity that Treatment 4 plots experienced due to a higher late season N fertility status. All other N treatments resulted in micronaire values less than 5.0.

Marana

The DP 33b at Marana developed a very strong fruit load (Figure 2) but did experience a distinct drop in FR near first bloom (~1200 HUAP), primarily in relation to a moderate infestation of lygus bugs. Fruit retention levels recovered substantially through the mid to later portion of the fruiting cycle. Plant vigor (HNR) patterns were low early in the season but increased rapidly to levels near the optimum baseline beyond mid-season.

Lint yield results (Table 4) revealed significant differences among the N fertilization treatments, with the Treatment 3 and 4 plots (feedback approach with 100 lbs. N/acre total applied as fertilizer and Treatment 4 with 200 lbs. N/acre) yielding the highest. A conservative approach to N management, as employed in treatment 3 (100 lbs. N/acre total) was sufficient for crop needs and optimum yields.

Summary

The patterns of crop growth experienced at both locations with this project were representative of crop growth conditions and problems commonly encountered across many parts of the State in 2000. Generally, FR levels were good and crop experienced a relatively uniform fruiting pattern. These results serve to reinforce the use of plant measurements in an attempt to gain an assessment on the FR and HNR status of the crop for use in adjusting N fertilization accordingly. These results are also consistent with results from previous years with this project that have demonstrated the value of a conservative approach to fertilizer N management in irrigated cotton.

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References

Navarro, J.C., J.C. Silvertooth, and A. Galadima. 1997. Fertilizer nitrogen recovery in irrigated Upland cotton. Cotton, A College of Agriculture Report. Series P-108, University of Arizona, Tucson, AZ. p. 402-407.

Norton, E.R. and J.C. Silvertooth. 1998. Field testing and validation of modeled soil solute movement in an irrigated cotton system. Agron. J. 90:623-630.

SAS Institute. 1990. SAS procedures guide. Version 6, 3rd ed. SAS Inst., Cary, NC.

Silvertooth, J. C., P. W. Brown, and J.E. Malcuit. 1991a. Basic crop development patterns. Cotton, A College of Agriculture Report. University of Arizona. Series P-87:43-49.

Silvertooth, J. C., L. J. Clark, E. W. Carpenter, J. E. Malcuit, P. T. Else, and T. A. Doerge. 1990. Nitrogen management in irrigated cotton. Cotton, A College of Agriculture Report. University of Arizona. Series P-81:169-174.

Silvertooth, J. C., L. J. Clark, J. E. Malcuit, and E. W. Carpenter. 1993. Nitrogen management experiments for Upland and Pima cotton, 1992. Cotton, A College of Agriculture Report. University of Arizona. Series P-94:297-311.

Silvertooth, J. C., L. J. Clark, J. E. Malcuit, E. W. Carpenter, T. A. Doerge, and J. E. Watson. 1991b. Nitrogen management experiments for Upland and Pima cotton, 1990. Cotton, A College of Agriculture Report. University of Arizona. Series P-87:209-221.

Silvertooth, J. C., L. J. Clark, J. E. Malcuit, E. W. Carpenter, T. A. Doerge, and J. E. Watson. 1992. Nitrogen management experiments for Upland and Pima cotton, 1991. Cotton, A College of Agriculture Report.

University of Arizona. Series P-91:183-198.

Silvertooth, J. C. and T. A. Doerge. 1990 Nitrogen management in Arizona cotton production. Report 9024. The University of Arizona, College of Agriculture. Tucson, AZ.

Silvertooth, J. C., E.R. Norton, B.L. Unruh, L. J. Clark, and E. W. Carpenter. 1994. Nitrogen management experiments for Upland and Pima cotton, 1993. Cotton, A College of Agriculture Report. University of Arizona. Series P-96:378-397.

Silvertooth, J. C., E.R. Norton, B.L. Unruh, J.A. Navarro, L. J. Clark, and E. W. Carpenter. 1995. Nitrogen management experiments for Upland and Pima cotton, 1994. Cotton, A College of Agriculture Report. University of Arizona. Series P-99:311-326.

Silvertooth, J.C. and E.R. Norton. 1996. Nitrogen management experiments for Upland and Pima cotton, 1995. Cotton, A College of Agriculture Report. University of Arizona. Series P-103:317-332.

Silvertooth, J.C. and E.R. Norton. 1997. Nitrogen management experiments for Upland and Pima cotton, 1996. Cotton, A College of Agriculture Report. University of Arizona. Series P-108:389-401.

Silvertooth, J.C. and E.R. Norton. 1998. Nitrogen management experiments for Upland and Pima cotton, 1997. Cotton, A College of Agriculture Report. University of Arizona. Series P-112:461-468.

Silvertooth, J.C. and E.R. Norton. 1999. Nitrogen management experiments for Upland and Pima cotton, 1998. Cotton, A College of Agriculture Report. University of Arizona. Series P-116:213-220.

Silvertooth, J.C. and E.R. Norton. 2000. Nitrogen management experiments for Upland and Pima cotton, 1999. Cotton, A College of Agriculture Report. University of Arizona. Series P-121:181-188.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.

Table 1. Nitrogen fertilization treatments used at the Maricopa, and Marana Agricultural Centers, 1989-2000.*

N Treatment Number	Fertilizer N Management
1	Check (No fertilizer N)
2	Standard: Preplant & Side-dress
3	Feedback approach from soil and petiole NO_3^--N analysis, 1X rate
4	2X rate from soil and petiole NO_3^--N feedback

* The Marana location was initiated in 1994.

Table 2. Fertilizer N applications for each N management treatment, MAC, 2000.

			N Management Treatment			
Date	**Form**	**Method**	**1**	**2**	**3**	**4**
				lbs. N/acre		
26 April	21-0-0	SD	0	50	50	100
9 June	21-0-0	SD	0	100	50	100
29 June	21-0-0	UN32	0	35		
		Total	**0**	**185**	**100**	**200**

Table 3. Fertilizer N applications for each N management treatment, Marana, 2000.

			N Management Treatment			
Date	**Form**	**Method**	**1**	**2**	**3**	**4**
				lbs. N/acre		
25 April	21-0-0	SD*	0	50	0	0
1 June	21-0-0	SD	0	50	50	100
23 June	21-0-0	SD	0	50	50	100
		Total	**0**	**150**	**100**	**200**

*Sidedress

Table 4. Lint yields from Maricopa and Marana N-management studies, 2000.

Treatments	Lint Yield (lbs. lint/acre)	Micronaire
Maricopa		
DPL 33B		
3	1608 a*	4.6
4	1588 ab	5.1
1	1542 bc	4.8
2	1518 c	4.5
OSL	0.0091	
C.V. (%)	1.96	
LSD (α=0.05)	49	
Marana		
DPL 33B		
4	1319 a	
3	1299 ab	
2	1278 b	
1	1213 c	
OSL	0.0007	
C.V. (%)	1.82	
LSD (α=0.05)	37	

Means followed by the same letter are not significantly different (α=0.05) according to a Fisher's LSD.

Table 5. Preseason soil nitrate-N analysis for each location and treatment, 2000.

Location/Treatment	**Depth**	**Nitrate-N (ppm)**
Maricopa		
1	1	4.70
	2	3.75
2	1	7.90
	2	5.20
3	1	5.30
	2	3.45
4	1	7.70
	2	5.30
Marana		
1	1	2.80
	2	1.90
2	1	7.13
	2	6.20
3	1	4.55
	2	4.65
4	1	4.70
	2	3.00

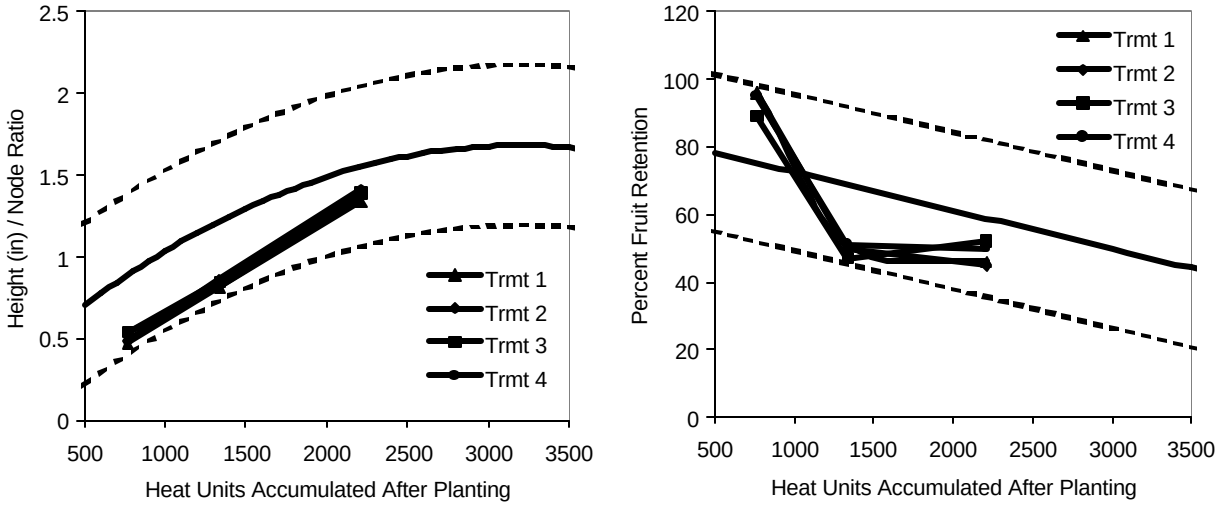

Figure 1. Height to node ratio and fruit retention levels for N-management study, Maricopa, 2000.

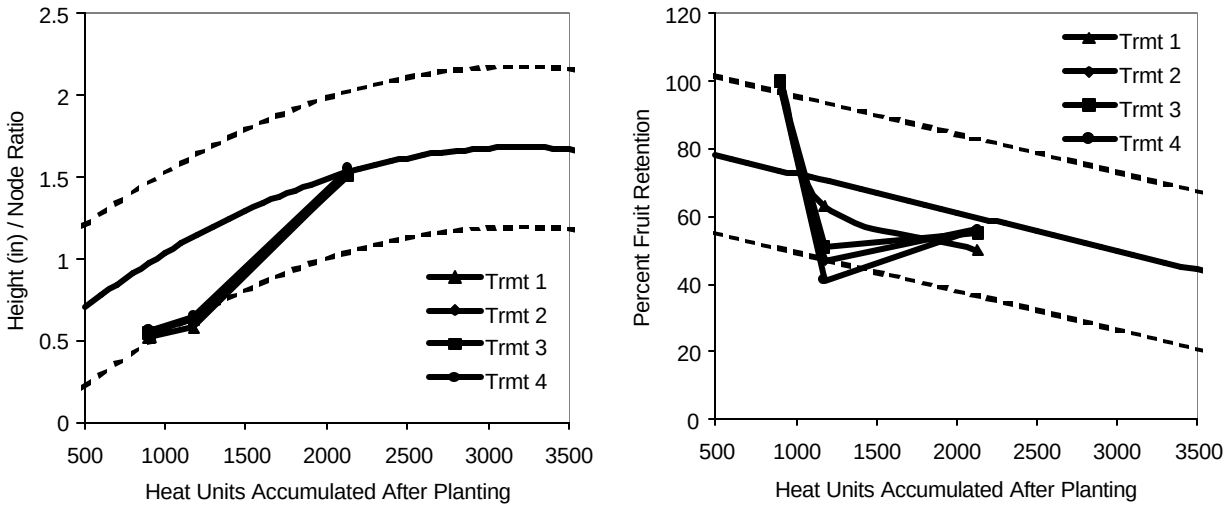

Figure 2. Height to node ratio and fruit retention levels for N-management study, Marana, 2000.