2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

COTTON NITROGEN MANAGEMENT IN THE SOUTHWEST REGION

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Abstract

Nitrogen is the most frequently applied nutrient for cotton production in the Southwest Region (Texas and Oklahoma) and is also the most difficult to manage because of its reactivity and mobility. Inadequate nitrogen (N) reduces fruiting sites and yield, whereas excess N can create rank growth, lower yield and quality, and increase problems with disease, insects, and defoliation. Recommended N rates are normally based on a realistic yield goal and modified by residual soil nitrate (NO_3) to a 2-ft depth. Significant residual profile NO_3 concentrations in both Texas and Oklahoma indicate that additional research is needed to determine the scope of the problem, to identify the sources/reasons for these levels, and to develop management plans to reduce these concentrations.

Introduction

Nitrogen is usually the most important fertilizer nutrient applied to cotton, but is also often the most difficult to manage. Nitrogen deficiency can reduce leaf size, node production, fruit retention, yield and quality, cause early cutout, and limit water and nutrient uptake. Excess available N can delay maturity, cause excessive growth, decrease boll retention and fiber quality, and increase insect attack, boll rot, and problems with effective defoliation. Accurately predicting a crop's need for fertilizer N is made more difficult because of the intricacies of the N cycle. Leaching, denitrification, and mineralization/immobilization are processes that can quickly alter the quantity of plant available N.

Production Regions

Texas is the #1 cotton-producing state in the US, while Oklahoma ranks 14th. Thus, improper N fertilization can have potential economic and environmental effects across a very large acreage. Upland cotton is produced in 21 of Oklahoma's 77 counties and in 141 of the 254 counties in Texas. Soils used for cotton production in both states are predominately Mollisols, although Vertisols are important for cotton production in the Texas Coastal Bend, Upper Gulf Coast, and especially the Blackland Prairie. Much of the cotton in both states is produced dryland, although irrigated acres usually account for the majority of overall production. Lack of rainfall and/or poor distribution is the primary limitation for dryland production.

Cotton production in the Southwest Region is almost continuous from south to north, with planting occurring in the Lower Rio Grande Valley of Texas in February and harvest being completed in December, or later, in northerly locations. Land Resource Regions in Texas that produce cotton include the Lower Rio Grande Valley, Coastal bend, Upper Gulf Coast, Central Blacklands, Winter Garden, Trans Pecos, Rolling Plains, and High Plains. This latter region in the Texas Panhandle accounts for 3 to 4 million acres of cotton annually, or more than 60% of Texas' acreage. About 60% of the acreage is at least partially irrigated. Texas annually produces approximately 5 million bales of cotton. Lint yield in Texas in 2001 ranged from 154 lbs lint/acre in Throckmorton County in the Rolling Plains to 1324 lbs/acre in El Paso County in the Trans Pecos.

The majority of Oklahoma cotton production is concentrated in the southwestern corner of the state, with additional production in northcentral counties bordering Kansas. Total production in Oklahoma in 2001 was approximately 200,000 bales, with average yield ranging from 192 lbs lint/acre in Kay County in northern Oklahoma to 916 lbs/acre in Jackson County in southwestern Oklahoma. Most cotton in the Southwest Region is produced with short-season management to avoid drought, insects, and other weather-related problems.

Nitrogen Recommendations for Cotton

Nitrogen is the plant essential nutrient most commonly deficient in cotton soils in Texas and Oklahoma and is also the nutrient applied in the largest quantities for cotton production. Fertilizer N management for cotton must attempt to maximize soil and crop health and economic return, while minimizing negative environmental consequences, primarily water pollution. Standard N recommendations for cotton in the Southwest Region are based on the following common principles:

- *Realistic* and *logical* yield goal
- Annual soil test
    - consider previous crop, manure, etc.
    - deep sample if possible (0-24 in.)
- Split N applications to improve efficiency, especially on sandy soils

What is lacking in the above scenario is an estimate of potentially mineralizable N from soil organic matter. With reliable information on residual soil NO_3 and mineralizable soil N, the following function provides a reasonable conceptual approach for predicting the quantity of fertilizer N required for production of a specific crop:

$$N_f = \frac{CR - (N_{om} + N_r)}{E}$$

where N_f is the amount of fertilizer N to apply, CR is the N requirement of the crop at a specific yield, N_{om} represents N mineralized from soil organic matter, N_r is residual soil NO_3, and E is the efficiency factor. It is assumed that mineralized N and residual NO_3 are used at the same efficiency as fertilizer N. Estimating mineralizable soil N in an accurate and rapid fashion has been an obstacle.

The amount of N needed for cotton is a function of yield. The total quantity of available N required to produce a given yield as determined by research in Oklahoma and Texas is given in Table 1. Texas Cooperative Extension recommends that 50 lbs N/acre be available from all sources for each bale of lint produced, while Oklahoma Cooperative Extension recommends 60 lbs N/acre for each bale. The yield goal should be both realistic and logical based on soil, climate, water availability, management skills of the producer, and past yield history. Amounts of fertilizer N required should be reduced by quantities of residual soil NO_3 present in the soil profile to at least a 2-ft depth plus any NO_3 that will be added in irrigation water. These quantities of NO_3 are determined through soil and water testing. Nitrate is mobile in water and can penetrate to deep depths in soil profiles, especially in sandy soils. Nitrogen rates to 60 lbs N/acre are common on sandy Oklahoma soils, while 40 lbs N/acre are commonly added on medium- and fine-textured soils low in organic matter. Maximum recommended rates are 80 to 100 lbs N/ acre for irrigated cotton unless NO_3 monitoring with depth suggests greater rates are warranted.

Nitrogen Application Timing

Cotton continuously takes up N from the seedling stage to maturity, but highest demand occurs during flowering and fruiting. Nitrogen demand is low early in the season, increases through early flowering, is greatest at peak bloom, and decreases as the crop approaches cutout. Low available N is desirable late in the season to prevent rank growth and hasten maturity, especially in the short-season management systems prevalent in the Southwest Region.

A common recommendation for cotton is that one-third to half the needed fertilizer N be applied preplant or at planting, with the remainder sidedressed between first square and first bloom (Table 2). Many producers, however, apply all the N preplant, which can result in N loss from leaching and denitrification and lower cotton N uptake efficiency and yield. Some producers in South Texas add an additional 10 to 20 lbs fertilizer N/acre/month for each month N is applied before planting to offset potential losses. Results from Texas showed that N applied as the plant enters reproductive growth can enhance N efficiency and yield, but withholding N until too late in the season (i.e. first green boll) may also decrease yield. Fertigation and foliar fertilization may also be used to supplement N during the growing season. Foliar application alone cannot sustain the N needs of the crop and should be used only as a corrective tool to avoid nutritional problems.

Foliar Fertilization

Foliar fertilization is a method of supplementing N when soil or added N is not sufficient to achieve potential yield. One lb of absorbed N has the potential to produce 5 to 10 lbs of lint. An average lint increase of 68 lbs/acre was achieved in a two-year Texas Coastal Bend study where 10.6 lbs N/acre were foliarly added (Table 3).

Petiole Nitrate Monitoring

Pre-season N fertilizer needs are best determined through soil testing for residual soil NO_3 to at least 2 ft of depth. Petiole NO_3 monitoring is potentially a means of tracking in-season needs of cotton. Monitoring is best suited for center-pivot or drip irrigation systems, or in high rainfall areas where soil water is consistently adequate for high yield. Environmental factors (drought, excess water, insect-related fruit loss) have a large effect on petiole N concentrations and make petiole monitoring less useful for dryland production.

Residual Soil Nitrate

Residual soil NO_3 not only is used to modify N fertilizer recommendations, but may also be used to track whether recommendations have resulted in deficit or excess fertilization over time. A recent five-year study in Texas demonstrated the importance of soil NO_3 monitoring with depth. Seven study sites across the state in 2000 showed profile NO_3-N ranging from 72 to almost 500 lbs N/acre (Table 4). Five of the sites exhibited profile NO_3-N amounts of greater than 100 lbs N/acre. Cotton lint response to added N has been minimal where NO_3-N is greater than or equal to this amount. Of the 39 site-years for this study, only 8, or ~20%, showed a significant yield response to added N (Table 5). Below normal rainfall was responsible for less response in some years, but the greatest contributing factor was excess residual NO_3. A similar study in Tillman County, Oklahoma showed residual NO_3 up to 139 lbs N/acre to a 4-ft depth and no response to added N during the three years of the study.

Not accounting for soil N mineralization may contribute to excess soil NO_3. Research to develop a rapid procedure to accurately assess soil N mineralization has been ongoing for the past several years. Organic N in excess of soil microbes' needs is mineralized as a consequence of soil carbon (C) mineralization. The developed procedure estimates the quantity of soil organic N that will be mineralized over 6 to 8 weeks of the growing season based on the quantity of CO_2-C evolved for 24 hours after rewetting dried soil. The procedure worked well in initial testing of soil N mineralization in manured soil and associated forage yield and uptake. Residual soil NO_3 was significantly correlated in three of five years with cotton lint yield in a Texas study, whereas results of the N mineralization procedure were correlated with lint yield in four of five years. The soil N mineralization test in conjunction with soil residual NO_3 may provide a better basis for cotton N recommendations.

Summary

Nitrogen is the most frequently applied nutrient to cotton in the Southwest Region and is also the most difficult to manage because of its reactivity and mobility. Inadequate N lowers fruiting sites and yield, whereas excess N can create rank growth, lower yield and quality, and increase problems with disease, insects, and defoliation. Nitrogen recommendations are normally based on a realistic yield goal as modified by residual NO_3 in the profile. High profile NO_3 values in both Texas and Oklahoma indicate that additional research is needed to determine the overall scope of the problem, to identify the sources/reasons for excess soil NO_3, and to develop practices to prevent further increases.

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Table 1. Nitrogen recommendations for various yields of cotton in Texas and Oklahoma.

Yield (bales/A)	**N Recommendation* (lbs/A)**	
	TX	OK
½ bale	25	30
1 bale	50	60
1 ½ bales	75	90
2 bales	100	120
2 ½ bales	125	135

*Recommended amount should be reduced by residual soil NO_3 present.

Table 2. Timing of nitrogen fertilization and cotton yield in Texas.

	Rate (lbs N/acre)	
Time Applied	**40**	**80**
Control (O N)	--706--	
Planting	841	894
1st Square	914	906
1st Flower	878	882
1st Green Boll	784	776

Table 3. Lint response to foliar N at 10.6 lbs N/acre in the Texas Coastal Bend, 1991-1992.

	Lint Yield, lbs/acre		
County/site	**No Foliar**	**Foliar N**	**Difference**
Calhoun 1	927	1043	116
Calhoun 2	885	1000	115
Nueces 1	777	870	93
San Patricio	558	632	74
Nueces 3	160	221	61
Nueces 2	878	925	47
Nueces 4	777	802	25
Victoria	854	870	13
Average Increase			68

Table 4. Residual soil nitrate with depth prior to the 2000 growing season.

	County						
	Pecos	**Hildalgo**	**Calhoun**	**Williams**	**San Patricio**	**Burleson**	**Collin**
Depth, in.	lbs N/A						
0-6	64	42	64	24	32	22	20
6-12	30	28	42	26	20	22	16
12-24	100	36	48	52	20	24	16
24-36	128	40	36	48	16	16	12
36-48	160	64	161	44	16	8	8
Total NO_3-N	482	210	206	194	104	92	72

Table 5. Overall response to fertilizer N in a five-year study in Texas.

		Sites	
Year	**Rainfall**	**Total**	**N Response**
1998	10% normal	6	3
1999	~ normal	7	1
2000	< normal	7	0
2001	< normal	10	2
2002	≤ normal	9	2
		39	8