EVALUATION OF TWO FOLIAR N SOURCES FOR COTTON FERTILIZATION

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Justification

Nitrogen (N) fertilization of cotton (*Gossypium hirsutum* L.) affects yield, maturity, and lint quality. Cotton's response to N fertilization varies with climate, soil, topography, cultivar and management of the producer. Research has been conducted throughout the cotton belt to determine the optimum N rate for lint production. Optimum N is essential for yield maximization and improved quality, while excessive or deficient N applications may reduce lint yields (Maples and Keogh, 1971). A high N application may produce excessive vegetation, delay maturity, and harvest which may reduce yields and affect lint quality due to early frost or prolonged fall rain (Hutchinson et al., 1995; McConnell et al., 1995). On the other hand, applying a low N rate causes premature leaf senescence and reduced yields (McConnell et al., 1995). Producers can obtain the recommended N rates resulting from these research efforts through the state's university soil test facility. However, the optimum N rate for maximum production on any field may differ slightly from that recommended due to soil differences and producer management skills. Traditionally, producers tend to apply an N rate higher than recommended to allow for possible N losses, poor fertilizer distribution, etc.

With the higher N costs of 2001, producers were prompted to reduce their N fertilization rate applied at planting. Producers in some states have the opportunity to evaluate the adequacy of their N fertilization program using petiole analyses. These programs however, are not available to producers in all cotton producing states. A potential problem associated with the petiole analyses program is the time differential between sample collection and data reception by the producer. In some instances, this time differential may delay needed N applications thus reducing yields. Nitrogen application, if needed, can be more timely applied by reducing this time differential by sampling and conducting the analyses the same day.

The growth stage of the cotton when deficient N is determined may determine the method of application. If N is determined to be deficient at or before pinhead square, additional N can be soil applied provided proper application equipment is available. However, if additional N is needed after flowering, soil applications may be less efficient except on irrigated fields. At this growth stage N needs to be foliar applied. Foliar applications are more efficient at this growth stage than soil applications since soils are generally dryer and root growth begins to be reduced as the plant begins the reproductive stage. Therefore, timely efficient N applications are essential to promote maximum yields. This is especially true for the fast-fruiting, high-yielding cultivars that set and fill the bolls over a short period of time. For these production situations, the most effective N application method would be foliar.

Nitrogen sources, KNO_3, $Ca(NO_3)_2$, and feed grade urea, traditionally used for foliar applications are subject to removal from the leaf by irrigation or rainfall. CoRoN®, a foliar N source has some advantages for the producer to consider. CoRoN is a controlled release N source and adheres to the leaf better than the other sources. These two traits may allow CoRoN to be more efficient and effective over a longer time period than other foliar N sources.

Objectives

To customize N fertilization of cotton for individual production fields by evaluating:

1. the effect of applying the recommended N rate and 2/3rd that rate.
2. petiole N concentration at critical growth stages using a Cardy Meter.
3. two foliar N sources.
4. these effects on cotton production at selected areas throughout the cotton belt.

Procedures

Field investigations were conducted at 16 locations through the cotton belt states in 2001. The cotton belt states included North Carolina, South Carolina, Georgia, Mississippi (2), Louisiana (2), Tennessee, Arkansas (2), Missouri, Texas (2), Oklahoma, New Mexico, and Arizona. The evaluations were conducted in cooperation with researchers located at the University and/or consultants.

The experimental design was a randomized complete block of treatments that were replicated four to six times at each location. The research consisted of the four N rate treatments. The first N treatment was the N rate recommended by the soil test laboratory of the area and three treatments of 2/3rd's the recommended N rate. Two of the three reduced N treatments were designated for foliar N applications, if needed. One of these two N treatments was to be foliar spray with feed grade urea, if petiole N was below the critical reading. Feed grade urea applied at 8 to 10 lb N/acre, or if foliar K was needed, KNO_3 was foliar applied at 10 lb material per acre (4.4 lb K_2O/acre). Foliar B was applied at pinhead square at 0.2 lb b/acre. For the second low N treatment, foliar treatments included applying boron at pinhead using 12-0-0-0.5 (HM9826-A) @ 1qt material/acre, a foliar phosphorus material (HM9870) was applied at 2 qt/ acre at mid-flower. If foliar N was needed, either 25-0-0-.5 (HM 9309) was applied at one gal/acre or if temperatures were 100^{o}F or above 28-0-0 (HM 9716) was applied at 3 qts/acre. If both N and K were needed to be foliar applied a 10-0-10-.5 (HM9827) was applied at 2.5 gal/acre (2.25 to 2.5 lb N and K_2O/acre). The third reduced N rate treatment was to be foliar sprayed with 0.2 lb B/acre pinhead square. If the other plots were to be foliar treated then these plots were to be sprayed with water.

Research plots located on experiment stations were to be 40 to 50 feet long and 4 rows wide (minimum). These plot lengths were necessary for frequency of petiole collection. Plot lengths in producer fields were to be 300 feet or longer for accurate weighting of seed cotton when using a boll buggy.

A soil test recommendation was required to determine pH and extractable P and K in order to establish nutrient application rates to the plots. The P and K rates were to be applied prior to or at planting. The N treatment was applied immediately before planting or applied as a side-dress whichever was preferred for cotton production of the area. Recommended fungicides and insecticides for cotton production, were to be applied at planting and throughout the growing season.

All foliar treatments were applied in 10, or less, gallons of water per acre which would allow for adequate plant coverage without material being lost from the plant. The nozzles were oriented over the row and a pressure of 20 to 40 psi maintained during the application process.

The Cardy nutrient meter was used to evaluate petiole N and K levels. Analysis was initiated at pinhead and continuing on a seven day interval until plant cutout. Approximately 30 petioles were collected from the top-most mature leaf, generally the third or forth leaf from the top. Leaves were detached and the petioles cut into ¼ to ½ inch lengths. These cut petioles were placed in a garlic press and the sap squeezed into a beaker or onto the N and K Cardy Meters. Foliar N and K was applied only when the N and K determinations from the Carty meter were below a critical level based on growth stage. The critical Cardy meter N readings were 1130 ppm through the second week of flowering and 912 ppm the third week of flowering through cutout. The critical Cardy meter K readings were 3000 ppm through the second week of flowering and 2000 ppm for the third week of flowering through cutout.

Averaged treatment yields and petiole N concentrations from each location were treated as a replication in the statistical analyses. A first yield analysis was conducted evaluating lint yields. A second analyses evaluated relative cotton yields for each location in an attempt to reduce variations due to weather, soils, and cultivars. Relative yields were calculated as a percent based on the highest treatment mean for each location and year.

Statistical analyses of treatment effect on yields was conducted utilizing SAS Mixed Model procedure (SAS Ins., 1997). The Mixed Model procedure provides Type III F values but does not provide mean square values for each element within the analysis or the error terms. Mean separation was accomplished through a series of protected pair-wise contrasts among all treatments (Saxton, 1998). Regression analysis of the Cardy meter N analysis as a function of days after emergence (DAE) were evaluated using SAS. The days after emergence were calculated based on the sampling date and assuming emergence to be five days after planting.

Results and Discussion

Yields

The ANOVA shows lint yields from sixteen locations were significantly affected ($P = 0.07$) by the foliar N treatments (Table 1). Relative yield evaluations were significant at $P = 0.54$. This difference shows a reduction in data variation due to weather, soils, cultivar etc. Foliar applying CoRoN significantly increased yields relative to the yields which resulted form applying the reduced N (Table 2). Yields were not significantly higher for applying the recommended N rate relative to applying 2/3 recommended N rate. The actual averaged yield difference was 26 lb lint/acre (1075 and 1049 lb/acre). For the individual sites, applying the higher N rate did significantly increase yields when compared to the reduced N rate. This observation strongly indicated the need to customize N rates for producer fields and also indicated that the recommended N rates may be higher than was necessary for the 2001 production year. Weather strongly affects cotton response to soil applied N and may have been a yield limiting factor for several sites.

The treatment producing a yield higher than the 2/3 N rate treatment was the foliar CoRoN treatment. Foliar applying CoRoN increased lint yields from 1049 lb/acre (2/3 N rate) to 1113 lb/acre. (Assuming the average N rate to be 100 lb N/acre (actual N rate was not calculated) the 2/3 N rate would be 33 lb N/acre which at $0.32/lb would be $10.56 savings/acre. The foliar application of 1 gal/acre of CoRoN/acre would cost $6.00 plus application costs.) The lack of yield difference between the recommended N rate and the 2/3 N rate may actually be the result of applying excessive N with the recommended rate restricting yields. It is obvious that the small amount of N applied with the CoRoN is far less than the difference between the recommended rate and the 2/3 N rate. There may be a need to further evaluate N fertilization rates for cotton production in some of the states.

Petiole N Concentrations

Petiole N concentrations of the four treatments were similar throughout the growing season (Fig. 1). The reduction in petiole N concentrations during the growing season was expected based on Arkansas research Hodges and Baker, 1993). These equations are an average of the data from the research locations. The R^2 values for the regressed equations are low indicating considerable variation in the data. This variation is substantiated by the regressed petiole N concentration equations for each location (Table 3). For certain locations, a cubic equation expressed the decrease in petiole N concentrations during the growing season while others were expressed by a quadratic equation. The R^2 values indicate that variation was high within some locations while variation was small for other locations. The petiole N concentration data was averaged across replications before developing the regressed equations. Data variation may be due to several factors including rainfall between sampling periods or simply sampling techniques.

Conclusions

1. Replicated field tests conducted at 16 locations throughout the cotton producing states showed that applying 2/3 the recommended N rate plus foliar applying CoRoN resulted in significantly higher lint yields relative the applying the 2/3 N rate without foliar N.
2. Broadcasting the recommended N rate did not significantly increase yields relative to applying the 2/3 N rate.
3. Cardy meter petiole N determinations appear to have a functional use for evaluating plant N concentrations throughout the cotton belt and growing season.
4. Petiole N concentration differences due to treatment were not identifiable when averaged over all research locations.

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Table 1. Mixed model 'F' statistical values for lint yields and relative lint yields of cotton produced at 16 locations throughout the cotton belt.

		16 locations			
		Lint yields		**Relative Yields**	
Source	**df**	**"F"**	**P>F**	**"F"**	**P>F**
Nitrogen (N)	3	2.53	0.070	2.76	0.054
Error a	42				

Table 2. Effect of N treatments (soil applied and foliar) on lint and relative yield of cotton produced on 16 locations.

Treatments	**Yield lb/acre**	**Relative yield**
Recommended N rate	1075 ab[†]	0.946 ab
2/3 N rate + urea	1067 ab	0.938 ab
2/3 N rate + CoRoN	1113 a	0.971 a
2/3 N rate	1049 b	0.913 b

[†] Yield means within a year column by soil, followed by the same letter, are not significantly different at = 0.05.

Table 3. Regression equations of Cardy meter N readings as affected by days after emergence for cotton produced at 13 locations.

Research Location	Regressed N equations with days after emergence	R^2
Oklahoma	$N = -15834 + 1007.8733DAE^{\dagger} - 16.9727DAE^2 + 0.08864DAE^3$	0.65
Mississippi - Buehring	$N = 12020 - 407.6047DAE + 5.2416DAE^2 - 0.0227DAE^3$	0.77
South Carolina	$N = 946.6443 + 43.3423DAE - 0.7247DAE^2$	0.80
Missouri	$N = -3271.2408 + 333.401DAE - 6.4419DAE^2 + 0.03542DAE^3$	0.90
North Carolina	$N = -43283 + 2221.9128DAE - 35.1288DAE^2 + 0.1772DAE^3$	0.57
Texas Tech	$N = -57875 + 1906.5716DAE - 19.7379DAE^2 + 0.0669DAE^3$	0.64
Louisiana	$N = -57349 + 2994.6171DAE - 50.1585DAE^2 + 0.2732DAE^3$	0.86
Tennessee	$N = 1428.74 + 28.6907DAE - 0.3531DAE^2$	0.92
Texas A&M	$N = -168314 + 6923.9853DAE -91.5026DAE^2 + 0.3976DAE^3$	0.60
Arkansas - McConnell	$N = -8435.3209 + 939.8163DAE - 17.6419DAE^2 + 0.09544DAE^3$	0.75
Arizona	$N = 12192 -352.7426DAE + 3.5664DAE^2 - 0.01184DAE^3$	0.93
Arkansas - Holman	$N = 3367.640726 - 87.03424DAE + 1.07899DAE^2 - 0.00452DAE^3$	0.53
Mississippi - Blythe	$N = -603.7495 + 78.4468DAE - 0.7263DAE^2$	0.86

† Days after emergence.

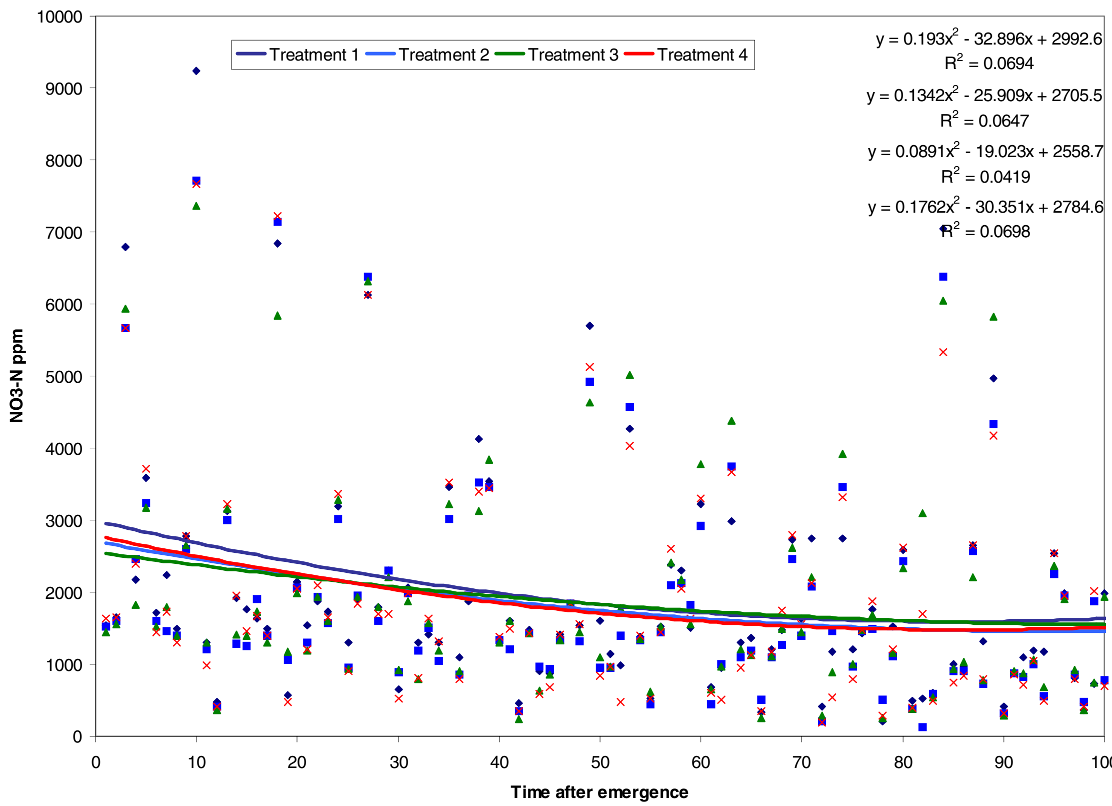

Figure 1 Petiole N concentrations for the four treatments thru the growing season.