# RESPONSE OF COTTON PRODUCED AT SEVERAL LOCATIONS TO SOIL AND FOLIAR N FERTILIZATION

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## Justification

Nitrogen (N) fertilization of cotton (*Gossypium hirsutum* L.) has been a subject of extensive research for several decades. These research efforts continue today evaluating the N requirements for the fast-fruiting, fast-maturing high yielding cultivars. These modern varieties mature over a shorter period of time and researchers have speculated this is a reason these cultivars display potassium (K) deficiencies in the upper third of the plant rather than the typical lower portion of the plant (Maples et al., 1988). Oosterhouis (1993), in a review of foliar K fertilization, stated that these cultivars develop higher yields over a shorter fruiting period allowing for less time to accumulate K in the above ground plant components before peak fruiting occurs. Potassium moving up through the symplast is being intercepted and utilized by the lower bolls at the expense of the upper portion of the plant. Research has been conducted throughout the cotton producing states evaluating foliar K fertilization using $KNO_3$ as the K source.

Research conducted in Tennessee (Howard et al., 1988) showed that non-irrigated upland no-till cotton responded to foliar applied N when the rate (80 lb N/acre) of N was applied at planting. Foliar N, applied at flowering, increased four year average yields 40 and 80 lb lint/acre on two soils. To improve N efficiency for cotton production, researchers have applied N as a side-dress or as a delayed application at pinhead square. Howard et al. (2001) reported that broadcasting or injecting or side-dressing higher than recommended N rates either at planting or at pinhead did not increase lint yields on three West Tennessee soils over a four-year period. If losses from broadcasting N at planting had occurred, then there should have been a yield response to the higher N rates or to side-dressing N. The yield response from foliar N applications (Howard et al., 1988) resulted even though 80 lb N/acre was broadcast at planting. This increased yield suggests foliar N supplements broadcast N during flowering when soil N uptake is insufficient by the plant. Two factors may affect the yield response at this growth stage. First, plant root growth at flowering is being reduced and second, flowering occurs later in the growing season when the soil is dryer. These factors limit root growth and soil proliferation affecting N uptake thus limiting maximum yield potential.

The source utilized in much of the foliar N research has been either $KNO_3$ or feed grade urea. Several problems have been encountered with both sources. They are difficult to dissolve in water and are easily removed from the leaf by rainfall. CoRoN®, a foliar N source, has some advantages that the producer should consider. CoRoN is a controlled release N source with the N resulting from urea methanal condensates and it adheres to the leaf more effectively than either urea or $KNO_3$.

## Objectives

1. The yield effect of foliar applied N to cotton fertilized with increased rates of soil applied N for cotton production in selected areas of the cotton belt.
2. Two foliar N sources for cotton production.
3. Two application rates of CoRoN.

## Procedures

Field investigations were conducted at 10 locations throughout the cotton belt in 1999 and continued through 2000. The locations included North Carolina, South Carolina, Georgia (2), Alabama, Louisiana, Tennessee, Texas, and California. The research was conducted in cooperation with respective University personnel or consultants. Soil and other characteristics are reported in Table 1. The experimental design was a split plot of a randomized complete block of treatments that were replicated four to six times at each location. The main plots were soil applied N rates of 20, 40, 60, and 80 lb N/acre that were broadcast at or before planting. Subplots were foliar N treatments of urea and CoRoN. Feed grade urea was foliar applied at 10 lb N/A. CoRoN was applied at one, two or three gal/acre of material. CoRoN, 28-0-0 containing 2.95 lb N/gal was applied in 1999 and 25-0-0 containing 2.53 lb N/gal was applied in 2000. The foliar applications were applied at flowering with the second CoRoN application applied 7d after the initial application. The one and two gal/acre CoRoN treatments were applied at most locations, with the 3 gal/acre application applied at only a few locations. Because of the low number of 3 gal/acre applications, yields from the treatment were not evaluated in this paper.

Locally adapted high yielding cultivars were selected for each location. Individual plot sizes were four rows wide with lengths determined by the cooperator ranging from 30 feet to 300 feet. Row spacing also varied with location ranging from 30 to 40 inches. Standard agronomic crop production practices were followed at each location.

An analysis of the variance was conducted by the individual cooperator and submitted along with treatment means in an annual report. Analyses across the two years were not submitted by the cooperators. In some instance's treatments, soil applied N rates and foliar N, did not significantly improve cotton yields when evaluated at P=05. The coefficient of variation (CV) percentage of several research plots were 15% or higher. These high CV's which would require approximately 100 lb/acre lint or more for a treatment to significantly affect yields. For this report, each location was treated as a replication. Two-year data from nine locations were analyzed to determine treatment effects on yields. Weather conditions at one location severely restricted any yield response to the treatments and was omitted from the analyses. A second analysis was conducted utilizing relative lint cotton yields for each location to reduce yield variations due to weather, soils, and cultivars. The 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 were 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). Means having Type III "F" error probabilities greater than 0.05 were categorized as non-significant.

## Results and Discussion

The ANOVA shows lint yields from nine locations over the two years were significantly affected by the foliar N treatments (Table 2). Lint yields were not significantly affected by increasing N rates from 20 to 80 lb N/acre. Apparently limited rainfall during the 1999 and 2000 growing seasons (beginning at mid-season and continuing though out the growing season) reduced the response to increased soil-applied N. A non-fertilized check (0 N rate) was not included in the N rate studies which would allow greater yield variation with increased N rates.

The soil and foliar N treatments effects on yields were consistent over the two years as indicated by the non-significant interactions of either N rate or foliar N treatments with year (Table 2). This ANOVA also showed the foliar treatments to be consistent for increasing yields as soil-applied N rates were increased (non-significant N rate-by-foliar N interaction). Since treatment effects on yields were consistent over the two years (non-significant treatment-by-year interaction), a second ANOVA was conducted. In this analysis, relative yields were evaluated rather than the actual yields and the annual data for each location were used as a treatment replication.

This ANOVA showed lint yields were affected by the foliar N treatments. A plot of these data indicates a trend of increased yields with N rates increased from 20 to 60 lb N/acre followed by a yield decreased from applying 80 lb N/acre. The ANOVA shows that yields were not significantly (P = 0.05) affected by increased N rates. Therefore, the resulting means for yields for the four broadcast N rates were connected by a line. Regression analyses showed that the response could not be represented by a linear equation.

Lint yields were increased by the three foliar N treatments applied to cotton fertilizer with each of the four broadcast N rates (Fig. 1).

Foliar applying 2 gal/acre CoRoN resulted in higher yields for the two lower N rates (20 and 40 lb/acre) while foliar applying 1 gal/acre CoRoN resulted in higher means for the two higher N rated (60 and 80 lb/acre). The ANOVA showed the yield response to the 1 and 2 gal/acre CoRoN treatments to be equal (0.88 and 0.88, respectively) when averaged across the four applied N rates. These two foliar treatments increased yields relative to the check (0.88 and 0.85 respectively). Foliar urea produced yields that were intermediate (0.87) between the CoRoN and the check treatments. The yields produced by foliar urea were not lower than the CoRoN treatments and were not higher than the check. Actual lint yields for the foliar N treatments when averaged across the four soil-applied N rates were 892, 891, and 877 lb lint/acre for the 1 and 2 gal/acre CoRoN rates, and urea, respectively. The yield from the check treatment (non-foliar treatment) was 854 lb lint/acre.

Foliar N increased yields, averaged from these nine locations, when applied during the dryer part of the 1999 and 2000 growing seasons. These yield increases were observed for each soil applied N rate and the magnitude of yield increase were similar the three foliar N treatments. This allows speculation that soil N absorption by the plant soil was being limited by dry weather. If the dry weather limited the yield response to soil applied N then there is no reason to suspect that the response to foliar N would be affected by increased N rates, no N rate-by-foliar N interaction. Yield responses, therefore, should be small (small amount of N foliar applied) but positive for all N rates.

## Conclusions

1. Replicated field experiments conducted at nine locations throughout the cotton producing states showed that foliar applying either 1 or 2 gal/acre CoRoN increased cotton yields an average of 38 lb lint/acre across four rates of soil applied N (20, 40, 60, and 80 lb N/acre) applied at planting.

2. Lint yields were not affected by increasing the N rate at or before planting from 20 to 80 lb N/acre apparently due to the dry growing conditions.

3. Differences in weather and other growing factors did not significantly affect cotton yields over the two years of production for the nine locations.

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## References


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Table 1. Location agronomic data (selected).

| Location | Soil Type | Row Spacing | Irrigation | Cultivar |
|---|---|---|---|---|
| Lucama, NC | Sandy Loam | 36" | No | DP436RR |
| Elko, SC | Loamy Sand | 40" | Yes | DP458BR |
| Athens, GA | Clay Loam | 36" | Yes | DP5111 |
| Chula, GA | Loamy Sand | 38" | Yes | DPL33B |
| Washington, LA | Loam | 36" | No | DP451RR |
| Randall Co., TX | Silty Clay Loam | 30" | No | PM4145RR |
| Auburn, AL | Loamy Sand | 38" | No | PM1220BR |
| Fresno, CA | Clay Loam | 30" | Yes | Maxa |
| Jackson, TN | Silt Loam | 38" | Yes | DPL5409 |

Table 2. Mixed model 'F' statistical values for evaluating soil and foliar applied nitrogen on cotton yields produced at 9 cotton locations.

| Source | df | Nine locations | |
|---|---|---|---|
| | | "F" | Pr>F |
| Year (Y) | 1 | 0.55 | 0.484 |
| Error a | 7 | | |
| Nitrogen Rate (N) | | | |
| 3 | | | |
| 0.14 | | | |
| 0.933 | | | |
| Y*N | 3 | 0.29 | 0.834 |
| Error b | 43 | | |
| Foliar (F) | 3 | 4.98 | 0.0025 |
| Y*F | 3 | 0.08 | 0.971 |
| N*F | 12 | 0.65 | 0.750 |
| Y*N*F | 9 | 0.77 | 0.643 |
| Error c | 162 | | |

Table 3. Mixed model 'F' statistical values for relative yields of cotton produced at 9 cotton belt locations as affected by soil and foliar applied nitrogen.

| Source | df | Nine locations | |
|---|---|---|---|
| | | "F" | Pr>F |
| Nitrogen Rate (N) | 3 | 0.32 | 0.809 |
| Error a | 49 | | |
| Foliar N (F) | 3 | 2.98 | 0.0326 |
| N * F | 9 | 0.32 | 0.9685 |
| Error b | 182 | 0.32 | 0.968 |

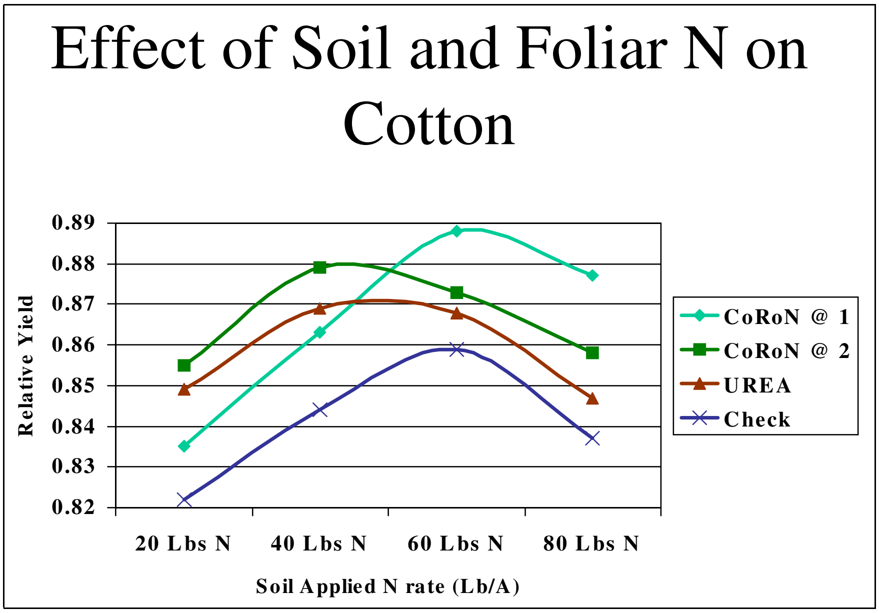


Figure 1. Effect of soil and foliar N on cotton expressed as relative yield.