FERTILIZER NITROGEN FORMULATION AND RATE EFFECTS ON COTTON YIELD

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Abstract

Fertilizer N is an essential component of profitable cotton production that affects yield and management costs. Experiments were conducted during 2006 and 2007 at the LSU AgCenter Macon Ridge Research Station near Winnsboro and the Northeast Research Station near St. Joseph to evaluate forms and rates of soil-applied and foliar-applied N fertilizers. The soil types were Gigger silt loam at the Macon Ridge Station and Commerce silt loam at the Northeast Station. Four N formulations, ammonium nitrate, urea URAN, Nitamin® 43G and 30L were soil-applied at rates of 0, 25, 50, 75, 100, and 125 pounds per acre. The application timings were: 1) 100% at-planting and 2) split applications with 50% or 75% at planting and the remainder at flower initiation. Three N formulations, urea, CoRon® and Nitamin®30L were foliar-applied to cotton that received optimal and sub-optimal soil-N applications. Application rates of urea and Nitamin® 30L were 10 pounds of N applied three times at flower initiation and then at 10 days intervals. Application rate of CoRon® was 2 gallons per acre applied at the same times and intervals. The different forms of soil-applied N had little to no effect on the lint yield or leaf N response to N rate. The optimal N rate for soil-applied N was 75 pounds per acre on Gigger silt loam and 90 pounds per acre on Commerce silty clay loam. Split applications of soil-applied N did not increase yield above that obtained with a 100% at-planting application. Foliar-applied N did not increase lint yield when soil N was sufficient and not a limiting factor to produce optimal lint yields. Foliar-applied N as urea or Nitamin® increased lint yield when soil-applied N was at sub-optimal rates. Even so, the foliar-applied N was not as economic as applying 100% of the N as soil treatments. The results validate the current N recommendations of applying 100% of fertilizer N, 75 pounds per acre and 90 pounds per acre, near planting time for cotton grown on silt loam and silty clay loam soils, respectively.

Introduction

Fertilizer nitrogen (N) is essential for profitable production of cotton but the optimal fertilizer timing and rate is difficult to predict for cotton because there are negative consequences from either too much or too little N, and excessive rates increase seasonal management costs (Ebelhar et al. 1996; Harris and Baker, 1997; McConnell et al., 1993). Recommended N rates for cotton in various cropping systems in Louisiana have been established from research studies conducted from the 1980s through 2002. Recommended N rates range from 75 pounds per acre on silt loam soils up to 100 pounds per acre on clay soils with consideration given to crop sequences and cover crop effects that either reduce or increase N needs of the following cotton crop (Boquet and Moore, 2000). In 2006 and 2007, additional experiments were conducted with N formulations and rates to verify that the current recommended practices remain accurate for optimal cotton production.

Materials and Methods

Five experiments were conducted during 2006 and 2007 at the LSU AgCenter Macon Ridge Research Station near Winnsboro and the Northeast Research Station near St. Joseph. The soil types were Gigger silt loam at the Macon Ridge Station and Commerce silt loam at the Northeast Station. In Experiment 1a on Gigger silt loam in 2006, three N formulations, ammonium nitrate, urea and Nitamin® 43G were soil-applied at rates of 0, 25, 50, 75, 100, and 125 pounds per acre. The application timings were: 1) 100% at-planting and 2) split applications with 50% or 75% at planting and the remainder at flower initiation. In Experiment 1b in 2007, the residual effects of the 2006 applications of Exp. 1a were evaluated without additional fertilizer N. In Experiment 1c on Commerce silty clay loam in 2007, two N formulations, URAN 32 and Nitamin® 30L were evaluated at the same rates and timing as in

Experiment 1a. In Experiment 2a in 2006, three N formulations, urea, CoRon® and Nitamin®30L were foliar-applied to cotton that received an optimal 80 pound soil-N application and a sub-optimal 40 pound soil N application. Application rates of urea and Nitamin 30L were 10 pounds of N applied three times at flower initiation and then at 10 days intervals. Application rate of CoRon was 2 gallons per acre applied at the same times and intervals. In Experiment 2b in 2007, the foliar application rates were the same as in Exp. 2a but the soil-applied rates were lowered to 30 and 60 pounds per acre.

Granular soil-N applications were made with a four-row Gandy® applicator. Sprinkler irrigation (0.25 in.) was applied the day after fertilizer application to prevent loss of urea N. Liquid soil applications were made with a 4-row coulter applicator with a John Blue ® pump and LM2000 Controller. The foliar applications were done with a four-row tractor mounted boom with AIG TJet 11003 nozzles spaced 20 inches apart in a total volume of eight gallons per acre. All experiments were planted in a randomized complete block design with four blocks except for Exp. 2a, which had seven blocks. Plots were four 40-inch rows 50 feet long. The foliar test plots were five rows wide to provide extra border rows for the spray tractor, avoiding possible damage to harvest rows.

Results and Discussion

Experiment 1a.

Nitrogen formulations performed similarly on Gigger silt loam, as there were no significant differences in lint yield among the three formulations (Figure 1). The optimal rate for lint yield for each formulation was 75 pounds per acre, which produced average lint yields of about 1400 pounds per acre. There was, however, a significant yield decrease with application of NH4NO3 above 100 pounds per acre, a negative response that did not occur with urea or Nitamin® 43G. Split applications, where 50 to 75% of the N was applied at planting and the remainder at flower initiation, did not increase yield above the 100% at-planting application of the same rate. Leaf N concentration increased with increase in N rate, with no differences among formulations in leaf N. Leaf N concentration at flower initiation (29 June) was highest (5.5%) with application of 75 pounds N per acre. During boll fill, (10 Aug) increase in leaf N concentration was linear and increased with application of N up to 125 pounds per acre (Figure 2). The results of Exp. 1a for lint yield and leaf N validate the current N recommendations of applying 75 pounds per acre near planting time for cotton grown on silt loam soil.

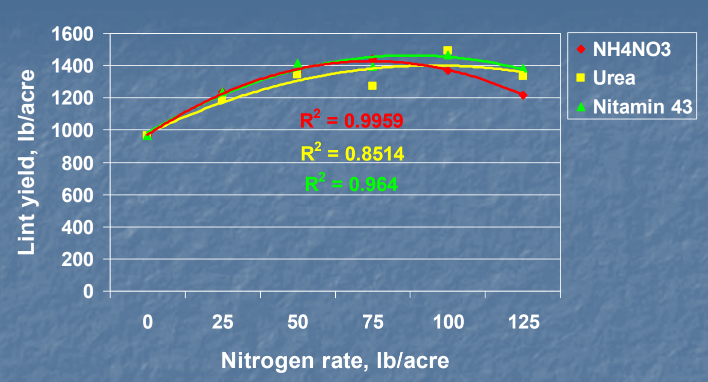

Figure 1. Cotton yield response to three formulations and six rates of N fertilizer on Gigger silt loam, 2006.

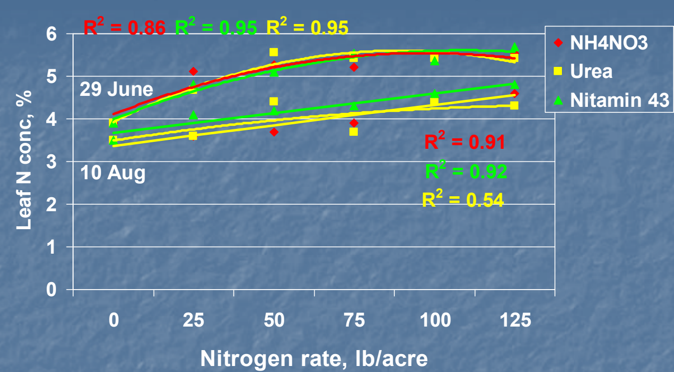

Figure 2. Cotton leaf N response at flower initiation (29 June) and boll fill (10 Aug) to fertilizer N forms and rates on Gigger silt loam, 2006.

Experiment 1b.

In 2007, there was no lint yield response to the residual N derived from the 2006 N applications although lint yields averaged about 900 pounds per acre without fertilizer application (Figure3). The lack of yield response to residual fertilizer N was unusual based on responses to residual N in previous experiments on other soil types (Boquet et al., 1995). However, the combination of high rainfall during winter months and possibility of leaching of N into the acid subsoil could, in some years, contribute to N losses and reduced availability on Gigger silt loam.

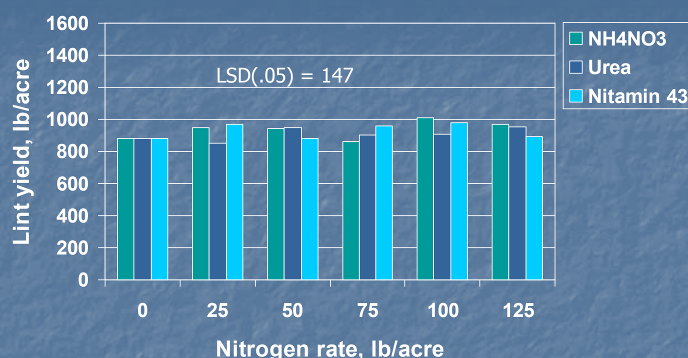

Figure 3. Cotton yield response to residual N formulations and rates on Gigger silt loam, 2007.

Experiment 1c.

Cotton yield response to fertilizer N on Commerce silty clay loam was similar for the two N formulations of URAN and Nitamin® 30L (Figure 4). With an optimal fertilizer N rate of 90 pounds per acre, lint yields averaged about 1300 pounds per acre. Splitting the fertilizer N into at-planting plus sidedress applications generally did not affect yield. The exception was with the 125 pound rate, where the split application yielded higher than the 100% at-planting application. However, this occurred partly because the single 125 pound application of URAN32 was excessive and tended to decrease yield.

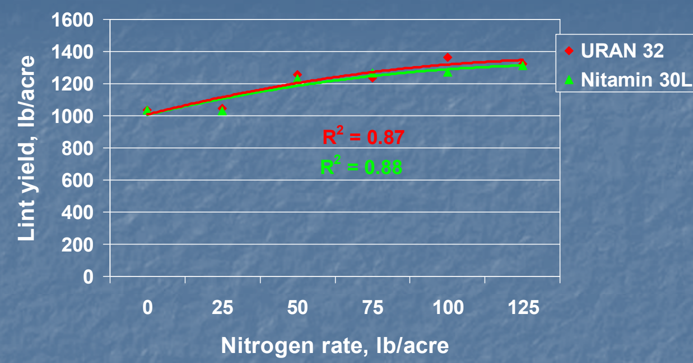

Figure 4. Cotton yield response to two formulations and six rates of N fertilizer on Commerce silty clay loam, 2007.

Experiment 2a.

The applied soil N rates of 40 and 80 lb acre in this study were designed to represent potentially deficient and optimal N fertilization, respectively, for the evaluation of the yield effects of the supplemental foliar N applications. The two soil-applied N rates had similar yields (966 lb lint/acre with 40 lb N and 937 lb lint/acre with 80 lb N), which means that the N fertility level of the experimental area was high enough to produce maximum yields with little need for applied N. Because of the high soil-N availability, it is also likely that there would be little opportunity for the cotton to respond to the additional N applied as foliar treatments. In fact, there was no yield response to the foliar-applied N (Figure 5). This agrees with previous research in Louisiana in which foliar N applications increased yield only in field situations where soil N was deficient (Boquet et al., 1993).

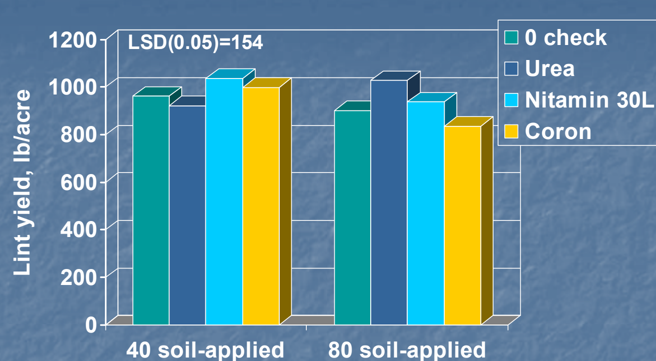

Figure 5. Response of cotton lint yield to soil- and foliar-applied N, 2006.

Experiment 2b.

As in 2006, the applied soil treatments of 30 and 60 lb N/acre were designed to represent potentially deficient and near optimal N fertilization, respectively, for the evaluation of the yield effects of the supplemental foliar N applications. The 60 pound soil-applied N rate produced significantly higher yield than the 30 pound soil applied N rate, demonstrating that the 30 pound rate was a sub-optimal level of fertilizer N. Under this scenario, foliar-applied

N in the form of urea and Nitamin® produced significant but small yield responses (Figure 6). The results showed that yield responses could be obtained from the foliar applications; however, this was not as efficient or economic as soil applied N because of the application costs involved with making the three foliar applications.

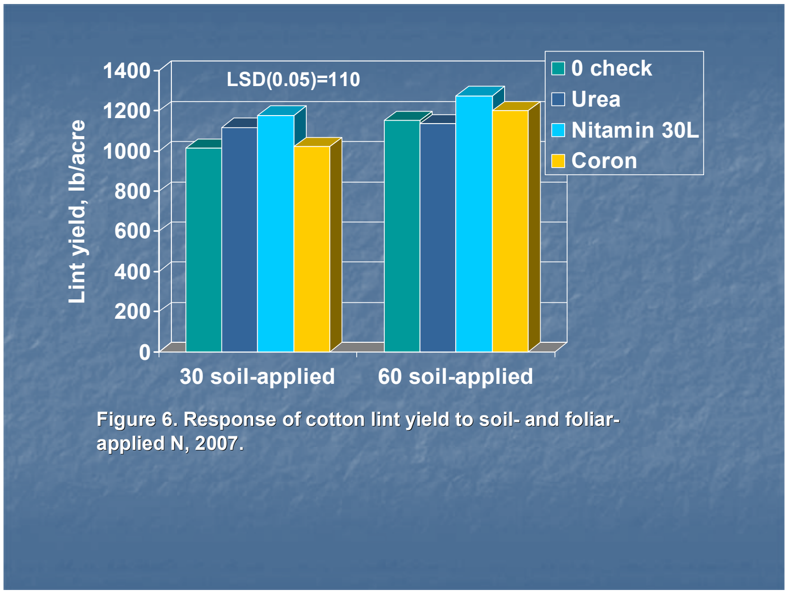

Figure 6. Response of cotton lint yield to soil- and foliar-applied N, 2007.

Summary

The different forms of soil-applied N, whether ammonium nitrate, urea, URAN or Nitamin® had little to no effect on the lint yield or leaf N response to N rate. The optimal N rate for soil-applied N was 75 pounds per acre on Gigger silt loam and 90 pounds per acre on Commerce silty clay loam. Split applications of soil-applied N, where 50 to 75% of the N was applied at planting and the remainder applied near bloom initiation, did not increase yield above that obtained with a 100% at-planting application. Foliar-applied N as urea, Nitamin® or CoRon® did not increase lint yield when soil N was sufficient and not a limiting factor to produce optimal lint yields. Foliar-applied N as urea or Nitamin® increased lint yield when soil-applied N was at sub-optimal rates. Even so, the foliar-applied N was not as economic as applying 100% of the N as soil treatments. The results validate the current N recommendations in Louisiana of applying 100% of fertilizer N, 75 pounds per acre and 90 pounds per acre, near planting time for cotton grown on silt loam and silty clay loam soils, respectively.

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