N MANAGEMENT IN SAN JOAQUIN VALLEY ACALA COTTON: GROWTH AND YIELD RESPONSES

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Abstract

The response of Acala cotton (*Gossypium hirsutum L.)* in California to a range of applied nitrogen treatments were investigated in a five year, multi-site experiment. Goals of the experiment were to identify crop growth and yield responses to applied nitrogen and to provide information to better assess the utility of soil residual N estimates in improving fertilizer management. Results obtained during this project have shown positive responses to increases in applied N across the 50 to 200 lbs N/acre range in only 16 out of 39 test sites.

Introduction

With cotton, it has been recognized for many years that mid and late-season nitrogen management has an impact on progress toward defoliation and harvest. High nitrogen levels delay harvest, can have a negative impact on the ease and costs of defoliation, and can increase problems with some late-season pests (silverleaf whitefly, aphids) that can influence lint quality. High nitrogen levels during bloom and early boll filling can also promote vegetative development at the expense of fruit retention under some conditions. An additional area of concern is the fate of nitrogen applied in excess of plant requirements. If plants grown in the rotation sequence don't have deep roots to intercept applied and residual nitrogen, its eventual movement through the soil profile can result in nitrate contamination of shallow groundwater in a wide range of conditions. Long-term field experiments were conducted across a range of soil types and cropping conditions in the San Joaquin Valley of CA to evaluate plant growth and yield responses to applied nitrogen.

Materials and Methods

The experiments were operated in University of CA Research Centers at the West Side and Shafter Research and Extension Centers plus five to six grower fields per year in Fresno, Madera, Merced, Kings, Tulare and Kern County in the San Joaquin Valley of CA.

Some field sites were utilized for multiple years (about 1/3 of the field sites over the five-year period), while the remaining sites were new each season due to continued changes in grower crop rotations. In all cases, soil samples were collected to a depth of 2 feet prior to planting and analyzed for beginning soil NO3-N and NH4-N. Four basic nitrogen (N) fertilization treatments were established each year at each site. The application amount used was equal to the desired N treatment level in lbs N/acre minus the calculated soil residual N value in lbs NO3-N/acre 2-ft determined using the soil samples prior to planting. If the initial amount of soil residual NO3-N was greater than 50 lbs NO3-N/acre, the residual value was used as the baseline for the 50 lb N treatment, and all other treatments were added in 50 lb increments above that baseline. Soil PO4-P and exchangeable-K were also tested on soil samples, and applications of these nutrients made as necessary to avoid P or K deficiencies in this nitrogen experiment.

In 1996, four treatments of 50, 100, 150 and 200 lbs N/acre were applied in late May (prior to the first within-growing season irrigation), and in three supplemental treatments (50, 100 or 150 lbs N/acre initially applied), a second N application of 50 lbs N/acre was applied in June just prior to the second (pre-flower) within-season irrigation. In 1997 through 2000, the experiments were simplified down to four basic treatments (50, 100, 150 and 200 lbs N/acre) due to the lack of crop growth and yield responses to split-application treatments.

Plant petiole samples were collected at intervals during the season to monitor for adequacy of plant nutrient status during late vegetative growth and through bloom. This data will not be discussed in this report. Basic plant monitoring information was collected but will also not be reported in this paper. Seed cotton yields were determined on two to four row widths the full length of the fields in all plots, harvested with a commercial spindle picker and weighed using weighing boll buggies or truck scales on cotton trailers (varies with location and equipment available). Six pound seedcotton samples were collected to determine gin turnout and to provide lint for HVI analyses.

Results and Discussion

Initial Soil Nitrogen Levels

In most years of the study, a wide range of soil NO3-N levels across field sites was observed. The yield data in this paper will cover all five years of the experiment, but for brevity, only a few examples of the soil N data will be discussed. Beginning soil NO3-N in the upper two feet of the soil profile were highly variable across years and sites in the experimental sites. For example, in the upper two feet of the soil profile in 1997, soil NO3-N concentrations ranged from a low of 9 mg NO3-N/kg soil dry soil to over 35 mg/kg.

These soil NO3-N levels corresponded with a range of 34 lbs N as NO3-N per acre in the upper 2 feet of the soil (at a site where cotton followed wheat) to a high of more than 130 lbs N as NO3-N/acre in the upper 2 feet (cotton following corn and processing tomatoes). Soil NO3-N levels in the upper 2 feet of the profile at the Spring 1998 sampling ranged from a low of 37 lbs N as NO3-N per acre at the Shafter REC site to 103 lbs N as NO3-N per acre at the Madera County site in spring of 1998, with an 8-location average of about 65 lbs N as NO3-N/acre.

The range in soil sample spring nitrate levels was even greater in 1999, with the highest N site having over 200 lbs N as NO3-N available in the upper two feet of the profile (in a field where cotton planting followed corn). Soil NO3-N levels in the upper 2 feet of the profile at the Spring 1999 sampling ranged from a low of 36 lbs NO3-N per acre in the low N treatment at the West Side REC to a high of 241 lbs NO3-N per acre at the Madera County site. Most other sites in the spring upper 2-foot sampling in 1999 ranged from about 45 to 110 lbs NO3-N per acre in the upper 2 feet of soil (data not shown).

Cotton Lint Yield Responses to Treatments.

1996 Results. It is important to get a multi-year, multi-location perspective in analyzing lint yields across these nitrogen treatments. Lint yields in 1996 were moderate across all sites, ranging from lows of 1000 lbs lint/acre to over 1550 lbs/ acre, and averaging about 1200 lbs/acre across all locations. In all but one of the field sites in 1996, there were no significant effects of nitrogen treatments on lint yields (ie. increasing nitrogen applications did not result in yield responses). Soil residual N levels and release of soil and organic matter N during the growing season under the 1996 growing season conditions could support moderate (by CA standards) yields and acceptable growth with 100 lbs or less of supplemental N/acre.

1997 Yields. In 1997, there were more locations showing significant yield reductions with N applications of 50 to 100 lbs N/acre. Only one 1997 location showed significantly higher yields with increasing applied N through 200 lbs N/acre. Each location with significant responses to increasing applied N had moderate to high yields (>1500 lbs N/acre), where

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more N is taken up by the plants and more is required to mature developing seed. Initial (post-planting) soil NO3-N levels in sites with lint responses were not uniformly low.

1998 Yields. Results from the 1998 year have to be analyzed in part with some perspective on how unusual a year it was in weather and progression of normal growth patterns. 1998 was a very difficult production year, with cool and wet spring conditions, delayed growth, and abnormal progression of crop development associated with early cool conditions, hot late summer conditions which influenced flower and boll retention, and a cool fall which delayed progress toward defoliation and harvest. Under these low yield potential conditions, less N is required by developing seed, and it would be expected that responses to applied N would be less than in moderate to high yield years. Out of eight field sites, only two showed a signficant response to increases in applied N (Fresno and Kings County sites), and those responses were small (in the range of 50 to 80 lbs lint/acre when going from 50 to 150 lbs N/acre at the Kings County site)

1999 and 2000 Yields. Higher yields at most study sites in 1999 and 2000 (intermediate between 1997 and 1998 yields) put a higher N "load" on the plants (higher need for N to meet fruit development requirements) at most locations. In both years, the early-season period was cool, delaying plant growth and development, mild summer temperatures and a long, warm fall allowed high yields to be realized at many locations. Although four out of seven sites (1999) and five out of eight sites (2000) showed significant yields responses to increasing applied N, three out of seven test plot sites (1999) and two out of eight sites (2000) had significant yield responses to N applications in excess of 100 lbs N/acre. Spring soil residual NO3-N levels have become very low in low N treatments at several sites (soil NO3-N of < 6 mg / kg dry soil). This was particularly true in Shafter, Kings County and West Side REC sites, where repeated tests have been done in the same fields for several consecutive years.

Residual Soil NO3-N Relationship to Lint Yields

Putting all this information together over the five years of the study, one of the primary goals of the study was to develop some basis for the use of soil residual N as NO3-N levels as part of the decision process in estimating crop N application needs each year. The pre-plant or immediate post-planting soil samples in the upper two feet of the soil profile were selected as a minimal level of soil sampling that would be easily collected and inexpensive enough to be accepted by growers and consultants.

Figures 1 to 3 show the results of analyses in which the fields have been grouped according to planting-time residual soil NO3-N levels of: (1) less than or equal to 55 lbs of NO3-N/acre 2-feet (Figure 1); (2) between 55 and 100 lbs NO3-N/acre 2-feet (Figure 2); and (3) greater than 100 lbs NO3-N/acre 2-feet (Figure 3). Although these levels are somewhat arbitrary, the approximately 50 lbs steps used correspond roughly to the increments used in the application treatments. There are recognized limits in interpreting just soil nitrate data, as it is recognized that there are other forms of Nitrogen present in the soil and the relative mix of these forms changes over time and with changing temperature, moisture and biological conditions. However, these changes in soil NO3-N over time still represent a general index of soil changes in N status resulting from crop uptake and other processes / losses during the growing season.

Some generalizations can be observed with this grouping according to beginning soil residual NO3-N. With residual soil NO3-N less than 55 lbs/acre 2-feet, cotton yields significantly increased in 7 out of the 10 sites that fell into this residual soil N level category (Fig. 1). Only about one-half of the sites (6 out of 13 in Fig. 2) showed significant yield increases with increasing applied N when beginning soil residual NO3-N was between 55 and 100 lbs NO3-N/acre 2-feet. Only 2 out of 16 sites showed significant yield increases when residual soil NO3-N exceeded 100 lbs NO3-N/acre 2-feet (Fig. 3). The average responses grouped across all 39 sites (5 years times 7-8 sites per year) by these three initial levels of residual soil NO3-N in the upper 2-feet are shown in Figure 4.

Summary and Conclusions

Yield responses to applied N were not always observed in locations with low initial soil NO3-N levels, indicating that some care must be exercised in the use of soil residual NO3-N tests for consistency in being able to estimate locations with likely responses to applied N. In reviewing whether or not lint yields respond to increases in applied N within the 50 to 200 lbs per acre range, it is important to look not only at whether or not yields are statistically different, but to also evaluate the existence of non-significant trends toward higher yields with higher applied N. However, in attempting to reduce applied N and make better use of residual N "reserves" in the soil, growers will need to rely even more on use of information on prior crop history and N loading, and measurements of crop N status and fruit loads to decide when likely plant needs warrant supplemental N applications.

Acknowledgements

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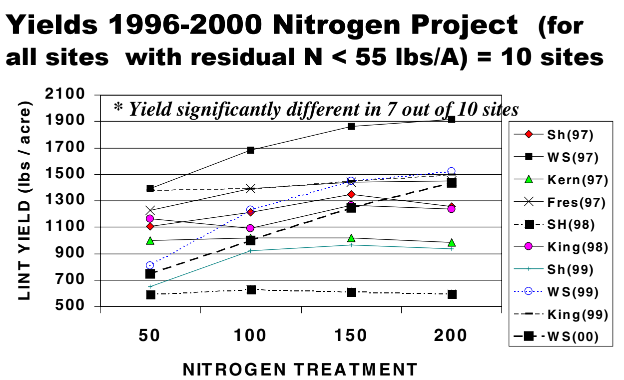

Figure 1. Lint yield responses to increases in applied nitrogen at locations/sites in 1996 through 2000 in which residual soil NO3-N in the upper two feet of soil was less than 55 lbs NO3-N/acre 2-feet.

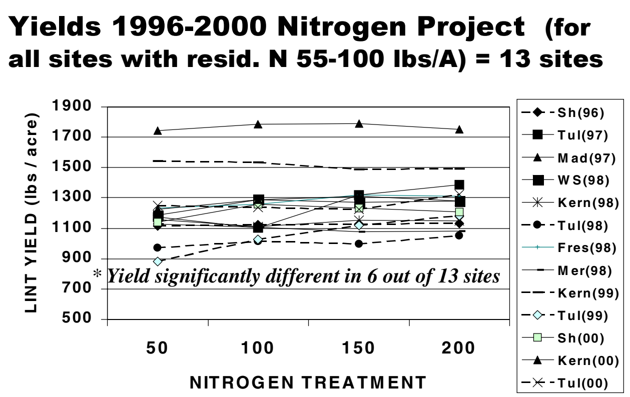

Figure 2. Lint yield responses to increases in applied nitrogen at locations/sites in 1996 through 2000 in which residual soil NO3-N in the upper two feet of soil was between 55 and 100 lbs NO3-N/acre 2-feet.

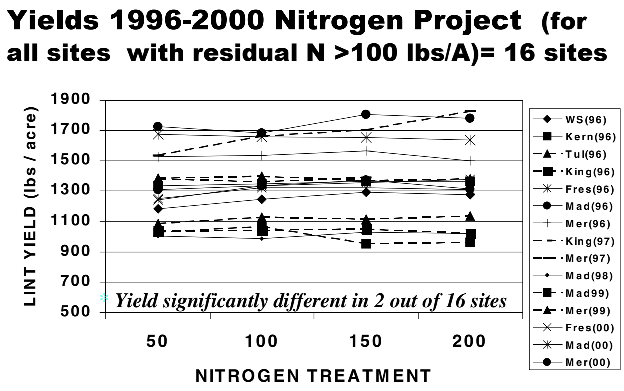

Figure 3. Lint yield responses to increases in applied nitrogen at locations/sites in 1996 through 2000 in which residual soil NO3-N in the upper two feet of soil was greater than 100 lbs NO3-N/acre 2-feet.

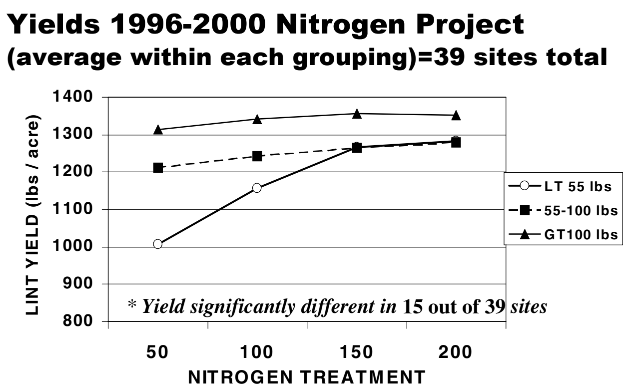

Figure 4. Fitted curve for the yield response to applied nitrogen levels (50 to 200 lbs) across all locations/sites having less than 55 lbs NO3-N/acre 2-feet (LT 55lbs); between 55 and 100 lbs NO3-N/acre 2-feet (55-100 lbs); and greater than 100 lbs NO3-N/acre 2-feet during the 1996-2000 period in the nitrogen study.