WHY DEVELOP NEW NITROGEN GUIDELINES FOR CALIFORNIA COTTON?

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Abstract

A multi-location study to evaluate the response of California Acala cotton varieties to applied N was conducted in the San Joaquin Valley from 1995 through 1999. The test plots included a range of soil types, production conditions, and levels of residual soil N. Soil NO_3-N was measured post-planting and post-harvest. Fertilizer N rates, 50, 100, 150 and 200 lbs N/acre, were applied prior to the first irrigation. Initial soil NO_3-N levels ranged from 30 to over 200 lbs N/acre. Across all locations and years, cotton lint yield increased significantly with each fertilizer increment up to 150 lbs N/acre. However, only 10 of the 31-site/year locations showed significant yield increases to added fertilizer. Soil NO_3-N in the surface 4 feet decreased from spring to post-harvest in all treatments. The lower fertilizer rate treatments utilized more soil NO_3-N than the higher rates. In 1996, a moderate yield year, soil NO_3-N averaged across all locations increased in the 4 - 8 foot depth for all N rates except for 50 lbs N/acre. In 1997 with higher yields, only the two higher N fertilizer rates had increased soil NO_3-N in the 4 - 8 foot depth. Residual soil NO_3-N from the previous crop can have a significant impact on N fertilizer utilization by the subsequent cotton crop and must be accounted for.

Introduction

The impact of residual soil nitrogen on crop response to applied nitrogen fertilizer can be substantial. A change in cropping patterns and rotations in the San Joaquin Valley has occurred over the past several years. With fewer acres of cotton being grown, there is less cotton following cotton and the rotations include more vegetable crops. These crops generally have a shallow rooting system and are usually heavily fertilized. Nitrogen management in cotton is a balance between sufficient levels to produce optimum yields for the growing conditions and excess levels that encourage rank growth, influence the balance of vegetative and reproductive growth, delay maturity and reduce the effectiveness of defoliants. Timing of planting, fruit retention, environmental stress, management problems, and pest damage can have a dramatic effect on plant nitrogen use, fertilizer use efficiency, and the fate of excess soil nitrogen.

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The objectives of this study were to identify responses of current dominant cotton varieties in CA to applied N and the utility of soil nitrate-N measurements in assessing potential soil contributions to crop N requirements.

Materials and Methods

The impact of residual soil nitrogen on Acala cotton (*Gossypium hirsutum* L.) crop response to applied nitrogen fertilizer in the San Joaquin Valley was evaluated in a multi-location study from 1996 to 1999. The studies were conducted at the University of California Shafter (SREC) and Westside (WSREC) Research and Extension Centers and at a location in each of the six San Joaquin Valley cotton-growing counties. These sites represent a wide variety of soil types, crop rotations, and production practices. All sites were furrow-irrigated with 30, 38, or 40-inch row spacing. In 1996 and 1997 Acala Maxxa was grown at all locations. At the county locations, some farmers made other variety choices in 1998 and 1999. In addition to Acala Maxxa, other Acala varieties were grown including GTO Maxxa and Phytogen 33. Most sites were not on the same plot area each year. Growers were unable or unwilling to accommodate continuous cotton due to concerns for disease pressure, production problems in the specific fields or changes in crop rotation needs at the farm level. The plots at SREC were in the same spot for the 1997, 1998, and 1999 cropping years. Plots at WSREC were also continuous in 1998 and 1999 but on new plot areas the other years. Only 7 sites were grown in 1999.

Fertilizer treatments were 50, 100, 150, and 200 lbs N/acre adjusted for residual soil nitrate. Plots were soil sampled in late April or early May following planting and in late October or early November following harvest each year. Soils were sampled at five locations per replication to a depth of eight feet at all sites for analysis of soil NO_3-N. Samples were collected in one-foot increments to a depth of 4 feet, and in two-foot increments from 4 - 8 feet. Analyses were conducted on KCl extracts. Plots were spindle-picker harvested for seed cotton yield measurements. Sub samples were collected and ginned for lint yield weights. Lint samples were analyzed for quality.

Results and Discussion

Lint Yield

Averaged over all locations and all years, cotton lint yield was significantly higher with each N rate increase up to 150 lbs N/acre (Fig. 1). This covered a wide range of growing conditions and yield levels. However, only 10 of the 31 site/year locations had a significant positive lint yield response to added N fertilizer. Yields in 1996 were moderate across all test sites, ranging from a low of about 1000 lbs lint/acre to over 1550 lbs lint/acre, averaging about 1200 lbs lint/acre. Only one location had a significant yield increase with increasing N rate. Half of the locations had significant yield increases in 1997. These locations had moderate to high yields (in excess of 1500 lbs lint/acre). With high yields, more N is required to build larger plant frameworks for high yields and to mature out developing seed. Only one location had a significant yield increase at 200 lbs N/acre.

Yields in 1998 ranged from 590 to 1317 lbs lint/acre. Yields were severely reduced because of very poor growing conditions. Only two sites had significant yield increases and those responses were quite small (50 to 80 lbs lint/acre). Much higher yields in 1999 put a higher N "load" on the plants at most locations. Four of the 7 test plot sites had significant yield responses to N applications in excess of 100 lbs N/acre. Only one site had a significant increase at 200 lbs N/acre. The locations where the tests were repeated showed the largest response to fertilizer additions (Fig. 2). Much of the non-response to fertilizer nitrogen addition was because of a high soil nitrate level prior to cotton planting.

Soil NO_3-N Status

Wide ranges of soil NO_3-N levels were measured each year. In 1996, NO_3-N levels in the surface 2 feet ranged from a low of 34 lbs NO_3-N/acre following wheat to more than 130 lbs NO_3-N/acre at two locations following corn and processing tomatoes. Similar levels were observed in the spring of 1997 and 1998. A site in 1999 with over 200 lbs NO_3-N in the upper 2 feet of soil was part of the study. Data in general indicated that most net depletions of soil NO_3-N was in the upper 4 feet of the soil profile.

In 1996 soil NO_3-N depletion in the upper 4 feet ranged from a low of 12 lbs NO_3-N/acre to a high of over 150 lbs NO_3-N/acre and averaged over 100 lbs NO_3-N/acre (Fig. 3). It could be argued that this depletion could result from leaching losses as well as denitrification. However, the measured presence of significant root mass at depths down to 6 feet at several locations indicates that plant uptake can also be a reason for net NO_3-N depletion even within the 4 - 8 foot zone. Soil NO_3-N in the 4 - 8 foot depth decreased in the 50 lbs N/acre treatment only. The other treatments had an increase in soil NO_3-N. The increase was greater for each higher N application rate. This indicated the potential for leaching nitrate beyond the effective rooting depth of cotton. Due to surface soil infiltration characteristics, soil water storage capacity and timing of irrigations, about half of the sites in the 1996 and 1997 studies had relatively limited potential for significant leaching losses of NO_3-N into the lower profile. The other sites in those years had soil types and characteristics that could allow significant downward water/solute movement under some crop, weather and management conditions. Careful attention to soil water storage capacity and irrigation timing and amounts could reduce potential downward solute movement even in this second group of sites.

Soil NO_3-N in 1997 showed similar patterns to 1996. The only change in pattern from the previous year was soil NO_3-N in the 4 - 8 foot depth in the 100 lbs N/acre treatment decreased (Fig. 4). Yields in 1997 were higher than in 1996, which may account this change. Spring soil residual NO_3-N levels continued to drop each year to very low levels in low N treatments at the sites were plots were in the same location each year. These low N treatment plots had a large decline in lint yield as residual N was depleted and not replenished with sufficient fertilizer inputs. In contrast, the county locations that consistently did not show a positive response to added N had the greatest declines in soil NO_3-N. Were these plots were moved to new locations each year, no continuous depletion of the low N fertilizer plots occurred. Yield response remained flat to added N fertilizer at these locations.

Summary

The change in crop rotations in the cotton growing areas of the San Joaquin Valley has added a challenge for nitrogen fertilization management. The addition of vegetables and other highly fertilized rotation crops has prompted the need for reanalyzing nitrogen recommendations for cotton. A combination of low yield, high residual soil NO_3-N from previous non-cotton crops, and high fertilizer N can combine to create a high potential for nitrate leaching. For soils with less than 50 lbs NO_3-N/acre in the upper two feet of soil, cotton lint yields responded positively to added fertilizer N up to 150 lbs N/acre. Additional experiments need to be conducted to assess high soil NO_3-N levels where no yield response was observed and intermediate levels where lower N recommendations may be appropriate. Soil sampling for nitrogen status is an important tool for nitrogen management. Better management of fertilizer inputs is thus possible. Cotton may be the crop in the rotation that is used to "mine" and deplete the soil of excess nitrogen from other crops.

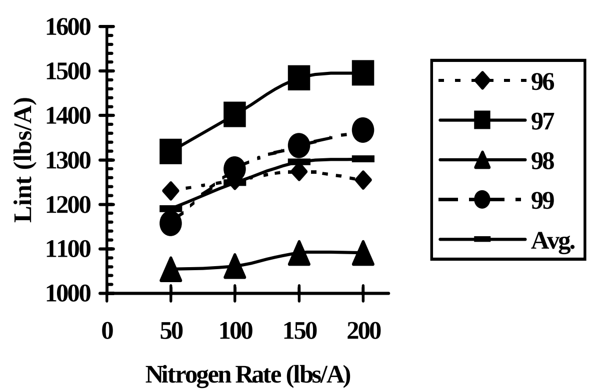

Figure 1. Lint yields averaged across all locations for each year and averaged across locations and years.

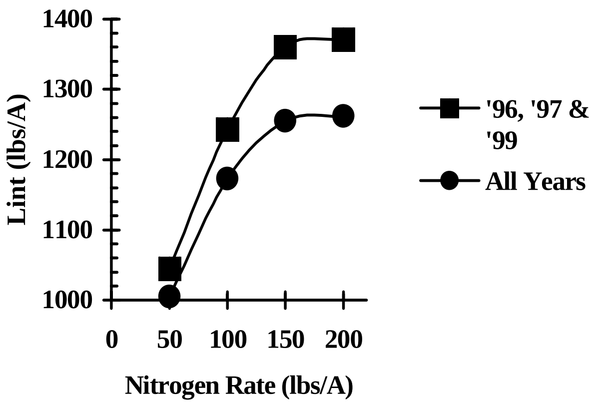

Figure 2. Lint yields averaged across years at continuous cotton sites.

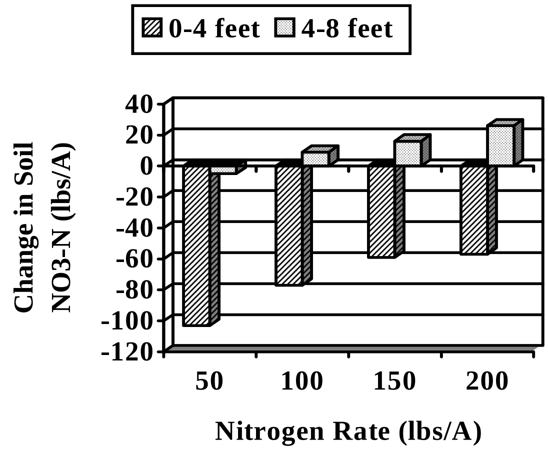

Figure 4. Change in soil nitrate-N averaged across all locations, 1997.

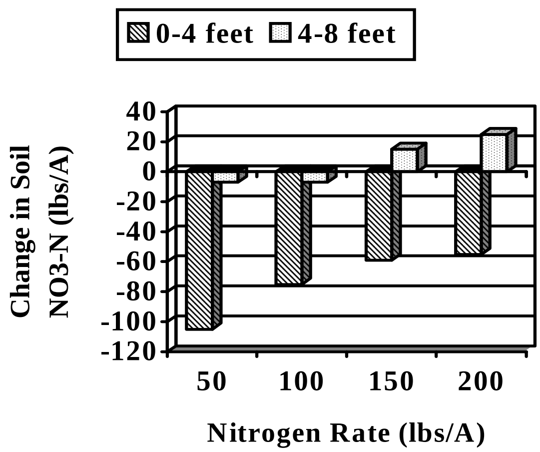

Figure 3. Change in soil nitrate-N averaged across all locations, 1996.