

LONG-TERM NITROGEN MANAGEMENT TRIALS

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Summary

The response of Acala cotton in California to a range of applied nitrogen treatments are under investigation in a multi-year, multi-site experiment. Goals of the experiment are 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 the first three years of this project have shown positive responses to increases in applied N across the 50 to 200 lbs N/acre range in only 6 out of 24 test sites (8 locations by 3 years). These findings indicate that while it is still true that 50 to 55 lbs N are needed per bale of cotton produced under CA conditions, more efforts should be put into identifying the amount of plant N requirements that can be met from residual soil N, rather than solely from fertilizer N applications.

Incentives to consider adjusting nitrogen management practices for cotton and other CA crops come from several areas of concern. 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, 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. Higher than desired 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 in recent years has been the fate of nitrogen applied in excess of plant requirements. If plants grown in the rotation sequence do not have deep enough roots to intercept this applied and residual nitrogen, its eventual movement through the soil profile has been shown to cause nitrate contamination of shallow groundwater in a wide range of conditions.

Materials and Methods

In the first full year of the multi-site studies (1996), the fertilizer treatments ranged from a low of 50 lbs total N/acre to 200 lbs N/acre. 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 and 1998, 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 as well as grower concerns over the practicality and expenses involved in split applications and potential for damage to plants associated with getting application equipment in

prior to the second irrigation. Soils were sampled at five locations per replication to a depth of 8 feet at all sites for analysis of soil NO₃-N, NH₄-N, PO₄-P and K.

Results and Summary of Data

Soil samples were collected to a depth of 8 feet in May (or in several cases, April) (post-planting) in 1997 and 1998 and again in the Fall (post-harvest) at all field sites and in all N treatments. This report will focus mostly on soil test data from the 1997 studies. When soil N as NO₃-N is converted into lbs N/acre-foot of soil volume, and soil bulk density is known or measured, the net changes in soil test N as NO₃-N during the growing season (planting to post-harvest) can be calculated.

The wide range of soil NO₃-N levels across field sites was again apparent in 1997 (Spring and Fall data) and 1998 (data for spring available for 1998). 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

Data indicated that most net depletion of soil NO₃-N was seen in the upper four feet of the soil profile. It could be argued that this depletion could result from leaching losses as well as denitrification, but the measured presence of significant root mass at depths down to 6 to 7 feet indicates that plant uptake is another reason for net depletion even at the 4 to 8 foot zone. Most other sites had root activity primarily in the upper 3 to 4 feet of the soil profile. As levels of applied N increased at most sites, soil NO₃-N levels in the 4 to 8 foot zone of the soil profile generally increased. Due to surface infiltration characteristics, soil water storage capacity and timing of irrigations, half of the sites in this study (Shafter REC, Kern County, Tulare County, West Side REC) had relatively limited potential for significant leaching of nitrate-N into the lower profile. The Fresno County, Kings County, Madera and Merced County sites had soil types which could allow significant downward water / solute movement under some conditions, but again, soil water storage capacity and irrigation timing and amounts at these sites were managed during the growing season so as to limit downward movement beyond the 8 foot zone measured in this study.

Lint Yields

1996

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 about 1000 lbs lint/acre to over 1550 lbs/ acre, and averaging about 1200 lbs/acre across all locations. In all but one of the eight field sites used in 1996, there were no significant effects of nitrogen treatments on lint yields (ie. increasing nitrogen applications did not result in yield responses). There were trends toward increases in yield when 150 lbs N/acre was applied at several sites, but only at the West Side REC was lint yield significantly lower at 50 lbs applied N/acre or 100 lbs applied N/acre than at higher application amounts. 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

In 1997, there were more locations showing significant yield reductions with N applications of 50 to 100 lbs N/acre (data not shown). The Tulare County, Merced County and Fresno County locations showed yield reductions at the 50 and/or 100 lbs N/acre levels when compared with higher N applications. Only one location in 1997 showed significantly higher yields with continued increases in applied N all the way through 200 lbs N/acre. Each location with significant responses to increases in applied N had moderate to high yields (in excess of 1500 lbs N/acre), where more N is taken up by the plants and more is required to mature out developing seed. Initial (post-planting) soil NO₃-N levels in sites with lint responses to applied N were not uniformly low. Yield responses to applied N were not observed in locations with low initial soil NO₃-N levels, regardless of the levels at each site, casting some doubt as to the efficacy of soil residual NO₃-N tests for estimating locations with likely responses to applied N.

1998

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. Yields were extremely low in fields across most of the San Joaquin Valley. 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 significant response to increases in applied N (Fresno County and Kings County sites), and those responses were quite 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) (Table 5). It is interesting to note that there was a trend at many locations for gin turnout to decrease with increasing applied N, which reduced some of the apparent yield differences seen in seedcotton yield across treatments. These results of course are highly dependent upon the soil retentive characteristics, amount of water applied and leaching loss potential, as well as the contributions to soil organic and inorganic N reserves from prior cropping practices. Some of the cotton fields represented in these studies were cotton following a prior crop of cotton, but many were in rotation schemes involving alfalfa, processing tomatoes, small grains, corn or vegetables. This is becoming more typical of the highly diversified agriculture in the San Joaquin Valley. In order to avoid waste of inputs or risk nitrate contamination of groundwater supplies, it is becoming desirable to use yield potential estimates in combination with some measure of soil residual N when deciding upon proper levels of applied N.

Table 1. Lint yield (lbs lint/acre) as a function of location (field site) and N application treatment in 1998.

N applic. Treatment (lbs N per acre)	Shafter (40" rows)	West Side REC (40" rows)	Kern County (38" rows)	Kings County (40" rows)	Tulare County (38" rows)	Fresno County (30" rows)	Madera County (30" rows)	Merced County (30" rows)	Mean across all sites (lbs lint per acre)
50	590	1189	1159	1163	971	1233	1006	1127	1029
100	633	1289	1110	1092	1014	1260	987	1108	1033
150	612	1274	1154	1267	997	1317	1031	1078	1058
200	597	1280	1147	1236	1052	1311	1021	1083	1059

It is also important to note that recent work the principal investigators have conducted in the San Joaquin Valley largely confirms earlier work in CA and Israel which indicated that about 50 to 55 lbs N are needed per bale of cotton produced. These results are important in light of the lack of yield response noted in current studies across a wide range of applied N. The results of the current study do not indicate that only 50 or 100 lbs of N/acre are needed to produce 1200 or 1600 lbs lint/acre, but rather indicate that soil residual N (from various forms) can serve as a major source of N in meeting crop nitrogen requirements. It is to be expected that when the N "load" or requirements are much higher due to a high fruit set, there will be more yield separation across a range of applied nitrogen. Growers need higher yields to effectively compete and achieve profitability in 1999 in CA cotton. It would also be very useful in this project to have several more data sets representing responses to applied plus residual N under moderate to high yield conditions to give more balance to the "picture".