Fertility

The Importance of Residual Soil Nitrate in Upland Cotton Production Using Subsurface Drip Irrigation

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ABSTRACT

The importance of residual soil nitrogen (N) in the production of upland cotton in Central Arizona has not been adequately studied. A subsurface drip irrigation experiment was conducted at the Maricopa Agricultural Center to examine the effect of residual soil nitrate content on lint yields of upland cotton, and to evaluate the validity of current cotton petiole nitrate interpretations under high yielding conditions. Different levels of water and N fertilizers applied to the plot area in previous years had resulted in a range of residual NO_3-N content ranging from 36 to 166 lbs/acre. Lint yields increased from 2.8 to 4.3 bales/acre as residual soil N increased from 5.7 to 27.7 ppm NO_3-N although the correlation between yield and soil N was relatively low. This was thought to be due to difficulty in obtaining soil samples that accurately reflect the true plant availability of N in soils irrigated with drip systems. The interpretation of cotton petiole data under high yielding conditions (>4 bales/acre) proved to be essentially the same as that currently recommended for conventional furrow irrigated cotton.

INTRODUCTION

Past research in Central Arizona has investigated various aspects of water and nitrogen (N) management of subsurface drip irrigated short staple cotton. Optimum yields have consistently required about 120% to 130% of the consumptive use of cotton which is 41.2 inches of water (Erie et al., 1982). Analysis of cotton petiole nitrate levels has indicated that interpretating the nitrogen status of plants grown under drip irrigation is essentially the same as for plants grown under conventional furrow irrigation (Pennington and Tucker, 1984).

Yield responses to nitrogen fertilizers were very modest during the first three years' experiments at the Maricopa Agricultural Center. This has been attributed to high residual soil nitrate levels and appreciable nitrate contained in the irrigation waters used. The ability to reduce or eliminate leaching with precise applications of water using drip irrigation undoubtedly enhances the efficient use of nitrogen from these sources.

The importance of residual soil N has been implied by initial findings, but to date has not been adequately studied. Lint yields of slightly above 3 bales/acre have been attained, although it would be of interest to evaluate various aspects of nitrogen management under high yielding (> 4 bales/acre) conditions.

In 1986, a subsurface drip irrigation experiment was conducted at the Maricopa Agricultural Center to achieve the following objectives: 1) to examine the importance of residual soil nitrate content and its effect on lint yields of upland cotton, and 2) to evaluate the validity of current cotton petiole nitrate interpretations under high yielding conditions.

METHODS

The site of this experiment was the exact plot area used for the water X nitrogen trial conducted in 1985 (Tucker et al., 1986). In that experiment, three water levels (60, 100, and 130 % of consumptive use) and six nitrogen rates (0, 50, 67, 100, 200, and 300 lbs N/acre) were applied to subsurface drip irrigated upland cotton grown in plots 58 feet by 26.7 feet in size. All treatments were replicated three times in a split-plot design with water levels as main plots and N rates as the subplots. It was expected that the residual nitrate levels in these plots would range from below 50 to nearly 200 lbs NO_3-N in the root zone of drip irrigated cotton which is about 18 inches.

In January of 1986, intensive soil sampling was done to obtain residual soil NO_3-N profiles from all of the 54 plots in the 1985 experiment. Samples were taken in six inch increments to the base of the root zone (i.e. 0-6", 6-12", and 12-18") and then one foot below that point (18-30"). The sampling procedure used was that proposed by James et al.,1967, in which three soil cores are taken perpendicular to the drip lines across a distance of one- half the line spacing.

In practice, subsamples were taken from the center (top) of the planting bed, from the bottom of the furrow, and half way in between. The three subsamples are then mixed to give an average sample for each soil strata. The NO_3-N content of the samples was measured using a water extraction and determination by the Kjeldahl steam distillation method.

Drip tubing was buried approximately eight inches below the soil surface of each cotton bed. The row spacing was 40 inches. Irrigation water was applied through the buried drip irrigation system consisting of Chapin Twin Wall IV, 14 mil drip tubing.

Upland cotton (Deltapine 61) was seeded into dry soil on March 27, and irrigated up beginning on March 31. The soil was a Casa Grande sandy loam. A total of 56.6 inches of water was applied with applications scheduled using the Crop Water Stress Index and soil moisture measurements. A total of about 30 lbs N/acre was applied in the irrigation water. Plants were hand-thinned at the 3 to 4 leaf stage to a population of 25,000 plants per acre.

The 1985 water level X nitrogen subplots were split in half. One of the sub-subplots was untreated (designated as '-N')and the other received additional fertilizer (designated as '+N'). A total of 95 lbs N/acre was applied to all +N sub-subplots as urea-sulfuric acid solution ('N-pHuric', 28% N).

The exact quantity of N applied was based on monitoring of the nitrate content of the cotton petioles throughout the season. Petioles were sampled 13 times during the season in accordance with the methods of Pennington and Tucker (1984). The goal was to apply an amount of N fertilizer that would supply adequate, but not excessive, N to the plots with the highest level of residual soil N, with a progressively decreasing supply of available N to the plots with lower initial N content.

Nitrogen applications were made once per week, beginning just prior to the first squares (May 29) and ending at full flower (July 9) as shown in Figure 3. The fertilizer was injected directly into the irrigation water delivered to the +N sub-subplots.

The center two rows of each sub-subplot were machine harvested on October 28. Four random samples of seed cotton were taken during the harvest and ginned on a small experimental gin to determine the percent lint (gin turnout).

RESULTS AND DISCUSSION

The average quantities of residual soil nitrate and the average 1986 lint yields from all treatments are listed in Table 1. As expected, increasing rates of N fertilizer applied in the preceeding year resulted in greater amounts of residual soil N. Also, the application of increasing quantities of irrigation water in the preceeding year resulted in lower levels of residual soil N. This is presumably due to greater leaching and greater plant removal of N with the higher levels of irrigation water applied.

Figure 1 shows the relationship between lint yields and residual soil N levels for both -N and +N sub-subplots. The relatively low coefficients of determination for these regression equations suggest that factors other than residual soil nitrate content are important in the variation of lint yields measured in this experiment. It is also probable that the samples taken may not accurately reflect the true plant available nitrogen levels in these soils due to spatial variation in soils irrigated and fertilized with drip systems.

The correlation between lint yield and residual soil N in the -N treatments was considerably lower the that obtained under furrow irrigated conditions by Gardner and Tucker (1967), that is $R^2 = 0.49$ for drip and $R^2 = 0.75$ for furrow irrigation.

The difference in yield between the +N and -N sub-subplots were calculated to determine the 'yield response' to the application on N fertilizer. On the average, positive yield responses to the application of 95 lbs N/a were observed in all of the 1985 water X nitrogen treatments. Yields in some -N sub-subplots, however did exceed the yields of the +N sub-subplots, as shown in Figure 2. In general, yield responses to the application of N fertilizer were very small when the residual soil level of NO_3-N was about 25 ppm or greater.

Table 1. The average soil test NO3-N levels in the surface 18 inches of soil and the average 1986 lint yields of -N and +N treated sub-subplots obtained in plots receiving various rates of water and nitrogen fertilizer in the preceeding crop year.

Water Level in 1985	N Applied in 1985	Residual Soil* Test NO_3-N	1986 Lint Yield# -N	1986 Lint Yield# +N
% C.U.	lbs/acre	ppm	lbs/acre	
60	0	6.6	1629	1858
	50	7.3	1763	2169
	67	11.7	1813	2246
	100	9.9	1828	2146
	200	15.4	1847	2125
	300	27.7	2066	2089
100	0	5.7	1323	1880
	50	5.4	1536	1854
	67	6.8	1410	1860
	100	7.0	1318	1885
	200	10.8	1632	1983
	300	16.3	1767	1917
130	0	5.8	1392	1820
	50	5.2	1503	1813
	67	6.3	1701	1822
	100	6.0	1413	1834
	200	10.6	1540	1813
	300	14.6	1455	1667

** Values are the mean of three observations.*
 # Based on a 37.7% average gin turnout from the first picking.
Values are the mean of three observations.

Results of cotton petiole data for subplots that had received 0 and 300 lbs N/acre the previous year are summarized in Figure 3. These results have been averaged across all three previous water levels giving two pairs of curves, that is the -N and +N curves for the treatments with the lowest and the highest levels of residual soil N. The zones of the diagram corresponding to 'Deficient', 'Warning', 'Adequate', and 'Excess' have been included to facilitate interpretation of the four curves.

As expected, the low residual N plots receiving no additional N remained in the 'Warning' zone early in the season and became 'Deficient' after the last week in June. This corresponded to the lowest average lint yields measured in any of the treatments; about 3.0 bales/acre. Yield data from the plots corresponding to the remaining three curves substantiates that lint production decreases the longer petiole levels have dropped below the 'Adequate' zone (see Table 1 and Figure 2).

Figure 1. Cotton lint yields as affected by residual soil test levels of nitrate-N in sub-subplots receiving 0 and 95 lbs N/acre.

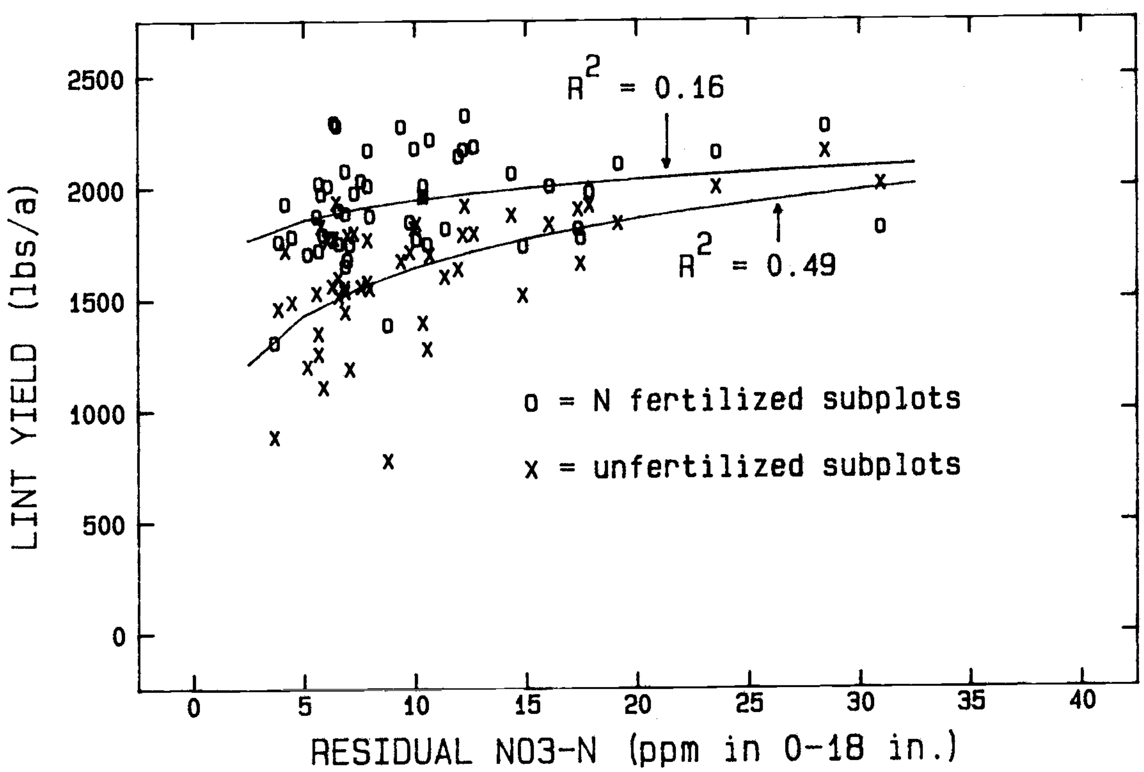


Figure 2. Lint yield response of cotton to the application of 95 lbs N/acre as affected by residual soil nitrate-N levels.

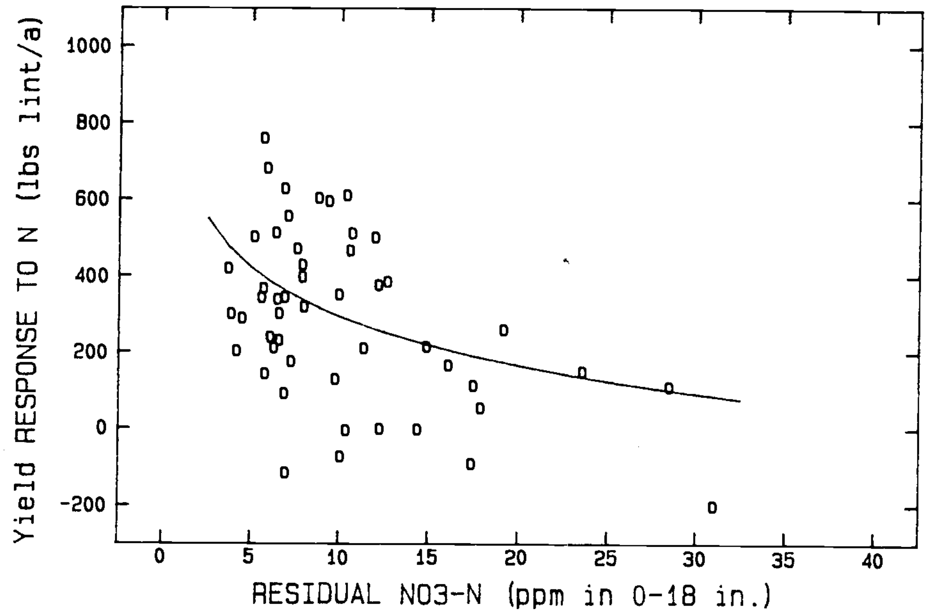
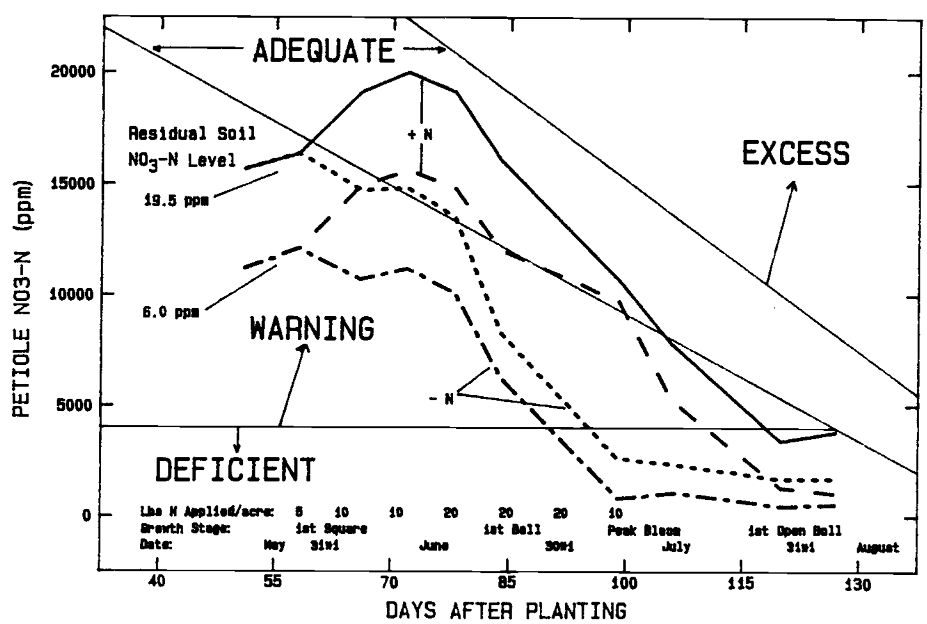


Figure 3. Seasonal nitrate levels in cotton petioles from sub- subplots of low and high residual soil nitrate content to which 0 and 95 lbs N/acre had been applied.



CONCLUSIONS

Significant accumulations of residual nitrate-N were found in drip irrigated fields when nitrogen fertilizers applied in previous years exceeded the plant's requirement for optimum growth. The yield of unfertilized cotton was significantly influenced by the level of residual soil N as measured in this experiment.

The correlation between residual soil NO_3-N and lint yields ($R^2 = 0.49$) suggests that other factors are also important in determining the lint yields; improved techniques of sampling soils irrigated with drip systems are probably needed. The interpretation of cotton petiole data under high yielding conditions (>4 bales/acre) proved to be essentially the same as that currently recommended for conventional furrow irrigated cotton.

REFERENCES

1. Erie, L.J., O.F. French, D.A. Bucks, and K. Harris. 1982. Consumptive use of water by major crops in the southwestern United States. USDA-ARS Conservation Research Report No. 29.

2. Gardner, B.R. and T.C. Tucker. 1967. Nitrogen effects on cotton: II. Soil and petiole analyses. Soil Science Society of America Proceedings 31:785-791.

3. Pennington, D.E. and T.C. Tucker. 1984. The cotton petiole: A nitrogen fertilization guide. Cooperative Extension Service, University of Arizona. Report No. 8373.

4. Tucker, T.C., D.D. Fangmeier, S. Husman, J.L. Stroehlein, and Tom Doerge. 1986. Nitrogen and water effects in drip irrigated cotton. Cotton: A College of Agriculture Report. Series P-63. pages 143-147.