Nitrate and Ammonium Sources of Nitrogen for Cotton

(T. C. Tucker, J. L. Abbott, and B. R. Gardner)

Almost a countless number of investigations have been conducted that were concerned with the relative value of nitrogen sources for different crops. In general, workers have concluded that ammonium and nitrate sources of nitrogen are equally effective for most crops. Nevertheless, many farmers and agricultural workers alike hold a preference for one nitrogen source or another and still ask questions as to the "best" form of nitrogen for a given crop.

The purpose of this study was to investigate such questions:

(1) Does the amount of water supplied affect relative effectiveness of different nitrogen sources?
(2) Does the time of application influence the relative value of different nitrogen forms on cotton?
(3) What interrelationships can be detected among the variables studied?

This study was initiated in 1958 on an Adelanto clay loam soil located on the University of Arizona Cotton Research Center near Phoenix, Arizona. All comparisons were made at a nitrogen rate of 50 pounds per acre. For a valid comparison between sources, an additional nitrogen response should result from higher rates of application.

In the first year a nitrogen response occurred only when the highest level of soil moisture was maintained. A response to rates higher than 50 pounds N per acre did not result. Unfortunately, the control of soil moisture was not adequate.

In 1959 and 1960, tensiometers were used in the wet treatments. The soil moisture tension was allowed to reach a maximum of 0.6 atmospheres during the growing season at a depth of 18 to 24 inches. The dry treatment received about one-half as many irrigations with about 60 per cent as much water. Preirrigation was the same for both moisture levels. No significant differences in yields resulted from variations in soil moisture level in either 1959 or 1960. The nitrogen treatment-moisture level interaction was not significant.

Table 1 shows that an overall yield difference occurred between years. A highly significant treatment effect resulted. However, the year by treatment interaction was not significant. Therefore, the treatment effect was considered on the two years combined data. Involved in the treatment effect were nitrogen sources and time of application.

The nitrogen sources were ammonium nitrate, ammonium sulfate, calcium nitrate, urea, and anhydrous ammonia. These materials were banded in the side of the bed in March prior to the preplant irrigation. This preirrigation was sufficient to wet the soil to a depth of about six feet. The other time of application was on June 14 or at the first square stage of the cotton. This application was banded to the side of the row.

Table 1. Analysis of yield data showing treatment and year effects.

Source of Variation	df	M.S.	f.
Years	1	164.44	25.80**
Treatments	11	39.58	6.21**
Y X T	11	6.05	0.95 N.S.
Error	220	6.373	

**Significant at (0.01) level
N.S. Non-significant

Table 2 will give the components of the treatment effects. A highly significant yield response resulted from nitrogen application and the 100 pound rate resulted in higher yields than the 50 pound treatment. The June side dress application was more effective than the preirrigation application. Since the source effect was significant and the source by time interaction was not significant, the overall source effects were considered and are given in Table 3.

Table 2. Analysis yield data showing the components of the treatment effect.

Source of Variation	df	M.S.	F.
Control vs. N	1	138.10	21.66**
Time of Application	1	94.95	14.90**
Source	4	15.48	2.43*
Source X Time	4	6.35	1.00 N.S.
Rate	1	133.00	20.8 **
Error	220	6.373	

**Significant at the (0.01) level.
*Significant at the (0.05) level.

Table 3. Analysis of yield data showing the components of the source effect.

Source of Variation	df	M.S.	F.
NH_4 Sources vs. $Ca(NO_3)_2$	1	54.91	8.66**
Other	3	3.92	0.62 N.S.
Error	220	6.373	

**Significant at the (0.01) level.

Of chief concern is the comparison of ammonium sources and nitrate. The ammonium sources were more effective in influencing yield. The other possible comparisons were not made, since the combined effects were not significant.

Data in Table 4 are expressed as mean pounds of seed cotton per plot. Source by time or source by moisture level interactions were not detected. However, it is of interest to note that the lowest actual yield for the ammonium sources occurred when the materials were applied before preirrigation on the high moisture level. For calcium nitrate the highest yield was for the June side dress treatment under low moisture.

Table 4. Mean yields of seed cotton. Pounds per plot.

Source	Time of Application	
	Preirrigation	June
NH_4 Sources		
Low Moisture	18.6	18.7
High Moisture	16.8	19.0
$Ca(NO_3)_2$		
Low Moisture	16.6	18.6
High Moisture	16.0	17.0

The petiole nitrate values shown in Figure 1 follow a pattern similar to the data in the previous table. Under low moisture, petiole nitrate throughout the season was not influenced by calcium nitrate when applied prior to preirrigation as can be seen by comparing with the control. Time of application was important in the case of calcium nitrate but not for the ammonium sources. Calcium nitrate was equal to the ammonium sources when applied as a side dress treatment. One should recall that these values are for petiole nitrate and not yield. Perhaps the petiole value is a more sensitive indicator of source effectiveness than yield.

The petiole nitrate data illustrated in Figure 2 appear somewhat different for the high soil moisture level. Relatively little effect of either source is shown for the application prior to preirrigation. The petiole nitrate levels resulting from calcium nitrate side dressed in June were somewhat lower than for the ammonium sources for much of the season. The rate effect is illustrated also by these data.

Considerable data are available which support the use of the petiole nitrate value as a tool in evaluating the nitrogen status of the cotton plant. For some time we have been concerned with the possible contribution that the ammonium form of nitrogen may make to the nutrition of the cotton plant and the effect this would have on the validity of the petiole nitrate values. This question was approached by growing cotton plants in nutrient solution in the greenhouse using ammonium and nitrate sources of nitrogen.

The data in Table 5 illustrate some interesting aspects of this study. Relatively little growth resulted from the ammonium source. A small but detectable quantity of nitrate was present in the petioles. Probably this was a result of some nitrification in the aerated nutrient solution. The growth from the nitrate source was greater by sevenfold while the petiole nitrate was increased at least 30 times. Thus, it appears that we do not need to be concerned about the effect of ammonium nitrogen on the validity of the petiole nitrate values. Some differences in the appearance of the plants were observed.

Table 5. Yield and petiole nitrate content of cotton plants grown in nutrient solution in the greenhouse.

Treatment	Yield Dry Weight gms./plant	Petiole NO_3 N, ppm
NO_3	2.05	24,600
NH_4	0.32	800

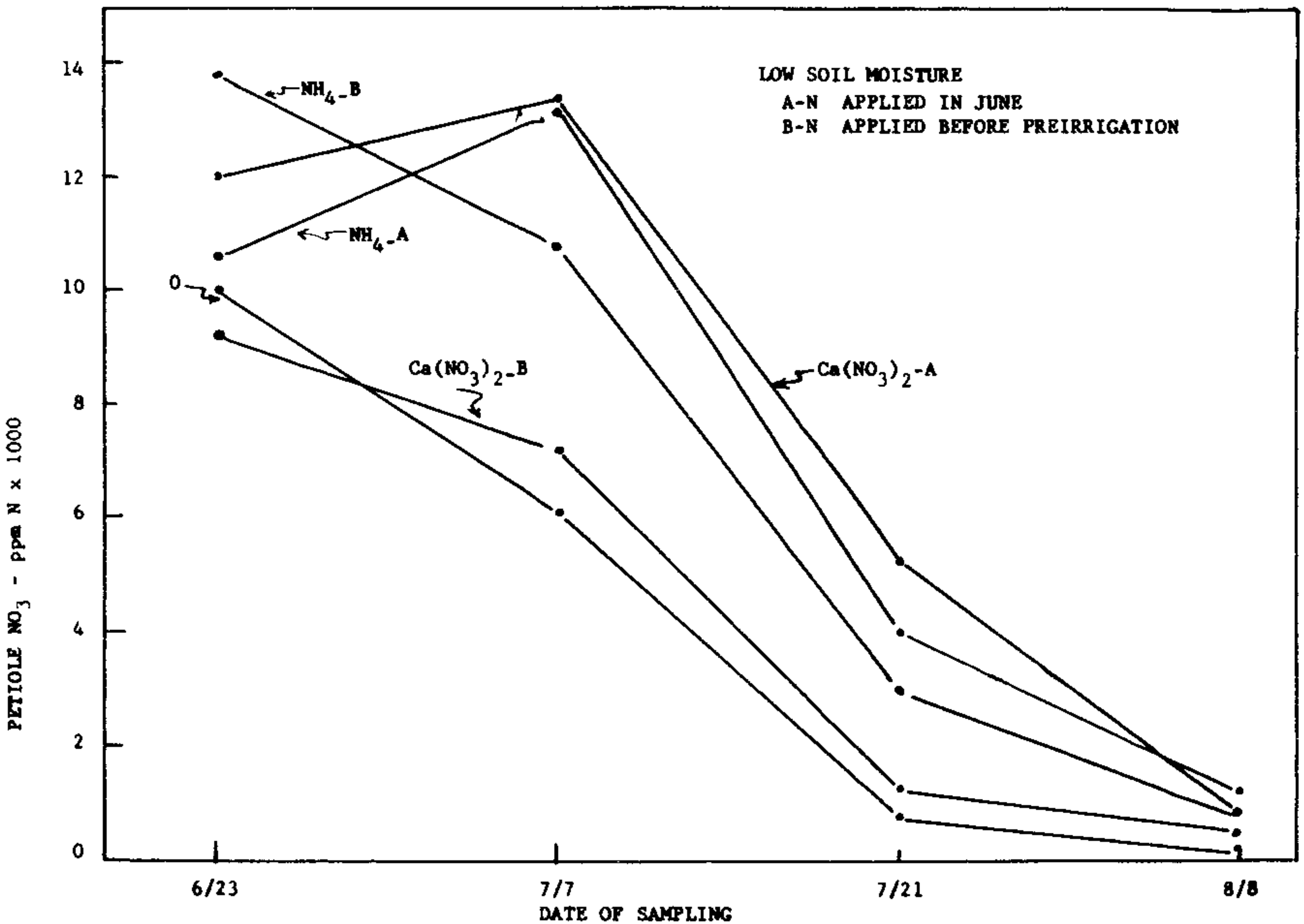

FIGURE 1. PETIOLE NITRATE AS INFLUENCED BY SOURCE, TIME OF APPLICATION AND TIME OF SAMPLING UNDER LOW MOISTURE.

The color of the leaf blades, succulence of the plant and the root development appeared to be affected. Dark green to blue-green leaf blades resulted from the ammonium source. Differences were more pronounced at later stages of growth.

In summary, the amount and frequency of water applied and the nature of the soil can influence the relative effectiveness of nitrogen sources. The more water or the more frequently water passes through the soil the greater the advantage for the ammonium sources. The soil texture can be an important factor here.

Time of application is an important factor in determining the behavior of different nitrogen forms. Ammonium forms are favored by early application, particularly when large amounts of water are added subsequently to the soil. However, a nitrate form may be advantageous when a severe nitrogen deficiency occurs and should be corrected in a minimum period of time.

Under most normal field conditions the detrimental effects of ammonium observed in nutrient solution probably would not result. Three factors are involved: Nitrification, presence of some nitrate, and the proportion of the plant root system in contact with ammonium ions in the soil.

Additional experiments are in progress and are planned for cotton and other crop plants to study the effects of nitrate and ammonium.

Root Development in Upland Cotton

(Howard E. Ray & T. Curtis Tucker)

Growth and development of cotton roots are influenced by soil texture, structure and depth, moisture supply, cultivation, fertilizer placement and numerous other factors. Such influences must be considered in making decisions concerning tillage, fertilizer placement, irrigation, etc.

Numerous studies have been conducted to determine the size and extent of cotton root systems. At Shafter, California, taproots of cotton planted on May 9 had reached a depth of 40 inches by June 16 and 77 inches by July 16. In contrast, maximum rooting depths in two West Tennessee soils were only 30 and 32 inches. Variability in lateral root development is illustrated by the same Tennessee investigations in which maximum lateral root development was found in the zone 0 to 6 inches beneath the surface in a well-drained medium textured soil as contrasted to maximum development in the 6- to 18-inch zone of a poorly drained soil with similar texture. Also, total weight of roots produced was more than twice as great for the well-drained soil.

The present study was undertaken to determine rate and extent of both vertical and lateral root development by Acala 44-10 and Deltapine Smooth Leaf cotton in a typical fine-textured soil of Southern Arizona.

METHODS

The excavation site was at the Cotton Research Center near Phoenix on soil classified as Adelanto clay loam. In land leveling operations performed three years earlier, approximately two feet of fill had been placed over the original