

Critical Tissue Levels for Predicting Nitrogen Needs of Sugarbeets at Mesa, Arizona¹

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Commercial sugarbeet production in Arizona has developed only within the last decade. Although considerable progress has been made in determining suitable cultural practices for economic production (1, 2)³, improper use of fertilizers has often been a major factor limiting grower profits. Information provided by California research (5) has been valuable in making fertilizer recommendations in Arizona, but did not always result in optimum sugar yields.

Availability of essential nutrients is inherently high in the desert soils of Arizona except for nitrogen (N) and phosphorus (P). Indigenous soil N levels are seldom sufficient for commercial production of a single crop, while P levels are frequently adequate for several years of cropping. Typically, sugarbeet growers apply both nutrients at planting followed by sidedressing of N at thinning or later in the growing season. Recent surveys have shown that excessively high available soil N and petiole NO₃-N levels are common (Stroehlein, unpublished data) and may account for poor yields or low sugar percentage of many fields.

The following research was undertaken to study sugarbeet responses to residual and applied N and to evaluate relationships between yield parameters and tissue levels of N during the growing season.

Materials and Methods

Sugarbeet cultivar 'US H9B' was planted September 12, 1970, and September 17, 1971, on Laveen loam (typic calciorthid) at the University of Arizona Agricultural Experiment Station, Mesa, Arizona. Information on soils and climate of the Mesa Station was recently published by Post, Hendricks, and Hart (3). The growing

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³Numbers in parentheses refer to literature cited.

season for beets at this location is characterized by rapid early growth during warm fall weather, retarded growth during cool winter months (January and February), followed by active growth and maturation during spring and early summer. Both crops were furrow irrigated and plantings were made on 40-inch double-row beds with on-bed row spacings of 12 to 14 inches. The two crops were grown in adjacent portions of a large experimental field which has a 12-year history of continuous differential N and P applications. This field provided four different soil levels of each nutrient in a split plot randomized complete block design with four blocks in which P variables were main plots and N variables were the subplots. Main plots were 240 by 27 feet and sub-plots were 60 by 27 feet in size. Phosphorus levels ranged from no P during the previous 10 years to an average of about 40 lb P/acre annually. Levels of N ranged from zero during the past 10 years to an average of 185 lb/acre annually. Only N results will be considered in this paper.

1970-71 Season

Main plot P levels for the 1970-71 growing season, categorized according to fertilizer application history, were: (a) low residual P, no P during last 10 years; (b) low residual P, 50 lb P_2O_5 /acre in 1969 only; (c) high residual P, no P in 1969; (d) high residual P, P applied annually (40 lb/acre to 1970-71 crop). Subplots received N as urea at rates of 0, 80, 160, and 240 lb N/acre. These rates were consistent with relative rates applied during the past 10 years. Phosphorus was applied preplant in a band six inches below and one inch to the side of the seed row in the form of ordinary superphosphate to treatments categorized c and d. The beets were thinned October 1 to an in-the-row spacing of 9 inches. The first application of nitrogen was sidedressed at a rate of 80 lb/acre on October 20 to all plots except the zero treatment. On January 21, 1971, an additional 80 to 160 lb N/acre were applied to obtain the 160 and 240 lb N treatments.

Approximately 20 petioles of most recently matured leaves were obtained from each plot November 13, 1970, December 21, 1970, February 5, 1971, April 8, 1971 and June 11, 1971. The samples were oven dried at 60°C, ground, and analyzed for NO_3 -N content using the phenoldisulfonic acid procedure.

A 183 ft² area, 6.6 by 27 feet, was harvested from each subplot June 15, 1971. Harvested beets were weighed and a subsample analyzed for sucrose content by the Spreckles Sugar Company.

1971-72 Season

The 1971-72 experiment was conducted according to a protocol similar to that of the previous year except that N rates were increased to 0, 100, 200 and 300 lb/acre; petioles were also sampled June 6, and harvest occurred June 8. The 1971-72 site was adjacent to that used the previous year. Potatoes were grown on the site the previous year and were fertilized with a high rate of N.

Results and Discussion*1970-71 Season*

Petiole $\text{NO}_3\text{-N}$ levels differed during the season in relation to N fertilizer rates and time of application (Fig. 1). Prior to January 21, petiole $\text{NO}_3\text{-N}$ was significantly higher for plants receiving the October sidedress N application. Average available soil N (NH_4 plus NO_3) for four samplings of each treatment measured to a depth of three feet prior to planting was 10.0, 11.0, 10.6, and 10.0 ppm for the control, low, medium, and high N treatments, respectively, and did not reflect past N treatments. Total organic N ranged from 0.12% in the surface foot to 0.045% in the 2 to 3 ft depth and was similar for all treatments. These data indicate that the differences in petiole levels were due only to October N application and not to any residual N from the previous year.

The addition of 80 or 160 lb/acre of N on January 21, to provide the medium and high N treatments, respectively, induced higher petiole NO_3 levels during the winter and early spring. These rates of N were not excessive since each increment of added N resulted in a highly significant (0.01 level of probability) increase in

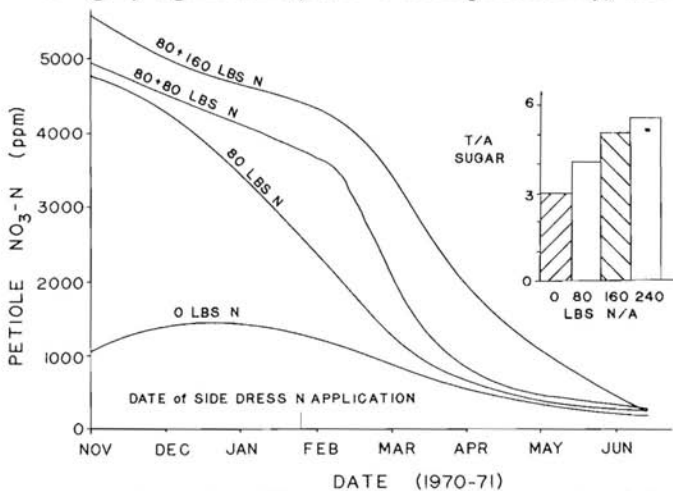


Figure 1.—Effect of fertilizer N on 1970-71 seasonal petiole $\text{NO}_3\text{-N}$ levels and June sugar yield.

sugar yield. Optimum sugar yield may have been approached by the highest N rate which provided abundant N during early spring growth, yet allowed plant N to decline to or become below the desired level of 1000 ppm prior to harvest. Beet sucrose content decreased significantly at rates of N over 80 lb N/acre (Fig. 2). Each additional 80 lb N caused an additional increase in beet yield which compensated for the decrease in sucrose content to the extent that total sugar yield was significantly increased by added N. Similar results would not be expected on soils where residual soil N is higher than found in this study.

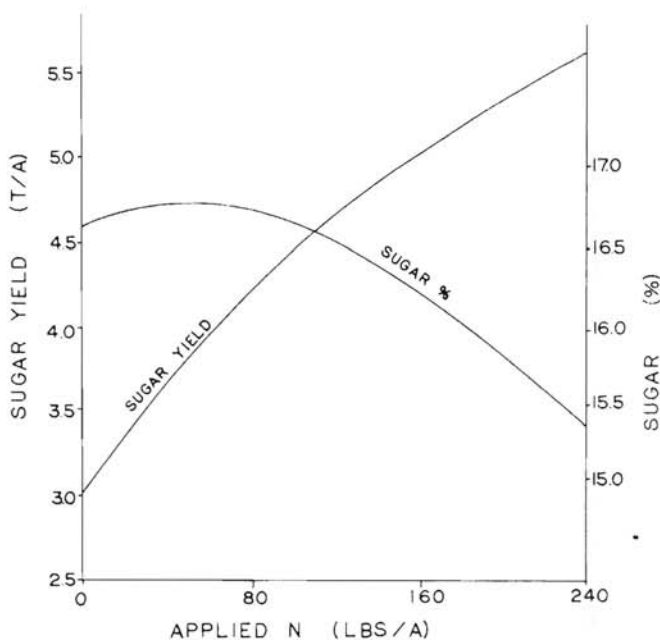


Figure 2.—Relationship between sugar yield and sugar concentrations as influenced by fertilizer N, 1970-71.

Petiole $\text{NO}_3\text{-N}$ levels measured in February, two weeks after the second N application was made to the high N treatments, were best correlated with sugar yields obtained in June ($R^2 = 0.64$). The regression, for this date, of petiole $\text{NO}_3\text{-N}$ concentration on sugar yield (Fig. 3) predicts that maximum sugar yield is obtained when February petiole $\text{NO}_3\text{-N}$ levels are near 5,000 ppm. Petiole $\text{NO}_3\text{-N}$ levels before and after this date were also related to sugar yield.

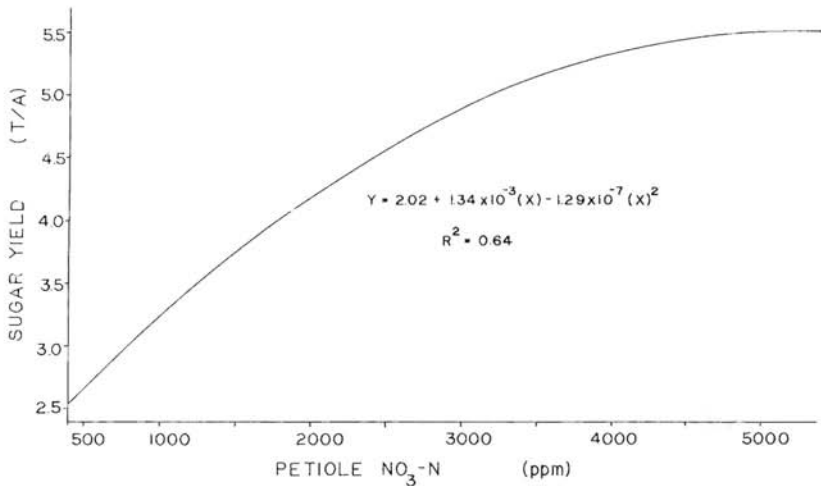


Figure 3.—Relationship between February petiole NO₃-N and June sugar yield, 1970-71.

However, these have little practical importance since yield was influenced by N applications after the earlier samplings, and the later samplings were too near harvest time to be used for predicting fertilizer needs.

Beet yields were also significantly correlated with February petiole NO₃-N levels ($R^2 = 0.65$) (Fig. 4). The regression of petiole NO₃-N levels found in February (4400 ppm) was considerably below that needed for maximum beet yields. Extrapolation beyond the observed data points (dashed line) suggests that maximum beet yields would have been obtained with petiole NO₃-N levels of 6900 ppm in February. However, the small predicted increase in beet yield associated with an increase in petiole NO₃-N from 4400 to 6900 ppm would cause a decline in sucrose content and consequently sugar yield would probably not be improved (Fig. 3).

1971-72 Season

High residual soil N caused initial petiole NO₃-N levels to be much greater than that for the previous year (Fig. 5). Nitrogen soil test results indicated available N levels at planting time to be 29, 16, 31, and 40 ppm N for the plots treated with 0, 100, 200 and 300 lb N/acre, respectively. The effect of higher residual N on petiole NO₃-N is illustrated by comparison of the November petiole values for the 0 N treatment for the two years.

Sugar yield response to added N was markedly different from that of the previous year. The addition of 100 lb of N in October resulted in elevating petiole NO₃-N levels to 10,000 ppm or greater.

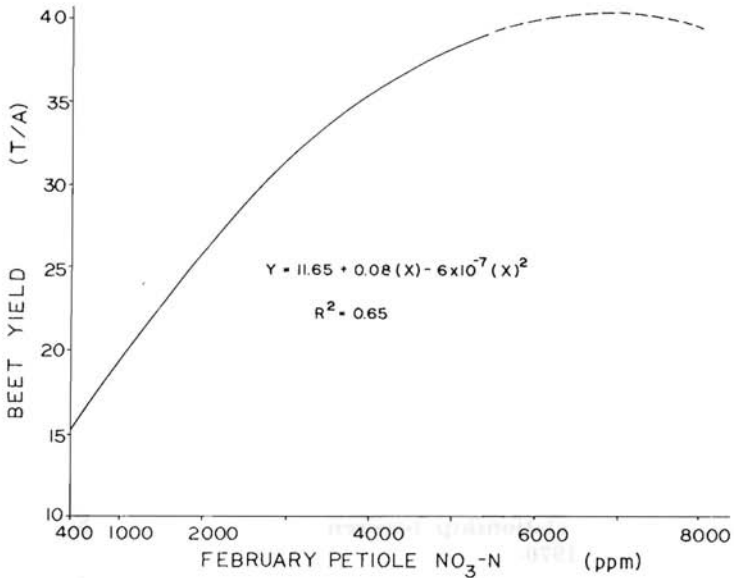


Figure 4.—Relationship between February petiole $\text{NO}_3\text{-N}$ and June sugarbeet yield, 1970-71.

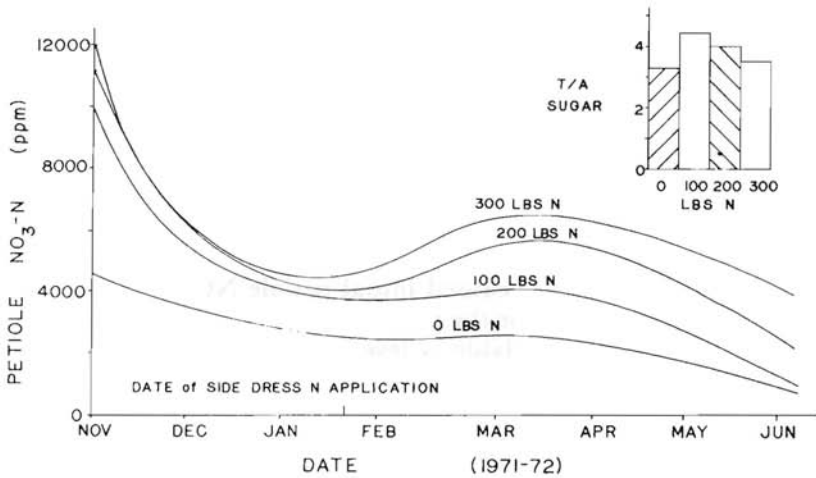


Figure 5.—Effect of fertilizer N on 1971-72 seasonal petiole $\text{NO}_3\text{-N}$ levels and June sugar yield.

By January these levels were all below 5,000 ppm, the desired level indicated by results of the previous year (Fig. 3). An additional N application of 100 and 200 lb/acre in January significantly reduced sugar yield (Fig. 5). Beet yield increased from an average of 20.3 to 29.2, 30.0 and 31.2 tons/A with each additional 100 lb increment of fertilizer, respectively. The corresponding decline in sucrose of the beets was 15.7, 14.9, and 13.3%, respectively. The apparent slight increase in beet yield resulting from N applied in excess of 100 lb/acre did not compensate for the large decline in sucrose concentration. The petiole $\text{NO}_3\text{-N}$ levels at harvest resulting from the two highest N treatments were above 2000 ppm, indicating the detrimental effect of high $\text{NO}_3\text{-N}$ on sugar content.

The difference between the two years in sugar yield response to N fertilization above 200 lb/acre, at least in part, was due to differences in available soil N at planting. The November petiole $\text{NO}_3\text{-N}$ levels for the 71-72 season for fertilized plots were about twice the level of similarly treated plots for the 70-71 season. The maximum sugar yield resulting from 100 lb N/acre applied at thinning suggests that petiole $\text{NO}_3\text{-N}$ levels above 10,000 ppm in November are indicative of adequate soil N for the remainder of the growing season. The extent to which petiole $\text{NO}_3\text{-N}$ levels above 10,000 ppm may adversely affect sugar yield cannot be evaluated from this trial since reduced yield was associated only with treatments receiving additional N in January. Multiple correlation analysis showed sugar yield to be significantly related to February petiole $\text{NO}_3\text{-N}$ levels. However, the small coefficient of determination value ($r^2 = 0.16$) indicated multiple regression would be of no predictive value, apparently as a result of the response to excessive N applied in January.

Conclusions

Sugarbeet production at low elevations in Arizona is strongly influenced by N fertilization practices. Knowledge of available soil N at planting and petiole $\text{NO}_3\text{-N}$ levels at thinning and during late winter may be used to indicate dates and rates of fertilizer N application. Consideration should be given to soil type, past crop history, and the nitrogen content of irrigation water. Results of this study suggest the following guidelines to N fertilization:

1. When available soil N at planting is less than 10 ppm, 40 to 80 lb N/acre should be applied at thinning.
2. Late October — early November petiole $\text{NO}_3\text{-N}$ levels above 10,000 ppm indicate adequate N for the remainder of the season.
3. Petiole $\text{NO}_3\text{-N}$ levels should be above or near 5000 ppm from November through February for optimum sugar yield.

The above guidelines have been detailed in a publication for growers (4) which has been successfully used during the past four years.

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