Predicting the Nitrogen Needs of Sugar Beets by Petiole Analysis

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Sugar beets are grown extensively in areas where fertilization and irrigation can be regulated to maximize sugar production and net returns per unit area. The yield and sugar content of sugar beets can be materially affected by either deficiencies or excesses of water and fertilizer. Nitrogen, in particular, has a great effect on yield and sugar content of beets. Inadequate nitrogen limits root yield. On the other hand, excess residual or applied nitrogen stimulates top growth and reduces root sugar percentage.

A reliable early season soil test is needed for determining nutrient requirements before planting or early side-dressing. Beet petiole tissue testing can be used to supplement soil tests in evaluating the adequacy of nitrogen at the time of the test and predicting the adequacy for the remainder of the growing season.

In the treatments discussed here, the M1 and M2 treatments were irrigated simultaneously, but for 12-and 24-hour durations, respectively. The optimum nitrogen fertilization rate, F, was determined by soil test, and rates 0.5 F_o, F_o, 1.5 F_o, and 2 F_o were used.

The NO_3-N level in sugar beet petioles varied with the plant growth stage, level of applied nitrogen, and to a limited extent with the moisture level as shown in Figs. 1 and 2. NO_3-N concentration in the petioles increased during the early plant growth stages at all nitrogen application levels and declined rapidly after the first part of July as the plant growth increased. However, NO_3-N concentration at any selected plant growth stage was directly related to the applied nitrogen level. Excessive irrigation leached nitrogen from the root zone and thus caused a more rapid decrease in the NO3-N in the petioles on the lower nitrogen treatments. There was very little difference in the NO3-N content between irrigation levels on the higher nitrogen treatments.

The generally accepted critical low range for NO_3-N, based on water-extractable nitrates from mature petioles, is between 1000 and 2000 ppm. If the NO_3-N concentration drops below 1000 ppm for any appreciable time before midseason, root and sugar yield will be reduced. On the other hand, the available nitrogen supply must not be too large. In order to maintain high sugar percentages in the beets, the soil should be depleted of available nitrogen about 4 to 6 weeks before harvest.

Predicting the nitrogen level in the petioles 4 to 6 weeks before harvest from petiole analyses early in the season is the tissue testing goal. Such predictions would enable the producer to apply additional nitrogen fertilizer if needed for maximum production of a high-quality beet root.

Analysis of the data indicates that after the nitrate-nitrogen concentration has reached a peak, the decline in NO_3-N follows a definite functional relationship on all treatments, as shown in Figs. 1 and 2. The solid lines after July 8 represent the equation:

$$N = N_o \exp(-Ct)$$

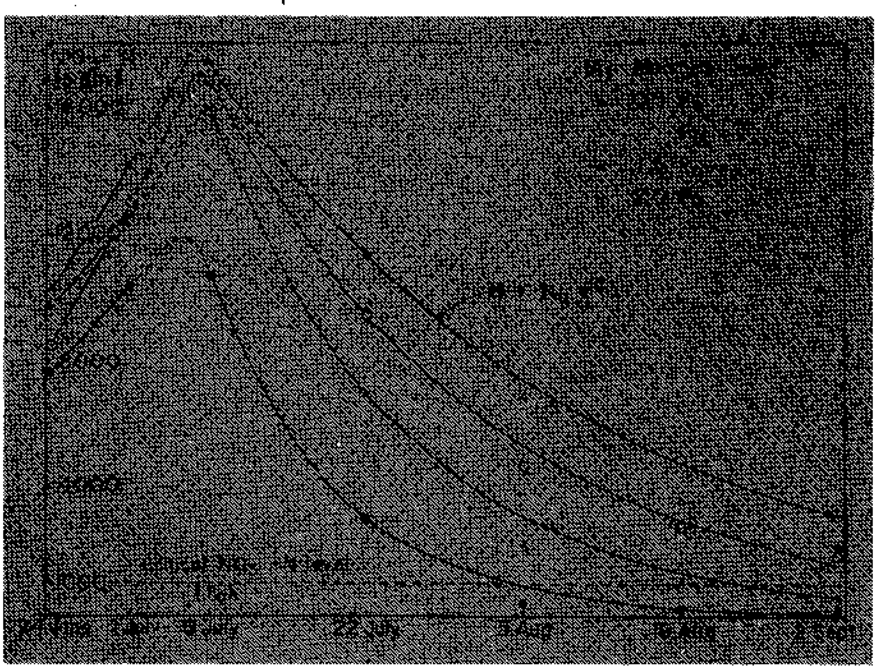
where:

- N = the calculated NO3-N concentration,
- N_o = the peak concentration,
- = the time after the peak occurs,
- t = the time after the peak occurs,
- C = a constant for any given treatment or beet field.

The peak concentration in these beets was on July 8 and C was determined by the change in NO_3-N between July 8 and July 22.

The solid lines prior to July 8 were fitted to data points. The dashed lines represent the estimated increase in NO3 from July 1 to July 8. The data presented indicate that this equation adequately predicts the NO_3-N in the sugar beet petiole for all practical purposes. Therefore, if NO_3-N content of the pe-

Fig. 1. Effect of sampling time and nitrogen fertilizer addition on the NO_3-N concentration in the beet petioles on the M1 moisture level.



tioles can be determined on two dates after the peak has been reached, the NO_3-N concentration during the remainder of the season can be predicted to determine the adequacy or inadequacy of available nitrogen.

The use of this equation for predicting nitrogen needs requires that the method of determining the NO_3-N in plant tissue be accurate. Comparisons have been made between a quick-test on fresh tissue that is normally used by commercial concerns and a more detailed laboratory analysis used to develop these equations. A composite graph of the quick-test and laboratory data presented in Fig. 3 shows that variation occurred between the two methods on all sampling dates. The quick-test method appears to be suitable for roughly determining if a field of beets had low, medium, or high levels of nitrogen available for plant growth. The variation encountered in the quick-test prohibits its use to predict nitrogen needs with the given equation.

Other factors need to be considered in using a tissue test for recommending nitrogen for sugar beets. When nitrogen fertilizer is mixed in the upper layers of the soil or is side-dressed with adequate water for distributing the fertilizer throughout the root zone, a functional relationship based on the NO_3-N concentration of the petioles early in the season for predicting nitrogen needs is possible. But if the beets have been side-dressed and the root system is not utilizing this nitrogen for lack of water or other reasons, the nitrate content of the petioles may not reflect the soil nitrogen that could become available later in the season. Also, if heavy rainfall occurs during the season, nitrates may be washed from the ridges into the root zone, increasing the nitrate levels in the petioles.

Petiole analyses, if used properly, can be an important tool in recommending fertilizer for sugar beets. The use of the theoretical approach discussed in this paper for predicting nitrogen needs, should improve the accuracy of this recommendation. Through the use of these procedures, adequate nitrogen for maximum production of sugar can be used with greatest net return per acre from this important crop.

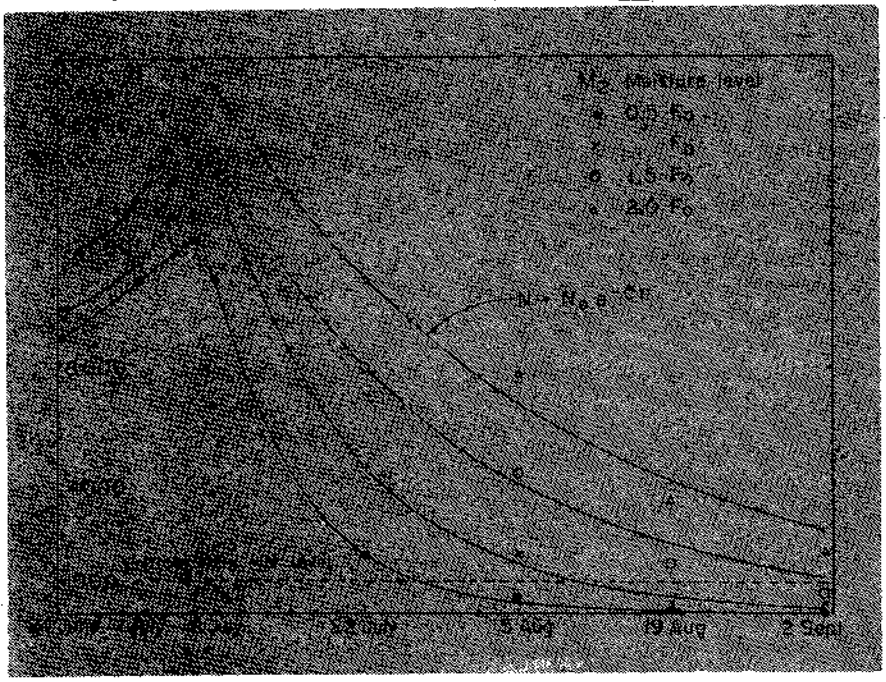
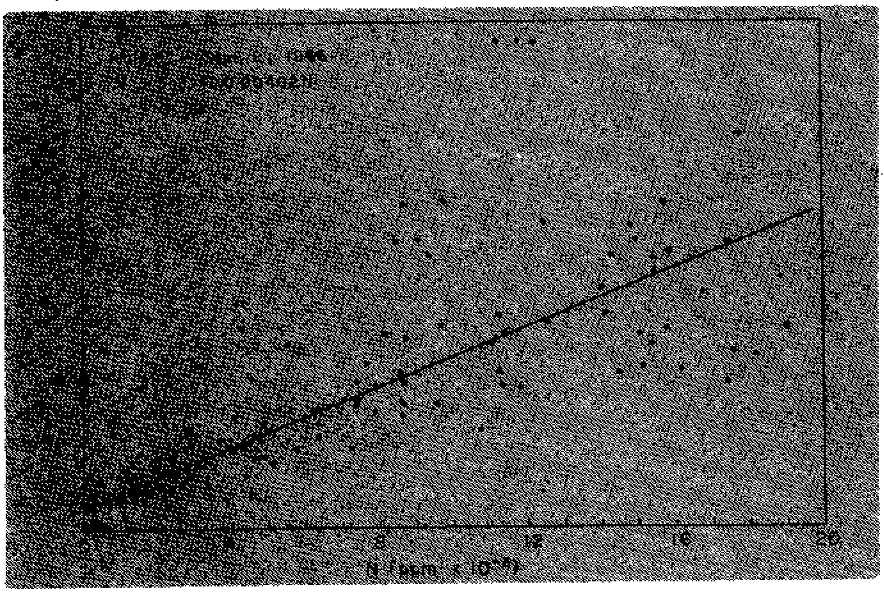


Fig. 2. Effect of sampling time and nitrogen fertilizer addition on the NO_3-N concentration in the beet petioles on the M2 moisture level.

Fig 3. Comparison between a quick-test on the fresh tissue (F) and a laboratory analysis on the dried, ground petioles for NO_3-N(N) concentration in sugar beet petioles.



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