

# Testing for precise sugarbeet fertilization

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**By testing to "ask" plants how well they're fertilized, the sugarbeet grower can avoid applying more nitrogen than needed for maximum yield.**

When just enough fertilizer nitrogen is applied to sugarbeets to achieve maximum sugar production, the farmer maximizes his net income, the sugarbeet processor receives quality beets, fertilizer (and the energy required to make it) is not wasted, and excess nitrate is not left in the soil as a potential pollutant of groundwater (fig. 1 and 2).

Thus, sugarbeets are a "nitrogen-sensitive" crop, and extensive research has gone into the development of procedures for more efficient use of fertilizer. It is not simple, however, to determine the correct amount of nitrogen to apply. A given soil may vary considerably from year to year in the amount of nitrogen (N) it may supply to a sugarbeet crop. Other crops preceding the sugarbeets, along with the fertilizer and irrigation used to produce them, may leave greatly differing amounts of nitrate. In some cases, little nitrate is left, and in others there may be enough to produce a sugarbeet crop without additional fertilizer N. What is needed is a procedure to inventory the fertility level of a field just before it is planted to sugarbeets.

The changing nature of the available nitrogen pool in soils has led many to conclude that there is little hope for the use of simple soil tests to predict the amount of fertilizer N to apply. Yet researchers in several beet-growing areas of the United States have had considerable success in developing procedures that have enabled growers to use fertilizer N more efficiently. In California the warm climate and long growing season produce sugarbeet crops that annually average more than 25 tons per acre; yields of 35 to 40 tons per acre are common. Large differences in growing conditions exist throughout the state. This means that any procedure for determining the need for fertilizer N must be applicable to a broad range of conditions and contain

insurance that growers will maintain high yields.

A system that we believe will work in California uses: soil analysis and crop history to estimate the initial application rate of fertilizer N; plant analysis to monitor and fine-tune the recommendation; and commercial agriculturalists and local soil and plant testing laboratories to deliver the technology to growers.

To develop such a procedure, researchers and Cooperative Extension farm advisors have conducted many field trials throughout the sugarbeet growing areas of California. In 21 trials there was only one case where sugarbeets responded to fertilizer N when nitrate-N in the soil at the start of the growing season was 225 pounds or more per acre 3 feet. Thus, when soil nitrate is near or above this level, fertilizer N should not be applied unless later plant samples indicate a need.

A second finding was a correlation between soil nitrate-N per acre 3 feet and the root yield of unfertilized beets. This gave a regression equation for estimating root yield from the amount of soil nitrate-N present at the start of the growing season (fig. 3). Soil sampling to a depth of 2 feet gave nearly as good a correlation as sampling to 3 feet, but the correlation was much poorer when samples represented only the first foot of soil. Sampling deeper than 3 feet gave no additional improvement.

Third, it was found that when beets did respond to fertilizer N, it took about 16 pounds of fertilizer N per ton of increased root yield to reach the yield that maximized sugar production.

## Estimating fertilizer N

Based on these findings, the required fertilizer N for maximum sugar yield can be estimated as follows:

1. Sample the soil to a depth of 3 feet just

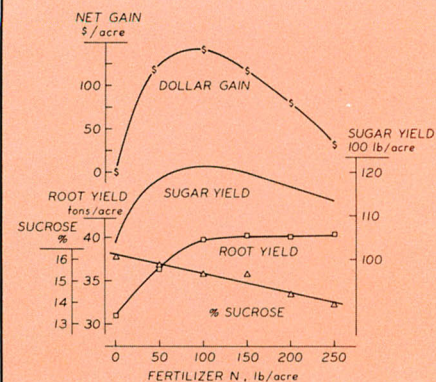


Fig. 1. Effect of fertilizer N on root yield, sucrose concentration, sugar yield, and dollar gain per acre. For this field, 100 pounds of N per acre maximized profit.

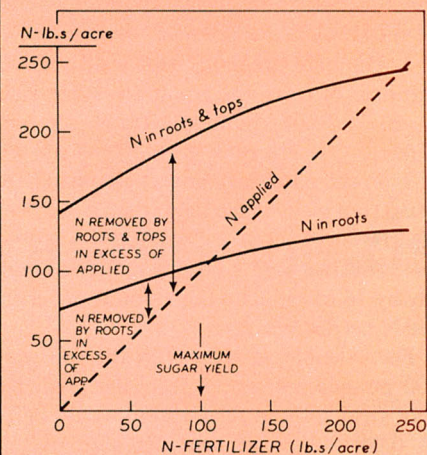


Fig. 2. When crop is fertilized for maximum sugar yield, roots take up as much N as has been applied. Thus, careful fertilization contributes little to potential nitrate pollution.

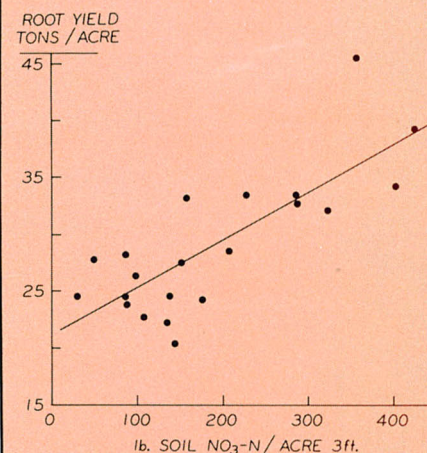


Fig. 3. Relation of sugarbeet root yield to soil nitrate-nitrogen determined early in the growing season for 21 California locations;  $y = 21 + 0.04X$ .





Field experiments testing the response of sugarbeets to fertilizer nitrogen are conducted by (left to right) U.C. Davis staff research associate Gary Peterson, co-author Bob Sailsbery, and Glenn County field assistant Vic Freitas.



Sugarbeets respond to fertilizer nitrogen—those on the right were not fertilized. The goal is to supply just the amount a particular field needs to give maximum sugar yield.

after seedlings emerge, or no earlier than just before planting, and determine pounds of nitrate-N per acre 3 feet.

2. Estimate potential root yield without fertilizer N from the equation. Root yield =  $21 + 0.04$  (pounds  $\text{NO}_3\text{-N}$  per acre 3 feet).

3. From past field history, estimate the usual root yield of the field when it has been well fertilized.

4. Subtract step 2 from step 3 and multiply by 16 to estimate the amount of fertilizer N needed per acre.

For example, if  $\text{NO}_3\text{-N}$  in the soil were 100 pounds per acre 3 feet, the predicted root yield without fertilization would be  $21 + 0.04(100) = 25$  tons per acre. If this field, when well fertilized, has always produced at least 30 tons per acre, the grower needs to fertilize to achieve the extra 5-ton yield; thus  $5(16) = 80$  pounds of fertilizer N to be applied.

## Monitoring the fertilizer program

Plant analysis is a procedure for “asking” plants how well they are fertilized. It is important to determine how well the fertilizer recommendation based on soil analysis actually meets the needs of a crop and to decide whether or not additional N is needed. These objectives are accomplished by collecting leaf samples at four different times: about one month before midseason, two weeks later, halfway between midseason and harvest, and at harvest.

A well-fertilized crop is one whose petioles contain more than 1,000 ppm  $\text{NO}_3\text{-N}$  until four to ten weeks before harvest. Plotting the  $\text{NO}_3\text{-N}$  concentrations against time is a convenient way to see what is happening (fig. 4). Petiole samples taken two and four weeks before midseason can be used to determine the need for a supplemental N application. Bisecting the angle made by the slope of these two samples with the horizontal, and continuing the bisect to its intersection with the line representing 1,000 ppm  $\text{NO}_3\text{-N}$ , allows an estimation of the number of weeks of deficiency before harvest. If this will be more than ten weeks, the crop could profitably use an additional 40 to 60 pounds of N per acre.

Care must be taken to collect adequate soil and plant samples. For information on correct sampling procedures, contact your farm advisor or seek other expert advice. (Details on sampling are also given in Bulletin 1891, *Sugarbeet Fertilization*, available from U.C. Cooperative Extension county offices.)

## Using the system

For soil and plant analyses to serve as guides to fertilization four conditions must be met:

1. Growers must have an appreciation of the gains to be made through efficient fertilization.

2. The proper samples must be collected.

3. Local laboratories must be available to quickly and accurately perform the correct analyses.

4. There must be trained agronomists to properly interpret the results so that growers can make sound management decisions.

A delivery system to provide these conditions has been tested for three years in the beet-growing area of Tehama, Glenn, and Butte counties. Following an intensive effort to inform growers of the benefits to be obtained from soil and plant analysis, more than 20 growers have participated in an annual program since 1977. Each grower has selected a local agricultural fieldman and laboratory to collect and analyze the proper samples. The Cooperative Extension area farm advisor has facilitated contact between growers, fieldmen, and laboratories; has trained fieldmen in sampling techniques; has helped fieldmen and growers to interpret the information and to make management decisions; and has worked with the laboratories as necessary to ensure that they are using effective analytical methods. He has also set up field trials to test the efficacy of the recommendations.

The results of this pilot program indicate that tailoring fertilizer recommendations to specific fields has resulted in more precise fertilization. Root yields have been maintained with reduced rates of fertilizer N and sugar contents have increased 0.5 percentage point and sometimes more.

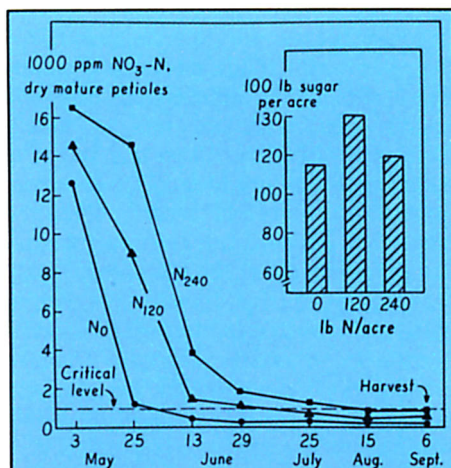


Fig. 4. Maximum sugar production in this field resulted when petioles of beets fertilized with 120 pounds N per acre contained less than 1,000 ppm  $\text{NO}_3\text{-N}$  for 8 weeks before harvest.

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