Greenhouse Studies for Diagnosis of Sugarbeet Nutrition Problems

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SUMMARY

The yield of sugar from similarly established and managed sugarbeets in adjacent fields often varies greatly, even when stands have been full and when disease, insect or other problems do not account for the difference in performance. The objective of this study was to identify possible explanations for such yield differences from plants in paired fields located near Coolidge, Sacaton, and Buckeye, Arizona. For the fields near Coolidge, high levels of nitrogen in the soil and water probably caused plants to be excessively vegetative and this resulted in low sugar yield. The explanation for low sugar yield at Sacaton and Buckeye is more difficult. Some of the evidence suggests that iron deficiency may at least partially explain why beets there produced a low yield. Beets grown with soil from low-yield fields at Sacaton and Buckeye also contained levels of calcium that seemed unusually high.

MATERIALS AND METHODS

Three pairs of fields, one of which produced a low and the other a high yield of sugar, were selected from the Sacaton, Coolidge and Buckeye areas in central Arizona. Representative soil samples from the top 8 inches were obtained from each field following sugarbeet harvest in 1979. The soil from each field was composited and sifted and a sub-sample was taken for analysis. The sugarbeet hybrid US H9 was planted September 14, 1979 in air-dried soil in half-gallon plastic pots. Water from the source used to irrigate each field was collected, analyzed and used to irrigate plants in half of the treatments in the first experiment. In the first experiment nitrogen, phosphorus and a check were used, and in the second experiment the effects of eight combinations of nitrogen, phosphorus and potassium were evaluated.

The total number of leaves per plant, and the fresh and dry weights of tops (blades, petioles and crowns) and roots were determined. These plant samples were ground for chemical analyses. Subsequently the concentration of 12 different elements in each of the samples was determined by emission spectroscopy.

RESULTS AND DISCUSSION

First Experiment

The weights of sugarbeet plants from pots that received nitrogen were triple those obtained from plants in pots that received phosphorus only or no fertilizer. Soils near Sacaton and Buckeye that produced a low yield of beets performed similarly by producing low yields under greenhouse conditions. For the Coolidge soils, plants grown with the soil from the low-yield field produced a higher yield of leaves and roots than did those that were grown using soil from the high-yield field. Two factors may be responsible for this extra production by plants grown on the soil from the low-yield field. The first was the high NO_3 content of this soil and the second, which perhaps could be of greater importance, was the higher NO_3 content of the water used to irrigate these plants. Tissue analyses indicated that plants grown in soil from the low-yield field at Coolidge, contained excessive nitrogen.

Results of tissue analyses showed a highly significant effect of fertilizer treatments on the concentration of phosphorus, potassium, calcium, magnesium and manganese, and a similar effect of soil sources on the concentration of calcium, magnesium, manganese, copper and zinc. Concentration of calcium was found to be higher in top tissue of plants grown in soils from the low-yield fields. Use of farmer's well water increased the concentration of sodium in the top tissue, however, when nitrogen was applied, the sodium percentage in the plants was lower, even than that of those produced with distilled water. When nitrogen fertilizer was applied, plants grown in soils from the low-yield fields contained a higher concentration of manganese than those grown in soils from the high-yield fields.

Second Experiment

Of the eight fertilizer treatments used in this experiment, nitrogen was the major element ...sible for increasing yield of sugarbeets. When $CaSO_4$ was added to the NPK treatment, yield was ...gnificantly reduced, compared to NPK alone. Soils that produced a low yield of beets under field conditions performed similarly in the greenhouse except for the Coolidge soils. Excessive amounts of nitrogen in the soil, and nitrogen in the irrigation water used for the low-yield field from Coolidge, probably caused the reduction in commercial yields since vegetative production was probably at the expense of sugar production.

The concentration of calcium and barium in sugarbeet tops grown in the low-yield field soils collected from Sacaton and Buckeye was significantly higher than for tops grown in their high-yield counterparts. Iron concentration was higher in tissue of plants grown in the soil from the high-yield fields.

REFERENCES

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Sugarbeet Nutritional Research

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Summary

Nitrogen and phosphorus sugarbeet fertilization problems continue to plague growers and researchers alike. Three wet winters since 1977 caused more difficulty than expected. Cold winter soils reduce phosphorus uptake, and soil kept wet by frequent winter rains loses nitrogen by denitrification. If sucrose concentration can be increased for a given yield of roots, growing this crop in Arizona can become much more profitable. Research continues to look for answers through soil and foliar application of needed nutrients, when they are needed, for production of a profitable crop.

Sugarbeet nitrogen and phosphorus availability problems studied during the past decade at the Mesa Experiment Farm have given some useful information, but more questions have arisen, particularly in the past three winters, when published fertilizer recommendations have been of little help to growers.

The information gained so far might be summarized as follows:

(1) Analysis of sugarbeet petioles for acetic acid-soluble nitrate and phosphorus may be helpful in judging whether a crop is getting enough of both nitrogen and phosphorus for its needs.
(2) Phosphorus plays a significant role in sugar production, as well as being a nutrient essential for growth.
(3) Phosphorus is not uniformly available to fall-planted sugarbeets during the growing season--
(4) soil does not release phosphorus to beets as well during the winter months when soil is cold, as in fall and spring, when soil is warm. This is shown by a decrease in phosphorus in plant tissue when soil temperature at 8 inch depth, drops below about 60^{o}F.
(5) Foliar sprays of phosphorus compounds can affect growth and sucrose percentage in beet roots, but concentration of spray and time of application are critical.

Two field experiments are under way at Mesa for 1981 harvest. One will evaluate three ways to apply phosphate fertilizer to soil, on high and low soil phosphorus levels. The other will follow up on what was learned in last season's pilot experiment testing foliar sprays as a means of getting nitrogen and phosphorus into sugarbeets when the soil is unable to supply adequate amounts to the crop, and when ground field equipment cannot be used to apply fertilizers. More than two hundred sub-plots will test six spray solutions, in single and double applications.

Last year's foliar spray experiment demonstrated that:

(1) Phosphorus deficiency developed in both high-phosphorus and low-phosphorus soils earlier than expected, as soon as soil temperatures dropped in November.
(2) Timing of spray application is important--early February was too late for phosphorus.
(3) Solutions for foliar sprays must be slightly acid--near a pH of 5.8.
(4) Concentrations of phosphorus sprays was too low for the two rates used--0.2% and 0.4% phosphorus.

Results from the 1979-80 soil-applied phosphate experiment were inconclusive--likely because of the climatic conditions. Average yield was 29.7 tons per acre, with average sucrose concentration of 13.8%.