THE EFFECT OF VARYING RATES OF NITROGEN ON BEET YIELDS AND SUGAR PRODUCTION

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Nitrogen is the most talked about plant nutrient in the sugar beet industry. The agriculturists and growers have run many tests through the years and determined that in this Eastern area the maximum gross sugar per acre requires 80 to 100 pounds per acre of actual nitrogen. Before we talk about an actual recommendation of nitrogen for our area, let us consider what we know about nitrogen.

At the present time we cannot determine the nitrogen in our soils by a soil test. We can determine the total nitrogen in the soil and/or the "available" nitrogen in the soil at any one particular day, but neither of these values give a good correlation to nitrogen response. Another factor that complexes a nitrogen soil test is the amount of nitrogen fixed by bacteria in a well aerated soil.

The nitrogen available for sugar beets, therefore, comes from the soil and micro-organisms in the soil plus nitrogen fertilizer. Figure 1 shows some examples. The organic nitrogen is the decaying plant residue plus the nitrogen in the soil micro-organisms.

As you can see, there are two major types of nitrogen; the ammoniacal nitrogen and the nitrate nitrogen. By looking at a few nitrogen reactions that occur in the soil (Figure 2) you are able to see why the ammonia forms are recommended for fall application and no preference is given for spring or summer application.

The nitrate form is subject to reduction to gaseous nitrogen by bacteria in a cool, wet soil, as well as being subject to leaching. The ammonium ion is tied up by the netatively-charged soil colloid. In a warm soil the ammonium ion is oxidized rapidly to the nitrate form by soil organisms; therefore, a sidedress application of either form results in high available nitrate nitrogen.

The sugar beet plant is unique in that it can absorb both forms of nitrogen. Figure 3 shows a simplified path of nitrogen in the beet plant. Any nitrate in the beet must be reduced to the ammonium ion before it can be utilized to form an amino acid. The amino acids are necessary for growth of the sugar beet; in growing the beet converts the amino acids into proteins. When most of the nitrogen in the sugar beet is converted into protein, growth stops and the storing of sugar occurs. We should also remember, however, that any process that stops growth of the sugar beet results in the storage of sugar but not necessarily a high purity.

Our job as fieldmen and agronomists is to supply the factory with sugar beets low in amino acids and high in protein. If there

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is low amino acid content in the beets, usually the beets will be high in sugar and purity.

How can this be done? One method being used is to test the nitrate nitrogen content in the beet petiole and when it drops below 1000 ppm, wait three weeks and then harvest. This method works fairly well in areas where there are long harvest seasons. A disadvantage to this method is the gradual supplying of nitrate from the soil and there is no cutting off of the nitrate supply. This nitrate-supplying power of some of our soils is very important, especially under good aeration.

Another method is to restrict the total amount of nitrogen applied to the crop. In an average year it is assumed that 80 to 100 pounds per acre of actual nitrogen will be utilized by the crop and the beets will run out of nitrogen by the end of the growing season. This practice is the one used generally in the Eastern area. The major disadvantage is the dependency of "average" weather conditions to insure complete use of nitrogen.

When a fixed amount of nitrogen is applied in an area, harvest date is determined by the seeding date or the thinning date. The reason for using these criteria is the longer growing season allows more time for the nitrate to transform into protein. This method, however, does not insure the delivery of high sugar and purity and low amino acid beets. The sugar content of a field sample would be a better indication for harvest time, but it also does not eliminate the problem. Any limiting factor for sugar beet growth (cool weather, drought, etc.) will cause sugar storage and a high sugar content but when the lack of amino acids stop growth and causes sugar storage, the beets are high both in sugar content and purity.

Table I gives the basis for the nitrogen recommendation of 100 pounds of actual nitrogen per acre. This recommendation is based on the maximum gross sugar per acre. In 1963 we were able to obtain clear juice purity, in addition to sugar content, thanks to M. G. Frakes and Michigan Sugar Company. By using this data we were able to obtain recoverable sugar per acre for a recommendation. Table II gives the results of these studies and shows that the nitrogen application should be less than 50 pounds per acre.

This amount of nitrogen required for a sugar beet crop, however, is dependent upon the plant population. Table III shows the effect of various plant populations on the yield of recoverable sugar. This response is largely a nitrogen response. Since the average plant population in the Eastern area is about 14,000 plants per acre, you can see that a blanket nitrogen recommendation is not advisable.

In conclusion, it appears as each state, area, farm and field will require a different amount of nitrogen fertilizer. Plant population, along with previous crops, farmer knowledge of his field, and strip tests will determine the amount of nitrogen required for maximum recoverable sugar per acre. To determine this amount of nitrogen will require much more research on nitrogen.

Figure 1

Some Nitrogen Sources for Sugar Beets

Symbol	Name
NH_2	Organic Nitrogen
$(NH_2)CO$	Urea
NH_3	Anhydrous Ammonia
$(NH_4)_2SO_4$	Ammonia Sulfate
NH_4NO_3	Ammonia Nitrate
$NaNO_3$	Sodium Nitrate

Figure 2

Soil Nitrogen Reactions

Cool Wet Soil

$$NH_4^{+} + \overline{\text{Soil Colloid}}^{\,-} \quad NH_4\,\overline{\text{Soil Colloid}}$$

$$2NO_3^{-} + 12H^{+} \xrightarrow{\text{Bacteria}} N_2 + 6H_2O$$

Warm Dry Soil

$$NH_4^{+} + 3H_2O \xrightarrow{\text{Bacteria}} NO_3^{-} + 10H^{+}$$

Figure 3

Sugar Beet Nitrogen Reactions

$$NO_3^{=} + 10H^{+} \qquad NH_4^{+} + 3H_2O$$

$$NH_4 + OH^{-} + \begin{matrix} COOH \\ C{=}O \\ R \end{matrix} \;\overline{\underline{\qquad\qquad}}\; \begin{matrix} COOH \\ H\text{-}C\text{-}NH \\ R \end{matrix} + H_2O$$

Keto Acid — Amino Acid

$$\text{Amino Acid} \;\overline{\underline{\qquad\qquad\qquad}}\; \text{Protein}$$

TABLE I

A Summary of the Effect of Nitrogen Fertilizer on the Yield and Quality of Sugar Beets in Ohio Prior to 1962

Lbs. Nitrogen	Tons Beets/A.	Percent Sugar	Tons Gross Sugar/A.
0	18.6	17.2	3.20
50	19.6	17.0	3.33
100	20.8	16.4	3.41
150	20.6	16.0	3.29

TABLE II

A Summary of the Effect of Nitrogen Fertilizer on the Yield and Quality of Sugar Beets in Ohio in 1963

Lbs. Nitrogen	Tons Beets/A.	Percent Sugar	Clear Juice Purity	Tons Recoverable Sugar/A.
0	21.8	17.7	90.7	3.13
50	21.7	17.6	89.0	2.96
100	21.9	17.2	88.9	2.89
150	22.4	15.9	87.8	2.68
200	20.9	16.8	87.5	2.74

TABLE III

The Response of Sugar Beets to Plant Population (32" rows) on Rigel Bros. Farm 1963 (Thinned June 26) (Harvest Nov. 1)

Plant Population Thinned	Plant Population Harvested	Yield Tons/ Acre	% Sugar	Purity Clear	Tons Sugar/ Acre
5,000	5,360	15.82	17.30	85.08	1.89
10,000	10,800	17.97	18.55	89.53	2.64
15,000	17,080	18.62	18.23	89.65	2.70
20,000	20,040	18.82	19.18	89.48	2.86
25,000	24,480	18.67	19.68	90.18	2.96
30,000	28,240	17.92	19.20	90.48	2.79
35,000	32,400	16.80	19.18	89.28	2.53
40,000	37,440	17.40	19.40	90.60	2.75
LSD .05	------	1.27	1.00	3.06	0.32
LSD .01	------	1.73	1.36	N.S.	0.44
r	------	----	0.708**	0.466**	0.485**

** - Significant at the 1% level

r - 0.331 is significant at the 5% level