The Effect of Fertilizer Treatments Upon Yield and Sugar Content of Sugar Beets at Garden City, Kansas[1]

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Many questions regarding fertilizer needs for sugar beets have not received a satisfactory answer. In the Garden City area most farmers are using fertilizer on sugar beets with little knowledge of what benefits they are receiving from it.

Many workers (1, 2, 3)[3] have reported that high rates of nitrogen fertilizer tend to reduce the sucrose percentage in the beets. If a farmer is to produce more sugar per acre, he must get a substantial increase in beet yields, if the above statement is true.

Chemical soil tests, plant analyses, or a combination of methods often are useful in diagnosing nutrient needs. According to certain workers (4, 6), a more generally applicable method of assessing the nutrient status, is found in plant analysis, if the "critical" nutrient level for a given element and crop has been established previously by correlation studies. In this study the experimental technique of sampling and analyses proposed by Ulrich was used on three beet locations in an attempt to evaluate the nitrogen status of beet leaves on a series of three nitrogen treatments.

This study was conducted to examine the effectiveness of commercial fertilizers in increasing the yield of sugar per acre. The experiments were conducted in cooperation with the Garden City Sugar Company on farms in the Garden City area.

Experimental Design and Procedure

Five fertilizer experiments, each located on farmers' fields, were conducted during 1952. The preparation of the land, planting, irrigation and cultivation were done by the farmers. The placement of the fertilizer, supervision of thinning, and harvesting were done by Station personnel. The design employed for each experiment was a randomized block comprising a factorial combination of three levels of nitrogen and phosphorus—0, 60, and 120 pounds of N and P_2O_5 per acre. An extra treatment receiving 120 pounds each of N and P_2O_5 and 60 pounds potash was added. The fertilizer treatments were replicated four times. Plot size was 6 rows wide and 50 feet long. The nitrogen was applied as ammonium sulfate and phosphate as treble-super phosphate. The fertilizer was banded 2 inches deep and 2 inches to the side of the seed after planting and before germination, using a belt fertilizer machine.

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[3] Numbers in parentheses refer to literature cited.

Soil samples were taken to an 8-inch depth prior to fertilization. Available phosphorus was determined by the sodium bicarbonate method as described by Olsen and others (5). The exchangeable potassium was extracted with neutral normal ammonium acetate and determined by means of a Perkins Elmer flame photometer. Organic carbon was determined by the Walkley and Black rapid titration method. Results of these analyses are shown in Table 1.

Table 1.—Chemical Properties of Soils Included in Sugar Beet Fertility Studies.

Location	Available P_2O_5 Lbs./A.	pH 1 to 5	Percent Organic Carbon	Available K Lbs./A.
Roth	83.0	8.2	1.07	1,320
Knipp	82.5	7.9	0.94	1,460
Gross	56.8	8.7	0.79	1,620
Brenner	89.1	8.3	0.88	1,020
Mayo	8.5	8.4	0.83	880

Petiole samples, taken three times during the growing season, consisted of taking 30 leaves, selected at random, from 30 plants. Each petiole selected for analysis was from a leaf defined by Ulrich (8) as "a youngest mature leaf." The leaves were taken to the laboratory, washed, cut into 2-inch lengths and placed in the oven at 70° C. for 40 hours. Nitrate nitrogen and phosphate were determined by the method suggested by Ulrich (7) .

Beets were harvested by taking five rod-row samples from each plot. Six beets were collected from each end of the plot for sugar analyses. The sugar analysis was made at the laboratory of the Garden City Sugar Company, Garden City, Kansas.

Experiment Results

Yield Response to Fertilizer

The yield of beets in tons per acre is shown in Table 2. Nitrogen fertilizer significantly increased yields on two locations, and phosphate fertilizer increased yields on one location. Two locations failed to respond to either nitrogen or phosphate fertilizer. Yields on the unfertilized plots ranged from 10.3 to 16.7 tons per acre. Yield increase from fertilizer on Brenner location was 7.6 tons per acre maximum and at the Mayo location fertilizer increased yields as much as 8.5 tons per acre. The yield increase on the Mayo location in the plots receiving potash fertilizer indicates that potassium may be low in this soil. As shown in Table 1, the exchangeable potassium in the soil from the Mayo farm is somewhat lower than that of soils from other locations.

Sucrose Content as Related to Fertilizer Treatment.

The sucrose percentage in sugar beets at different nitrogen treatments is shown in Figure 1. The tons sugar produced per acre appears in Table 2.

At all locations, application of nitrogen tended to reduce the sucrose percentage. The reduction was great enough to be significant at three loca-

Table 2.—Yield in Tons Per Acre of Roots and Sugar at Various Locations and Fertilizer Treatments.

Treatment			Roth		Knipp		Gross		Brenner		Mayo	
N	P_2O_5	K_2O	Roots T/A	Sugar T/A	Roots T/A	Sugar T/A	Roots T/A	Sugar T/A	Roots T/A	Sugar T/A	Roots T/A	Sugar T/A
0	0	0	16.7	2.39	13.4	2.05	10.3	1.61	13.8	2.32	12.6	1.65
0	60	0	16.3	2.89	12.7	1.91	9.9	1.51	15.8	2.56	16.0	2.10
0	120	0	14.7	1.95	12.5	1.92	10.6	1.66	13.7	2.25	16.8	2.22
60	0	0	16.2	2.01	13.4	1.92	12.4	1.85	19.0	3.18	13.3	1.55
60	60	0	15.9	2.14	15.2	2.09	11.7	1.55	17.8	2.95	14.3	1.85
60	120	0	15.9	2.07	15.5	2.14	11.5	1.61	19.7	3.25	15.8	1.95
120	0	0	15.6	1.88	14.3	1.86	10.8	1.48	21.3	3.40	13.6	1.60
120	60	0	16.3	1.95	15.8	2.06	11.5	1.49	21.4	3.38	15.8	1.94
120	120	0	18.1	2.14	16.5	2.40	12.4	1.57	20.1	3.33	18.3	2.22
120	120	60	14.7	1.72	16.1	2.15	11.4	1.51	20.5	3.27	21.1	2.65
L.S.D. .01			NS	0.45		NS	NS	NS	4.1	0.71	4.3	0.84
L.S.D. .05				0.33	2.4				3.1	0.53	3.2	0.63

tions. The greatest reduction occurred in the Roth soil. Here the 60-pound nitrogen rate reduced the sugar content more than 2 percent of that of the phosphated check. The decreased sugar content resulted in a decrease of 635 pounds of sugar per acre on the Roth location. On the Knipp location the reduced sugar percentage resulted in the nitrogen fertilizer plots producing no more sugar than the untreated plots even though the nitrogen increased root yield by nearly 3 tons to the acre.

On the Brenner location the presence of nitrogen had no deleterious effect on the sugar content even though the yields of roots were increased by as much as 6 tons. The sugar content on the Mayo location was depressed *in* the presence of nitrogen fertilizer, but not significantly. On the Roth and Gross location no root yield response was obtained, but nitrogen fertilizer severely depressed the sucrose content of the beets.

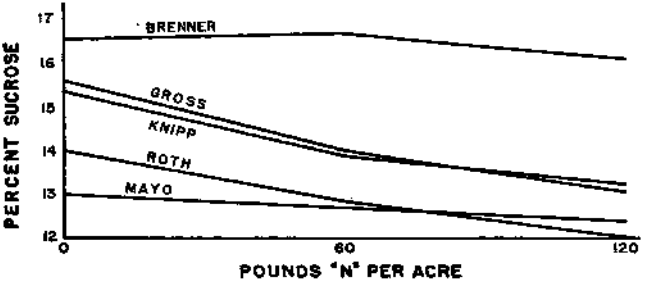

Figure 1.—Sucrose content of beets at different nitrogen levels.

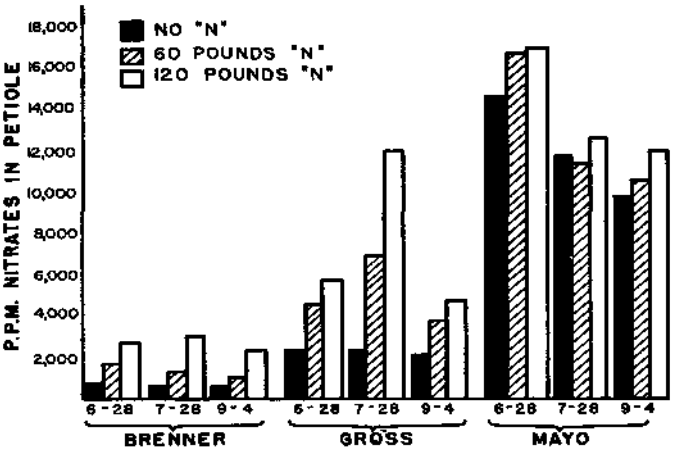

Figure 2.—Nitrate-nitrogen in sugar **beet petioles.**

It appears that phosphate fertilizer did not depress sucrose content. The presence of a combination of nitrogen and phosphate showed in general a smaller depressive effect than the same amount of nitrogen used alone.

Nitrate and Phosphate in the Leaf Petiole.

Results of an analysis made for nitrates in plant petioles are shown in Figure 2. The data show that the nitrogen applied as a fertilizer had a marked effect on the nitrate-nitrogen content of the beet petioles.

The petiole samples from the check plots varied a great deal in the nitrate content. The Brenner location responded to nitrogen fertilizer while the other two locations did not. The beets on the Gross farm showed a response early and late in the season.

The phosphate content was above 1,500 p.p.m. in petioles all during the season, even on the check plots. The Mayo location responded to phosphate fertilizer but the other two locations did not.

Discussion

From the data given here it is evident that responses to nitrogen vary so markedly from field to field that it is impossible, even on the basis of field experiments, to arrive at general recommendations which will be

satisfactory for a high percentage of fields. Results show that either a deficiency or an excess of available soil and fertilizer nitrogen may have important economic consequences in sugar beet production.

When the nitrate-nitrogen content of beet petioles falls below 1,000 p.p.m., sugar beets can be expected to respond to nitrogen fertilizer. This critical level is in agreement with findings of other workers (4, 8). However, the levels at which quality is lowered does not agree with that of other workers. In this experiment the nitrate-nitrogen level was much higher on the Mayo location than on the Gross location. The sucrose percentage was lowered significantly on the Gross location but not on the Mayo location. The only explanation that can be offered is that the Gross location suffered severe hail damage early in August.

The sodium bicarbonate soil test for available phosphate appears to give an estimate of the supplemental requirements. The Mayo location had the lowest amount of available phosphate in the soil and was the only location that responded to phosphate fertilizer.

Summary

A factorial design experiment was used in which three rates of nitrogen and phosphorus were included on 5 locations.

Results showed that nitrogen fertilizer decreased pounds sugar produced per acre significantly on one location and increased it significantly on another. Phosphate fertilizer increased pounds sugar produced significantly on one location.

Plant tissue tests proved to be a good indicator of which soils would respond to nitrogen fertilizer but not an indication of which soils would respond to phosphorus.

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