The Effect of Fertilizer Treatment Upon Three Different Varieties in the Red River Valley of Minnesota for: I.—Stand, Yield, Sugar, Purity, and Non-Sugars

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Numerous observations have shown that the problems of phosphorus and nitrogen fertilization are prominent ones in the sugar beet growing areas of the United States. Many workers (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)[2] have shown that a close inverse relation exists between nitrogen fertilization and sugar beet quality. Some workers have shown that this reduction in quality is due to a lowering of sucrose percent, while others (3, 6, 14) show this reduction in quality was due to both a decrease in sucrose percent and an increase in non-sugars. Thus, yields and quality of sugar beets are so markedly affected by the quantity of available nitrogen and phosphorus that neither a deficiency nor a large excess should be tolerated.

The reaction of different varieties to several levels of nitrogen has been investigated by several workers (7, 9). Hills et al. (7) found a significant variety x nitrogen interaction while Krantz and MacKenzie (9) using the same two varieties did not detect a significant interaction. However, these two experiments were not grown at the same location.

Since it has been shown that nitrogen fertilization and nitrogen content of plant tissue are related to depression of sugar and purity of the extract juice of beet roots and since more and more farmers in the Red River Valley of Minnesota and North Dakota are trying to increase their yields through the use of commercial fertilizers, a study was conducted with the following objectives in mind:

1. To study the effects of fertilizer treatments upon yield and chemical constituents of sugar beets.
2. To determine if phosphate fertilizer will tend to offset an excess of nitrogen fertilizers.
3. To determine if varieties react similarly under different fertility levels.

Material and Methods

The experimental data used in this study were obtained from an extensive field experiment on Fargo silty clay loam with a

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[2] Numbers in parentheses refer to literature cited.

pH of 8.0, at East Grand Forks, Minnesota. Soil samples from this field tested by the Minnesota University Soils Department showed available phosphate as medium and available potassium as very high. The cropping rotation of the experimental area since 1950 has been a three-year rotation of sugar beets, grain and sweet clover, and sweet clover summer fallow. In June 1955, the year prior to the experiment, a good stand of sweet clover was plowed under. For the remainder of the year the field was cultivated sufficiently to control weed growth and to permit the soil to absorb moisture.

In October 1955, the test area was laid out in plots 30 feet wide by 50 feet in length with five-foot alleys surrounding each plot. A factorial split plot experimental design (3 x 3 x 3) was used which included three rates of nitrogen and phosphorus as the main plots, three different varieties as the sub-plots, and six replications. The nitrogen was applied as 33.3 percent ammonium nitrate at 0, 75, and 150 pounds per acre while the phosphate application rates included 0, 200, and 400 pounds of actual "P_2O_5" per acre applied as 42 percent treble super phosphate. The materials were carefully weighed for each plot and distributed uniformly over each plot by hand. After the nitrogen and phosphorus were applied the total area was double disced to work the material into the soil and then ridged with the field cultivator to prevent the soil from blowing during the winter.

The three varieties used were (V_1) 47-801-0, (V_2) 52-801-00 and (V_3) F54-11HB. Variety 47-801-0 was a dual variety producing a good tonnage and having an acceptable sucrose percent. Variety 52-801-00 was a sugar type variety and variety F54-11HB was a Beet Sugar Development Foundation monogerm hybrid (13H15 x US 400). The first two varieties were selected and bred for the Red River Valley area.

Six rows of each of the three varieties were planted on each fertilizer treatment on May 21, 1956. The five-foot alleys running parallel to the rows were planted to sugar beets as a buffer between fertilizer treatments. The test was harvested on October 17 and 18 by taking four of the six rows from each variety sub-plot for yield data, with one row divided into two samples for chemical analysis. Fifty grams of pulp were taken from each of the two samples, quick frozen, and analyzed at Rocky Ford, Colorado.

Sucrose determinations were made by the cold digestion procedure. Purity and non-sugars were determined utilizing expressed juice from the beet and were reported as percent on juice.

Results and Discussion

Significant differences were detected due to fertilizer treatments in four of the six characteristics studied while the varieties differed significantly from each other for three of these characters. Table 1 shows the characteristics studied and the levels of significance obtained from each. Since the amounts of "N" and "P_2O_5" applied were in arithmetical progression, treatments were subdivided into their linear and quadratic effects as shown in Table 1.

Table 1.—Levels of Significance Obtained for Six Different Characters as a Result of Nitrogen and Phosphorus Fertilization and the Varieties Grown.

Source of Variation	No. of Roots	Lbs. Sucrose Per Acre	Tons	Percent Sucrose	Percent Purity	Percent Non-Sugars
Nitrogen	NS	NS	*	**	**	**
Phosphorus	NS	NS	**	*	NS	NS
Nit. x Phos.	NS	NS	NS	NS	NS	NS
Varieties	NS	**	**	**	NS	NS
Var. x Nit.	NS	NS	NS	NS	NS	NS
Var. x Phos.	NS	NS	NS	NS	NS	NS
Var. x Nit. x Phos.	NS	NS	NS	NS	NS	NS
Nitrogen linear	NS	NS	**	**	**	**
Nitrogen Quadratic	NS	NS	NS	NS	NS	NS
Phosphorus Linear	NS	NS	**	**	NS	NS
Phos. Quadratic	NS	NS	NS	NS	NS	NS

NS = Non Significant. * Significant at the 5% point. ** Significant at 1% point.

Stands were very adequate and no significant differences were detected as shown in Tables 1 and 2. All varieties averaged within one root of each other and the main effects for nitrogen and phosphorus rates did not differ by more than five beets. The standard errors also were low which indicated that this test had an adequate population of uniformly spaced beets. Therefore, any differences in tonnage or sucrose percent cannot be due to the effect of stand.

Table 2 shows the average main effects for nitrogen and phosphorus rates and varieties for each attribute studied. Where the main effects were significantly different the L.S.D. values also are given.

Tables 1 and 2 show that nitrogen fertilization produced a significant increase (at the 5% level) in tons of beets per acre, and that the tonnage increase was in a linear regression with the amount of nitrogen applied. A highly significant increase in tonnage also was shown for the phosphorus fertilization and this increase too was highly significant for a linear trend. Varieties differed significantly in tons, as was expected, because they were chosen so in the beginning. Although the tons per acre increased

significantly with increasing rates of nitrogen and phosphorus, the sugar percentage decreased significantly as shown in Table 2. No significant interactions in yield were detected.

The decrease in percent sucrose due to nitrogen fertilization was highly significant and followed a linear trend as shown in Tables 1 and 2. Phosphorus, likewise, decreased the sucrose content (at the 5% level) and followed the same linear regression trend that nitrogen produced, however, the downward slope was not as great. Varieties also were significantly different at the one percent level for sucrose content. Again no significant interactions were detected between fertilizer treatments or varieties and fertilizers.

When the two components of yield were multiplied together for pounds sugar per acre it was learned that the increase in tonnage due to nitrogen and phosphorus was offset by the decrease which occurred in sucrose content. No significant differences were detected for fertilizer treatments as shown in Table 2.

Table 2.—The Average Main Effects for Nitrogen and Phosphorus Rates and Varieties for Number of Roots, Sucrose Per Acre, Tons Per Acre, Percent Sucrose, Percent Purity and Percent Non-Sugars.

Nitrogen Applied	Number Roots	Sucrose Per Acre	Tons Per Acre	Percent Sucrose	Percent Purity	Percent Non-Sugars
0 Lbs./A	159	5003	14.87	16.85	83.20	3.46
75 Lbs./A	154	4970	15.32	16.25	81.83	3.73
150 Lbs./A	157	4924	15.53	15.88	80.18	3.87
LSD (0.05)	NS	NS	.48	.30	.94	.20
LSD (0.01)	NS	NS	NS	.40	1.25	.27
Degrees of Freedom = 2 and 40						
Phosphorus Applied						
0 Lbs./A	156	4883	14.79	16.55	81.79	3.69
200 Lbs./A	155	4996	15.34	16.32	81.87	3.62
400 Lbs./A	158	5018	15.60	16.11	81.85	3.75
LSD (0.05)	NS	NS	.48	.30	NS	NS
LSD (0.01)	NS	NS	.65	NS	NS	NS
Degrees of Freedom 2 and 40						
Varieties						
V_1	156	5132	15.76	16.31	81.89	3.62
V_2	157	4967	15.04	16.56	81.92	3.75
V_3	156	4798	14.92	16.12	81.71	3.69
LSD (0.05)	NS	97	.26	.18	NS	NS
LSD (0.01)	NS	129	.34	.24	NS	NS
Degrees of Freedom 2 and 90						

Highly significant differences were detected among the varieties with 47-801-0 outyielding the other two for sugar per acre. This variety was a dual purpose type, i.e., it produced a good

tonnage and has an acceptable sucrose content. It also was selected and bred for this area, whereas F54-11HB was a randomly picked monogerm hybrid which was not expected to yield as well as the varieties selected in this area.

As previously shown, nitrogen significantly decreased the sucrose percent in a linear regression and also significantly decreased the purity and increased the non-sugars. The fact that sucrose content was decreased and non-sugars were increased by nitrogen points out that the quality of juices was lowered by a doubling effect. This lowering of beet juice quality appears to be directly proportional to the amount of nitrogen applied.

Phosphorus was shown to have little or no effect on purity, non-sugars and varietal differences.

The data in Table 2 readily point out that there is a close inverse relationship between nitrogen fertilization and sugar beet quality. It is evident that the decrease in juice purity resulted from a combination of both a reduction in sucrose percent and an increase in non-sugar. These two characters, percent sucrose and percent non-sugars, were not significantly related in this test as shown by their correlation coefficient in Table 3.

Table 3.—Correlation Coefficients Between Sucrose Percent, Purity, and Non-Sugars.

Percent of	Sucrose	Purity
Sucrose	.....	.....
Purity	.161*	
Non-Sugars	.117	.718**

* Significant at the 5% level .155
** Significant at the 1% level .203

This test indicated that in the Red River Valley of the North very little additional nitrogen is needed in producing a maximum yield of sugar per acre with high quality. The general agronomic practices in this area include the plowing down of a good legume, such as sweet clover, prior to planting sugar beets. If such a practice is followed, as was the case in this test, excess nitrogen will decrease the amount of sucrose produced per acre and also result in poor quality beets by lowering the sucrose percent and increasing the non-sugars.

Summary

The results of this test show that excessive applications of nitrogen fertilizer lowered the quality of beet juice by increasing the percent of non-sugars and decreasing the percent sucrose. The slight gain in tonnage did not compensate for the lowered quality of juice.

These data also show that excessive applications of phosphorus fertilizer will not offset the detrimental effects of excessive nitrogen applications. Phosphorus at the higher rates also reduced the sucrose percent, but did not adversely affect any of the other characteristics studied. In general, an excess of phosphorus can be tolerated.

Nitrogen and phosphorus each produced its own individual effects upon each characteristic studied as no interactions were detected.

Varieties differed significantly. However, each variety studied reacted the same to each fertilizer treatment as none of the interactions were significant.

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