Glutamic Acid Content of Sugar Beets as Influenced by Soil Moisture, Nitrogen Fertilization, Variety and Harvest Date[1]

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More effective use of the sugar beet and its byproducts will add needed stability to the sugar beet industry. During this time of acreage allotments, it is even more important that sugar beet processing be carried out in the most efficient manner.

The non-sugar constituents in the beet have been largely responsible for failure to extract all of the sugar (1)[3]. As an aid to solving this problem, there is need for a better understanding of the chemical constituents of the sugar beet and the effects of various physiological factors upon them.

One of the non-sugar constituents of the sugar beet which has received attention recently is glutamic acid. Preliminary investigations at the Utah Agricultural Experiment Station[4] showed that of the eight chemical constituents determined glutamic acid was the most variable. These results are in harmony with earlier work in the field (2) (4).

Derivatives of glutamic acid have considerable commercial value as food seasoners. A new industry has developed to manufacture and market these food seasoners, using the sugar beet as the main source of glutamic acid. The industry uses more than 100 tons of beet molasses daily (5).

Problems associated with glutamic acid in sugar extraction, and the value of the acid as a byproduct, prompted this study of the effects of some of the major agronomic factors upon the glutamic acid content of the sugar beet. The effects of these factors on root yields will be presented in a later paper.

Experimental Procedure

The effect of soil moisture, nitrogen fertilization, variety, and harvest date on the glutamic acid content of sugar beets was studied in a field experiment at Logan, Utah, in 1955. The

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[3] Numbers in parentheses refer to literature cited.

[4] Greenwood, D. A. and Bennett, W. H. Progress report on determination of the variation of constituents in a sufficient number of individual sugar beets for investigation of processing qualities of sugar beets. (Unpublished data) Utah Agr. Exp. Sta. Proj. 447. December 1955. This work was supported by Western Utilization and Research Division, ARS, USDA. Contract No. 12-14-100-299 (74) to Utah State University, Logan, Utah.

design was a 3x3x2x2 split-plot factorial with moisture levels and varieties on the whole plots (30′ x 32′) and nitrogen levels on the sub-plots (10′ x 32′). Each sub-plot was divided into two sub-sub-plots (10′ x 16′) for use in measuring the effect of harvest date. The treatments were replicated four times. The plots were seeded with Planet Jr. hand seeders on April 30, using a uniform seeding rate of 15 pounds per acre. The rows were 20 inches apart, making 18 rows in each whole plot and 6 rows in each sub-plot. The plants were hand-thinned to an in-row spacing of 12 inches on June 8.

The moisture treatments were as follows:

M_0—Low moisture—irrigated when the moisture content of the root zone reached 25 ± 10 percent available water (about four atmospheres tension).

M_1—Medium moisture—irrigated when the moisture content of the root zone reached 50 ± 10 percent available water (about 1.5 atmospheres tension).

M_2—High moisture—irrigated when the moisture content of the root zone reached 80 ± 10 percent available water (about 0.5 atmospheres tension).

Bouyoucos blocs and tensiometers were used to measure the soil moisture tension. The bouyoucos blocks were installed at depths of 6, 12, 18, 24, and 48 inches on all moisture plots. Tensiometers were installed at the six- and twelve-inch depths on the M_2 plots only.

During the months of May and June the root zone was considered to be the six-inch depth; during July, the 12-inch depth; August, the 18-inch depth; and throughout September it was considered to be the 24-inch depth. As the season progressed the averages of the moisture tensions throughout the root zone were used to determine the time of irrigation.

Parshall flumes were used to measure the amount of water flowing on to the plots and also the amount of surface runoff. Irrigating was done by the furrow method. The soil moisture level was brought to field capacity with each irrigation. The amounts of irrigation water and natural precipitation received by the plots are shown in Table 1.

The three nitrogen levels were:

N_0—No nitrogen

N_1—80 pounds of elemental nitrogen per acre, applied at planting time in bands approximately 2 inches deep and 3 inches from each side of each row.

N_2—250 pounds of elemental nitrogen per acre, one-half side-

Table 1.—Amounts of Irrigation Water and Natural Precipitation Received by Sugar Beet Plots. Logan, Utah, 1955.

Treatment	Total Irrigation Water Applied Inches	No. of Application	Natural Precipitation Inches	
			Early Harvest	Late Harvest
			10/8/55	11/11/55
M_2—Moist	34	15	5.69	6.83
M_1—Medium	30	7	5.69	6.83
M_0—Dry	27	5	5.69	6.83

dressed near planting time and one-half side-dressed at mid-point in growing season (July 20).

All of the nitrogen was applied in the form of ammonium sulfate in bands approximately two-inches deep and three inches from each side of each row. All of the plots received 100 pounds of P_2O_5 per acre. This was broadcast on the surface of the soil and worked into the seedbed just prior to seeding.

The two varieties of sugar beets used in the experiment were US 22 Improved (SL 028), and Stewart's 53104-0[5]. The latter is the result of numerous selections from crosses between US 216, US 12, and US 22.

The two harvest dates were early (October 8, 1955) and late (November 11, 1955). At harvest the beets up to two feet from each end of each plot were discarded. To eliminate the effect of fertilizer and moisture from adjacent plots, only the center four rows of each sub-plot were sampled. At each harvest two samples, each containing 15 beets, were taken at random (avoiding the skips) from each plot (4 rows, 14 feet long). When the beets were dug they were immediately placed in ice water and held at 0° C. while they were transported to the laboratory. At the laboratory each 15-beet sample was taken from the ice water, thoroughly cleaned with cold water and bristle brushes, and weighed to the nearest one-tenth pound. Each sample was then placed in a Hobart food cutter (model T215) and chopped for one minute. This coarsely ground composite of each 15-beet sample was thoroughly mixed and a two-pound sample was returned to the chopper for an additional two minutes. This process produced a fine pulp of macerated material with no expressed juices. Several 10-gm. aliquots were taken from each sample for chemical analysis.

The glutamic acid content was determined microbiologically on a hot water extract using a modification of the method of Schweigert et al. (7).

[5] Obtained from Dewey Stewart, Sugar Beet Section, U. S. Department of Agriculture, Agricultural Research Service, Beltsville, Maryland.

Results and Discussions

Nitrogen fertilizer influenced the glutamic acid content of sugar beets in a highly significant manner (Figure 1). The relationship was almost linear. Each increase in nitrogen fertility increased the glutamic acid content of both varieties at both harvest dates. Beets which received nitrogen ranged from 0.019 to 0.216 percent glutamic acid and those without nitrogen ranged from 0.009 to 0.061 percent.

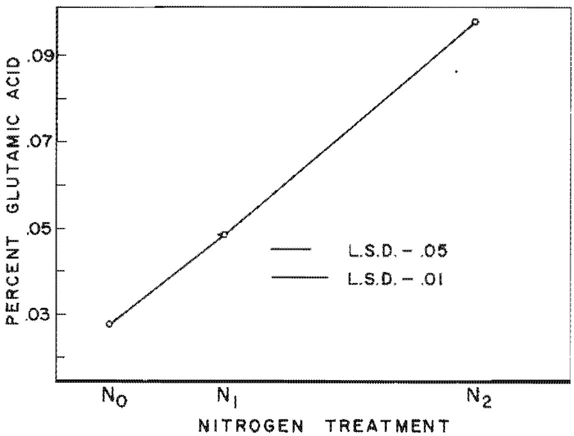

Figure 1.—Influence of nitrogen fertilization on the glutamic acid content of sugar beets, Logan, Utah, 1955 (Percentages given are averages over both varieties and both harvest dates).

The effects of the interaction between nitrogen and soil moisture on glutamic acid content are shown graphically in Figure 2. The data show that increased nitrogen applications up to 250 pounds per acre increased the glutamic acid content at each moisture level. The greatest moisture effect was observed at the high nitrogen level.

Hac et al. (3) found that the glutamic acid content of sugar beets increased progressively as the application of nitrogen increased up to 2500 pounds per acre.

The influence of moisture on glutamic acid content is shown in Figure 3. The beets were significantly higher in glutamic acid content under the low (M_0) moisture treatment than under the medium (M_1) and high (M_2) moisture treatments. However, no significant difference was found between the M_1 and M_2 treatments. Each increase in soil moisture depressed the glutamic acid content in both varieties at both harvest dates. For any given nitrogen regime an increase in available moisture tended to depress the glutamic acid content (Figure 2). This

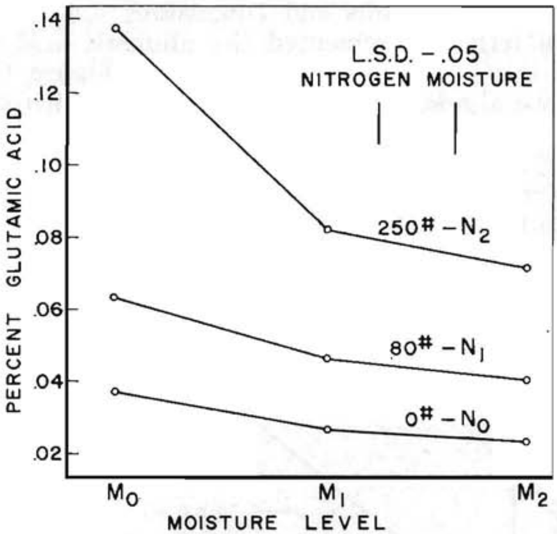

Figure 2.—Influence of soil moisture and nitrogen fertilization on the glutamic acid content of sugar beets, Logan, Utah, 1955 (Percentages given are averages over both varieties and both harvest dates).

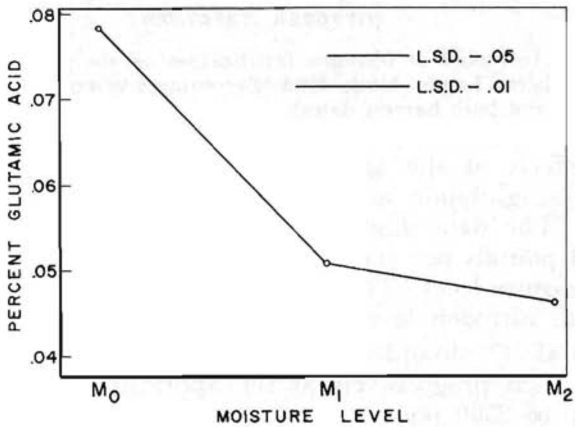

Figure 3.—Influence of soil moisture on the glutamic acid content of the sugar beet, Logan, Utah, 1955. (Percentages given are averages over both varieties and both harvest dates).

was most apparent at the high (N_2) fertility level and at the lower moisture levels. These results are in agreement with the work of Walker and Hac (8) who in cooperation with Haddock found that under any given nitrogen regime, an increase in available moisture tended to depress the glutamic acid content.

Haddock (4) reported a corresponding effect on many of the other nitrogenous components of the sugar beets.

Any difference in glutamic acid content due to moisture treatment must be attributed to the total amount of water applied and to the number of irrigations given each plot. The difference in the total amount of water applied in the three (M_0, M_1, and M_2) moisture treatments is indicated in Table 1. The highly significant difference between the M_0 and M_1 treatments can probably be attributed to the three additional inches of water and to the two additional irrigations that the M_1 plots received. If this is true, then it can be concluded that a delicate relationship exists between glutamic acid and soil moisture. These data would suggest that the M_2 moisture level was near the optimum for glutamic acid suppression. They also indicate that further studies using higher soil moisture tensions (approaching the wilting percentage) would be advisable. Walker and Hac (8) and Haddock (4) found that the glutamic acid content of sugar beets increased with increasing moisture tensions up to about eight atmospheres.

The differences due to harvest date and variety were non-significant. However, there was a slight consistent reduction in glutamic acid at the late harvest date. Variety US 22 Improved was slightly higher in glutamic acid than Stewart's 53104-0.

Summary

A factorial field experiment was conducted at Logan, Utah, in 1955 to study the influence of soil moisture, nitrogen fertilization, variety, and harvest date on the glutamic acid content of sugar beets. Highly significant differences were found between the low (M_0) and the medium (M_1) as well as between the low (M_0) and the high (M_2) moisture treatments. The glutamic acid content was depressed with each increase in soil moisture.

Highly significant differences in the glutamic acid content of sugar beets were found between low (0 pounds N) medium (80 pounds N) and high (250 pounds N) nitrogen levels. The glutamic acid content increased in a linear manner with each increment of nitrogen fertilizer.

The effects of varieties and harvest dates on glutamic acid content were small and non-significant under the conditions of this experiment.

The nature of the relation between nitrogen fertilization and glutamic acid response suggests that this may be a useful method of determining the nitrogen needs of the sugar beet.

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