The Sucrose-Sodium Relationship in Selecting Sugar Beets

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Introduction

The high negative correlation existing between sodium and sucrose content in the sugar beet has been studied and reported by several investigators. A few articles are as follows: Doxtator and Calton (1) [2] in 1950, Brown and Wood (2) in 1952, Doxtator and Bauserman (3) (4) in 1952, Wood (5) in 1954, and Finkner and Bauserman (6) in 1956. The underlying aim in the larger portion of the above endeavors has been to test the possibility of enhancement of selection for sucrose content in the sugar beet by using sodium content as a second criterion for judgment of superior individuals. Obviously, yielding ability must be simultaneously maintained or improved, lest the value of an increase in sucrose content be lost in the ultimate production of sucrose per acre. Finkner (6) concluded that use of sodium analysis as an additional aid for improvement of sucrose content of beets was of questionable value. In previous work by Great Western (5), tests of progenies of four selections having varying degrees of selection pressure by use of sodium analysis failed to provide sufficiently definitive evidence to either support or deny a value for the method.

Materials and Methods

In 1955, 1250 roots of commercial variety GW359 were taken consecutively "down the row," numbered, weighed, and analyzed for sucrose and sodium content. Roots with weight and sucrose content above the population means for those characters were classified for sucrose content. From the individuals within each sucrose classification, equal numbers of high and low sodium content roots were selected and grouped accordingly. Population means and the limits of analytical values found for the field and selected groups are to be found in Table 1.

Seed was harvested from approximately 50 roots in each group and the seed numbers assigned were C744 for the progeny of the high sucrose-low sodium selection and C745 for the progeny of the high sucrose-high sodium group. Testing of progeny was in variety trials with plots 18′ long x 6 rows wide and all rows harvested for test; 6 replications at each location.

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[1] Agronomist, Statistician, and Plant Breeder, respectively, The Great Western Sugar Company, Longmont, Colorado.

[2] Numbers in parenthesis refer to literature cited.

Table 1.—Means and Range of Analytical Values for Original Population and Selected Groups, Sucrose-Sodium Selection—1955.

Acc. or Group	Roots	Weight per Root	Range Wt. of Root	Sucrose	Range Sucrose	Na	Range Na
	(No.)	(Lbs.)	(Lbs.)	(%)	(%)	(%)	(%)
GW359	1229	3.18	8.3-0.1	15.78	20.0-9.0	.0522	.182-.010
5513 (744)	54	3.88	7.4-3.2	16.94	18.7-15.8	.022	.013-.036
5514 (745)	47	4.02	6.4-3.2	16.83	18.6-16.0	.058	.035-.122

Results and Discussion

A comparison of the performance of the two progenies and the parent for the years 1956 and 1957 is given in Table 2; test results are from three locations in each of the two years.

Table 2.—Progeny Tests of Sucrose-Sodium Selections (6 Tests).

Acc. No.	Beets per A.	Sucrose	Gross Sucrose per Acre	Sodium
	(tons)	(%)	(Lbs.)	(%)
GW359	20.23	17.04	6901	.0549
C744	19.08	17.69	6756	.0351
C745	19.91	17.43	6941	.0585
LSD 5%	0.49	0.25	193	.0052

Selection pressure appeared to be particularly effective in reducing sodium content in the low-sodium progeny; no significant change upward in sodium content in progeny of the high sodium selection is evident. A study of the means of the original population and the selected groups (Table 1) clarifies this somewhat in that the difference between the mean of the original population and that of the high sodium group is only .006; the difference between the original population mean and that of the low sodium selection is .030.

As result of both selections, sucrose content was significantly increased over the parent. Further, the high sucrose-low sodium selection resulted in progeny higher in sucrose than the high sucrose-high sodium selection, at the 5 percent level of significance. Therefore, strictly from the standpoint of increase in sucrose content, the sucrose-sodium relationship was more effective than sucrose content alone. This is contrary to the findings of Finkner (6). The significant reduction in yield of C744 as

compared to its parent, indicates that selection based upon the sucrose-sodium relationship to increase sucrose content, resulted in a loss in yield, generally associated with selections based on sucrose content alone.

It is of interest to examine the frequency distribution of the original population for sucrose and sodium content (Figure 1 and Table 3). Selections for the two groups were made in the sucrose content range of 15.70 percent to 18.70 percent as indicated in Table 1 and defined by the heavy lines of Table 3.

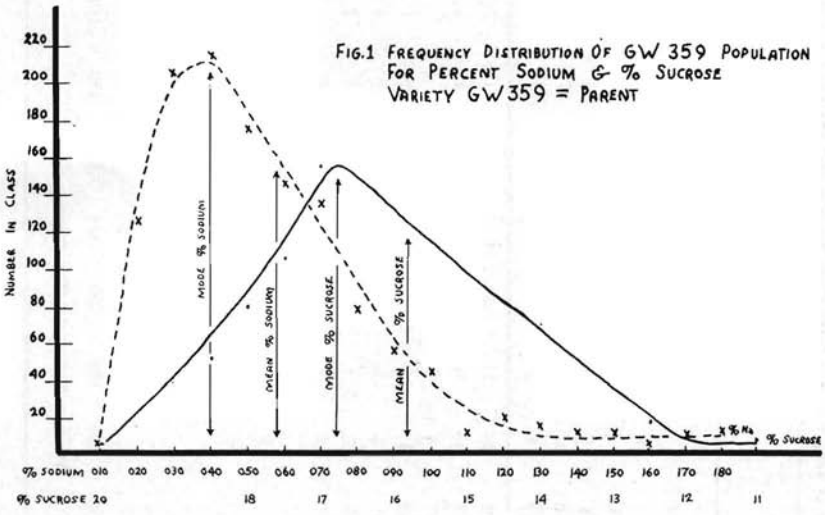

Figure 1.—Frequency distribution of GW359 population for percent sodium and percent sucrose, variety GW359 = parent.

The population distribution curve for sodium is heavily skewed to the left; for sucrose, less so but in the same direction.

It should be of perhaps more than academic interest to develop a type of beet having both high sucrose and sodium content. The data of Finkner (6) indicate a significant, positive correlation between weight of root and sodium content. Other work (7) shows a slightly less than significant, positive correlation for these characters. In Table 3 individuals having both high sucrose and sodium content would fall somewhere in the region of 0.110 plus percent on beets for sodium and 17.5 plus percent for sucrose content. In the present 1250 root population of variety GW359, no individual root meets these specifications; however, it would appear that recurrent selection methods of some type might be used to develop such a segment in a beet population.

Table 3.—Frequency Distribution of 1250 Roots of GW359 for Sucrose and Sodium Content.

% Sucrose	.010	.020	.030	.040	.050	.060	.070	.080	.090	.100	.110	.120	.130	.140	.150	.160	.170	+.170
20.5	1	1	2															
19.5		9	5	2														
19.0		22	10	4	3													
18.5		23	19	6	4													
18.0		19	29	16	9	5		2										
17.5		17	39	30	13	6	1											
17.0		23	45	40	19	12	8	5	1	1			1					
16.5		7	26	27	42	19	10	2		2								
16.0		4	19	36	21	32	19	5	3	3		1						
15.5		1	4	25	30	20	22	14	11	6		1	1					
15.0			3	13	14	22	23	15	12	2		1	2	2				
14.5			4	10	8	14	18	8	7	5					1			
14.0				2	7	11	19	11	7	7	3	2	2		1			1
13.5				1	1	2	6	6	7	3	2	3	2	4	2	1		
13.0					2	1	5	5	4	12	3	7	2	2			2	
12.5					2		2	3	1	3		2	1			1		2
12.0									1	2			1	1				
11.5								2	1								1	1
11.0											1	1		1	2	1	2	1
10.5														1	2			2
10.0													1				1	
9.5																		
9.0																		1

Percent Sodium In Beet Roots

Conclusions

1. Data are presented to show that sucrose content may be increased more by selection pressure which makes use of sodium and sucrose content than by sucrose content only.

2. Inverse relationship between percent sucrose and weight appears to be of such magnitude that marked pressure to increase sucrose content, even with use of sodium content data, is accompanied by loss in tonnage to the extent that total sucrose per acre remains relatively unchanged.

3. Conclusive evidence was obtained to show that sodium content of beets can be altered by selection methods.

Literature Cited

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