Sugar Beet Germination Selection Results in Osmotic Pressure Solutions II. Yield and Chemical Constituents of Progenies, of Four Varieties from Osmotic Selection

C. W. DOXTATOR, P. C. HANZAS, AND R. F. OLSON[1]

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There is a continuing need for new selection methods, for the purpose of increasing yield, improving quality, and other factors associated with variety improvement in sugar beets. Reference is made to Section I of this osmotic pressure selection study regarding literature cited and also the results which were obtained from germination tests.

If selection in osmotic pressure solutions can cause changes in yield and quality of the sugar beet, this method would be of value in obtaining the desirable characters which were affected. Further, since very large numbers of seeds could be run with minimum effort, the cost of such selection would be greatly reduced. This paper presents the data obtained for yield and juice quality of osmotic selections of sugar beets grown in replicated field tests in 1956-57.

Materials and Methods

Four American Crystal Sugar Company multigerm varieties, American No. 2, No. 3 N, No. 3 LSR and No. 3 S, were processed and graded to 7-9/64 inch and having a potential germination of 85 to 90 percent were used; and in September 1955 a four percent selection of the early sprouts and four percent for late sprouts was made from a solution of three-fourths percent sugar (sucrose) and three-fourths percent salt (NaCl). The early sprouts were obtained between 24 and 48 hours after the germination tests were started, and the late sprouts between 192 and 240 hours. These selections, designated "A" and "B" respectively, were planted in pots and allowed to grow for two months in the greenhouse, after which they were photo thermally induced for 70 days and returned to the greenhouse for seed production. Seed was produced by means of sib pollination using white kraft bags, either by bagging plants together or by bag switching between plants.

Mature seed of these sib progenies was bulked by selection and enough seed was obtained of the early and late selections of American No. 2, American No. 3 N and American No. 3 LSR to make a small nursery test in 1956. American No. 3 S selections

[1] Plant Breeder, Research Chemist, and Research Chemist, respectively, American Crystal Sugar Company, Rocky Ford, Colorado.

did not produce enough seed to be included. Selections of the four varieties made at a later date were also photo thermally induced and were transplanted in eight isolated groups in the field for summer seed production. These summer seed lots were reselected for early and late sprouters (AA and BB) in September 1956 using the same techniques with the first selections, except that seven and one-half percent inositol (approximately 10 atmospheres) was used. Isolation of these selections for pollen control in the greenhouse was accomplished by use of polyethlene plastic cages. Adequate quantities of seed were obtained from all selections for the 1957 field test.

In 1956 the A and B selections of the three varieties American No. 2, American No. 3 N. and American No. 3 LSR along with the parents were planted in six replications of plots. Single row plots were used. 15 hills long, 20 inches apart, in rows 22 inches apart. The split plot design was used, with the A and B selections and parent being considered as sub-plots, and all three being considered as main plots of varieties. In 1957 the reselections were planted in 10 replications of plots two rows wide by 35 feet long, also in the split plot design. The 1956 test was planted May 21 and harvested September 26: and the 1957 test was planted May 21 and harvested September 29. The 1956 harvest was by individual beet with crown. Each beet was analyzed separately, after which the data was accumulated by plot. Topping was by the standard method in 1957 with all beets taken for yield. Two 10-beet samples taken from each plot were used to obtain pulp for chemical tests.

Chemical analysis of the 1956 samples was obtained for sugar, sodium, galactinol, raffinose, and the nine amino acids—aspartic, glutamic, asparagine, glutamine, glycine, alanine, gamma amino butyric acid, valine, and isoleucine[2]. In 1957, purity of juice, calcium, and potassium were included in the chemical analysis. All mineral elements were determined by the Beckman Flame Spectrophotometer and reported as percent on beet. Galactinol, raffinose and the nine amino acids were determined by paper chromatography and are reported as percent on dry substance.

Experimental Results

In Tables 1 and 1a are given the yield and chemical data of the two selections of each of three varieties and the parent.

In this test there were no significant differences between varieties for yield of beets per acre. A significant difference was obtained between selections, however, with the early sprouting selection (A), being higher in yield per acre than the late sprout-

[2] Lucine determined as isoleucine.

Table 1.—Root Yield Per Acre, and Percent Sugar, Sodium, Galactinol, and Raffinose on Early and Late Sprouting Selections from One and One-Half Percent Sugar-Salt Solution, on Three Commercial Varieties (1956 Results).

Variety	Selection	Tons Beets Per Acre	Percent Sugar	Percent Sodium[2]	Percent Galactinol[2]	Percent Raffinose[2]
American No. 2	A[1]	18.22	11.90	.12	.61	.63
	Parent	16.85	12.61	.11	.60	.68
	B[1]	17.00	11.80	.13	.52	.74
American No. 3 N	A	19.32	10.78	.17	.83	.72
	Parent	16.00	10.83	.14	.84	.73
	B	15.25	12.01	.13	.64	.81
American No. 3 LSR	A	16.60	11.36	.17	.78	.70
	Parent	16.37	10.87	.13	.78	.74
	B	16.50	12.27	.13	.60	.60
Variety Averages:						
American No. 2		17.36	12.10	.12	.58	.68
American No. 3 N		16.86	11.21	.15	.77	.75
American No.3 LSR		16.49	12.00	.14	.72	.68
Selection Averages:						
	A	18.05	11.35	.15	.74	.68
	Parent	16.41	11.42	.13	.74	.72
	B	16.25	12.03	.13	.59	.72
Significant Differences 19:1 for:						
Varieties		NS	.52	.01	NS	NS
Selections		1.19	.29	.01	NS	NS
Varieties × Selections		NS	.71	.01	NS	NS

[1] A= Early Sprouts; B = Late Sprouts
[2] Percent on Dry Substance

ing (B), and the parent. In sugar percent, significant differences were obtained between both varieties and selections. The variety American No. 3 N was lowest in sugar. The B selection, as an average of the three varieties was significantly highest in sugar percent. The variety-selection interaction for sugar percent was significant. Although some of these selections showed only a slight variation from each parental variety the combined effect of the inconsistent responses was great enough to make a significant interaction. In sodium, the A selection was significantly high.

There was no significant difference between varieties in amino acids. However, the selections were significantly different for glutamic acid, glutamine, alanine, and valine, with near significant differences obtained for total amino acid content.

There was a negative relationship in this test for beet yield and sucrose in the selections of these varieties; but in other quality characteristics where significance was obtained the relationship with yield was generally positive. Therefore, there is an indication that selection for early sprouting did increase ton-

Table 1a.—Percentage of Nine Amino Acids, and Total, Calculated on Dry Substance, of Early and Late Sprouting Selections from One and One-half Percent Sugar-Salt Solution, on Three Commercial Varieties (1956 Results).

Variety	Selection	Percent of Amino Acids									
		Asp. A.	Glut. A.	Aspa.	Gluta.	Gly.	G.A.B.A.	Ala.	Val.	Isol.	Total
American No. 2	A[1]	.61	.13	.29	1.08	.38	.23	.10	.09	.12	3.02
	Parent	.47	.09	.23	.92	.32	.20	.08	.08	.11	2.47
	B[1]	.64	.09	.30	1.02	.44	.28	.11	.10	.15	3.13
American No. 3 N	A	.29	.12	.27	1.45	.29	.29	.12	.08	.12	3.14
	Parent	.43	.10	.22	.98	.34	.24	.08	.07	.10	2.55
	B	.42	.08	.22	.86	.28	.26	.08	.08	.11	2.39
American No. 3 LSR	A	.48	.13	.27	1.08	.30	.25	.12	.09	.14	2.86
	Parent	.40	.09	.24	.94	.25	.22	.08	.08	.10	2.39
	B	.42	.07	.22	.93	.28	.24	.07	.08	.12	2.43
Variety Averages:											
American No. 2		.57	.10	.27	1.01	.38	.24	.10	.09	.13	2.87
American No. 3 N		.41	.10	.24	1.10	.30	.26	.09	.08	.11	2.69
American No. 3 LSR		.43	.10	.24	.98	.28	.24	.09	.08	.12	2.56
Selection Averages:											
	A	.49	.13	.28	1.20	.32	.25	.11	.09	.13	3.01
	Parent	.43	.09	.23	.95	.34	.22	.08	.08	.10	2.47
	B	.49	.08	.25	.94	.33	.26	.09	.09	.13	2.65
Significant Differences 19:1 for:											
Varieties		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Selections		NS	.01	NS	.11	NS	NS	.02	.01	NS	NS[2]
Varieties × Selections		.16	NS	NS	NS	NS	NS	NS	NS	.03	NS

[1] A = Early Sprouts; B = Late Sprouts

[2] Nearly Significant

Table 2.—Field and Chemical Analysis Data Obtained from Four Commercial Varieties, and from the Reselections of Early and Late Sprouting Types Obtained in Osmotic Germination Tests (1957 Results).

Variety	Selection	No. Beets Harvested Per Plot	Tons Per Acre	Percent of: Sugar	Purity	Na.	K.	Ca.	Gal.[2]	Raff.[2]
American No. 2		69.8	8.88	13.69	84.91	.088	.179	.026	.098	.150
American No. 3 N		71.4	9.42	13.34	83.84	.094	.185	.026	.099	.159
American No. 3 LSR		69.9	9.22	12.97	83.65	.097	.189	.025	.102	.158
American No. 3 S		71.3	9.21	13.28	83.52	.094	.183	.027	.100	.153
F Values[3]		.54	.58	.94	.58	.51	.85	1.01	1.00	.45
	AA[1]	69.2	9.17	13.45	84.04	.089	.181	.026	.100	.164
	Parent	71.7	9.01	13.19	84.20	.098	.184	.027	.100	.157
	BB[1]	71.0	9.37	13.33	83.70	.093	.186	.025	.099	.155
F Values[3]		1.41	.92	1.24	.54	2.06	.12	1.26	.0001	.67

[1] AA = Early Sprouting; BB = Late Sprouting

[2] Percent on Dry Substance

[3] F Value Required for Significance at 5% point: For Varieties 2.42
For Selections 3.08

Table 2a.—**Field and Chemical Analyses Data Obtained from Four Commercial Varieties, and from the Reselections of Early and Late Sprouting Types Obtained in Osmotic Germination Tests (1957 Results).**

Variety	Selection	Percent (on Dry Substance) of:									
		Asp. A.	Glut. A.	Aspa.	Gluta.	Gly.	G.A.B.A.	Ala.	Val.	Isol.	Total
American No. 2		.644	.030	.094	.669	.209	.172	.043	.045	.094	1.977
American No. 3 N		.715	.033	.096	.705	.181	.175	.039	.043	.092	2.079
American No. 3 LSR		.791	.045	.116	.682	.186	.184	.044	.048	.094	2.226
American No. 3 S		.680	.045	.097	.746	.187	.162	.038	.050	.089	2.102
F Values[2]		.82	1.75	.42	.76	.35	.56	.60	.29	.63	.66
	AA[1]	.701	.038	.105	.720	.193	.168	.040	.045	.091	2.101
	Parent	.698	.033	.100	.665	.179	.175	.043	.049	.094	2.034
	BB[1]	.725	.044	.098	.716	.185	.178	.041	.046	.092	2.153
F Values[2]		.60	1.50	.001	.25	.39	1.73	.33	.20	1.60	1.24

[1] AA = Early Sprouting; BB = Late Sprouting

[2] F Value Required for Significance at 5% Point: For Varieties 2.42
For Selections 3.08

nage along with sodium and certain of the amino acids, and decreased sucrose percent. The only interaction of importance is in sucrose, and if this were found to be consistent it would be necessary for the plant breeder to select for sucrose in each variety which had been subjected to osmotic pressure selection.

In Tables 2 and 2a are given the yield and quality data of the two reselections of the four varieties and the parents obtained in the 1957 tests.

In this test no significant differences were found between any of the varieties or selections for any of the characters tested. To be significant at 19:1 odds, F values would have to be 2.42 and 3.08 respectively. Further, there was no significant variety-selection interaction.

Since the average root yield of the test was only 9.18 tons per acre with a sugar percent of 13.32, it appears possible that the full expression of growth was not obtained in this season. It is known that the field was not in good condition due to climatic factors, and growth was observed to be slow throughout the season. However, since the selections were planted in 10 replications and there was no significant difference in stand, it would be expected that some reliable differences would occur if osmotic selection had been effective.

Discussion

The field tests of the second osmotic pressure selections gave no evidence of difference in yield or chemical characteristics, which was a somewhat different result than that obtained from tests of the first selections. There is still no conclusive proof, therefore, that osmotic selection can be used to change yield and quality characteristics of sugar beet varieties. Reference is made to Section I of this osmotic report wherein significant differences in favor of the early sprouting selections for germination percent were obtained. This increased speed of germination will undoubtedly tend to improve yield under some field conditions as a secondary effect.

Summary

Yield and quality data were obtained from early and late sprouting selection progenies in osmotic solution of three commercial varieties in 1956. Reselections of four varieties were tested in 1957.

Although there was some evidence that the early sprouting selection progenies were higher in yield than the late sprouting selections, and the parent variety in 1956, evidence of this relationship was not obtained in the 1957 tests.