SUGAR BEET IMPROVEMENT

The Great Western Sugar Company
H. E. Brewbaker

Historical

Breeding work was begun in 1910 under the supervision of Hans Mendelson using a number of European sources of seed. In early work considerable emphasis was placed on sugar content - when reorganized in 1925 with Asa Maxson in charge a greater emphasis was placed on yield. Major emphasis placed on LSR and a broader genetic base in 1937 and 1938 under current leadership.

Accomplishments

The improvement program was reviewed and the principal accomplishments[1] related to the 1950 A.S.S.B.T. meeting at Detroit. In that paper it was shown that rapid progress in increasing total sugar was made from 1925 to 1932, but the curve leveled off at that point[2], this being considered as the inevitable result in an adaptation program of breeding. GW59 with a little leaf spot tolerance showed some improvement, it being introduced in 1938.

GW85 was the first fairly leaf spot resistant introduction. It came out of the regular selection program, the first commercial increase being made in 1943. It served a useful purpose for several years in leaf spot areas, although it was not quite as productive as GW59 under non-leaf spot conditions.

About this time major emphasis was placed on resistance to leaf spot, a dragnet type of program being initiated to bring in a broader base. GW215 and GW304, resulting from this program, have shown marked increases in production in both leaf spot and non-leaf spot areas. These, and other numbers still to be completely tested, apparently have reached a new level of performance.

Problems yet to be solved

These are infinite. Perhaps we might say at this point that the overall problem is how to approach the job of synthesizing or bringing together the many new characters (see list attached) into combination with all of the genes for size of root and sugar content. This problem becomes somewhat staggering as we emerge from a period of relative simplicity so far as number of characters is concerned. It is worthy of the combined thinking and cooperation of geneticist, cytologists, pathologists, physiologists, chemists, agronomists, perhaps entomologists, and others.

Immediate future breeding objectives

The immediate G.W. program involves:

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[1] Brewbaker, H.E., H.L.Bush and R.R.Wood - A Quarter Century of Progress in Sugar Beet Improvement by The Great Western Sugar Company, Proc.A.S.S.B.T., 1950.

[2] Brewbaker, H.E., and B.F.McGreevy - A Critical Study of Family and Group Breeding method for Sugar Beets, Proc.A.S.S.B.T., 1938.

1. Continuation of certain broad selection phases - using the newly developed high producing LSR numbers - through mass selection attempting to make some improvements for such characters as cold resistance, low respiratory activity, low Na, low raffinose, resistance to rots.

2. Develop mono-germ equivalents of these new numbers through a backcross program.

3. Step up an inbreeding program, along with male-sterile equivalents - indexing all good uniform inbreds for various characters.

4. Continue making and testing male-sterile crosses for possible immediate releases.

Breeding Methods

The Great Western program until recently was grooved pretty much along family groupings and progeny testing from open-pollinated individuals. The better progenies were saved and selection was continued in these. This method has proven to be of value, not only in bringing about adaptation to new areas, but also in rather rapid improvement for certain characters such as leaf spot resistance. It is slow and of doubtful value when the program involves several characters.

The methods to be used in the future are covered to some extent in the preceding section. The broader methods, particularly mass selection, will be used where some quick gains of commercial value appear possible - these to be introduced to the grower for immediate use. The more important and comprehensive improvements, however, will surely come from a long-time inbreeding and hybridizing program.

What Material and Information Would be of Most Value?

1. Basic or fundamental information re - inheritance and linkage relations of various sugar beet characters; further development of linkage groups; correlation in inheritance of such characters as sucrose, raffinose, Na and K in the root, enzyms action responsible for respiration and pulp discoloration, etc.

2. (a) What top cross tester or testers (high yield - high sugar or low yield - low sugar) will give the most accurate information as to combining ability of inbreds in specific crosses.

   (b) Determine correlation of size of root, sugar content, Na, K, and raffinose for inbreds and hybrids between inbreds.

3. Intensive search for new genes in wild and other relatives of the sugar beet.

4. Cataloging of all available uniform or near-homozygous inbreds, indexing such inbreds for all characters of specific interest in improvement programs, and making such lists available to cooperating bona fide breeders.

5. Annual meetings of breeders to interchange ideas and materials.

CHARACTERS TO BE OBSERVED ON INBRED LINES

	Character	Rating
1.	Root - size	1 - 10, large to small
2.	" - shape	1 - 10, long to short
3.	" - crown	1 - 10, good to poor
4.	" - sucrose %	1 - 10, high to low
5.	" - Na % on beet	1 - 10, low to high
6.	" - K " " "	1 - 10, " " "
7.	" - raffinose % on beet	1 - 10, " " "
8.	" - glutamic acid	1 - 10, high to low
9.	" - N	1 - 10, low to high
10.	" - respiratory activity, O_2 per kg. beet per hr.	1 - 10, " " "
11.	" - resistance to storage rot	0 - 10, immune to susc.
12.	Plant - color of hypocotyl	R or r
13.	" - size of top	1 - 10, large to small
14.	" - shape of top	1 - 10, flat to upright
15.	" - bolting	1 - 10, non-bolting to annual
16.	" - resistance to leaf spot	0 - 10, immune to heavy
17.	" - " " curly top	0 - 10, " " "
18.	" - " " Aphanomyces	0 - 10, " " "
19.	" - " " downy mildew	0 - 10, " " "
20.	" - " " rust	0 - 10, " " "
21.	" - " " cold - germination	1 - 10, res. to susc.
22.	" - " " " - seedling	1 - 10, " " "
23.	" - " " " - mature	1 - 10, " " "
24.	Reproductive - degree of self-fertility	1 - 10, good to poor
25.	" - type (relative to male sterility)	XZ, Xz, xZ, xz
26.	" - seed - No. of locules	Range and mean
27.	" - " - size of germ	1 - 10, good to poor
28.	Strain - combining ability (tonnage)	1 - 10, " " "
29.	Miscellaneous - color of root; resistance to nematodes, leaf miner, other insects; resistance to Fusarium, Rhizoctonia, or other diseases not listed above; calcium and magnesium content of roots.	

From 1950 Variety Test at Fort Morgan

Variety	Tons per A.	% Sugar	% Raffinose on sugar	% on beets Na	% on beets K
332	25.61	17.00	0.37	0.040	0.27
463	27.30	17.95	0.32	0.043	0.29
304	25.33	19.48	0.30	0.020	0.25
389	24.51	19.95	0.29	0.023	0.24
381	24.51	18.35	0.46	0.015	0.25
359	25.95	20.03	0.30	0.017	0.24
R&G"N"	22.49	17.65	0.43	0.052	0.25
305	26.75	18.73	0.35	0.021	0.26

From Variety 359. McCook. 1950

Beet No.	% Sugar	% Raffinose on sugar	% Sodium	% Potassium
1	16.9	0.63	0.0224	0.262
2	15.9	0.90	0.0328	0.372
3	15.5	0.95	0.0350	0.326
4	15.7	0.80	0.0224	0.420
5	15.3	0.53	0.0376	0.332
6	15.5	0.63	0.0350	0.324
7	16.0	0.83	0.0412	0.240
8	16.5	0.83	0.0156	0.332
9	17.3	0.85	0.0210	0.240
10	17.0	0.65	0.0196	0.304
11	17.7	0.85	0.0260	0.218
12	17.6	0.75	0.0280	0.296
13	18.6	0.90	0.0216	0.280
14	18.3	0.68	0.0180	0.314
15	16.6	1.05	0.0336	0.256
16	16.8	0.70	0.0320	0.356
17	16.7	1.00	0.0256	0.280
18	18.1	0.70	0.0290	0.250
19	15.9	0.90	0.0400	0.356
20	16.3	0.90	0.0280	0.348

r values: % sugar with % raffinose = - 0.426
% raffinose with % sodium = - 0.09
For significance .05 level = 0.444

Inbred lines (Deming, U.S.D.A.) compared with genetically heterogenous commercial GW 201 for weight, sugar% and sodium content.
(Roots taken from uniform stands)

	Demings Inbreds			GW201		
Str. No.	Wt. (Lbs.)	Sugar (%)	Sodium (%)	Wt. (Lbs.)	Sugar (%)	Sodium (%)
1036	1.9	13.1	.047	1.3	16.8	.019
	2.0	13.8	.042	1.7	16.4	.015
	1.4	14.6	.042	1.8	16.2	.027
	1.5	15.4	.040	2.9	13.6	.058
	2.1	13.5	.040	2.2	16.5	.035
	1.3	14.0	.049	2.4	15.4	.028
	1.4	13.7	.048	1.1	15.4	.047
	2.0	13.9	.042	2.0	16.6	.015
	2.2	14.8	.038	1.4	13.6	.040
	1.6	13.1	.051	1.6	14.1	.106
				1.7	15.4	.031
Mean	1.74	13.99	.0439	1.0	15.0	.036
				1.9	15.4	.036
1058	1.6	14.8	.081	0.8	16.2	.018
	1.4	14.4	.092	2.8	15.6	.050
	1.6	15.1	.084	2.4	16.0	.020
	2.0	14.0	.096	1.4	17.7	.024
	1.5	13.1	.089	0.5	16.6	.029
	1.1	14.9	.086	0.5	16.8	.030
	1.6	13.4	.099	2.0	14.5	.033
	1.3	13.3	.070	1.2	16.5	.020
	1.3	13.0	.100	1.4	16.1	.021
	1.1	14.6	.080	2.0	16.6	.053
				1.8	14.3	.037
Mean	1.45	14.06	.0877	0.8	13.1	.053
1079	1.5	16.5	.032	Mean 1.62	15.62	.035
	1.7	16.5	.037			
	1.3	15.2	.032			
	1.5	17.0	.039			
	1.3	15.1	.060			
	1.7	16.9	.037			
	1.4	17.0	.033			
	2.0	14.7	.039			
	1.3	16.5	.028			
	0.9	15.7	.040			
Mean	1.46	16.11	.0377			

RESPIRATORY RATE (in storage)

The primary loss of sucrose from sugar beets during storage results from oxidation. This burning is accomplished by the action of respiratory enzymes inherent in the beet or by microorganisms. Under average storage conditions, and at room temperature, the sucrose lost is nearly completely oxidized, the end products then being carbon dioxide and water. There is some loss of sucrose due to hydrolysis and accumulation of invert sugars, but this loss is probably of the order of two percent of that lost by respiration. If reliable measurements and techniques can be employed with reasonable rapidity in the determination of respiration rates for individual beets, it should be relatively easy to incorporate in the breeding program and make gains in this storage quality character.

Research related to storage losses is not merely justified but is of major importance. For example, the storage losses of sucrose for The Great Western Sugar Company are of the order of 30 million pounds annually, or 5 - 6 percent of the total sugar purchased by the Company. Even though environment (manner of handling beets) plays a large role in this total loss, the inherent storage qualities of the beet should not be overlooked.

Preliminary tests on present day varieties and advanced breeding groups show losses in sucrose ranging from 0.5 pounds to 0.7 pounds per ton per day when handled under good comparable conditions at room temperature. This is a range of approximately 30 percent and was obtained between nine lines tested. While the above differences were obtained on representative samples (40 beets per sample and tested in duplicate) from each line, it should also be possible to obtain differences between individual beets in any one of the heterozygous lines. Again trials (very preliminary) substantiate this latter assumption and indicate the order of differences within heterozygous lines to be much greater than differences between lines.

- R. T. Nelson

TOTAL SUGAR IN % OF G.W.18

QUARTER CENTURY OF PROGRESS