A Preliminary Test of the Efficiency of a Modified Gamete-Selection Method for Breeding Sugar Beets

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It was pointed out by Brewbaker and McGreevy (1)[2] in 1938 that the family-breeding methods employed by The Great Western Sugar Company for varietal improvement had resulted in a similar pattern to that observed in corn (2). When these methods were adopted in 1925, improvement in yield of roots and total sugar was fairly rapid, with the percentage of sugar remaining fairly stable. Since 1931, however, improvement became increasingly difficult to obtain and it was concluded that the family- or progeny-test method had definite limitations for continued improvement of the sugar beet except as it might be used to increase resistance to such diseases as leafspot and curly top, and thereby to improve yielding ability and quality.

More recently, the family-breeding method has been applied with moderate success in breeding for resistance to curly top in the northern Wyoming and Montana districts. Since this work was started in 1942, improvement in yielding ability was anticipated for a few generations of what might be considered the adaptation phase.

Some of the earlier work leading up to the more recently developed gamete-selection method was done by Sprague (4) who advocated early testing of the combining ability of inbred lines of corn by top-crossing with a "tester" strain. Stadler (5) proposed the gamete-selection method, which applied to corn consists briefly of "direct testing of individual plants of a variety x inbred-line F_1 followed by a similar test-controlled selection in the S_1 of exceptional plants." This makes the gamete the unit of selection as based on the top-cross test. Richey (3) refers to these choice gametes as "superior" and any combination of such gametes as a "superlative" zygote. The importance of placing selection emphasis on the gamete rather than the zygote can be appreciated when one realizes that a frequency of 1 superior gamete in 100 would lead to 1 superlative zygote in 10,000. Selfing of an individual which produces superior gametes would, of course, result in the production of a much higher frequency of superlative individuals.

Our adaptation of the gamete-selection method to the sugar beet crop involves the use of a relatively large group (400 or more roots) of carefully selected individuals. A part of the inflorescence on each individual is

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[2]The numbers in parentheses refer to literature cited.

bagged for selfing and the remainder is permitted to open-pollinate with other plants in the group, the group itself constituting the "tester" line. The open-pollinated seed from those plants for which some selfed seed (50 or more) is available is used for immediate "top-cross" or progeny-test evaluation. The selfed seed from the plants represented as female parents of the 6 to 10 high-producing top-crosses is then planted for selection of so-called superlative individuals, which are to be immediately grouped together for two or more successive mass increases into commercial proportions.

Materials and Methods

In 1943, selection was made from a Colorado increase of the curly-top-resistant variety U.S. 22. Some 408 roots were quartered, the four quarters from each root being planted at random within the group. This was done to increase seed production and the opportunity for wider source of male gametes for each female individual. All plants were bagged for selfing. Open-pollinated seed and bagged branches were harvested from a total of 403 roots, the quarters of each original root being collected together. The open-pollinated seed from each individual which produced 50 or more selfed seed was planted in a progeny test of triple lattice design with 6 replications for each family. A total of 168 strains were included in this test.

Selections were made in both the selfed and open-pollinated progeny of the ten strains which had the highest performance in production of total sugar per acre in the top-cross test. In the inbred phase, 43 selected roots were grouped together, the open-pollinated seed being harvested en masse and tested as B353. These same plants were also selfed as a source of good inbreds, this, however, being incidental to this particular study. In the open-pollinated phase the seed was also harvested en masse and tested as B355.

The performance tests were conducted at Billings, Huntley, and Hysham, Montana, in 1947. At the first two locations there were 9 replications of each variety and at the latter location 6 replications, or a total of 24 replications for each variety. Stand was good at all three locations, and no disease or hail injury of note was encountered.

Experimental Results

The performance of the two numbers (B353 and B355) previously described, as compared with A53-42 (U.S. 22), follows:

	Roots per Acre				Sugar			
Acc. No.	B.	Hu.	Hy.	Ave.	B.	Hu.	Hy.	Ave.
	Tons				Percent			
B353	23.62	19.45	23.97	22.35	14.93	18.45	16.39	16.59
B355	22.64	18.59	22.98	21.40	15.26	18.10	16.41	16.59
A53-42	22.41	18.05	22.02	20.83	15.46	18.19	17.29	16.98
LSD 5 percent pt.	1.52	1.10	1.61	.94	.73	.59	.88	.41

Acc. No.	Gross Sugar per Acre				Beets per 100 Feet		
	B.	Hu.	Hy.	Ave.	B.	Hu.	Hy.
	Pounds				No.		
B353	7053	7177	7857	7362	100	109	95
B355	6910	6730	7542	7061	94	103	92
A53-42	6929	6567	7615	7037	101	103	89
LSD 5 percent pt.	564	455	667	360			

In tonnage of beets per acre the difference between the averages for B353 and B355 is just significant at the 5 percent level. For percentage of sugar, both varieties appear to be nearly significantly below the standard (A53-42) at one location, there being no material differences at the other two locations. In sugar per acre the progeny of the selfed lines (B353) produced consistently more than either of the other lines at all three locations, the average falling only slightly below the 5 percent level for significance.

Summary and Conclusions

On the basis of a preliminary test at three locations in 1947, lot B353, which was developed by an adaptation of the gamete-selection method, produced a slightly but significantly higher tonnage of roots at the 5 percent level than either the original variety (A53-42), or lot B355 which resulted from the older family-breeding method. In this respect the apparent superiority of B353 was consistent at all locations.

The differences in yield of roots were reflected in total sugar, although not quite sufficient to be significant at the 5 percent level. In percentage of sugar the differences were not very consistent and not significant.

While these results can hardly be considered as definite proof of the effectiveness of a modified gamete-selection method applied to sugar beets, they are encouraging enough to merit further test. On the basis of purely theoretical consideration this method would appear to be sound in principle and particularly well adapted for use with the sugar beet crop as an intermediate step between the broader mass and family-selection methods, and selection in self-fertilized lines.

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