Results of Divergent Selection for General Combining Ability[1]

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The red-marker beet has been used as a top-cross parent to identify lines high in general combining ability. (1, 2)[2] Use of the red-marker beet as a tester for general combining ability is desirable in that large numbers of lines may be top crossed in one isolation, thus reducing costs of top-cross seed production and, at the same time, increasing the number of lines that can be handled. In addition, these top-cross hybrids are easily distinguished from other crosses and selfs by plant color, thus insuring stands completely of top-cross origin in the progeny testing program.

If the red-marker beet used as a top-cross tester is effective in identifying lines high in general combining ability, then those lines should be superior combiners, on the average, in specific crosses with male sterile lines, also selected as being high general combiners.

This paper reports a study of eight lines selected for either high or low general combining ability by use of the red-marker beet, and the subsequent performance of these lines when used in single crosses with three male-sterile lines. Based on data from other variety tests, two of these male-sterile lines were considered to be high and one intermediate in general combining ability. Tests for their general combining ability with the red-marker beet are not available, however.

Materials and Methods

In 1954 about 250 roots of the red-marker beet were planted in an isolation in alternate rows with 250 roots of MW 391. Approximately half of the flowering branches of each MW 391 plant were bagged for self-pollinated seed production. Flowers on the remaining half of each MW 391 plant were allowed to open pollinate with the red-marker beet.

In 1955 the S_1 seed produced by bagging in 1954 was planted in the inbred line nursery for root production. Sufficient top-cross seed for testing was obtained from 141 of the 250 MW 391 plants. These top crosses were tested at Sheridan, Wyoming, in a triple lattice design with three replications in single-row plots 50 feet long. From this test, four high-combining lines and four low-combining lines were selected for further study.

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[1] Plant Breeder, Holly Sugar Corporation, Sheridan, Wyoming, and Plant Breeder and Pathologist, Holly Sugar Corporation, Tracy, California, respectively.

[2] Numbers in parentheses refer to literature cited.

The S_1 roots produced in 1955 of each of the eight lines selected were used as pollinators in eight isolations planted at Sheridan, Wyoming, in 1956. Also included in each isolation were 100 roots of each of three male-sterile lines: 5152-01, CT9MS and SL34.611HO.[3] The first two lines were considered to be high and the third intermediate in general combining ability. The male-sterile lines were rogued to eliminate pollinators where necessary and three lots of single cross seed were harvested from each of the eight isolations, making a total of twenty-four single crosses produced.

In 1957 these twenty-four single crosses, the eleven parental lines and one commercial check were tested at Sheridan, Wyoming, and Sidney, Montana. A triple lattice design with six replications was used in testing this material. Plot size was one row, 35 feet long. The entire plot was harvested for weight and sucrose analyses.

Experimental Results

Table 1 presents yield data of the eight red-marker beet top crosses, together with the average single cross yields of the same eight lines when crossed to the three male-sterile lines, 5152-01, CT9MS and SL34.611HO.

Table 1.—Yield of Top Crosses and Average Yield of Single Crosses of Four High-and Four Low-Combining Lines as Measured by Top Crosses with the Red-Marker Beet.

	Beet Yield in Tons Per Acre	
High Lines	**Top Cross[1]**	**Single Cross[2]**
2	24.643	19.446
3	24.061	18.609
4	24.688	19.098
5	23.706	17.133
Ave.	24.274	18.567
Low Lines		
6	18.244	16.616
7	17.492	16.769
8	17.760	17.233
9	15.649	17.118
Ave.	17.286	16.934
LSD 5%	2.969	1.789
Check (MW 391)	21.365	17.444

[1] Data from 1955 test at Sheridan, Wyoming.
[2] Data from 1957 tests at Sheridan, Wyoming, and Sidney, Montana.

[3] CT9MS and SL34.611HO were developed at the U. S. Department of Agriculture Field Station at Salt Lake City by Dr. F. V. Owen and Dr. V. F. Savitsky, respectively.

It is readily apparent that the tonnage figures for the four high combining top crosses are significantly greater than those for the four low combining top crosses. It was also found that the average single cross yields are closely associated with the top-cross yields as indicated by the correlation coefficient of .79, significant at the 5 percent level. The mean value of all single crosses involving high-combining lines was 18.567 tons per acre, and the mean value of all single crosses involving low-combining lines was 16.934 tons per acre. This difference is significant at odds of 99:1 as calculated by the t test for significance.

These data indicate that on the average the four lines selected as high combiners are significantly better combiners in regard to tonnage than the four lines selected as low combiners.

Average tons per acre for all single crosses was 17.750 tons, whereas average tons per acre for the pollinator lines was 13.695 tons, and average tons per acre for the male-sterile lines was 12.849 tons, indicating heterosis for yield in these crosses.

In addition, several single crosses in the high-combining group were significantly greater in tons of beets per acre when compared to the commercial check.

Table 2 gives the sucrose percentages corresponding to yields given in Table 1.

Table 2.—Percent Sucrose of Top Crosses and Average Percent Sucrose of Single Crosses of Four High- and Four Low-Combining Lines as Measured by Top Crosses with the Red-Marker Beet.

	Percent Sucrose	
High Lines	Top Cross[1]	Single Cross[2]
2	12.76	15.05
3	12.26	14.56
4	12.60	14.47
5	12.80	14.33
Ave.	12.60	14.60
Low Lnes		
6	12.94	15.20
7	13.12	14.73
8	13.16	15.01
9	12.63	14.81
Ave.	12.96	14.94
LSD 5%	.62	.52
Check (MW 391)	15.72	14.48

[1] Data from 1955 test at Sheridan, Wyoming.
[2] Data from 1957 tests at Sheridan, Wyoming, and Sidney, Montana.

Very little emphasis was placed on percent sucrose in selecting the high- and low-combining lines. The difference in means between high and low top-cross groups is not significant on the basis of the four comparisons tested. The relationship between the percent sucrose of the top crosses and the average percent sucrose of the single crosses was weak as indicated by the correlation value of .46. The mean value, 14.60 percent sucrose, of all single crosses involving high-combining lines was significantly less than the mean value, 14.94 percent sucrose, of all single crosses involving low-combining lines at odds of 99:1 as calculated by the t test.

Data from this table indicate that on the average lines selected for high general combining ability by the red-marker beet, with little emphasis placed on sucrose, will produce single crosses lower in percent sucrose than lines selected for low general combining ability.

A further study of the percent sucrose for four of the single crosses is set forth in Table 3.

Table 3.—Percent Sucrose of Four Selected Single Crosses Together with Percent Sucrose of the Parents and Parental Means.

Single Cross		Percent Sucrose			
No.	Pedigree	P_1	P_2	F_1	$\frac{P_1 + P_2}{2}$
1	5152-01 x 6112-0	14.56	14.23	15.28	14.40
2	CT9MS x 6112-0	14.38	14.23	14.92	14.31
3	5152-01 x 6113-0	14.56	13.75	14.70	14.16
4	CT9MS x 6114-0	14.38	13.56	14.48	13.97
	LSD at 5% level = .52				

It is interesting to note that single crosses 1 and 2 showed heterosis for percent sucrose in that the sucrose contents of the F_1 hybrids were significantly greater than the sucrose content of the higher parent. Single crosses 3 and 4 exhibited dominance for percent sucrose in that the sucrose content of the F_1 hybrid was significantly greater than the average sucrose content of the two parents.

Average percent sucrose for all single crosses was 14.78 percent, whereas percent sucrose for the pollinator lines was 14.40 percent, and average percent sucrose for the three male-sterile lines was 14.68 percent. Although these differences are not significant, it is interesting to note that the single crosses show a greater percent sucrose than either parent, rather than an intermediate value.

It was also observed that the four single crosses showing heterosis or dominance for percent sucrose had as their pollinators, lines from the high-combining group.

Several single crosses, especially those showing heterosis and dominance for sucrose, had a significantly higher percent sucrose than the commercial check.

In Table 4 is given the sugar per acre yields corresponding to yields and sucrose percentages given in Tables 1 and 2.

Table 4.—Sugar Per Acre Yields of Top Crosses and Average Sugar Per Acre Yields of Single Crosses of Four High- and Four Low-combining Lines as Measured by the Top Crosses with the Red-Marker Beet.

	Pounds Sugar Per Acre	
High Lines	Top Cross[1]	Single Cross[2]
2	6289	5854
3	5900	5414
4	6221	5522
5	6069	4909
Ave.	6120	5426
Low Lines		
6	4722	5049
7	4590	4941
8	4674	5172
9	3853	5072
Ave.	4485	5059
LSD 5%	813	552
Check (MW 391)	6716	5052

[1] Data from 1955 test at Sheridan, Wyoming.
[2] Data from 1957 tests at Sheridan, Wyoming, and Sidney, Montana.

It is quite apparent that the top-cross sugar per acre yields of the four high-combining lines are significantly greater than the top-cross sugar per acre yields of the four low-combining lines. This is a reflection of the large spread in tonnage between the two groups of top crosses. The association for sugar per acre between top crosses and average single crosses is intermediate between tons and percent sucrose as shown by the r value of .54 which is not significant at the 5 percent level. The mean value, 5426 pounds sugar per acre, for all single crosses involving high-combining lines is significantly greater than the mean value, 5059 pounds sugar per acre, for all single crosses involving low-combining lines at odds of 98:2 as calculated by the t test for significance.

These data indicate that lines selected as high general combiners by the red-marker beet will, on the average, produce significantly more sugar per acre than lines selected as low general combiners.

It should also be pointed out that several single crosses in the high-combining group produced more sugar per acre than the commercial check.

Summary and Conclusion

As stated before, if the red-marker beet used as a top-cross tester provides good measure of general combining ability, then lines identified by it as superior in general combining ability should produce, on the average, superior hybrids when used in specific single cross combinations.

The data presented in this paper show that on the average single crosses utilizing lines high in general combining ability produced a greater tonnage per acre, a lower percent sucrose, and more sugar per acre than single crosses utilizing lines low in general combining ability.

Certain single crosses were shown to exhibit either heterosis or dominance for percent sucrose and for the material tested, dominance and heterosis were found in single crosses arising from high general combining lines.

The single crosses showing the greatest production of sugar per acre were those whose parents were high in general combining ability when crossed to the red-marker beet and at the same time showed heterosis for percent sucrose.

Literature Cited

(1) DICKENSON, D. D. and PETERSON, D. F. 1956. Results of use of the red-marker beet as a top cross parent. Journ. Amer. Soc. Sug. Beet Tech. IX (3) :217-220.

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