A Genetic Study of 17 F_1 Hybrids And Their Inbred Parents[1]

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Greater improvement in sugar beets can be expected, in a given period of time, if our knowledge of the characteristics of the parent stocks can be used to predict, with reasonable accuracy, the characteristics of the F_1 plants. It may never be possible to predict which inbred lines will "nick" to produce a large amount of hybrid vigor but it may be possible to predict, with a fair degree of accuracy, such characteristics in the F_1 as percent sucrose, smoothness of root, and resistance to Cercospora leaf spot. If such predictions can be made, it will be a great time saver over the old trial and error method of developing hybrids.

A review of the literature adds very little to our knowledge of the subject. However, Stewart, Gaskill and Coons (7)[3] made a study of root yield, percent sucrose and yield of sugar in 35 hybrids and found relatively few hybrids exceeded significantly, in the attributes measured, the mean of the parents or a synthetic check. Other workers, (3), (4), (5), have reported hybrids with yield increases of 12 to 19 percent above good commercial varieties. Yield increases of more than 60 percent above inbred parent have been found but these same workers (8) also found hybrids which showed little or no increase over their parents. Snyder (9) states that crossed inbred lines may bring all the dominant genes together *in* the hybrid, if each inbred line carries the vigor factors which the other one lacks. Thus, all crosses between inbred strains do not result in the same degree of heterosis.

Savitsky (1) working with crosses involving sugar beets, mangels, Swiss chard and garden beets, is reported as giving evidence that 4 genetic factors are responsible for high sugar; one pair in Swiss chard and the other 3 in sugar beets. The work of Culbertson (2) with 3 F_1 crosses shows that the sugar percentage of the hybrids is about equal to the mean of the parents. He states that it is doubtful whether these are genetic factors which influence only sugar percentage. He and Pack (6) believe that many factors which influence morphologic characters of the plant may influence to a greater or less extent the sugar percentage of the beet. Culbertson (2) summarizes by saying that the ability to store sugar was found to be inherited in a quantitative manner and to be dependent upon the interaction of several genetic factors.

There seems to be no published information on the inheritance of resistance to Cercospora leaf spot and smoothness of root (lack of forking or sprangling) in sugar beets. Reference is made to crosses between sugar

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

and wild beets and the forked and sprangled type of root from such crosses. Apparently sprangled root type is partially dominant, if not completely so.

The purpose of this paper is to report the findings from comparisons of 17 F_1 hybrids with their inbred parents. These hybrids involve 17 inbred strains, 15 as male parents and 2 as male-sterile female parents. The small quantity of seed produced made it necessary to limit the test to one year, 1948. The method of developing the male-steriles and the field technique of testing the hybrids and their parents has been reported previously (4).

The hybrids significantly out-yield their lower yielding parent and most of them out-yield both parents (Table 1). A few are not significantly different from their higher yielding parent. One out-yields the standard variety. The yield of some of the hybrids is about equal to the combined yield of the two parents. It appears, from the data, that some of the male strains are similar to one or the other female line in their factors for yield, because the F_1 between them yields about the same as the higher yielding parent. Parents which produce hybrids which yield much more than either parent are probably quite different from each other in their yield factors. These data are in agreement with previous reports (3), (4), (5), (7), (8), and (9) and is what may be expected from common knowledge of other crops, such as corn.

The percent sugar of 4 hybrids is lower than their higher parents, but not significantly above the lower parent. There are 2 hybrids with percent sugar above the lower parent, but not significantly below the higher parent. The mean of the hybrids is about equal to the mean of the parents and not significantly different from either. The mean of the lower parents is different from the mean of the higher parents. These data agree with the work of Culbertson (2) and show that the sugar percentage of the hybrids is about equal to the mean of the parents.

Since sugar makes up a very large part of the total solids in sugar beets it is natural to expect the inheritance of the percent purity to be similar to the inheritance of sugar. In the data, presented here, there is a significant difference between the means of the parents. The mean of the hybrids is about midway between the parents. These data are similar to those for percent sugar and indicate that the inheritance of percent purity, probably, is the same as the inheritance of percent sugar, intermediate between the two parents.

Recoverable sugar is the product of tonnage, percent sugar and purity. The great influence of tonnage on recoverable sugar is shown in Table 2.

These data are very similar to the data for tonnage in Table 1. One hybrid is not significantly different from either of its parents in recoverable sugar. Two others are not above their higher parent. The mean of the lower parents is significantly different from the mean of the higher parents, and both are below the mean of the hybrids.

Inheritance of smoothness of root seems to follow the same pattern as percent sugar. The mean of the hybrids is about equal to the mean of

Table 1.—A comparison of hybrids with their inbred parents, for tonnage, percent sugar and percent purity of juice, expressed in terms of a standard variety as 1.00.

Male parent	Tonnage			Percent Sugar					
	Lower parent	Hybrid	Higher parent	Lower parent	Hybrid	Higher parent	Lower parent	Hybrid	Higher parent
Ac. 35 411802	.59 [x]	[A] .78	.70	.90	.98	.95 [A]	.99 [x]	.98	.99
Ac. 145 431901	.59 [x]	1.01	.87	.95 [x]	.98	1.00	.96	.99	.99 [x]
Ac. 297 624702	.39	[bA] .95 [bA]	.59 [A]	.95 [x]	.98 [bB]	1.06	.99 [x]	1.01	1.01
Ac. 310 851714	.43	[aB] 1.05 [aB]	.59 [x]	.95 [x]	1.00	1.02 [x]	.98	1.00	.99 [x]
Ac. 310 851909	.58	[aB] 1.08 [aB]	.59 [x]	.95 [x]	.91 [bb]	1.05	.99 [x]	.98	1.00
Ac. 312 620104	.59 [x]	[aB] 1.10 [aB]	.73	.91	.89	.95 [x]	.96	.95 [bb]	.99 [x]
Ac. 327 S.P.S. No. 1	.59 [x]	[aA] 1.07 [A]	.79	.95 [x]	.95 [bb]	1.07	.99 [x]	1.00	1.02
U. S. 200	.56 [y]	[aB] .85	.80	.96 [y]	[aa] 1.04	1.02	1.00 [y]	1.01	1.00
Ac. 32 57301	.56 [y]	[bB] .92 [bB]	.59	.95	.97	.96 [y]	.99	.99	1.00 [y]
Ac. 32 57305	.56 [y]	[aB] 1.19 [aB]	.57	.94	.94	.96 [y]	1.00 [y]	.99	1.01
Ac. 35 410602	.56 [y]	[bB] 1.06 [aB]	.81	.94	.94	.96 [y]	1.00 [y]	1.00	1.00
Ac. 35 411802	.56 [y]	[aA] 1.11 [aA]	.60	.96 [y]	.96	.96	1.00 [y]	1.01	1.02
Ac. 40 416003	.56 [y]	[aA] 1.02 [aA]	.66	.96 [y]	.94	.98	1.00 [y]	1.00	1.00
Ac. 60 420104	.56 [y]	[bA] .97 [aB]	.61	.96 [y]	.92 [b]	.98	1.00 [y]	.98	1.00
Ac. 265 433603	.56 [y]	[bB] 1.01	.84	.94	.99	.96 [y]	.98	.99	1.00 [y]
Ac. 297 624702	.26	[bB] .92 [aB]	.56 [y]	.96 [y]	[aB] 1.04	1.06	1.00 [y]	.98 [b]	1.02
Ac. 312 620102	.36	[bA] .71	.56 [y]	.96 [y]	.96	1.02	1.00 [y]	.99	1.01
Average	.45±.06	.99±.06	.69±.06	.94±.02	.96±.02	1.01±.02	.98±.01	.99±.01	1.01±.01
L. S. D.		.18 5% .24 1%			.06 5% .08 1%			.03 5% .04 1%	

[A] —hybrid significantly above the parent at the 5% level.
[aB]—hybrid significantly above the parent at the 1% level.
[b] —hybrid significantly below the parent at the 5% level.
[bB]—hybrid significantly below the parent at the 1% level.
[x] —female parent, Ac. 32 57301
[y] —female parent, Ac. 35 410605

Table 2.—A comparison of hybrids with their inbred parents, for recoverable sugar per acre, smoothness of roots and resistance to Cercospora leaf spot, expressed in terms of a standard variety as 1.00.

Male parent	Recoverable sugar: Lower parent	Recoverable sugar: Hybrid	Recoverable sugar: Higher parent	Smoothness of root: Lower parent	Smoothness of root: Hybrid	Smoothness of root: Higher parent	Leaf Spot resistance: Lower parent	Leaf Spot resistance: Hybrid	Leaf Spot resistance: Higher parent
Ac. 35 411802	.57 [e]	.69	.61	1.01 [x]	1.03	1.01	.84	.85 [bb]	.99 [x]
Ac. 145 431901	.57 [x]	[na] .98	.83	1.01 [x]	1.01 [bh]	1.08	.80	[ag] .87 [bb]	.99 [x]
Ac. 297 624702	.40	[ak] .94 [an]	.57 [x]	1.01 [x]	[bk] 1.10	1.14	.86	.85 [bb]	.99 [x]
Ac. 310 851714	.42	[ak] 1.05 [an]	.57 [x]	1.01 [x]	[ak] 1.07	1.09	.91	[bb] .85 [bb]	.99 [x]
Ac. 310 851909	.57 [x]	[ak] .97 [an]	.61	1.00	1.00	1.01 [x]	.92	[h] .89 [bb]	.99 [x]
Ac. 312 620104	.57 [x]	[an] .95 [ad]	.68	.99	1.00	1.01 [x]	.93	[bb] .86 [bb]	.99 [x]
Ac. 327 S.P.S. No. 1	.57 [x]	[an] 1.02 [an]	.87	1.01	1.00	1.02	.99 [x]	.97 [bh]	1.04
U. S. 200	.51 [y]	[ak] .90	.81	.95 [y]	[ak] 1.01	1.01	.98 [y]	.98	.98
Ac. 32 57501	.51 [y]	[an] .89 [ad]	.57	.95 [y]	.98	1.01	.98 [y]	1.00	.99
Ac. 32 57306	.51 [y]	[an] 1.10 [an]	.53	.95 [y]	.98 [b]	1.02	.98 [y]	.99 [bb]	1.03
Ac. 35 410602	.51 [y]	[ba] 1.00 [ba]	.75	.95 [y]	.98	.99	.90	[ba] .95 [b]	.98 [y]
Ac. 35 411802	.51 [y]	[ba] 1.09 [ba]	.59	.95 [y]	[k] 1.00 [b]	1.04	.84	[a] .87 [bb]	.98 [y]
Ac. 40 416003	.51 [y]	[an] .95 [ad]	.65	.95 [y]	[k] 1.00	1.02	.98 [y]	.97 [b]	1.00
Ac. 60 420104	.51 [y]	[ba] .88	.60	.95 [y]	.99	1.02	.96	[bb] .90 [bb]	.98 [y]
Ac. 265 433603	.51 [y]	[ba] .99 [na]	.77	.95 [y]	.99 [bh]	1.05	.87	[a] .89 [bh]	.98 [y]
Ac. 297 624702	.27	[an] .51 [y]	.51 [y]	.95 [y]	[ad] 1.02 [b]	1.07	.83	[ag] .89 [bb]	.98 [y]
Ac. 312 820102	.36	[a] .66 [ag]	.51 [y]	.95 [y]	[a] 1.00 [b]	1.06	.90	[bb] .85 [bb]	.98 [y]
Average	.42±.06	.94±.06	.66±.06	.99±.02	1.01±.02	1.04±.01	.90±.01	.91±.01	1.00±.01
L. S. D.		.18 5% .24 1%			.05 5% .06 1%			.03 5% .04 1%	

the parents (Table 2), and suggests that many factors which influence morphologic characters of the plant may also influence the smoothness of the root.

Resistance to Cercospora leaf spot seems to be inherited in a manner different from the characters discussed previously. There are only 2 hybrids which are not significantly different from their higher parent, all the others being below the higher and more resistant parent. Five are above, 5 below and 7 are about equal to the lower parent. The mean of the lower parents and the mean of the hybrids are not significantly different, but both are below the mean of the higher parents. It appears, from these data, that the hybrids are usually more like the susceptible parent, and a few may be even more susceptible than either parent. In 2 cases the lower parent, higher parent and hybrid are not significantly different from each other.

The data show that the yielding ability of the F_1 hybrids can not be predicted from our knowledge of the yielding ability of the parent stocks. Percentage of sugar and purity and smoothness of root are about intermediate between the two parents and can be predicted fairly accurately. Resistance to Cercospora leaf spot can be predicted only to the extent that the F_1 usually is more like the less resistant parent.

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