GENETICS, BREEDING, SEED, AND VARIETIES

A Comparison of Selected and Random Advanced Generations of Hybrid Beet Strain 520[1]

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Hybrid beet strain 520 was produced at Rocky Ford, Colo., in 1985. A description of this hybrid and a review of yield trials of 520 and some early advanced generations of it were presented to this Society at its Denver meeting in 1940 (I)[3]. Briefly, hybrid strain 520 is a white-rooted third generation of a cross of a sugar type variety sugar beet and a globe type red garden beets. For the production of hybrid 520, white beets of desirable type and good to high weight and percentage sucrose were selected from the second generation of this cross and planted as an isolated group for seed production. Approximately 110 pounds of seed was obtained from this group of a few hundred plants.

Since 1939 the generations of this hybrid have been advanced and yield trials continued at Fort Collins, Colo.[1] The advancement of the generations has followed two lines, both starting from 520 as a base: (1) Continuous selection as for the original strain 520 and (2) continuous random increases. Selected generations have been advanced to the seventh and random generations to the sixth generation, respectively. Seed of the various generations has been produced from isolated group plantings of approximately 150 to 500 roots each. For the selected line, beets were picked at harvest for type and for average to large size. After individual analyses of these roots for percentage sucrose, the group for planting was made up of roots which were average or better for both weight and percentage sucrose. For the random line all beets as they grew in the field were saved to the number of several hundred and a group planting made the following spring for seed production, without selection in any way for type, weight, or sugar content. Tn general, storage losses of these roots have been light and any effect of a natural selection due to such stor-

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

[4]Agronomic investigations of the Division of Sugar Plant Investigations at Fort Collins, Colo., are cooperative with the Agronomy Section of the Colorado Agricultural Experiment Station and are conducted on the Agronomy Farm of the latter agency.

age losses of roots is believed to be negligible for any of these random increases.

In the early trials hybrid strain 520 produced high yields of roots with usually somewhat lower percentage sucrose than that of comparable commercial varieties of sugar beets. However, because of the high yield of roots of the hybrid, the acre yields of gross sugar frequently equalled or exceeded those of the best comparable commercial variety. On the basis of these early trials it was believed that the hybrid might be of value, particularly in sugar beet growing areas where the tonnage types of sugar beets normally produce the largest acre yields of sugar. However, it was obvious that commercial production of third generation seed of this or similar hybrids was impractical because of the cost. For this reason the performance of advanced generations of this hybrid became of interest.

In 1944 seed production of advanced generations of hybrid 520 had proceeded to the selected seventh and the random sixth generation, thus making it possible in 1945 to compare the selected fourth to seventh and the random fourth to sixth generations with the original selected third generation in one comprehensive variety test. Also included in this test were a local commercial variety as a check and 3 other strains, making a total of 12 varieties in the test. This test was planted on the Agronomy Farm at Fort Collins, Colo. The soil is Fort Collins Loam, light textured phase, and the general level of fertility is moderately high. The preceding crop was spring wheat. The wheat stubble was fall-plowed after the application of about 10 loads per acre of barnyard manure. The test consisted of 6 randomized replications with the plots 8 rows in width and 30 feet in length; the 6 inside rows of each plot were harvested and two 20-beet samples taken for percentage sucrose determinations. Thus the yield of roots was determined from the weight, after washing, of all beets from 180 feet of row per plot. The test was planted May 10, thinned June 19 to 22, and harvested October 16 and 17. The planting date, May 10, was at least 2 weeks later than the optimum date for the region, but unfavorable weather prevented earlier planting. The yields obtained in this test were not high but are considered very good for May 10 planting.

In mid-June, just before thinning, it was observed that the beet plants on much of this part of the field had an abnormal appearance. The leaves were curled and slightly brittle and there was more or less burning of the leaf edges. Growth of many of the plants appeared to have stopped. Frost injury on June 16 was at first suspected as a cause of this condition; however, a closer examination revealed the presence of great numbers of a small, gray leaf hopper and it is be-

lieved that the feeding of these insects had had a toxic effect on the beet plants. Most areas of this test and all the varieties included were more or less affected. However, it was observed that the random fifth and sixth generations of hybrid 520 were probably more generally and severely affected than any other of the varieties in the test. Recovery was rapid after thinning and all parts of the test had resumed normal growth by late June. In general excellent stands were obtained on all plots and no conditions, other than the leaf hopper damage, were observed during the season to impair the validity of the test. The general reliability of this test is believed to be very good. A summary of the test is presented in table 1.

Varieties 9 and 10 are of interest in the present discussion only in that they indicate the possibility that other strains may be obtained from crosses of sugar beet with other beet varieties which may equal or surpass the relatively high root yields of hybrid strain 520. This test was not affected by leaf spot. The performance of variety 11 (U. S. 215 x 216) is not in line with previous tests or a companion test in 1945 in which 2-1-00 compared more favorably with the local commercial check variety.

Table 1.—General summitry hybrid 520 strains trial, Fort Collins, Colo., 1945. (Data given as six-plot averages).

Variety or strain		Acre yields: Gross sugar (pounds)	Acre yields: Roots (tons)	Percentage sucrose
1.	520 Sel. 3rd	3,961	14.48	13.32
2.	'37-304 Sel. 4th	3,802	14.16	13.42
3.	'39-303 Sel. oth	4,230	15.17	13.96
4.	'42-309 Sel. Oth	4,244	15.47	13.76
5.	'44-306 Sel. 7th	3,924	14.12	13.92
6.	'38-301 Rand. 4th	3,925	15.10	13.02
7.	'42-305 Rand. 5th	3,685	13.73	13.41
S.	'44-305 Rand. 6th	3,644	13.56	13.47
9.	'42-306 Sel. 3rd	4,054	16.23	12.52
10.	'43-300 Sel. 3rd	4,042	16.68	12.14
11.	2-1-00 U.S. 215 x 210	3,273	11.33	1441
12.	Localcomcl check	3.748	14.14	13.26
	General mean of teat	3,877	14.55	13.38
	F value	4.12**	8.39**	5.14**
	2 x the S. E. of a Diff. (odds of 19:1)	pounds 378	tons 1.36	percentage 0.78
	S. K. of mean in percent of general mean	percentage 3.44	percentage 3.31	percentage 2.06

Notes:

No. 9 is the selected third generation of a cross of U. S. Nos. 200 and 215 x globe type red garden beet.

No. 10 is the selected third generation of a cross of commercial sugar beet x Giant Pink Top Half Sugar stock beet.

No. 11 is a leaf spot resistant variety. This test was not affected by leaf spot.

In this test none of the advanced generations of the hybrid differed significantly from 520 in yield of gross sugar or roots and none of them had a significantly higher or lower percentage sucrose than 520. Certain of the differences between some of the advanced generations themselves exceed the amounts required at the 5 percent level for probable significance. The selected fifth and sixth generations were higher in gross sugar production than the selected fourth or the random fifth and sixth generations. In root yield the random fifth and sixth generations were significantly below the selected fifth and sixth generations. Also the selected sixth very nearly exceeds the sleected fourth and seventh generations by amounts sufficient for significance. Only one of the generations, the random fourth, had a markedly low sugar content; its percentage sucrose in this test of 13.02 was significantly lower than either that of the selected fifth or seventh generations. In comparison with the commercial sugar beet check variety, only the selected fifth and sixth general tons of the hybrid produced significantly more gross sugar, and none of the hybrid strains differed significantly from this check in yield of roots or in percentage sucrose.

This test was inconclusive as to progressive improvement or deterioration of the 520 strain through either of the lines of selection. In root yield the selected fifth and sixth generations and the random fourth generation were relatively high, while the random fifth and sixth generations and, to a lesser degree, the selected fourth and seventh generations were relatively low. In the case of the selected line of advancement the low fourth is followed by the high fifth and sixth generations which in turn are followed by a low seventh generation. In the random advancement of generations there was an apparent deterioration in yield from the fourth to the fifth generation which was not followed by further decrease in the sixth generation. In connection with the above comparisons it should be noted that the leaf hopper infestation in June appeared to have had a more consistently adverse effect on the random fifth and sixth generations than on other strains in the test. Only one of the advanced generations differed significantly from any of the others in percentage sucrose. This was the random fourth generation, which was low in sugar content.

A possible explanation of the apparent variations from generation to generation lies in the fact that seed production has been from group plantings of at most a few hundred roots each. Thus, the parent material for each succeeding generation may or may not have been a true sample of the previous generation. This could be particularly true in the case of random advancement.

In the period from 1936 to 1945 there have been many tests of the original hybrid 520 and the successive generations as seed of these became available. These tests have varied from observational strip plantings to extensive replicated tests. Very few of these tests have consistently included the same strains of the hybrid, and the commercial sugar beet check variety used in each of them has varied from extreme sugar to tonnage type. However, in every instance the commercial sugar beet check variety was a variety in general use by growers in the area where the test was conducted. Any adequate statistical analysis of the combined data from all 1hese tests appeared impractical if not impossible and has not been attempted. For these reasons no general summary of these tests will be presented. However, some general conclusions which are believed to be valid may be drawn from these older tests.

In the earlier tests a sugar type sugar beet check variety was more frequently the commercial check variety used for comparison with hybrid 520. In these tests the hybrid usually had a lower percentage sucrose than the commercial check variety and the difference was often highly significant. In the later years of testing, the commercial sugar beet check variety has more often been of a tonnage type and the various hybrid generations have often equalled or slightly exceeded the commercial check variety in percentage sucrose. However, whatever the differences, they have seldom reached the level of probable significance in these later tests.

Individually or in varying combinations the original hybrid strain 520 and each of the advanced generations, with the exception of the random sixth and selected seventh generations, have been included in two or more tests since 1936. In every case the average root yield of any one of the hybrid strains, regardless of the generation, has exceeded the average of the comparable commercial sugar beet check variety, often by a highly significant margin. The instances in which the commercial variety has exceeded some one strain of the hybrid in a single test have been rare. The random sixth and selected seventh generations of the hybrid were included in only one test (1945) and their root yields were 95.9 and 99.9 percent, respectively, of the commercial check variety in that test.

One or more strains of the hybrid and a commercial sugar beet variety as a check have been included in 21 different tests. From these 21 tests a total of 71 individual comparisons of some one strain of the hybrid with the commercial check variety are possible. Out of these 71 possible comparisons the hybrid strain has exceeded the check 27 times in yield of gross sugar per acre. In a majority of these cases the difference was probably not significant.

In the period 1939 to 1945, inclusive, there have been eight tests in 5 of these years which included a commercial sugar beet variety, the original hybrid strain 520, and one or more each of the selected and random advanced generations of the hybrid. Ignoring the differences, if any, in the successive generations in each line of advancement, the average performance of the four varieties in the eight tests was as shown in table 2.

Admitting that the earlier generations of advancement of the hybrid have contributed a greater share to the averages than were contributed by the later generations, and that random and selected generations were not represented equally in all tests, certain of the trends shown by these averages seem to be worthy of note. The advancement of generations by continuous selection appears to hnve maintained root yield and to have improved slightly the percentage sucrose. When the advancement in generations was at random, percentage sucrose was maintained but root yields declined about 4 percent. The Joss in root yield when the advancement of generations was at random has a little more than cancelled the original advantage of the hybrid over the check in yield of gross sugar per acre but has

Table 2.—Summary of performance of hybrid strain 520, selected advanced generations of 520, random advanced generations of 520, and commercial sugar beet check variety. Averages of eight tests in 5 different years (1939-45).

Variety	Acre yields		Percentage sucrose (Percentage)	Total single values used in averages
	Gross sugar (Pounds)	Roots (Tons)		
1. Hybrid 520	4,338	14.70	14.86	8
2 Selected advanced gen. of hyb.	4,385	14.60	15.39	23
3. Random advanced gen. of hyb.	4,140	14.11	14.86	16
4. Commercial variety check	4,194	13.65	15.47	S
No. 1 in percent of No. 4	103.43	107.69	96.06	
No. 2 in percent of No. 4	104.55	106.96	97.74	
No. 3 in percent of No. 4	98.71	103.37	96.06	
No. 2 in percent of No. 1	101.86	99.32	101.75	
No. 3 in percent of No. 1	95.44	95.99	100.00	
No. 3 in percent of No. 2	94.41	96.64	98.28	

Notes:

1939: Replicated tests at Fort Collins and Rocky Ford, Colo., and at Sheridan. Wyo. Strip plantings at Fort Morgan, Colo.

1941, 1943, 1944 and 1945: Replicated tests at Fort Collins, Colo.

Hybrid 520 and a commercial check variety occurred once" in. each of the tests. One of more selected and one or more random advanced generations of the hybrid occurred in each of the tests.

When two or more generations of either line of advancement of the hybrid occurred in a test, all values for that line of advancement were averaged and the resultant figure used as the appropriate value for the line in that particular test, thus bringing the data for each of the four varieties to a common basis for the averages of all tests.

not entirely cancelled its advantage over the check for root yield in these tests.

The possibility that a variety hybrid such as 520 could be carried to commercial production, after some degree of selection, by random seed increases is not entirely ruled out by these tests.

Conclusions

A high-yielding third-generation hybrid beet variety can be obtained from sugar beet x garden beet and probably from other similar variety crosses by the careful selection of the most desirable second-generation roots for seed production.

Because of the amount of time and expense involved in producing a relatively small amount of third-generation hybrid seed, the commercial production of such a variety is impractical.

Advancement of a hybrid variety to the seventh generation by continuous selection has had little effect on its performance. A possible slight loss in yield of roots, in comparison with the original third generation, has been offset by a slight increase in percentage sucrose.

Advancement of the same hybrid variety to the sixth generation by continuous random increases has resulted in a small loss in yield of roots and no change in percentage sucrose.

Evidence of any progressive change in this hybrid variety by either of the lines of advancement of the generations has been inconclusive.

The possibility of obtaining a high-yielding hybrid variety similar to hybrid beet strain 520 for commercial use, particularly in regions where the tonnage types of sugar beets give highest acre production of sugar, appears to justify further production and testing of such hybrids and the investigation of methods by which seed of the hybrid variety may be made available in quantity and at a moderate cost. Direct increase of the seed of such a hybrid variety to commercial quantities without further selection in the later generations has not been definitely proved impractical by these tests.

Literature Cited

1. Deming, G. W. Comparison of Some Advanced Generations of a Hybrid Strain of Sugar Beet with the Original Third Generation Selection, Proc. Amer. Soc. Sug. Beet Tech. Part I, 149-154. 1940.