Comparison of Sugarbeet Single-Cross Hybrids with Double-Cross Hybrids for Seed and Root Characteristics

KENT NIELSON, DOUGLAS QUAYLE AND SHELTON BERGESON[1]

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The use of F_1 crosses between inbred lines to produce superior corn hybrids was outlined by Shull in 1909 (4)[2]. However, hybrid corn on a commercial basis did not become a reality until after Jones (3) suggested the use of the double-cross system to overcome the economic problems involved in producing commercial single-cross hybrids. Hallauer (1) states that with the development of improved inbreds, improved cultural practices and a better understanding of gene action involved in heterosis, the trend is now toward single-cross and three-way hybrids. In the Iowa corn yield tests for potential commercial varieties, 1.6% of the entries were single crosses in 1957 while 30.8% of the entries were single crosses in 1965 (1).

Primary disadvantages of commercial single-cross varieties are:

1—Seed production costs are increased since inbreds produce the seed in the case of single-cross hybrids while F_1s are the seed bearing parents for double-cross hybrids.

2—Single-cross hybrids are less likely to be adapted to as wide an environmental range as three-way or double-cross hybrids.

Advantages from the use of single-cross hybrids are:

1—Higher yielding ability than three-way or double-cross hybrids (2).

2—Greater uniformity than more complex hybrids.

3—Restorer lines or lines with Mendelian male sterility are not required to produce seed for the commercial hybrid.

4—Testing of hybrids which combine three or more inbreds is not necessary.

Data presented in this paper were gathered over several years to weigh the advantages and disadvantages connected with the use of single-cross sugarbeet hybrids.

Materials and Methods

Single-cross sugarbeet hybrids have been tested by the Utah-Idaho Sugar Company for 5 years as potential commercial varieties. In 1967, a double-cross hybrid and four single-cross

[1] Geneticist, Seed Production Manager and Fieldman (now Senior Fieldman Idaho district); Utah-Idaho Sugar Company, respectively.

[2] Numbers in parentheses refer to literature cited.

hybrids, made up of inbreds contained in the double cross, were compared. Tests were conducted at Garland, Utah; Idaho Falls, Idaho; Toppenish, Washington and Moses Lake, Washington. Tests were planted in a randomized block design. Hybrids were replicated ten times at each location.

In 1968, the same double cross tested in 1967 was compared with two selected single crosses at West Jordan, Utah, as well as at the locations where the 1967 tests were grown. Hybrids were planted in a randomized block design replicated 10 times at each location. Gross sugar per acre, tons of beets per acre, percent sucrose and impurity index data were obtained for all hybrids at all locations for both 1967 and 1968.

In each of 3 years (1965, 1966 and 1967), cytoplasmic male-sterile inbred lines were compared with CMS F_1 crosses for yield of seed per acre, clean off percentage and percent germination. In 1968, six CMS inbred lines were evaluated for the above characters but were not compared with a CMS F_1.

CMS lines and crosses were planted in strips with a pollinator in an adjacent strip. In 1965, one non-replicated planting was made comparing four inbreds with one F_1. In 1966 and 1967, tests were conducted in each of three fields. Only two fields were used in 1968. All seed tests were conducted at St. George, Utah.

Results

The double cross hybrid in 1967 was significantly higher in production of sugar per acre, beets per acre and impurity index than either single cross having 11863 CMS as the female parent (Table 1). Single crosses with the 511866 pollinator were relatively low in percent sucrose (Table 1).

Table 1.—Comparison of a double-cross hybrid with single-cross hybrids.

Year	Hybrid	Pounds of sugar per acre	Tons of beets per acre	Percent sucrose	Impurity index
1967	(11863CMS × 12163) CMS × (511866 × 512066)	9153	29.63	15.56	7064
	11863CMS × 511866	8522[a]	27.55[a]	15.54	6192[a]
	11863CMS × 512066	8354[a]	26.18[a]	16.06[b]	6282[a]
	12163CMS × 511866	9131	30.66	15.02[a]	7324
	12163CMS × 512066	8952	28.43	15.87[b]	7060
1968	(11863CMS × 12163)CMS × (511866 × 512066)	7066	22.17	15.95	6160
	12163CMS × 511866	7536[b]	24.13[b]	15.63[a]	6405
	12163CMS × 512066	7632[b]	23.24[b]	16.39[b]	5828[a]

[a] Less than the double cross at the .05 level of significance.

[b] Greater than the double cross at the .05 level of significance.

The locations × hybrids interaction was significant for pounds of sugar per acre, tons of beets per acre and impurity index. Differences among hybrids were significant at the .05 level.

In 1968, 12163CMS × 511866 and 12163CMS × 512066 were significantly higher than (11863CMS × 12163) CMS × (511866 × 512066) for pounds of sugar per acre and tons of beets per acre (Table 1). As shown in Table 1, one single cross was higher and the other lower than the double cross for percent sucrose. Hybrids were significantly different for all characteristics studied but none of the locations × hybrids interactions were significant.

Table 2 lists the CMS inbreds grown for seed in 1965. In this non-replicated planting, seed yield of inbreds compared favorably with the CMS F_1. In 1966, the F_1 was superior to the inbreds for production of seed per acre (Table 2) but there was no significant difference for percent germination. The F_1 had a similar clean-off percentage to one inbred but was better than the other.

Table 2.—Seed characteristics of inbred CMS lines and F_1 CMS crosses grown at St. George, Utah.

Year	CMS		Yield of clean seed lbs/acre	Clean-off percent	Germination percent
1965	11563	(Strip)	4623	26.0	76
	11863	(Strip)	3415	25.0	66
	12163	(Strip)	4657	24.5	80
	13063	(Strip)	4470	19.2	75
	11863	(Blended)	4530	9.6	60
	11863CMS × 12163	(Blended)	3916	14.4	81
1966	11863CMS × 12163		4546[a]*	30.0[a]	81[a]
	12163		3922[b]	33.3[a]	83[a]
	1761		2151[c]	45.2[b]	82[a]
1967	11863CMS × 12163		4779[a]	19.3[a]	90[a]
	100363 × 12163		4735[a]	21.3[a]	92[a]
	100363		3262[b]	26.2[a]	91[a]
	12163		3139[bc]	24.5[a]	84[a]
	106666		2793[c]	28.3[a]	88[a]

* Duncan's multiple range test. Means having the same suffix letter are not significantly different at the .05 level.

Data in 1967 indicated no difference among F_1s and inbreds tested for clean-off percentage or percent germination (Table 2). Both F_1s had significantly higher seed yields than the inbreds. Inbred 12163 produced 86% and 66% as much seed as did 11863 CMS × 12163 in 1966 and 1967, respectively.

Using a monogerm CMS F_1 cross, production of commercial seed at St. George, Utah, averaged 4005 pounds of clean seed per acre for 1965 and 1966. Using a monogerm CMS inbred

for commercial sugarbeet seed production, yield of clean seed per acre decreased to 3637 pounds in 1967 and to 2500 pounds in 1968. Yield of the best CMS F_1 crosses was about 10% above the yield of the CMS inbred in 1967 and about 35% above in 1968. Year to year differences as well as material grown would, of course, affect seed production.

Discussion

Inbred 11863 appeared to be the inferior component of the double cross, (11863CMS × 12163) CMS × 512066). Inbred 12163 had good combining ability for yield of beets but was not as good as 11863 for combining ability for percent sucrose. Using 12163 as the CMS and either 511866 or 512066 as pollinators resulted in single crosses superior to the double cross for all characters studied in 1968. Line 511866 had good combining ability for yield of beets while 512066 had good combining ability for yield of beets and excellent combining ability for percent sucrose.

Significant locations × hybrids interactions in 1967 indicated that hybrids responded differently at a given location. However, in 1968 when only the two best single crosses were tested there were no significant interactions. The single crosses were consistently superior to the double cross at all locations where tests were conducted.

Seed yields of inbreds decreased considerably as compared to F_1s. However, the production obtained from inbreds was high enough to make production of single crosses economically feasible. Selection of inbreds for greater seed production should be possible. Clean-off percentage and percent germination of the better inbreds was equal to that of the F_1s tested.

Summary

A high yielding sugarbeet double-cross hybrid was compared with four single-cross hybrids in 1967 and two selected single-cross hybrids in 1968. Single-cross hybrids tested were composed of two of the component inbreds from the double cross. Selected single-cross hybrids were superior to the double-cross hybrid for percent sucrose in 1967 and for sugar per acre, tons of beets per acre and percent sucrose in 1968. Location by hybrid interactions were significant in 1967 but not in 1968. The best single-cross hybrid was equal or superior to the double-cross hybrid at each location in both years. In 1968, the best single cross produced 8% more sugar per acre than the double cross over all locations.

Seed yield dropped from about 4000 pounds per acre to 3600 pounds per acre in 1967 and to 2500 pounds per acre in 1968 when CMS inbred lines were used instead of CMS F_1s. Clean-off percentage and percent germination were not affected.

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