The Relative Performance of Some Non-Rogued Male Sterile Hybrids

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Considerable interest exists among sugar beet breeders in the commercial utilization o£ hybrid vigor. Several investigators (1, 2, 3, 5)[2] have produced small quantities of experimental hybrid seed and have clearly demonstrated the superiority of hybrids over open-pollinated varieties. The discovery of cytoplasmic male sterility in sugar beets (4) opened the way for commercial utilization of heterosis by providing an effective means of crossing selected strains on a large scale for the production of commercial quantities of hybrid seed.

Further study is needed on several problems associated with cytoplasmic male sterility and the commercial production of hybrid seed. One of these problems concerns the effect on hybridization and yield of semi-male sterile and fertile plants within the male sterile seed parent. At the present time, available curly top-resistant male sterile lines are not completely male sterile. Varying numbers and degrees of semi-male sterile and fertile plants occur within them. Before commercial production of hybrid seed can be undertaken, the frequency and degree of semi-male sterile plants within male sterile strains and their effect upon hybridization must be determined.

This paper deals with the relative performance of two rogued, and two non-rogued, hybrids (top crosses) made by utilizing as seed parents two curly top-resistant male sterile lines which differ appreciably in degree of male sterility. Additional non-rogued top crosses made with a common male sterile seed parent and selected pollen parents are also reported.

Methods and Procedure

Seed of the male sterile strains SL 9090M1 and SL 9031Ml was obtained from the division of Sugar Plant Investigations office in Salt Lake City. SL 9090M1 is the male sterile equivalent of inbred CT9 (SL 9090). SL 9031M1 in an F_1 hybrid between inbreds CT 9 and CT 31.

Seed of each of these strains was planted in August, 1950, at Avon, in Cache Valley, and at Eden, in Ogden Valley. An open-pollinated selection, TF-48, was used as the common pollen parent at both locations. The male sterile strains were planted on opposite sides of TF 48, and occupied approximately .2 acres each at both Avon and Eden. At Eden both male sterile strains were carefully rogued during the flowering period. All semi-male sterile and fertile plants were removed while the flowers were in the bud stage. The male sterile plants at Avon, on the other hand, were not rogued. During the flowering period random samples of the male sterile strains were classified for degree of male sterility.

In July, 1951, the following seed lots were harvested:

1 Plant Breeder, Amalgamated Sugar Company, Ogden, Utah. [2] Numbers in parentheses refer to literature cited.

Variety	Pedigree	Location	Description
1313	SL 9090M1 x TF 48	Eden	Rogued
1314	SL 9090M1 x TF 48	Avon	Non-Rogued
TF 48	Pollen Parent		
1315	SL 9031M1 x TF 48	Eden	Rogued
1316	SL 9031M1 x TF 48	Avon	Non-Rogued

The rogued and non-rogued hybrids were evaluated and compared with the pollen parent at five locations in 1952 field tests.

Three additional non-rogued top crosses were made in separate isolations in the summer of 1951. Reserve stecklings of SL 9090M1 were utilized for the female parent and roots of SL 824, N-50 and T50 as the respective pollen parents. The top cross seed was designated 1323, E26 and E27 respectively. E21 and E22 were made in a similar manner in the summer of 1952. SL 9090M1 was used as the female parent in both cases and the inbred SL 19.2 and C-51-1, a high sugar, low sodium selection out of C47, were the respective pollen parents.

A one-half acre over winter increase of the hermaphrodite SL 9090 and its male sterile equivalent SL 9090M1 was planted in August, 1951, at Plain City near Ogden. The seed of this increase was harvested in the summer of 1952 and designated A2-90 and A2 90H0 respectively. Reserve stecklings from this seed increase together with additional SL 9090M1 stecklings were used to plant a two-acre crossing field at Providence *in* the spring of 1952. This planting consisted of alternate strips of two rows of SL 824 pollen parent and four rows of SL 9090M1 seed parent. The male sterile plants were classified for degree of male sterility (Table 1) during the flowering period but were not rogued. The hybrid seed produced on the male sterile seed parent was designated 2323. This seed was widely tested in strip plantings and replicated field trials in 1953.

Experimental Results

The differences between SL 9090M1 and SL 9031Ml in degree of male sterility are shown in Table 1. SL 9031Ml has approximately 7.5 percent less male sterile plants and 5.2 percent more normal pollen-producing plants than SL 9090M1. In the semi-male sterile class, which consists of plants with abortive anthers but which may shed varying amounts of viable pollen, SL 9031Ml has 2.3 percent more plants than SL 9090M1.

Table 1.—Percentage of Male Sterile, Semi-Male Sterile and Fertile Plants in SL 9090M1 and SL 9031M1— June, 1951, and SL 9090M1— June, 1952.

	Variety		
Plant Classification	SL 9090M1	SL 9031M1	SL 9090M1 June, 1952
Male Sterile (No Viable Pollen)	93.9	85.8	92.1
White Anthers	79.1	66.1	75.7
Pale Yellow Anthers	14.2	19.7	16.5
Semi-Male Sterile	6.4	8.7	7.3
Fertile (Viable Pollen)	.3	5.5	.6
Number of Plants Examined	667	528	1,105

The average performance of rogued and non-rogued hybrids with respect to gross sugar, root yields per acre and percent sucrose is shown in Table 2. In both cases the differences between rogued and non-rogued hybrids are small and not significant. It is known from previous tests that, in yield of gross sugar and tons of beets per acre, SL 9031Ml is equal to or slightly better than U. S. 22/3. SL 9090M1 on the other hand generally yields approximately 10 percent less than U. S. 22/3 in gross sugar and tons of beets per acre. The comparatively high yield of 1313 and 1314 indicates that effective hybridization took place between SL 9090M1 and TF 48. Further evidence of hybridization cannot be obtained from a study of the sucrose content of the hybrids, since the parental lines are low in percent sucrose.

Table 2.—Performance of Rogued vs. Non-Rogiied Hybrids (Top Crosses) in 1952.

		General Means		
Variety	Pedigree	Gross Sugar/A	Tons Beets/A	% Sucrose
1313	SL 9090M1 x TF 48 (R)	8,065	25.99	15.47
1314	SL 9090M1 x TF 48 (NR)	8,201	26.37	15.43
TF 48	Pollen Parent	7,843	25.25	15.56
1315	SL 9031M1 x TF 48 (R)	8,558	28.21	15.44
1316	SL 9031M1 x TF 48 (NR)	8,436	27.68	15.13
Difference required for significance (19:1)		681	2.29	.61

(R) = Rogued (NR) = Non Rogued

The performance of additional non-rogued hybrids expressed as percent of the commercial variety U. S. 22/3 is shown in Table 3. The female parent in each case, SL 9090M1, is the same as in hybrids 1313 and 1314 for which the degree of male sterility is shown in Table 1. The pollen parents, however, represent open-pollinated strains with a considerable range in sucrose content. C-51-1, the pollen parent of E22, is a curly top, high sugar, low sodium selection out of the sugar type variety C47. N-50 and T-50 are selections out of U. S. 22/3 which do not differ appreciably from U. S. 22/3 in sucrose content.

Table 3.—Performance of Non-Rogued Hvbrids (Top Crosses) Expressed as Percent of U. S. 22/3.

		General Means		
Hybrids	Pedigree	Gross Sugar Per Acre	Tons Beets Per Acre	Sucrose
1323	SL 9090M1 x SL 824	109	107	103
E 22	SL 9090M1 x C-51-1	116	110	105
E 26	SL 9090M1 x N 50	110	109	101
E 27	SL 9090M1 x TF 50	108	108	100
U. S. 22/3—Commercial Check		7,774 lbs.	25.72 tons	16.38%

In all cases the hybrids shown in Table 3 are superior to the commercial variety U. S. 22/3. The increased yield of each hybrid over U. S. 22/3 indicates that effective hybridization took place between the respective

parents. The higher sucrose contents of 132.S and E22 in which high sugar pollen parents were used is further evidence that hybridization was effective.

Table 4.—Comparison of Hybrids 2323 and E21 with Their Respective Parents for Gross Sugar per Acre, Tonnage, and Percent Sucrose.

		Gross Sugar		Root Yield		Sucrose	
Strain	Pedigree	Lbs. per Acre	% of M.P.[1]	Tons per Acre	% of M.P.	%	% of M.P.
2323	SL 9090M1 x 824	9,016	125	26.18	125	17.22	100
SL 9090M1	MS of C19	7,001	97	20.75	99	16.87	98
824	High Sugar Variety	7,415	103	21.21	101	17.48	102
E 21	SL 9090M1 x A2-19.2	8,328	125	24.18	123	17.22	101
SL 9090M1	MS of C19	7,042	105	21.06	107	16.72	98
A2-19.2	Inbred Pollinator	6,323	95	18.20	93	17.37	102
Diff. Req. for Sig. (19:1)		1,035		3.16		.45	

[1] M.P. = Mid Parent = $\frac{(P1 + P2)}{2}$

Table 4 shows a comparison of hybrids 2323 and E21 with their respective parents for gross sugar per acre, tonnage and percent sucrose. Both hybrids show a substantial increase over their parents in gross sugar and tons of beets per acre. The sucrose content of the hybrids is approximately the same as their mid-parents $\frac{(P1 + P2)}{2}$. This is in agreement with the observations of others (2, 5) and further demonstrates that the sugar content of hybrids is generally equal to the mean of their respective parents. Again, the fact that the sugar content of the hybrids is approximately equal to the mean sugar content of their parents indicates that effective crossing took place in the seed field.

Discussion

Since the male sterile seed parents SL 9090M1 and SL 9031Ml carry the Sf gene it may be assumed that viable pollen produced from semi-male sterile and fertile plants within these strains would result in a proportionate amount of sib- and self-pollination with a corresponding reduction in the amount of hybridization between the male sterile seed parents and the respective pollen parents. The data show, however, that the differences between rogued and non-rogued hybrids are small and not statistically significant. Furthermore, all non-rogued crosses made with SL 9090M1 as the seed parent exceeded the commercial variety U. S. 22/3 in gross sugar and tons of beets per acre. In cases where higher sugar pollen parents were used the sucrose content of the hybrids was approximately equal to the average sucrose content of the parents, which indicates that hybridization was effective.

Jt would appear that the number of semi-male sterile and fertile plants present in SL 9090M1 is not sufficient to adversely affect hybridization or yield of the resulting hybrids. Either very little viable pollen was liberated by the semi-male sterile plants or the resulting self- and sib-pollinated seed was unable to compete with the hybrid seed under field conditions.

The results obtained indicate that male sterile strains which possess a degree of male sterility similar to that of SL 9090M1 could be used as female parents for commercial hybrid seed production if the necessary amounts of stock seed could be produced without significantly changing the degree of male sterility. It would seem that, for the present time at least, the commercial production of top cross varieties is feasible and that the resulting hybrid seed would be acceptable by present standards of varietal performance.

Summary

1. The relative performance of two rogued and two non-rogued hybrids (top crosses) and six selected non rogued hybrids are reported.

2. Differences between rogued and non-rogued hybrids of the same pedigree were small and not significant.

3. All non-rogued hybrids were superior to the commercial variety U. S. 22/3 with respect to root yields and gross sugar per acre. The general increase in root yields together with a higher sucrose content for hybrids in which high sugar pollen parents were used indicates that hybridization was effective between the respective parents.

4. Utilization of the better currently available male sterile strains for commercial production of hybrid and top cross varieties appears to be feasible.

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