

Breeding for Resistance to Curly Top in Hybrids With Monogerm Beets

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Introduction

The original parental monogerm plants, SLC 101 and SLC 107, were derived from the curly-top-susceptible variety Michigan Hybrid 18. Therefore, it was not expected that these monogerm beets would show curly-top resistance.

Experimental Methods

To obtain monogerm curly-top-resistant varieties, the first monogerm beets (SLC 101 and SLC 107) were crossed to the multigerm curly-top-resistant self-sterile strains SL 92, SL 824, SL 88-3 and SL 941 furnished by Dr. F. V. Owen, and to the non-bolting variety U. S. 75 furnished by Dr. J. S. McFarlane. SL 92, a selection from the widely grown commercial variety U. S. 22/3, represents the very highest degree of curly-top resistance. SL 824, also known as U. S. 35/2, is a high-sugar type also selected from U. S. 22/3. SL 88-3 and SL 941 represent hybrids between U. S. 22/3 and the sugar-type variety U. S. 35. The non-bolting variety U. S. 75 was developed from two successive selections from U. S. 22/3.

F₁ seed was produced by bagging the plants of self-sterile curly-top-resistant varieties and pollinating them with pollen from monogerm beets. In order to speed up the breeding program, F₁ seed was produced in the greenhouse at Salt Lake City during the spring of 1949. Through the courtesy of Vernal Jensen, F₂ hybrids and most of the backcross populations were produced in the Amalgamated Sugar Company greenhouse at Ogden, Utah, and ripe seed was harvested in early June, 1950.

Study and selection of hybrids in 56 F₁, F₂ and backcross (b₁) populations were conducted in a special nursery during the summer of 1950 and 1951 at Jerome, Idaho. Each hybrid was planted in a single row 480 feet long. The curly-top exposure was increased by planting these hybrid populations in June and also by the procedure worked out in the beet breeding field whereby plantings were made adjacent to susceptible beets planted about two months earlier. The field in which this work was done bordered the semi-desert weed areas which harbor the beet leafhopper. Virulent strains of the curly-top virus were introduced by transplanting diseased beets from the previous year. When the seedlings emerged from the test plantings the older susceptible beets were already showing severe curly-top symptoms. These older beets also served as a host for new generations of virus-bearing beet leafhoppers. The late planting of the hybrid populations in this environment provided a very effective method for selecting for curly-top resistance. In September an appraisal of curly-top resistance was made for each population of beets and expressed as a curly-top grade recorded with a range of one to five. Selections from the plantings were made in November.

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Experimental Results

Resistance to Curly Top in Parents

During the two years of the experiment, SLC 101 showed only a low degree of resistance to curly top (Table 1). The original variety Michigan Hybrid 18, in which SLC was found, was still more susceptible and, in fact, was as susceptible as any European variety tested.

Table 1.—Curly-top Resistance of the Monogerm Beet SLC 101 Compared with F₂ Populations, Backcross Populations and Different Sugar-Beet Varieties.

Variety	Year	Average curly-top grade ¹	Percent of plants with curly-top grades, ² as follows:				
			1	2	3	4	5
Monogerm SLC 101	1950	4.15	....	....	19	46	35
Monogerm SLC 101	1951	4.31	....	....	8	54	38
Mich. Hybrid 18	1950	4.84	....	....	....	17	83
Klein E., SL 1-300	1950	4.84	....	....	7	33	60
Klein E., SL 1-300	1951	4.42	....	....	8	42	50
US 33, SL 333	1950	3.97	....	....	26	49	25
US 33, SL 333	1951	3.60	....	....	36	36	24
US 35/2, SI. 824	1950	2.00	16	72	8	4	....
SL 92	1950	1.86	30	56	12	2	....
SL 92	1951	1.64	50	38	10	2	....
F₂ Populations derived from SL 92 x Monogerm SLC 101							
F ₂ open pollinated	1950	2.40	6	64	16	12	2
F ₂ open pollinated	1951	2.34	18	40	34	6	2
F ₂ self-pollinated	1951	2.30	14	26	22	24	14
Backcross populations							
SL 92 x (SL 92 x SLC 101)	1950	2.36	10	66	2	22	....
SL 92 x (SL 92 x SLC 101)	1951	2.06	24	48	22	4	2
SL 824 x (SL 92 x SLC 101)	1950	2.22	14	62	12	12	....
SI. 824 x (SL 92 x SLC 101)	1951	2.16	28	40	20	8	4
SLC 101 x (SI. 92 x SLC 101)	1951	3.74	....	2	20	44	34

Curly-top grades: 1—plants showing very little infection
 2—plants showing slight curling
 3—plants showing pronounced curling and some dwarfing
 4—plants showing pronounced curling and dwarfing
 5—plants near death from the disease

First Hybrid Generation F₁

Hybridization of the monogerm beet SLC 101 with curly-top-resistant varieties increased the resistance in the F₁ hybrids as compared with the susceptible parent. A similar increase in resistance was observed in triple hybrids derived from backcrosses of the curly-top-resistant varieties to F₁ hybrids between the two susceptible varieties, the mangel or fodder beet and SLC 101 (Table 2).

F₂ Generation

F₂ hybrids between curly-top-resistant varieties and the monogerm SLC 101 showed a higher degree of curly-top resistance than SLC 101 (Table 1). F₂ populations, as expected, were not uniform with respect to curly-top resistance when compared with F₁ hybrids. The number of plants in extreme classes was higher in F₂ populations because of segregation. Both curly-top-resistant and curly-top-susceptible plants appeared in the F₂ populations. Table 1 shows that the resistance to curly top in open-pollinated F₂ populations did not decrease as compared to that in populations obtained from selfing. In the open-pollinated populations some hundreds of F₁ plants, derived from crosses to many unrelated curly-top-resistant plants with SLC 101, were propagated together.

First Backcross Generation

Hybrids in the first backcross generation derived from recurrent crosses of F_1 hybrids to curly-top-resistant varieties showed very good resistance to curly top (Table 1). High resistance to curly top was also maintained in backcross populations when different curly-top-resistant varieties were involved in the first and second hybridization. In both cases there were very few severely injured plants. On the other hand, when SLC 101 was used as a recurrent parent in the backcross operation, only a small percentage of plants showed definite curly-top resistance.

Table 2.—Curly-top Resistance in SLC 101, SL 92 and the Backcross involving a Hybrid to Mangel or Fodder Beet.

Variety	Year	Average curly-top grade	Percent of plants with curly-top grades, as follows:				
			1	2	3	4	5
Monogerm SLC 101	1951	4.31	....	...	8	54	38
SL 824 x F_1 (Mangel x SLC 101)	1951	2.86	6	24	50	18	2
SL 92	1951	1.64	50	38	10	2	....

Reselections for Curly-Top Resistance

Severe infection of F_2 plants at Jerome, Idaho, made it possible to conduct very rigid selection work. A total of 1,212 of the most resistant and vigorous plants in 43 F_2 hybrid populations was selected in 1950. The best of these beets were replanted in the greenhouse at Salt Lake City. The remaining were planted in the spring in a field isolation. Only a few monogerm segregates were recovered from these F_2 populations. From 1,212 plants only 69 (5.6 percent) appeared to be monogerm. In populations grown from the same F_2 families without curly-top exposure and selection, the expected 3:1 ratios were obtained for multigerm and monogerm segre-

Table 3.—Seedling Color in F_3 Lines.

	F_2 Genotypes Determined from F_3 Segregations			Total
	RR	Rr	rr	
Number of lines	14	13	2	29
Percent observed	48.27	44.83	6.89	100
Percent expected	25	50	25	100

gates. The deficiency in monogerm plants after selection for curly-top resistance may have been caused in a significant degree by the death of replants with white hypocotyl color and also the Rr heterozygotes (Table 3). To obtain authentic hybrids, curly-top-resistant rr plants were always used as female parents and pollinated with the pollen of the monogerm SLC 101, which is homozygous RR for red hypocotyl color.

It can be assumed that, because of the severe exposure of F_2 hybrids to curly top at Jerome, Idaho, the newly selected monogerm races would manifest a high degree of curly-top resistance. One of the new monogerm lines, SLC 175, and an F_1 hybrid between this line and the curly-top-resistant variety SL 824, showed high curly-top resistance in greenhouse tests conducted by Dr. N. J. Giddings in the fall of 1951. This material, which represents a combination of curly-top resistance with the monogerm character, will facilitate further breeding work for development of monogerm varieties suitable for use in areas subjected to curly-top damage.