PROGRESS REPORT ON THE DEVELOPMENT OF MONOGERM, TYPE-O, LEAF SPOT RESISTANT, INBRED LINES OF SUGARBEET 1/

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The unique potential value of type-O sugarbeet lines is due to their ability to produce male sterile progenies when used as pollinators of cytoplasmic male sterile plants. Thus, the male sterile equivalent of a given type-O line can be produced by backcrossing and subsequently used in the production of commercial hybrids. The development of monogerm, type-O, inbred lines possessing a high degree of leaf spot resistance and other desirable characters has been a major undertaking at the Fort Collins station for several years. Progress to date has been encouraging, and the results of agronomic evaluation tests in 1962 are presented as preliminary indications of achievements which reasonably may be expected.

Material and Methods

The monogerm line, SLC 101, introduced by V. F. Savitsky (3) 3/, served as the basic source of the monogerm gene. Monogerm lines derived from crosses between SLC 101 and leaf spot resistant multigerm types actually were used as the source material at Fort Collins. Some of those lines were obtained from Dr. Savitsky and most of the others were furnished by Dewey Stewart (4). The lines supplied by the latter included the class designated "SP 51101-" and also material from which the earliest type-O lines (designated "F.C. type-O") were derived at Fort Collins. The multigerm line US 201 4/ was used in a number of crosses in an attempt to combine monogerm and type-O characters with a higher degree of leaf spot resistance.

Techniques for isolation of type-O lines were similar to those described by F. V. Owen (2), except that biennial-type male sterile plants were used, instead of annuals, as the source of cytoplasmic male sterility. Prompt flowering of hybrid populations for anther classification purposes was obtained by means of the seedling induction technique previously described (1).

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2/ Plant Pathologist, U. S. Dept. of Agriculture, Ft. Collins, Colo. Assistance of Joseph A. Elder and Luther W. Lawson, Agricultural Research Technicians, in conducting the experimental work, is acknowledged.

3/ Numbers in parentheses refer to Literature Cited.

4/ Dewey Stewart, unpublished.

Observational tests of new type-O material, in field plots where severe leaf spot exposure had been developed artificially, were used to identify the more resistant lines. Such lines were increased in greenhouse or field isolation plots. In each isolation plot, plants of the corresponding male sterile material were included in order to produce the next generation in the process of developing the male sterile equivalent. Successive steps in this process are the F_1, B_1, B_2, ...B_n. Several backcrosses are considered desirable. However, in order to obtain preliminary indications as to combining ability, a number of crosses were made in 1961, using B_1 male sterile lines, principally, as the females. The multigerm, leaf spot, blackroot resistant variety SP 5481-0 was used as the sole pollinator in a seed plot in which seven male sterile lines occurred. The curly top resistant, multigerm hybrid, SL 932 (CT5 x CT9), served as the pollinator in a similar seed plot. Pollinators occurring in seed plots having smaller numbers of male sterile lines included the following: SP 601153HO, a monogerm variety resistant to leaf spot and blackroot, and SP 601161HO, a leaf spot resistant, multigerm variety with fair resistance to curly top. Male fertile plants, if any, were rogued in all lines serving as females, in order to insure hybridization.

Type-O inbred lines were compared under relatively severe leaf spot exposure on the Hospital Farm at Fort Collins in 1962. Plots were three rows wide and 24 feet long. Rows were 20 inches apart. The number of plots for individual entries ranged from one to three, depending on seed supplies. A low percentage of contaminants occurred in some lines as a result of stray pollen in the seed increase plots. The majority of such plants were rogued at thinning time on the basis of hypocotyl color, and any obvious outcrosses remaining in the plots in the fall were eliminated before harvest. Accurately measured lengths of row with satisfactory stand, totaling about 19 feet per plot, were harvested for record. With minor exceptions, the harvested area was confined to the middle row. All roots from the harvested portion of each plot were topped, washed, weighed, and rasped for sucrose determination. Planting and harvest were performed on April 25 and September 24, respectively.

A top-cross test was conducted in 1962 in the same field as the inbred test, under severe leaf spot exposure. Plots were 1 row (20 inches) in width and 24 feet long. Randomized-block design was used, with 8 replications. The crop was planted on April 24 and harvested on October 2. Except for a few cases where minor plot size adjustments were required because of gaps in stand, all roots in 20 feet of row per plot were topped, washed, weighed, and rasped for sucrose analysis.

Results

The summarized results for the inbred test are presented in Table 1. Because of the variation in number of plots per strain, generalized LSD values were not computed. However, for sucrose percentage, LSD values (5-percent point) are 1.02 for comparisons between 2-plot averages and 0.83 for 3-plot averages. Thus, it is evident that highly significant differences in sucrose percentage occurred among the type-0 lines and that some of them were significantly above the multigerm variety SP 5481-0. Two distinct lines in this category (FC 502 and SP 581194s1) were essentially equal to US 201 in leaf spot resistance. As expected, the type-0 lines varied greatly in yield of roots and gross sucrose. Surprisingly, some of them were about equal to or closely approached SP 5481-0 in those attributes.

The results of the top-cross test are given in Table 2. Comparison of the SP hybrids with standards such as SP 5481-0 (entry No.701) and SL 122 MS x SP 5460-0 (entries 722 and 723) indicates that certain of the type-0 lines are quite promising in combining ability and worthy of further refinement and evaluation -- e.g. FC 502, SP 571702-0, SP 581194s1 and possibly others. Performance of the monogerm hybrid, FC 502 MS x SP 5481-0 (entry No.706), may be of special interest to those concerned with the control of both leaf spot and blackroot. That hybrid was equal to SP 5481-0 in leaf spot resistance and significantly exceeded that variety, and also entries 722 and 723, in sucrose percentage and in yield of roots and gross sucrose. Blackroot was not a factor in this test. However, the ♂ parent of entry 706 (i.e. SP 5481-0) is known to be relatively high in blackroot resistance.

A monogerm hybrid that would be of interest where both leaf spot and curly top are factors is SP 571702-0 MS x SL 932 (entry 713). In the top-cross test, that hybrid was at least equal to the leaf spot - curly top resistant hybrid, SL 122 MS x SP 5460-0 (entries 722 and 723), in leaf spot resistance and exceeded it by highly significant amounts in sucrose percentage, in yield of roots, and in yield of gross sucrose. The difference in gross sucrose yield was quite substantial, entry 713 exceeding the average of 722 and 723 by 31 percent. Curly top was not a factor in the top-cross test, but the ♂ parent of entry 713 is known to have high curly top resistance.

Discussion

Since yield data for inbred lines generally are regarded as poor indicators of combining ability, the value of the harvest results for the inbred test probably is confined largely to information regarding sucrose percentages. With the wide variation among lines in that respect, it appears that the results can be used profitably as a means of focusing future efforts on the more promising material.

The results of the top-cross test should be appraised with caution for several reasons. In the first place, the ♀ parents of most of the SP hybrids had reached only the B_1 stage in the development of male sterile equivalents of the respective type-O lines at the time the crosses were made. Consequently, those parents must not be considered as closely approaching actual equivalency. Secondly, the use of single-row plots and the presence of leaf spot probably tended to magnify differences between certain types of material. Furthermore, it should be recognized that, under greenhouse conditions favorable for pollen production, a low percentage of intermediate type plants can be found in the so-called "male sterile equivalents" of most of the type-O lines involved in the top-cross test. The importance of this degree of imperfection in the production of hybrid seed in the field has not been determined with respect to the material in the current study. Intermediate type plants produce relatively little pollen in the greenhouse and may produce less, or none at all, in the field. In this connection it is noteworthy that FC 502 appears to be free of this imperfection. Work currently is under way in an attempt to eliminate that flaw from other promising type-O lines.

In conclusion, it may be said that results obtained in field tests in 1962 indicated that substantial progress had been made toward the development of monogerm, type-O, leaf spot resistant inbred lines with good sucrose percentage and combining ability. Additional evaluation work will be required for confirmation of this conclusion. The 1962 results also will make it possible to focus attention on the more promising lines as a means of expediting further progress.

Summary

The development of monogerm, type-O, inbred lines of sugarbeet possessing a high degree of leaf spot resistance and other desirable characters has been a major objective at Fort Collins, Colo., for several years.

Results of field tests conducted in 1962 under leaf spot exposure indicated that substantial progress had been made toward that objective. Two distinct, monogerm, type-O inbreds were essentially equal to US 201 in leaf spot resistance and significantly above the multigerm commercial variety, SP 5481-O, in sucrose percentage. The B_1 male sterile phase of one of those inbreds (FC 502), when pollinated by SP 5481-O, produced a hybrid that equaled SP 5481-O in leaf spot resistance and significantly exceeded it in sucrose percentage and in yield of roots and gross sucrose. The differences in sucrose percentage and gross sucrose yield were highly significant, and the latter difference represented an increase of 17 percent over the gross sucrose yield of SP 5481-O.

Literature Cited

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Table 1. -- Comparison of monogerm inbred lines of sugarbeet, Fort Collins, Colo., 1962

Description or source	Strain a/ designation	Gen. of self.	Hypo. b/ color	Current seed no.	Entry no.	Plots	Acre yield: Gross sucr.	Roots	Sucrose	Leaf spot c/ 8/4	Leaf spot c/ 8/24	Fol. d/ vig. 8/24	Stand (per 100')	Crown e/ height
		No.				No.	Lbs.	Tons	Pct.					No.
Type-O, monogerm, leaf spot resistant inbreds														
US 201 (MM)x SP 51101-(mm)	FC 501	2	rr	SP 611162HO	801	1	983	4.03	12.20	1.0	1.0	6.0	110	7.0
US 201 (MM)x SP 51101-(mm)	SP 592087sl	2	R,r	SP 611154HO	802	2	1901	6.82	13.93	1.8	1.8	6.0	126	5.0
US 201 (MM)x SP 51101-(mm)	SP 592084sl	2	R,r	SP 611155HO	803	2	1313	4.84	13.58	1.0	1.3	5.0	105	7.0
US 201 (MM)x SP 51101-(mm)	SP 592018sl	3	rr	SP 611156HO	804	2	1208	5.13	11.75	1.8	1.8	4.5	125	6.0
US 201 (MM)x V.F.S. 715 (mm)	FC 502 (a)	1	rr	SP 611215HO	805	2	2527	8.36	15.10	1.0	1.0	4.5	109	5.0
Sub-line of FC 502	SP 602008sl (a)	2	rr	SP 621155HOA	806	2	3160	9.95	15.90	1.0	1.0	4.5	114	5.0
US 201 (MM) x F.C. type-O(mm)	SP 592124sl	4	rr	SP 621152HO	807	2	883	3.97	11.13	1.0	1.3	6.5	116	7.0
US 201 (MM) x F.C. type-O(mm)	SP 571333sl (b)	3	rr	SP 621151HO	808	2	1050	4.34	12.05	1.0	1.5	6.5	109	6.0
US 201 (MM) x F.C. type-O(mm)	SP 592023sl (b)	4	rr	SP 621153HO	809	2	1094	4.23	12.90	1.0	1.5	7.0	126	7.0
US 201 (MM) x F.C. type-O(mm)	SP 592175sl	4	rr	SP 611204HO	810	2	1194	4.83	12.33	1.0	0.5	7.0	120	6.0
US 201 (MM) x F.C. type-O(mm)	SP 592175sl	4	rr	SP 621154HO	811	2	1311	5.33	12.20	1.0	0.5	6.5	113	5.0
US 201 (MM) x F.C. type-O(mm)	SP 592060sl (c)	2	rr	SP 611205HO	812	1	1723	6.38	13.50	1.5	2.5	6.0	114	5.0
US 201 (MM) x F.C. type-O(mm)	SP 592102sl (c)	2	rr	SP 611160HO	813	2	1262	4.72	13.40	1.3	2.0	4.5	125	4.8
US 201 (MM) x F.C. type-O(mm)	SP 592039sl	2	rr	SP 611207HO	814	1	1272	5.11	12.45	1.5	2.0	4.0	115	5.0
US 201 (MM) x F.C. type-O(mm)	SP 581194sl	1	rr	SP 611216HO	815	3	2541	8.59	14.77	1.5	1.2	5.7	109	4.7
US 201 (MM) x F.C. type-O(mm)	SP 581220sl	1	rr	SP 611214HO	816	2	2298	7.92	14.50	1.8	1.8	5.0	111	5.0
Sub-line of SP 571702-0	SP 592162sl (d)	2+	RR	SP 611161HO	817	2	2347	8.09	14.50	1.3	1.5	5.5	107	4.8
Derived by selfing V.F.S. 716	SP 571702-0 (d)	1+	RR	SP 611211HO	818	3	2341	8.37	13.97	1.5	1.8	5.7	115	5.0
Derived by selfing V.F.S. 6-2	SP 592000sl (e)	2+	RR	SP 611208HO	819	3	2294	8.60	13.33	1.5	1.5	5.7	110	6.0
Derived by selfing V.F.S. 6-2	SP 592013sl (e)	2+	rr	SP 611209HO	820	3	2955	10.89	13.55	1.2	1.0	5.7	115	6.2
Derived by selfing V.F.S. 6-2	SP 592057sl (e)	2+	R,r	SP 611210HO	821	3	1910	7.64	12.50	1.8	1.8	4.7	118	6.3
SP 541201-00 (mm syn. var.)	SP 592063sl	4	rr	SP 611159HO	822	2	1824	7.20	12.65	2.0	2.0	4.5	116	4.0
Non-type-O, monogerm, leaf spot resistant inbred (fertility restorer type +)														
SP 5832-0 (mm LS-BR res.)	SP 592114sl	1	rr	SP 611000-0	823	3	1635	6.11	13.35	2.2	1.8	5.7	114	6.0

(Table 1 is continued on the next page.)

Strains included as standards

LSR inbred (MM)	US 201	SP 581001-0	824	3	2020	7.09	14.23	1.2	1.2	6.3	108	
LS-BR res. var. (MM)	SP 5481-0	Acc. 2483	825	3	2983	10.71	13.93	2.3	2.5	7.3	118	
European LSS (MM)	Syn. Ck.	Acc. 2269	826	3	2989	11.02	13.57	4.0	4.5	5.7	112	
LS-BR res. var. (mm)	SP 5831-0	Acc. 2233	827	3	2806	9.99	14.03	2.7	2.7	7.0	117	
Type-O inbr.; good sucr. w/o LS expos. (mm)	SP 561609-0	SP 601209HO	828	3	2560	9.31	13.73	4.0	4.3	4.0	118	5.0

a/ The strain number given for any inbred line represents the latest selfed generation or a subsequent increase. Strains derived, directly or indirectly, from the progeny obtained by selfing the same F_2 root are designated by identical letters in parentheses.

b/ Hypocotyl color: RR=homozygous red; rr=homozygous non-red; R,r=segregating.

c/ Basis of leaf spot readings: 0=no leaf spot; 10=complete defoliation.

d/ Foliage vigor; Larger no.=greater vigor.

e/ Crown height: Larger no.=higher crowns.

Table 2. -- Sugarbeet top-cross test, Fort Collins, Colo., 1962; results given as 8-plot averages.

Description	Ft. Collins seed no.	Entry no.	Acre yield: Gross Sucrose	Acre yield: Roots	Acre yield: Sucrose	Leaf spot a/: 8/7	Leaf spot a/: 8/23-24	Vig. b/: 8/23-24	Stand (hills per 100): No.	Bolters: Pct.
			Lbs.	Tons	Pct.					
SP 5481-0 (EL-1023) MM	Acc. 2483	701	3980	13.23	15.04	2.7	2.9	6.0	113.8	0.00
MS (B_1) of SP 571702-0 mm x SP 5481-0 MM	SP 611218H01	702	3960	12.88	15.38	3.4	3.6	6.4	115.4	0.50
MS (B_1) of FC 501 mm x SP 5481-0 MM	SP 611218H02	703	3617	11.99	15.07	2.8	2.7	6.6	119.4	0.00
MS (B_1) of SP 571333sl mm x SP 5481-0 MM	SP 611218H03	704	4528	14.65	15.44	3.2	2.9	6.3	115.6	1.60
MS (B_1) of SP 581220sl mm x SP 5481-0 MM	SP 611218H04	705	3873	12.70	15.24	3.4	3.7	5.5	118.1	0.00
MS (B_1) of FC 502 mm x SP 5481-0 MM	SP 611218H05	706	4659	14.47	16.09	2.9	2.8	6.1	115.9	1.86
MS (B_1) of SP 581194sl mm x SP 5481-0 MM	SP 611218H06	707	4322	13.55	15.95	2.4	2.5	6.4	114.4	1.16
MS (B_1) of SP 561609-0 mm x SP 5481-0 MM	SP 611218H07	708	4352	13.63	15.96	3.4	3.6	5.8	112.5	1.16
SP 601153H0 (SP 591101-0) mm	SP 611219H0	709	3976	12.92	15.39	2.5	2.1	5.9	117.5	0.00
MS (B_1) of SP 571702-0 mm x SP 601153H0 mm	SP 611219H01	710	4651	14.70	15.83	2.4	2.1	6.6	116.3	0.00
MS (B_1) of FC 501 mm x SP 601153H0 mm	SP 611219H02	711	3929	12.85	15.27	2.3	2.4	6.1	113.3	0.00
MS (B_3) of SP 561609-0 mm x SP 601153H0 mm	SP 611219H03	712	3593	11.00	16.34	3.8	3.9	5.3	116.3	0.00
MS (B_1) of SP 571702-0 mm x SL 932 MM	SP 611220H01	713	4979	15.48	16.08	3.4	3.3	6.0	116.3	0.00
MS (B_1+) of FC 501 mm x SL 932 MM	SP 611220H02	714	3978	12.86	15.47	3.0	3.3	5.3	112.1	0.00
MS (B_1) of SP 571333sl mm x SL 932 MM	SP 611220H03	715	3754	12.11	15.49	3.2	3.9	5.6	113.6	0.00
MS (B_1) of SP 581220sl mm x SL 932 MM	SP 611220H04	716	4089	12.63	16.18	3.9	4.3	5.0	113.1	0.00
MS (B_1) of SP 581194sl mm x SL 932 MM	SP 611220H06	717	4492	13.59	16.54	3.4	3.9	5.4	119.4	0.00
MS (B_3) of SP 561609-0 mm x SL 932 MM	SP 611220H07	718	4015	11.99	16.73	3.9	5.1	4.1	117.1	0.00
SP 601161H0 (SP 581817-00) MM	SP 611221H0	719	4073	12.88	15.82	2.7	2.1	6.3	112.1	0.54
MS (B_3) of SP 561609-0 mm x SP 601161H0 MM	SP 611221H01	720	4165	12.73	16.35	3.5	3.5	5.6	111.8	0.63
MS (B_2) of SP 571702-0 mm x SP 601161H0 MM	SP 611221H02	721	4889	15.26	16.02	2.8	2.4	6.9	110.3	0.00
NM1 (SL 122 MS mm x SP 5460-0 MM)	Acc. 2480	722	3749	12.16	15.42	3.4	3.6	5.6	114.4	0.00
M.S.C. Lot 1055 (SL 122 MS mm x SP 5460-0 MM)	Acc. 2286	723	3865	12.33	15.68	3.6	3.6	5.9	112.9	0.00
US H2 (063H1) MM	Acc. 2482	724	3455	11.36	15.21	3.6	4.7	4.6	114.4	0.00
General mean			4122.48	13.0815	15.7494				114.82	
SE of entry mean as % of gen. mean			3.00	2.98	0.77				1.92	
LSD (5% point)			346	1.09	0.34				NS	
LSD (1% point)			457	1.44	0.45				NS	

a/ Basis of leaf spot readings: 0 = no leaf spot; 10 = complete defoliation. b/ Foliage vigor: Larger no. = greater vigor.