Interaction of Components of Impurity and Location in Hybrids from Inbred Lines of Sugar Beets

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The inbred CT9 (6)[2], a curly-top resistant self-fertile line of sugar beets developed by the U. S. Department of Agriculture, is now recognized as a valuable component in the parentage of commercial hybrid sugar beets. CT9 hybrids are usually higher in sugar percentage than one would expect from analyses of the CT9 inbred beets grown under similar conditions. Hybrids with CT9 are sometimes exceptionally high in purity (7, 8). Chemical analyses of roots of six different hybrids grown at Twin Falls, Idaho, and at Salt Lake City, Utah, help to explain why CT9 hybrids may be exceptionally high in purity at one location but not at another.

Materials and Methods

Hybrid combinations were made between two types of male-steriles as female parents and six curly-top resistant inbreds as pollinators. One male-sterile, 211H3, was the cytoplasmic type (4), considered the equivalent of commercial variety US 22/3, and will be designated US 22 MS. The second source of male-sterility was a Mendelian type (5) designated US 35 *aa*, where *a* represents the recessive gene for abortion of pollen. US 22 is a yield-type curly-top resistant variety, whereas US 35 is a sugar-type curly-top resistant variety.

Five of the six pollinators (CT9, CT7, 289, 5030 and 5060) were self-fertile inbreds. Each line had been selfed two to five generations. Line CT9 was from a new source, sometimes indicated with the designation "New CT9," which carries a higher degree of curly-top resistance than the original. The sixth pollinator, SL 50, was a composite population consisting of a group of curly-top resistant, self-fertile lines selected for high sugar percentage.

The hybrids were grown in field plots at two locations, Salt Lake City, Utah, on Taylorsville loam type, heavy phase (3), and Twin Falls, Idaho, on soil type classified as Portneuf silt

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[2] Numbers in parentheses refer to literature cited.

Table 1.—Variance Analyses.

Source of Variation	Degrees of Freedom	Mean Squares for: Acre Yield: Gross Sugar Lbs. 10,000	Acre Yield: Tons Beets	Chemical Analyses: Sugar Percent	Chemical Analyses: Purity Percent	Chemical Analyses: Na, ppm 100	Chemical Analyses: K, ppm 100	Chemical Analyses: Amino N, ppm 10,000	Significant F Values: 5% Point	Significant F Values: 1% Point
Locations	1	8568[2]	1,262.22[2]	126.04[2]	147.76[2]	32,893[2]	153,200[2]	2678	5.99	13.74
Blocks within locations (Error a)	6	195	69.33	1.33	7.09	706	3,899	325		
Females	1	8	0.00	1.66	0.65	1,298[2]	163	120	5.99	13.74
Females × locations	1	28	4.05	0.70	1.28	396	41	1	5.99	13.74
Error b	6	56	24.09	0.86	3.09	84	504	243		
Pollinators	5	109[2]	76.47[2]	3.72[2]	3.12	631	3,049[2]	227[2]	2.37	3.34
Pollinators × locations	5	28	9.80	0.44	4.45[2]	160[1]	434	15	2.37	3.34
Pollinators × females	5	24	3.96	0.21	0.81	30	440	33	2.37	3.34
Pollinators × females × locations	5	13	7.99	0.22	2.21	17	107	32	2.37	3.34
Error c	60	15	5.46	0.27	1.03	49	284	28		
Total	95									

[1] = Significant at 5% point
[2] = Significant at 1% point

these two mean squares include variability for the conspicuous pollinator × location interactions. The pollinator × location interactions were significant for both purity and Na content.

Averages for locations, females and pollinators, are shown in Table 2. Averages for pollinators at each location are shown in Table 3. All hybrids took up more Na at Salt Lake City than at Twin Falls, Idaho, but the CT9 hybrids took up more than any of the other hybrids. There was a tendency for the same with K but the interaction for pollinators × locations (Table 1) was not significant. The SL 50 hybrids behaved somewhat like the CT9 hybrids. The CT7 and 289 hybrids with their low Na and K but very high amino N content were decidedly different. The chemical analyses for all hybrids are in line with analyses of the respective inbreds which were used as pollinators in production of the hybrids (8). Hybrids of 5060 showed the highest purity, 88.3 at Salt Lake City, but this does not represent a statistically significant superiority compared with the other hybrids. Comparing the two types of female parentage (Table 2) one observes that the tonnages of the respective hybrids were exactly the same, but higher sugar and lower Na were observed from the US 35 *aa* hybrids.

Table 2.—Average Yields and Analyses of Hybrids Summarized for Pollinators, Female Parents, and Locations.

Parentage and Location	Acre Yield: Gross Sugar Pounds	Acre Yield: Tons Beets	Sugar Percent	Purity Percent	Na ppm	K ppm	Amino N ppm	Beets per 100 Feet of Row
			Female parents combined, means of 16 plots					
Pollinator								
CT9	10,586	32.1	16.45	89.3	442	2545	3275	93
CT7	9,976	28.8	17.27	88.4	265	2348	4100	95
5030	9,566	27.4	16.87	88.1	335	2460	3825	94
5060	9,916	28.3	17.40	88.8	335	2538	3700	94
289	9,088	25.4	17.80	88.5	310	2190	4325	90
SL 50	9,822	28.8	16.88	88.2	392	2512	3650	84
LSD 5%	387	2.33	1.65	1.02	70	169	532	
			Pollinators combined, means of 48 plots					
Female parent								
US 22 MS	9,734	28.5	16.98	88.5	383	2446	3708	93
US 35 *aa*	9,850	28.5	17.24	88.6	310	2418	3917	91
			Genotypes combined, means of 48 plots at each location					
Location								
Twin Falls, Idaho	11,682	32.1	18.26	89.8	162	2033	4333	93
Salt Lake City, Utah	7,904	24.8	15.97	87.3	532	2830	3292	90

Normally one expects the highest purity to be associated with the highest sugar percentage but this was not true in the test at Twin Falls, Idaho. The CT9 hybrids with 91.2% purity were significantly higher in purity than any of the other hybrids while the average sugar percentage, 17.85%, was lowest of all hybrids.

Discussion

The three chemical determinations, amino N, Na, and K, representing some of the components of impurity or soluble non-sugar constituents in sugar beets, were chosen for the investigations because of their ease and accuracy of determination, and because they are representative of the major impurities with which the sugar processor is obliged to deal. The amino N measurement is considered an index to the total quantity of objectionable or soluble N because it has been shown to be highly correlated with total N and total soluble N (2, 7, 9). Inorganic salts constitute the other major component of impurity. Determinations additional to Na and K would probably be helpful, but Na and K at least give some index to the total quantity of inorganic salts present.

Under an environment such as that at Twin Falls, Idaho, where amino N appears to have been the major contributor to impurity, one would expect varieties low in amino N, like the CT9 hybrids, to be low in total impurities. To explain the fact that similar results were not obtained at Salt Lake City with CT9 hybrids requires consideration of other impurities consisting of inorganic salts represented by the Na and K measurements. The CT9 hybrids on the more saline soil at Salt Lake City were high (Table 3) in sodium and potassium. The authors assume, therefore, that when the salt content of the soil is high the CT9 hybrids may be expected to have less advantage in purity. If an inbred could be developed that would produce hybrids low in root sodium and potassium, similar to CT7 hybrids, and also low in amino N like the CT9 hybrids, then such varieties might have the advantage of higher purity at both locations. Promising studies of such a hybrid are now in progress.

Summary

Twelve hybrids, obtained by the use of six pollinators in combination with two types of male sterility, were grown in replicated plots at two locations: Twin Falls, Idaho, and Salt Lake City, Utah. Root yields were recorded and root analyses were made for sugar, purity, Na, K, and amino N. The most productive hybrids were obtained with the inbred CT9 as the

Table 3.—Means by Locations and Pollinators, and Differences Between Locations.

Pollinator	Twin Falls, Idaho	Salt Lake City, Utah	Difference	Pollinator	Twin Falls, Idaho	Salt Lake City, Utah	Difference
	Percent purity				Amino N, ppm		
CT9	91.2	87.5	3.7	CT9	3800	2750	1050
CT7	89.3	87.5	1.8	CT7	4800	3400	1400
5060	89.3	88.3	1.0	5060	4150	3250	900
5030	89.3	86.9	2.4	5030	4350	3300	1050
289	89.9	87.2	2.7	289	4850	3800	1050
SL 50	90.0	86.5	3.5	SL 50	4050	3250	800
LSD 5%	1.16	NS		LSD 5%	629	877	
	Na, ppm				K, ppm		
CT9	225	660	435	CT9	2110	2980	870
CT7	130	400	270	CT7	1940	2755	815
5060	160	510	350	5060	2200	2875	675
5030	155	515	360	5030	2095	2825	730
289	130	490	360	289	1820	2560	740
SL 50	170	615	445	SL 50	2035	2990	955
LSD 5%	50	134		LSD 5%	185	289	
	Percent sugar				Tons per acre		
CT9	17.85	15.05	2.80	CT9	35.0	29.2	5.9
CT7	18.25	16.30	1.95	CT7	32.0	25.6	6.4
5060	18.35	16.45	1.90	5060	31.8	24.9	6.9
5030	18.10	15.65	2.45	5030	32.0	22.8	9.2
289	18.95	16.65	2.30	289	28.4	22.4	6.0
SL 50	18.05	15.70	2.35	SL 50	33.4	24.2	9.2
LSD 5%	0.32	1.01		LSD 5%	2.24	4.20	

pollinator. A significant interaction between location and pollinators for percent purity was observed. The CT9 hybrids were the highest in purity at Twin Falls, Idaho, but the same hybrids were not the highest in purity at Salt Lake City. A tentative explanation for this interaction between location and pollinators for percent purity is advanced. Apparently the CT9 hybrids, which were comparatively low in amino N but comparatively high in Na and K, are more sensitive to soil salinity than to high nitrogen fertilization.

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