Mass Selection for Improvement of Cercospora Resistance and Sugar Content in the Northern Ohio Sugar Company Areas

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The warm, humid summer weather in the Great Lakes region is very conducive to the development and spread of sugar beet leaf spot disease (*Cercospora beticola* Sacc.). Ohio fields are particularly vulnerable to the fungus since they are located in the southern-most beet growing area of the Great Lakes and the temperature is not tempered to any extent by the cool lake winds.

The most recent leaf spot epidemic occurred in 1959. This was just prior to the introduction of monogerm seed on a commercial scale. The development of monogerm varieties highly resistant to this disease was necessary to insure continued profitable production in this area. Beginning in 1965, hybrid varieties have been introduced in the area. There is a need for the development of hybrid components with maximum leaf spot resistance if continued increase in productivity is to be achieved. Mass selection for resistance is the least costly method of crop improvement and is generally successful if inherent variability is present and if it can be identified and isolated. This is a report of the results from mass selection for leaf spot resistance.

Review of Literature and Background

Leaf spot infestations have been recorded (2)[3] as early as 1915 and have occurred quite frequently since that time. Cormany (5) discussed the severe epidemic which occurred in Ohio and Michigan in 1935. Dusting and spraying with fungicides to prevent leaf spot was practiced in Michigan (6) following severe outbreaks in 1936, 1937 and 1938. Dusting was also very common in the Ohio area at that time.

Newly developed leaf-spot-resistant varieties were reported (3) in 1942 by the U. S. Department of Agriculture, which would

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[3] Numbers in parentheses refer to literature cited.

increase both the tons per acre and percent sucrose above the levels of the susceptible varieties. This breeding has continued and newer leaf spot varieties have been introduced since that time.

The mass selection method for increasing leaf spot resistance was used by Peterson and Cormany (7) in developing two varieties for the Arkansas Valley in Colorado. They obtained an increase in gross sugar production of 13 and 21% over the commercial check.

Repeated mass selection was used by the U. S. Department of Agriculture in the development of some of their outstanding open-pollinated varieties (4). This was accompanied by hybridization, in some instances, to induce variability. Size of root and absence of leaf spot symptoms on individual plants were the criteria for mass selection.

The Great Western Sugar Company was successful in selecting leaf-spot-resistant individuals in combination with maternal line selection (family breeding) (1). This consisted of testing seed of selected individuals which had been grown in a polycross nursery. Remnant seed from the superior progenies was planted for the selection of individuals upon which the next cycle of testing and progeny selection could be made or from which a variety could be synthesized. Introduction of breeding material, diverse to that on hand, was practiced in the later years while using this method.

In 1949 and 1950, unmodified mass selections for leaf spot resistance were made within GW304 and GW359 with substantial increases in resistance. GW602, the selection from GW359, remained in general use with little change until 1960 when monogerm varieties came into extensive use.

Methods

Newly-developed open-pollinated monogerm varieties which were of pure Great Western ancestry or which had resulted from USDA material hybridized with Great Western material were planted on April 16, 1960 at Old Fort, Ohio, for selection. All had been observed to contain variability for leaf spot resistance or, by their ancestry, were expected to be variable. In order to increase the possibility of a leaf spot epidemic, a field which had been in beets the year before was chosen. No broadcast fertilizer was applied and 250 pounds of 3-18-9 was used as a starter with no subsequent application. By mid-August, the beets showed signs of being deficient in nitrogen.

The leaf spot epidemic reached its peak about September 1, at which time resistant plants in six varieties were staked with

bamboo canes. Later in September, staked plants which subsequently became infected, i.e. badly blighted, were eliminated. The intensity of the selection is illustrated by the fact that only 500 roots of variety B were selected from a three-acre section of the field. A similar portion was selected from five other varieties. Selected roots were shipped to Longmont, Colorado, and roots of four of the varieties (A, B, C and D) were weighed and analyzed for sugar content. Only about one-fourth of the analyzed roots were selected. The mean weight and sugar content of selected roots for variety A and B are summarized in Table 1.

Table 1.—Mean weight and sugar content of roots selected from varieties A and B in 1960 at Old Fort, Ohio.

	Mean wt lbs	Mean % sugar
Variety A, roots selected in field	3.22	16.3
Variety A, roots selected for seed increase	3.62	17.1
Variety B, roots selected in field	3.41	16.1
Variety B, roots selected for seed increase	4.02	16.9

Seed was grown from the selected roots of each variety. Varieties from newly selected roots were compared with the parental varieties in the same trials in Ohio. The production trials were of a triple lattice design consisting of nine replications of four-row plots, 18 feet long; sugar content was determined for only two of the four rows. The performance of the varieties is summarized in Table 2.

Results

The results of the variety trials, comparing the selected varieties with their respective parental varieties, unequivocally demonstrate that leaf spot resistance can be increased significantly by mass selection.

The improvement in leaf spot resistance remains consistent from year to year. The degree of improvement also was consistent over the years. For example, the relative difference between A and A selection was −0.7 and between B and B selection was −1.3 in 1961 while in 1962 their respective differences were −0.7 and −1.4. The same relationship existed in comparing A and A selection (−0.7) with C and C selection (−1.4) in 1962, and in 1963, −0.4 and −0.8 respectively.

Selected varieties A, B, C and D had higher sucrose percentages than the parental varieties in every trial in which they were tested. Selected varieties E and F, whose selection did not include sugar percent, actually had a lower sugar content in trials in 1963 where disease was not severe. Although it must be pre-

Table 2.—Differences in performance between six selected varieties of sugar beets and their respective parental varieties.

	Leaf spot[2] reading	Leaf spot	Tons roots	Sugar %	Purity[3]	Lbs sugar[4] per Acre
			MEAN 2 LOCATIONS 1961[1]			
A vs. A. sel.	(2.2-1.5)	—0.7	+.09	+.04	+.80	+110
B vs. B sel.	(2.3-1.0)	—1.3	+1.0	+.85	+.08	+544
X̄ difference		—1.0	+.55	+.45	+.44	+327
LSD 5%			1.46	0.55	0.94	417
Mean of selections		1.3	16.31	16.21	93.02	4508
			MEAN 3 LOCATIONS 1962			
A vs. A sel.	(2.6-1.9)	—0.7	—.47	+.40	.00	+71
B vs. B sel.	(3.3-1.9)	—1.4	+.04	+.86	+.47	+441
C vs. C sel.	(3.2-1.8)	—1.4	+.46	+.97	+.94	+687
D vs. D sel.	(2.4-1.5)	—0.9	—.90	+.63	+.11	+50
X̄ difference		—1.1	—.22	+.72	+.38	+312
LSD 5%			.90	.30	.60	267
Mean of selections		1.8	25.36	16.08	92.13	6857
			MEAN 2 LOCATIONS 1963			
A vs. A sel.	(0.8-0.4)	—0.4	—3.46	+1.10	+.40	—728
C vs. C sel.	(1.3-0.5)	—0.8	+1.16	+0.45	—.10	+484
E vs. E sel.	(1.1-0.5)	—0.6	—0.70	—0.12	+.31	—207
F vs. F sel.	(1.2-1.0)	—0.2	+3.52	—0.31	+.84	+1164
X̄ difference		—0.5	+0.13	+0.28	+.36	+178
LSD 5%			2.02	0.55	.99	691
Mean of selections		0.6	16.62	19.71	92.64	5532

[1] Leaf spot readings at only one location in 1961.

[2] Actual leaf spot readings of parent and selections; 0 = no disease, 10 = complete necrosis.

[3] Thin juice apparent purity; oxalic acid precipitation.

[4] Recoverable basis, calculated assuming 0.3% standard loss on beet and 62.5% molasses purity.

sumed that selection pressure for higher sugar content was responsible for most of the increase in sugar content, some of the increase of the selection over the parent in 1961 and 1962 could be attributed to increased leaf spot resistance. No doubt, the general trend for increased purity resulted from increased leaf spot resistance and increased sugar content.

Yield of roots was not appreciably changed but possibly trends can be noted in selections A (lower) and C (higher). The moderate selection for increased size of root was not expected to cause an increase in production. Recoverable sugar yields of all selections appear to have been increased in 1961 and 1962 when disease was a factor. Little change in sugar production was noted in the absence of severe disease as in 1963.

Summary

Mass selections for leaf-spot-resistant plants were made in six monogerm open-pollinated varieties in the fall of 1960 at

Old Fort, Ohio. Roots of four varieties were then reselected for higher relative sucrose contents.

Significant gains were made in leaf spot resistance by mass selection. Sugar contents were enhanced and approached significance for selections A, B, C and D. There was a trend for higher purity in all selections. Recoverable sugar yields of the selections approximated the parental lines or possibly increased when Cercospora was a factor.

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