Classification of Sugar Beet Strains for Resistance to Aphanomyces Cochlioides in Greenhouse Tests

C. L. SCHNEIDER[1]

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Increased resistance to the beet water mold, *Aphanomyces cochlioides,* is a major objective in the development of sugar beet cultivars for the Great Lakes region of the United States. Differences in degree of resistance to pure cultures of *A. cochlioides* in the greenhouse between sugar beet cultivars have been demonstrated (1,2,3)[2]. Resistance to *A. cochlioides* in the greenhouse was shown to be indicative of resistance in the field (2,3).

In 1957, a program of testing breeders' strains of sugar beets in the greenhouse for resistance to *A. cochlioides* was initiated. In this paper are presented methods employed and results obtained in testing over 2,900 strains from 1957 to 1961.

Methods

Seeds of the breeders' strains included in the tests were furnished by G. E. Coe[3] and G. J. Hogaboam[3]. Most of the strains were derived from plants selected for resistance to black root pathogens, including *A. cochlioides,* in field trials. Multigerm, monogerm, and monogerm-multigerm hybrid types were included.

The tests were conducted in greenhouses at the Plant Industry Station, Beltsville, Maryland. Seedlings to be inoculated were grown in steam-sterilized loam in well-drained clay saucers of 15 cm diameter and 3.5 cm depth. Twenty-five seed balls per saucer were planted uniformly spaced and at uniform depth. In each test were 24 to 36 entries arranged in 4 to 6 randomized blocks. A semiresistant variety was included in each test as a standard for comparison. In 1957-58 tests, variety US 400 was the standard; in 1959-61 tests, US 401 was the standard.

Zoospore inoculum was used because large quantities can be readily produced in the laboratory and expeditiously applied in regulated amounts in the greenhouse. Zoospores were obtained in accordance with previously described methods (3,4) from monosporous cultures previously isolated from blighted sugar beet seedlings and maintained on maize meal agar slants. Con-

[1] Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Logan, Utah.

[2] Numbers in parentheses refer to literature cited.

[3] Geneticist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

centrations of zoospores produced by mycelial mats of the fungus submerged in water were determined with a haemocytometer.

About 2 weeks after planting and after seedlings had been thinned to a maximum of 25 per saucer, each saucer was flooded with 50 ml tap water containing a known number of zoospores. In order to increase the likelihood of attaining the degree of disease intensity that would best distinguish resistant and susceptible host strains, several concentrations of inoculum were employed in each test. Usually the concentration varied with each randomized block of saucers. Concentrations of .2 to .5 million zoospores/saucer were employed in summer when high greenhouse temperatures increase the proclivity of sugar beet seedlings to black root. Higher concentrations, .5 to 1.5 million zoospores/saucer, were employed during cooler months when greenhouse temperatures rarely exceeded 25° C.

Early symptoms of black root—discoloration of the hypocotyl, damping-off—generally began to appear by the sixth day after application of inoculum. About 30 days later, the number of plants surviving and severity of above-ground symptoms displayed by survivors were recorded. Symptoms ranged in severity from a slight darkening at the base of the hypocotyl to a severe necrosis of the hypocotyl which appeared as a black thread.

An index of disease severity was computed for each entry. Each plant was assigned a numerical value according to severity of above-ground symptoms as follows: 0 (no symptoms); 1 (light); 2 (intermediate); 4 (severe); 5 (dead). The quotient of the assigned numerals summated and divided by the total number of plants inoculated equals the disease index.

An opportunity was afforded to compare greenhouse and field determinations of resistance to *A. cochlioides*. Forty-one of the entries had been grown at Waseca, Minnesota, in 1956 by H. L. Bissonnette[4] in field plots naturally infested with *A. cochlioides*. Following a relatively severe black root epiphytotic, harvest root weights of the 41 strains ranged from 75 to 144 percent of check variety US 400. After the 41 strains had been tested for resistance in the greenhouse, a correlation coefficient was calculated from paired greenhouse (disease index) and field (harvest root weight) data for each strain.

[4] Formerly Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

Table 1.—Distribution of sugar beet strains according to disease rating in greenhouse tests for resistance to *Aphanomyces cochlioides*.

Type of sugar beet and year tested	Number of entries	Percent of entries in indicated disease rating class[1]								Average[2] disease rating
		65-74	75-84	85-94	95-104	105-114	115-124	125-134	135-144	
Multigerm, diploid										
1957-58	140	—	5.7	30.7	37.1	24.3	2.2	—	—	98.6
1959	307	2.6	7.5	26.3	40.6	19.2	3.8	—	—	97.7
1960	654	.2	7.6	41.6	39.1	9.8	1.5	.2	—	95.6
1961	114	.9	32.4	50.0	14.9	1.8	—	—	—	88.4
Multigerm, tetraploid										
1961	239	—	.5	12.1	38.4	43.9	4.6	.5	—	104.1
Monogerm, diploid										
1957-58	268	—	2.2	16.8	39.6	20.5	14.2	6.3	.4	104.8
1959	381	—	3.7	31.3	32.3	25.8	6.4	.5	—	100.1
1961	374	1.4	13.9	49.0	26.9	6.4	2.4	—	—	93.0
Monogerm-multigerm hybrid, diploid										
1957-58	61	—	1.7	18.0	67.1	11.5	1.7	—	—	99.4
1959	73	1.5	6.8	21.9	43.9	23.2	2.7	—	—	98.8
1960	249	5.6	23.3	37.3	25.3	5.3	2.0	.4	.8	91.3

[1] Disease ratings expressed in percent of that of commercial check variety US 400 (1957-58 tests) and US 401 (1959-61 tests). The higher the rating, the greater the amount of disease.

[2] Weighted average based on the number of entries in the several disease classes.

Results

The disease index of the commercial check variety included in each test ranged from 2.8 to 4.8 and averaged 4.2. Disease indices of the breeders' strains were converted to percentages of that of the check variety in order to facilitate comparison of strains included in different tests.

The results of the tests are summarized in Table 1. There were differences in degree of resistance among each type of sugar beet tested: multigerm, monogerm, and monogerm-multigerm hybrid. Among all types, disease severity ranged from 65 to 144 percent of that of the check variety. Most of the entries were equal to or exceeded the check variety in degree of resistance (Figure 1). The results of these tests are in sharp contrast to

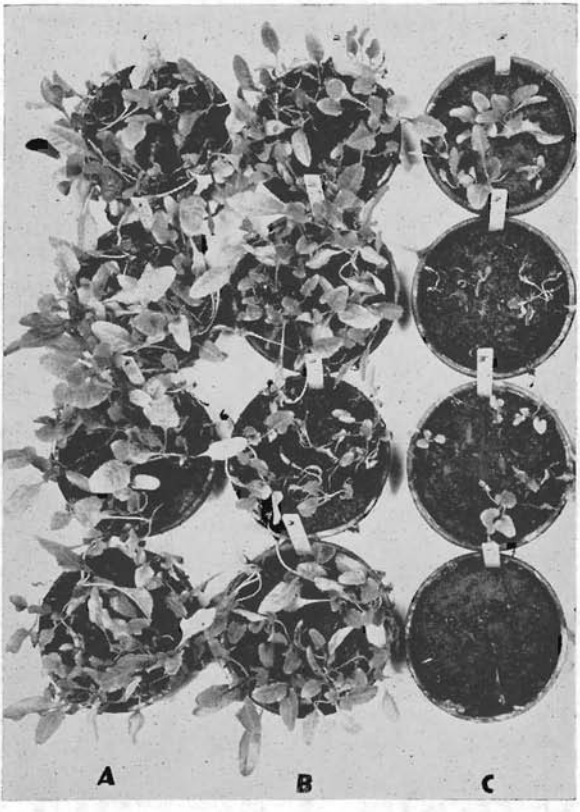

Figure 1.—Sugar beet strains in soil infested with zoospores of *Aphanomyces cochlioides* in the greenhouse. Row A, monogerm-multigerm hybrid SP59485-1; row B, monogerm-multigerm hybrid SP59495-1; row C, commercial check variety US 401.

previously reported results of similar tests of strains not derived from plants selected for black root resistance wherein most of the entries were less resistant than the check variety (5). The results also indicate a progressive improvement in resistance to *A. cochlioides* among breeders' strains developed during the period in which the tests were conducted. In 1957-58 tests a minority of entries were more resistant than the check variety; in 1961 tests, a majority were more resistant.

As in previously reported studies (2,3), resistance to *A. cochlioides* in the greenhouse was indicative of resistance in the field. A correlation coefficient of —.555 indicates a significant negative association between greenhouse disease indices and harvest root weights of 41 strains exposed to *A. cochlioides* in greenhouse and in field (Table 2).

Table 2.—Classification of 41 sugar beet strains according to greenhouse and field determinations of resistance to *Aphanomyces cochlioides*.

Greenhouse disease rating[1] (y)	Entries in indicated disease rating class in the field (x)[2,3]							
	75-84	85-94	95-104	105-114	115-124	125-134	135-144	Total
75-84	0	0	0	0	0	3	0	3
85-94	0	1	2	2	4	3	3	15
95-104	0	3	5	6	4	1	0	19
105-114	1	0	2	1	0	0	0	4
Total	1	4	9	9	8	7	3	41

Correlation coefficient (r_{xy}) = $-.555^{**}$

[1] Disease index in percent of check variety US 400. The higher the rating the greater the amount of disease.

[2] Root yield in percent of check variety US 400 in field plots naturally infested with *A. cochlioides*. Data based on 2 single-row plots, each 25 ft. long.

[3] Yield data furnished by H. L. Bissonnette.

Summary

A method of testing sugar beet seedlings in the greenhouse for resistance to the water mold, *Aphanomyces cochlioides,* is described. Greenhouse tests of over 2,900 breeders' strains included in the program of developing sugar beet cultivars for the Great Lakes area showed the majority to be more resistant than commercial check varieties US 400 and US 401. A progressive improvement in resistance to *A. cochlioides* was noted among the breeders strains tested during the period 1957-61. Additional evidence was obtained that resistance to *A. cochlioides* in the greenhouse is indicative of resistance in the field.

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