

## BREEDING FOR RESISTANCE TO APHANOMYCES ROOT ROT

C. W. Doxtator and A. R. Downiel<sup>1</sup>

Root Rot of Sugar beets caused by Aphanomyces Cochlioides (Drechs) has been prevalent in the Minnesota-Iowa sugar beet growing areas of the United States for many years.<sup>(1)</sup> During the past ten years, this disease has become increasingly severe in those areas where beets are grown for the American Crystal Sugar Company. In 1944, in the Mason City, Iowa factory district, 34% of all growers fields were affected, and 5% of total acreage was completely lost. This organism not only causes damping off, but also may persist through the entire season, attacking the tap root as well as lateral roots. This chronic phase of the disease may cause a reduction of yield to as low as 10% of original expectation, and has been the cause of abandonment of thousands of acres of beets during the summer and fall season in this area.

Breeding for resistance to this disease was begun by the Company in 1942. The results of the work are given in this report.

### EXPERIMENTAL WORK, 1942-44

In September 1942, a selection of 100 apparently resistant beets was made from a severely infested field in Southern Minnesota. The beets were stored over winter in a root cellar and replanted the following Spring. Due to flood water from the Minnesota River this group was lost. In September 1943, a selection of roots was again made in a severely infested field. The roots of this selection were shipped to Rocky Ford, Colorado, where 59 were selected as good enough for planting in the greenhouses for winter seed production. This selection was from American #1, 1941 Com'l Crop. The open pollinated seed obtained in March 1944 was harvested separately from each plant.

Plans were made in the Spring of 1944 to test all available selections under severe root rot conditions, to determine if any resistance had been obtained. Accordingly, a field was selected in Northern Iowa, on which the crop history indicated that the Aphanomyces disease was present. The 59 greenhouse produced progenies were each planted in single rows 48 feet long, along with 178 individual plant progenies from the general breeding program. A test of 22 Domestic varieties and 3 Foreign varieties in a four replicate test of single row plots 500 feet long was also planted in this field. These tests were planted in May in good moisture conditions. Damping off was most severe. At the end of six weeks there was almost a complete loss of stand. As the season progressed, those that had survived the seedling phase of the disease continued to die. By midsummer the field was abandoned even for selection purposes since there were no varietal differences nor any beets remaining which were of normal shape or size.

### EXPERIMENTAL WORK, 1944-46

During the summer of 1944 a survey was made of all beet fields in the Mason City and Chaska factory districts to determine how widespread the disease was in this territory. In this survey a field near Mankato, Minnesota (Field B) was found to be damaged rather severely, but still contained many good beets. The planting had been made with American #1 '41 Com'l seed crop.

<sup>1</sup> Plant Breeder and Plant Pathologist respectively, American Crystal Sugar Co.

A great deal of damping off had occurred in this field at time of emergence, and the disease had continued to eliminate beets during the summer season, but in September, damage had practically ceased. It was decided to use this field for beet selection, and to select only those disease-free beets which had diseased beets on either side in the beet row. 1080 beets were selected in the field, and later this was reduced to 536 beets for planting in the Rocky Ford, Colorado greenhouses for seed production during the winter months. In this group, twenty plants were bagged for inbred seed production, and forty plants were bagged in pairs for sib pollinated seed. All open pollinated seed produced was bulked and a total of 27.5 lbs. of this seed was obtained.

In the Spring of 1945, Field B, the same field in which the 1944 root selection was made, was used for test purposes. 3.2 acres were planted, .75 acres being planted with the greenhouse bulk open pollinated seed, along with all inbred and sibbed seed lots, and the remainder of the field was planted to the Check varieties, American #1 Com'l and American #3 Com'l. Damping off was severe and the disease persisted throughout the entire season. The Check varieties were abandoned in July, leaving only the .75 acre planted to the resistant selection. In this test field, the inbred and sib pollinated progenies showed great differences in resistance to the disease.

There were less than 1,000 commercial acceptable beets in the 3/4 acre area, and of this number, 417 were selected as being free of disease and satisfactory in size and shape. These 417 were selected as being free of disease and satisfactory in size and shape. These 417 beets were planted in January 1946 in the Rocky Ford greenhouses for winter seed production. Twenty of these were self pollinated and forty were sib pollinated (in pairs), the remaining plants being allowed to open pollinate. Seed from each plant was kept separate at harvest.

#### 1946 EXPERIMENTAL RESULTS

Active cooperation with the U.S.D.A. was begun in 1946 in the field testing work. During the period 1942-45, root rot resistant selections had been made by Culbertson, Downie, Henderson and Bockstahler (3) and it was thought advisable to select test areas where strains developed by both organizations could be planted in adjacent blocks and compared with the same Check varieties. Accordingly, five 1/4 acre tracts in Southern Minnesota were located. These areas are described as follows:

- Field A -- heavy infestation -- S.E. Exp. Station, Waseca, Minn., Univ. of Minn.
- Field B -- moderate infestation--J. Johnson farm, Mankato, Minn.
- Field C -- light infestation -- P. Haeffner farm, Mankato, Minn.
- Field D -- no infestation -- S. Poncin farm, St. Peter, Minn.
- Field E -- no infestation -- P. Ritz farm, St. Peter, Minn.

Seventy-one open pollinated plant seed progenies were selected from the Rocky Ford greenhouse production of 1946, and planted for test in these five areas. The Check varieties used were American #3 Com'l seed and the U.S.D.A. varieties U. S. #216 (1-16-0) and 1-9-00. The latter variety had been found in previous work to be very highly susceptible to this disease.(3) All progenies and Check varieties were planted in duplicate in each area. Plots were one row wide by twenty feet long.

Good stands were obtained on Fields C, D, and E, where practically no damping off occurred. These fields were practically free of the disease all season. On Field B some damping off occurred and the disease continued to affect surviving plants until mid-July. On Field A. severe damping off occurred and there was great variation in stand between lines. The disease continued to attack surviving plants, but gradually decreased in severity until September, at which time only plants in the most susceptible lines were being attacked. The greatest mortality of plants occurred during the damping off phase of the disease; however the root rot phase of the disease continued to develop, particularly in the susceptible lines and Check varieties.

Although stand counts and other notes were taken after thinning and before harvest on all test fields, only those data from Field A were of value. In this test the disease conditions were severe enough to allow for varietal differentiation.

In the following table are given data obtained on stand and vigor for the selections and the Check varieties in test Field A.

TABLE I  
Average % Stand and Vigor Indices for 71 Selected Plant Lines  
Compared with 3 Check Varieties

Varieties	Per Cent Stand		Index of Vigor of Top Growth at Harvest
	After Thinning	Before Harvest	
Ave. of 71 Selected Lines	54	52	4.9
Range	17-82	15-80	3.0-7.0
Ave. of 3 Check Varieties	40	35	6.5
Range	25-50	20-45	6.0-7.5

From the per cent stand and top vigor indices, it was possible to select 22 of the 71 lines tested as being promising enough to warrant digging of the roots and selection of the best for use in seed production. After all beets of these 22 lines had been harvested, two lines were discarded because of poor root shapes. From the remaining 20 lines a total of 246 mother beets were selected. Data obtained from these 20 lines and three check varieties is given in Table 2.

TABLE 2

Per Cent Stand, Foliage Vigor Index, Beets Selected and  
Yields of 20 Selected Plant Lines and  
3 Check Varieties--Field A, 1946

Line No.	After Thin.	At Harvest	Vigor(a) of Foliage	% Good Shaped Beets	Data on Sel. Beets		Wt. per Foot of Row of Perfect Shaped Beets
	Stand Count degrees(c)	Stand Count degrees(c)			No. Selected	Wt. per Beet	
US 216(ck)	45.0	42.1	6.0				
1-9-00(ck)	30.0	26.6	7.5				
Am #3 (ck)	42.1	39.2	6.0	22(b)	4(b)	1.05(b)	.11(b)
R-12-4	62.0	58.6	3.5	45	14	1.11	.36
R-16-4	53.3	56.8	4.0	43	12	1.50	.45
R-203	50.8	46.6	4.5	38	9	1.03	.23
R-218	48.5	48.5	4.5	62	13	1.20	.39
R-221	40.7	40.7	4.5	41	7	1.57	.28
R-242	56.9	50.8	4.0	46	13	1.25	.41
R-249	64.0	64.0	3.5	39	12	1.47	.44
R-252	57.6	55.7	3.0	50	14	1.34	.47
R-254	58.6	55.4	3.0	38	11	1.84	.49
R-236	61.7	56.8	4.5	39	12	1.63	.49
R-314	67.5	67.5	3.5	63	19	0.97	.46
R-366	57.6	54.2	4.0	36	10	1.42	.36
R-367	46.5	45.0	4.5	43	9	1.29	.29
R-371	46.6	46.5	4.0	62	13	1.15	.35
R-1	55.7	52.4	4.5	41	11	1.29	.36
R-110	52.5	52.4	4.0	44	11	0.86	.24
R-125	62.0	61.2	4.0	55	16	1.12	.45
R-144	52.3	49.4	4.0	40	10	1.39	.35
R-192	57.1	53.8	3.5	43	12	1.40	.39
R-197	60.0	58.4	4.5	70	21	1.17	.62
Ave. of 20 Sel. Lines	55.84	53.74	4.30	46.9	12.3	1.275	.394

Sign. Diff.  
(19:1)

20.0

20.6

2.0

(a) 1 = vigorous  
10 = weak

(b) roots taken for check purposes only

(c) % stand data transformed to degrees by means of tables prepared by Bliss  
as reprinted by Hayes and Immer.(2)

The stand data, both after thinning and before harvest, and the top vigor indices were statistically analyzed by the variance method, using the data from all plots of the 71 plant lines and the 3 Check varieties. F values showing significance beyond the 1% point were obtained for the stand data and beyond the 5% point for the vigor indices. For stand after thinning and before harvest, Line No. R-314 was significantly higher than two of the check varieties. Sixteen lines are significantly higher than the most susceptible check variety in stand after thinning and before harvest. In vigor of foliage index, 13 lines were significantly more vigorous than the best check varieties and all 20 lines significantly better than the poorest check variety.

The American #3 variety was checked for good shaped beets, and only 22% of the beets which were growing at harvest were of acceptable shape. The remaining beets were misshapen, having lost the tap root by disease and had grown lateral roots in order to survive. In the 20 lines selected, the percentage of beets at time of harvest which had withstood the disease and grown normally, ranged from 41 to 70, with an average of 46.9. The check variety yielded .11 lbs. of perfect shaped beets per foot of row, as compared to the average of the 20 selected lines of .394 lbs. per foot of row.

#### SUMMARY

Aphanomyces Cochlioides, responsible for the major part of sugar beet root rot in the Southern Minnesota-Northern Iowa beet growing area, causes serious loss of yield in this area.

A mass selection of beets made in 1944 under severe disease conditions in the variety American #1 (1941 Com'1) showed improved resistance as compared with check varieties in tests in a severe epidemic in 1945. Inbred and sibbed seed lots showed variation in resistance to the disease.

Individual open pollinated seed progenies obtained from the root selection made in 1945 were tested in five locations in Southern Minnesota in 1946. In one test where the most severe attack of root rot occurred, 20 out of 71 lines tested were judged to be superior in resistance to any of the three checks.

The average yield of perfect shaped beets, free of disease, of the 20 selected lines was .394 lbs. per foot of beet row, as compared to a yield of .11 lbs. for the American #3 Com'1 Check. Under the mild to medium severe root rot conditions obtained in this field, marked improvement in resistance to the disease was obtained in 20 of the 71 plant lines tested.

#### Literature Cited

- (1) Downie, A. R. Damping Off and Root Rot of Sugar Beets Caused by Aphanomyces Cochlioides (Drechs.) Thesis, Univ. of Minn. 1942
- (2) Hayes, H. K. and Immer, F. R. Methods of Plant Breeding. McGraw-Hill Book Co. New York and London. 1942
- (3) Henderson, R. W. and Bockstahler, H. W. Reaction of Sugar Beet Strains to Aphanomyces Cochlioides. Proc. Amer. Soc. Sug. Beet Tech. Pp--1945 (in press)