BEET BREEDING WORK

American Crystal Sugar Company

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Accomplishments

Breeding work conducted by the American Crystal Sugar Company has led to the following accomplishments during recent years:

1. The development of high leaf spot resistance combined with high sucrose content in one variety. Yield of this variety has been increased without lowering sugar content.

2. The development of good resistance to Aphanomyces root rot in a high sucrose variety moderately resistant to leaf spot. Resistance to damping off organisms and to Rhizoctonia has also been obtained.

3. Certain American varieties have been found to be low in sodium and potassium content and are higher in purity than others. Development of varieties still higher in purity is in process.

4. The development of mild resistance to the Southern root rot in one variety.

5. The combination of leaf spot resistance with some curly top resistance in one variety. Seed stocks are now being increased.

6. The development of a series of inbred lines, from which natural hybrids have been made, for the production of better synthetic varieties.

Problems Yet to be Solved

All of the above problems still need to be worked on, and others as follows:

1. The production of hybrid sugar beets.

2. The production of single germ adapted varieties.

3. Larger germ size in monogerm varieties.

4. Resistance to cold increased.

5. The development of large numbers of inbred lines having the SF factor, for use in hybrid production.

6. The combinations of characters in one variety, three of the most important of which are: Aphanomyces, Leaf Spot and Curly Top resistance.

Immediate Future Objectives

The immediate future objectives are as follows:

1. To obtain inbred lines having the SF factor for self fertility, and to develop such inbreds in both multi and monogerm types.

2. The indexing of these lines in the early inbreeding stages for "O" type pollen, as well as for resistance to the three main diseases mentioned above.

3. The production of experimental hybrids of sugar beets, first as top crosses and later as F_1 hybrids from inbreds, for test in all factory areas.

Breeding Methods Which have been Used and Which will be Used.

The breeding methods of mass selection and line breeding have been used most extensively in the past. Synthetic varieties have been developed by crossing of certain suitable self pollinated lines and reselection in the progeny.

The breeding methods to be used in the future will be mass selection and line breeding for the start of the work on new characters not previously investigated; and all other improvement work will be carried on through the inbreeding and hybridization method, similar to that used in corn.

What Material and Information Would Be of Most Value to You in Enabling Your Breeding Program to Meet the Objectives you have Set Up?

The material urgently needed for most rapid progress is a large number of homozygous inbred lines for pollen indexing purposes. All lines need to be indexed for agronomic characters also. The best lines would be obtained as male sterile equivalents for the immediate production of experimental hybrids.

Information on the inheritance of the monogerm character is also needed. Information on all selections, lines, etc., as regards bolting tendencies is also needed so that storage conditions can be set up which will allow for the control of the flowering of all strains at the correct time for crossing.

Materials having various combinations of resistances, yield, quality, and single germedness in the F_1 and F_2 generations are greatly needed so that selection of suitable adapted lines can be made for particular areas.

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The development of varieties suited to the areas in which the American Crystal Sugar Company operates has long been an agricultural project of the Company, as indicated by the paper, "Sugar Beet Breeding in the Arkansas Valley of Colorado", by Mr. A. W. Skuderna, published in the Journal of the American Society of Agronomy, October 10, 1925. Efforts to produce varieties highly resistant to Cercospora leaf spot were greatly expanded in 1935, which work has been continued to this date, with satisfactory success. The first selections in this enlarged program were made in a synthetic variety using the conventional mass selection method. In 1940, selections were begun in individual plant open pollinated progenies, which method of breeding quickly resulted in new varieties of beets highly resistant to leaf spot.

In the breeding for resistance, special attention was paid to maintenance of high sucrose content, as well as high yield insofar as this was possible. At this date a variety high in percent sucrose and in resistance to leaf spot and with good tonnage characteristics is available for the leaf spot areas of the Company. Field tests of this variety and its many reselections, as compared to susceptible foreign commercial varieties, have been frequently made to determine the improvements made. In the following table results from grower tests over the two year period 1946-47 are given:

Average Performance of American #1, 1946, with Foreign Check in 7 Variety Strip Demonstrations for the Years 1946-47. Arkansas Valley, Colorado

	Tons Beets per Acre	Percent Sucrose	Lbs. Sugar per Acre
* Parent of Am.#1, 1946 Com'l) ** Am. #1, 1946 Com'l)	17.67	15.58	5449
Foreign Check	16.88	12.53	4181

(696) 1/ The results of one of these strip tests are given in the following slide.

(906) The date of harvests (slide) show the effect on sugar percent of Cercospora leaf spot and the difference between varieties in this test.

(393) Improvements in leaf spot resistance continue to be made in selections of the American #1 variety as indicated by the following slide. This slide shows the difference obtained in mother lines in 1942. Differences in lines of recent date have not been so marked.

* 4-411 used in 1946
** Used in 1947
1/ Refers to slide numbers

Since 1942 great efforts have been made to increase the tonnage of leaf spot resistant types without loss of sugar percent. Comparisons of the earlier selections were made with those of 1945 in several tests in 1948. The results were as follows:

	Tons/A	% Sucrose	Lbs. S/A
American #1 1942 production	15.49	16.06	4981
American #1 1947 production	16.12	16.55	5334
Difference	.63	.49	353 *

Susceptibility to Aphanomyces cochloides has long been of serious concern in the beet growing areas of northern Iowa and southern Minnesota. Selections of beets apparently resistant to this root rot were made in 1942-1943 with little success. In 1945, a few individual plant progenies from the American #1 variety selection in 1944 showed resistance, and seed was obtained from these lines in the greenhouses the following winter. Since that date progress has been made each year in increasing the resistance to this disease.

In 1947, Aphanomyces was found in the Red River Valley of North Dakota and Minnesota and breeding work was begun on American #3 Northern type. In 1948 selections were made in US #33 in northern Montana, and in 1950 a field severely affected with Aphanomyces root rot was found near Sacramento, California, and selections of beets were made in that field from the US #33 variety.

The fine performance of the resistant variety developed by successive selections in Minnesota and Iowa can be graphically shown by the following slides:

(783) In this slide is shown typical Aphanomyces rotted beets at Drayton in northern Minn.

(131) The first indication of resistance was found in 1945 in certain individual plant progenies.

(944) Two standard commercial varieties and one susceptible check compared with plant progeny lines at Waseca, Minnesota show remarkable differences in favor of the resistant selections. 1947.

(523) At a later date of growth equally great differences were observed at Mason City, Iowa, in 1948.

(526) In this slide a comparison of yield between the standard Commercial variety and one resistant plant line (grown in 40 foot adjacent rows) is given. Shown in this slide is the total number of beets of the check. Only 13 beets, those weighing over 1.4 pounds, of the 30 produced by the resistant line, are shown.

(1171) At Moorhead, Minnesota, one resistant line is observed in a 55 plant line nursery test. Note uprightness of foliage.

* Significant

(1204) In a 5 replicate test of nursery progenies at Moorhead, Minnesota, in 1949, yields of a root rot resistant selection, a commercial variety and a susceptible check were taken. This slide shows the total production from each 20 feet single row plot of each variety. The yield of the resistant variety was 14.00 tons per acre, the commercial variety 5.49 tons per acre, and the susceptible check 2.16 tons per acre. There was no significant difference between varieties for sucrose percent.

Resistance to Aphanomyces appears to have been obtained not only for the rotting of large beets but also for the damping off stage. Much of the loss in susceptible check varieties continues to be after seedling emergence, whereas the resistant selections persist until conditions are favorable for growth. In 1946 a planting of one of the first resistant selections was made along with a susceptible check in August, on a field in which the spring planting had been lost. In the following
(149) slide the seedling stands of these two varieties is compared.

There is some indication that resistance to other organisms causing rotting of beets has been obtained. In the flooded Red River Valley of the north in 1950, plantings made with resistant varieties showed less damping off than plantings of other varieties made the previous three years. At Clarksburg, California, a much better stand of beets was obtained from the resistant variety than from three other commercial varieties in 1950. At Scottsbluff, Nebraska, in 1950, this variety, along with a Nebraska Rhizoctonia selection, planted in a field severely infected with Rhizoctonia, produced stands far superior to commercial varieties. At harvest the yields of four varieties were compared,
(1135) as shown in the following slide.

At this date, excellent root rot resistance along with high sucrose percent and moderate leaf spot resistance is combined in one commercial variety known as American #3 S. In 1948, 310,000 pounds of seed of this variety were produced. In 1951 it is estimated that over 500,000 pounds of seed will be produced from selections having more resistance than this earlier increase. As a result of the breeding work on this problem, large areas in southern Minnesota and northern Iowa which were abandoned for beet growing in the period of 1940 to 1945, will be reopened for beet production in 1951 and 1952.

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There is evidence that increased resistance can be obtained to Southern root rot caused by Sclerotium rolfsii.

Selections for resistance were made in the American #5 variety near Sacramento, California in 1946. Data obtained on percent survival at harvest indicated a 66 percent greater survival for the resistant selection, over the parent variety. Differences of significant magnitude for survival at harvest were also obtained between mother progeny lines. In 1950, tests of resistant selections made in the US #15 variety gave similar promising results.

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Recently certain American produced varieties have been found to be lower in sodium and potassium content than European produced varieties. As a result of this information the company purchased a Beckman Flame Spectrophotometer in 1949 for the study of these elements in all commercially used varieties. The preliminary results obtained from varieties tested in most areas of the Company were presented to the American Society of Sugar Beet Technologists meeting in Detroit in February 1950; the results of which can be briefly summarized as follows:

1. Highly significant differences were obtained between varieties for sodium and potassium content in replicated tests in seven factory areas.

2. Great differences also significant, were found between areas for sodium and potassium content, as an average of all varieties.

A selection of 500 beets was made in the American #1 high sucrose variety at Rocky Ford in 1949, and all beets were individually analyzed for percent sucrose, percent Na and percent K. From this group, 25 beets representing good material, and 25 beets representing poor material, were planted in the greenhouses for sib pollination within each group. The seed progenies thus obtained were planted, along with the parent variety, in adjacent rows in a nursery test in 1950. The average characteristics of the parent selections as determined by individual root test in 1949 and the average results of all progeny sibbed lines along with the parent variety in 1950, are given in the following table (slide).

Parents

	Wt. per Beet. Lbs.	% Sucrose	% Na	% K
"Good" Material	3.88	17.8	.015	.140
"Poor" Material	2.60	13.2	.107	.274

Progeny Test

	Wt. per Beet. Lbs.	% Sucrose	% Na	% K
"Good" progenies	2.32	15.9	.083	.168
"Parent" check	1.71	14.8	.112	.215
"Poor" progenies	1.85	14.0	.117	.228

These preliminary results indicate that varieties such as American #1 which are known to be high in purity of juice, may be still further improved by selection for low sodium and potassium content.