DEVELOPMENT OF SUGARBEET GERMPLASM LINES RESISTANT TO STORAGE ROT

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Almost all of the Red River Valley sugarbeet (*Beta vulgaris* L.) crop and up to 75 percent of the U.S. crop are stored in large exposed piles for up to 150 days. The stored roots are attacked by storage rot pathogens which not only destroy sucrose but also produce impurities that interfere with sucrose crystallization. One percent rotted tissue over a 130-day processing season will destroy one million pounds of sucrose and the increase in impurities will cause an additional loss of 1.4 million pounds of sucrose to molasses; a total loss of 2.4 million pounds of sugar from a factory processing 450,000 tons of sugarbeets per year. Losses vary considerably from year to year, but the above estimates are probably realistic for a typical Red River Valley factory (3).

Three storage rot fungi have been identified as major contributors to these losses (2). *Phoma betae* Frank is potentially the most dangerous storage rot pathogen because its disease cycle is closely associated with the life cycle of the sugarbeet. *Phoma betae* can infect the seed, survive in the plant and eventually cause storage rot after the roots have been piled. *Phoma* rot usually starts in the center of the crown and spreads downward in a cone-shaped pattern into the main taproot. Rotted tissue is black with occasional pockets lined with white fungal mycelium (masses of threadlike filaments which constitute the vegetative structure of the fungus). *Phoma betae* also is capable of causing a seedling disease and a foliar leaf spot disease; however, these forms of the disease have not posed serious production problems in the Red River Valley. While many species of *Penicillium* can cause rot, *Penicillium claviforme* Bainier is the most prevalent on sugarbeets in the Red River Valley. Rot caused by *Penicillium claviforme* can be identified by fungal structures of white tufts on columns that are produced on brown rotted tissue. *Penicillium* rot is usually associated with wounds and the fungus can occur in tissue rotted by *Phoma*. *Botrytis cinerea* L., the most aggressive of the three fungi, is able to rot tissue quickly over a wide temperature range. Rot caused by *Botrytis* is characterized by the formation of dark brown to black, round sclerotia (compact masses of mycelium with a darkened rind) and gray masses of spores. The sclerotia are 1/16 to 3/16 inch in diameter and form in clusters on the rotted tissue which is dark brown or black if *Phoma* rot is also present. *Botrytis cinerea* is not a major contributor to storage losses in the Red River Valley, perhaps because *Penicillium claviforme* is antagonistic toward *Botrytis cinerea* (1). *Penicillium* and *Botrytis* spores are readily disseminated by wind currents.

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Storage rot losses can be reduced by minimizing beet injury during harvest and piling. Lowering temperatures with forced ventilation and eliminating soil and debris from storage piles are beneficial (5, 6). Fungicides can be used (4) but often are costly and may impose health risks to consumers. This paper describes the development of sugarbeet lines with genetic resistance to the three storage rotting fungi described above.

SELECTION PROCEDURES

Selection for storage rot resistance was accomplished by rating individual sugarbeet roots for their response to the three important storage rot fungi. Roots grown under conditions similar to those used in commercial production were harvested, washed and stored for 60 to 90 days at 40°F and high humidity. Individual roots were then sampled using a special knife (Figure 1) to cut a longitudinal slice from a smooth surface of the root

Figure 1. Knife used to cut sample for rot evaluation, unsectioned slice and cubes made from slice.

below the crown. The strip was then cut into three 0.40-inch cube blocks. The blocks were placed in petri dishes in contact with pure cultures of the three rot fungi (Figure 2). These were observed for rot progression after being incubated at 70°F for 14 days. Each block was cut down the center and rated on a scale of 0 to 5 with 0 associated with an absence of rot and 5 indicating that the cube was completely rotted. Roots corresponding to cubes with low rot ratings were then planted in the greenhouse, induced to flower and produced seed for future selection cycles. Initially diverse sugarbeet germplasm sources, including inbred lines from other USDA breeding programs, introductions from the USSR and the USDA *Beta vulgaris* world collection, were evaluated for storage rot resistance. Selected lines with confirmed rot resistance were evaluated for vigor, quality and agronomic performance in replicated field trials.

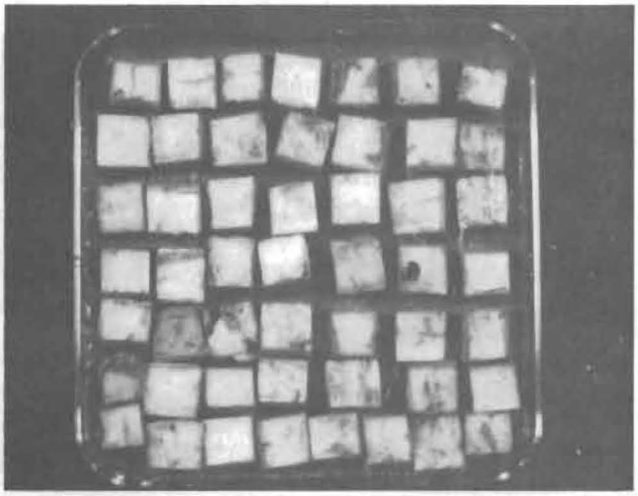

Figure 2. Cubes of root tissue on a pure culture of a single storage rot fungi. Each cube corresponds to an individual sugarbeet. Cubes are rated after a 14 day incubation period.

CHARACTERISTICS OF SELECTED LINES

Three germplasm lines have been jointly released by the USDA and North Dakota Agricultural Experiment Station as sources of storage rot resistance for use by commercial breeders. The lines have been designated F1004, F1005 and F1006.

F1004 is a multigerm line produced from six cycles of mass selection from VNIS F526, an introduction from the USSR. F1004 segregates for red and green hypocotyl colors.

F1005 is a multigerm, green hypocotyl line derived by five cycles of mass selection from VNIS F738, a USSR introduction. First cycle selection was for *Botrytis* resistance only. Subsequent cycles included selection for resistance to the other two fungi.

F1006 is a multigerm, red hypocotyl line selected from a population formed by interpollinating 55 rot resistant individuals from the world collection of *Beta vulgaris*. The original parents had high levels of resistance to one storage rot organism and were equal to or slightly superior to the commercial hybrid checks for resistance to the other two. Superior individuals were crossed in pairs for three subsequent generations. Individual pairs were maintained as lines in each cycle. Concurrent with selection for rot resistance, visual selection was used to eliminate lines with the tendency to produce sprangled or colored roots.

All three lines have been evaluated in replicated field trials for at least three years for storage rot response and agronomic characteristics (Table 1). Sugar content and purity (a measure of extractable sucrose) of the storage rot resistant lines were slightly lower than the commercial hybrid checks. Root yields of the selected lines were approximately 65 percent of the check hybrids, a value not unexpected when comparing inbred lines with adapted hybrids. These lines are intended to be used as pollinators for experimental hybrids, as parents in genetic studies and as genetic sources for the development of storage rot resistant parental lines. Genetic resistance to storage rot fungi is intended to complement other methods of reducing storage losses such as pile ventilation and reducing injury to roots. These lines and others in the program, hopefully, will serve as a basis for further progress in reducing storage losses in sugarbeet piles. Breeder seed of F1004, F1005 and F1006 will be maintained by the USDA-ARS sugarbeet research group at Fargo. Germplasm quantities may be obtained from the authors.

Table 1. Characteristics of three storage rot resistant germplasm lines, Fargo, North Dakota, 1981 to 1983.

Line	*Phoma*	*Botrytis*	*Penicillium*	Sucrose	Purity	Root Yield
	rating[1]			%		Tons/A
F1004	2.0	2.0	1.4	11.1	81.3	11.9
F1005	2.0	2.1	1.3	10.4	80.1	11.6
F1006	1.7	1.9	1.0	11.1	80.4	13.6
Checks[2]	3.1	3.6	2.8	11.7	85.5	18.4

[1]Rot rating indicates the distance rot progressed through a 0.40 in block of root tissue after incubation at 70°F for 2 weeks: 0 = no rot; 1 = not over 0.08 in; 2 = 0.08-0.16 in; 3 = 0.16-0.24 in; 4 = 0.24-0.32 in; 5 = entire block.

[2]Checks were not the same in all three years but included GW-R1, Beta 1345, Ultramono, Beta 1230 and Hilleshog 833.

[3]Root yield data for 1981 and 1983 only.

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