The Effect of Plant Age, Storage, Moisture, and Genotype on Storage Rot Evaluation of Sugarbeet

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ABSTRACT

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Sugarbeet roots aged under moisture stress were more resistant to storage rot caused by *Phoma betae* and *Botrytis cinerea*, but those with adequate moisture were more susceptible to those fungi and to *Penicillium claviforme*. However, aged roots of a susceptible commercial cultivar grown under adequate moisture in the fall and stored at 5 C for 80 days were less liable to rot than were those grown under moisture stress. It was concluded: that 80-day-old roots could be evaluated for resistance to *P. betae* and *B. cinerea* in dry or wet years and to *P. claviforme* in wet years, and that differences between susceptible and resistant reactions in roots stored 30 days at 5 C could be detected as well or better than under other storage regimes. This method shortens the growing period by 80 days and the storage period by 50 days and would be useful for identifying resistant roots in a breeding program. Rot ratings, averaged over root age and storage treatments, showed roots of a greenhouse-grown known resistant genotype to be superior to those of a susceptible commercial cultivar. Thus, roots to be evaluated for storage rot susceptibility may be grown in the greenhouse as well as in the field.

The results of research since 1971 have shown that storage rot resistance of sugarbeet (*Betae vulgaris* L.) roots could be measured after storage for at least 80 days at 5 C. Tissue cylinders are removed with a cork borer and placed on pure cultures of the test pathogens. Two germplasms with storage rot resistance have been developed by utilizing this method (1). The availability of seed of resistant and susceptible genotypes permitted a comparison of the effects of root maturity and storage environment on response to major storage pathogens. The objective of this study was to develop techniques for more rapid identification of storage-rot resistant sugarbeets.

MATERIALS AND METHODS

Ninety consecutive (within a row) roots each of a susceptible and resistant genotype were harvested from field strip plots at 80, 120, and 160 days after planting in 1976 and 1977. The susceptible genotype was a commercial cultivar, American Crystal 2 hybrid B (2B), and the resistant genotype, 75P6, was developed by selection and inter-pollination of six roots possessing a high level of resistance to *Phoma betae* (Oud.) Frank. The original seed source for the resistant genotype was VNIS F526, an introduction from the USSR. Then the roots were segregated into five groups per genotype. Group 1 was evaluated for storage rot reaction at harvest and the remaining groups were stored in perforated polyethylene bags for 30 or 80 days at 5 or 20–22 C at 95–98% relative humidity.

Cylindrical tissue samples (13 mm in diameter × 20–30 mm long) from roots were tested for resistance to three storage pathogens. Three cylinders were prepared from each root. The cylinders were immersed in 1.0% sodium hypochlorite for 1 min then rinsed twice in sterile distilled water. One cylinder was placed, on end, on a pure culture of *P. betae*, *Botrytis cinerea* Pers., or *Penicillium claviforme* Bainer in a storage dish, 100 mm in diameter and 80 mm high. After 2 wk of incubation at 20–22 C, the cylinders were cut longitudinally and rated on the basis of the distance rot had progressed along the cylinder (rating scale: 0, 0 mm; 1, 1 mm; 2, 1–5 mm; 3, 6–10 mm; 4, 11–15 mm, etc.). The treatments were replicated six times. A replicate consisted of three roots from each genotype.

Greenhouse tests. Forty roots of a susceptible genotype and 40 of a resistant genotype were grown for 8 wk in the greenhouse to a weight of 250–300 g. They were harvested, washed, and distributed into five groups of eight roots of each genotype. One group was evaluated immediately for resistance to storage rot and the remaining groups were stored as described above. The susceptible genotype was 2B and the resistant genotype, 1677, was a product of a single-root selection from VNIS F738, an introduction from the USSR. The resistant selection possessed resistance to all three pathogens used in this test. The treatments were replicated eight times, a replicate being one root. Six cylinders were taken from each root and two were tested against each of the three pathogens.

A replica of a root tissue sampling knife used by sugarbeet researchers in the Soviet Union was tested. The knife was used in the second year's field test to obtain 1-cm cubes of root tissue from the same roots from which the cylinders were taken (Fig. 1).

RESULTS

Field tests. Extremes in rainfall occurred during the two test years. In 1976, precipitation was low enough to reduce yields in the Moorhead, MN and Wahpeton, ND sugar factory districts. The

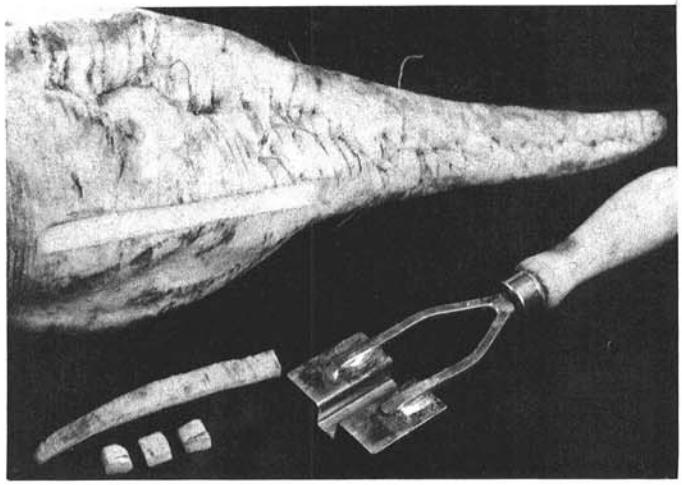

Fig. 1. Replica of sampling knife used in the USSR to obtain sugarbeet root tissue samples. The strip, which is 1 cm × 1 cm, is cut into blocks 1 cm long.

second year, 1977, was extremely dry until the last 6–8 wk when rainfall was plentiful. Yields from the experimental plots did not differ between those years. The average root weights of 180 mature roots were 1.08 kg in 1976 and 1.09 kg in 1977.

In 1976, stored roots of the resistant genotype showed less rot than those of the susceptible genotype with the exception of those stored 80 days at 20 C, certain age-storage combinations with *P. betae* inoculation or *P. claviforme*. The resistant genotype was less susceptible to rot by all three pathogens in 1977.

With aging, unstored roots of both genotypes became more resistant to *P. betae* and *B. cinera* but not to *P. claviforme* in 1976 (Table 1) and more susceptible in 1977 (Table 2). Roots harvested in 1976 that were 120 days old increased in resistance to *P. betae* and *B. cinera* but not *P. claviforme* when stored longer than 80 days at 5 or 20 C. In fact, roots of the susceptible genotype were moderately resistant to *P. betae* even after storage at 20 C for 80 days. The same trend was noted for the resistant genotype in 1977.

Tissue blocks and cylinders reacted similarly to the three pathogens. Correlation coefficients of rot ratings between the two shapes of tissue samples from 468 roots were 0.80 for *P. betae*, 0.78 for *B. cinerea*, and 0.81 for *P. claviforme*. All correlations were significant, $P = 0.01$.

The interaction among genotype, storage times, and temperatures was nonsignificant for roots produced in the greenhouse. There was a significant difference between the genotypes when averaged over storage time and temperature.

DISCUSSION

The water status of sugarbeet roots before or during harvest affects the incidence of storage rot. Roots that lose excessive amounts of moisture during storage are more susceptible to storage rots than are fully turgid roots (2,3). Increased amounts of rot caused by *P. betae* in stored roots was associated with low rainfall during the growing season (5). This agrees with my results with 160-day roots grown in 1976 under drought conditions. Even though the roots were resistant at harvest, rot progressed more rapidly during storage than in roots from 1977 (wet fall). Low rainfall limits the availability of nitrogen. Roots from the dry year had lower levels of alpha-amino nitrogen than those from the wet year (D. F. Cole, *unpublished*). This is desirable because high nitrogen levels in the root interfere with the sucrose extraction process. However, roots grown under low available nitrogen levels were rotted more severely by *P. betae* than were those grown under adequate levels (4). The combined effect of low nitrogen and water deficit on storage rot is not known. Under the environmental stress of 1976, the storage rot resistance of the resistant genotype ranked above that of the susceptible genotype. This supports the conclusion that 80-day-old field-grown roots can be evaluated for resistance to *P. betae* and *Botrytis*. Susceptibility to storage rot caused by *P.*

TABLE 1. The storage rot reaction to inoculation with *Phoma betae*, *Botrytis cinerea*, and *Penicillium claviforme* of susceptible (S) and resistant (R) sugarbeet roots of different ages at harvest and after storage in 1976

Storage			Storage rot rating[a] of roots from plants grown (days) and inoculated with:									
			P. betae			*B. cinerea*			*P. claviforme*			
Time (days)	Temp (C)	Host reaction	80 days	120 days	160 days	80 days	120 days	160 days	80 days	120 days	160 days	Mean
0		S	2.6	1.4	0.9	5.0	2.7	1.0	3.7	0.6	2.8	2.3
0		R	2.1	1.2	0.8	5.0	1.4	0.4	3.1	1.1	2.7	2.0
30	5	S	0.7	2.7	1.2	4.6	3.9	3.4	0.1	2.8	2.7	2.5
30	5	R	0.3	2.2	1.2	2.4	1.7	1.8	0.3	2.6	2.6	1.7
30	20	S	2.0	2.7	0.9	5.0	3.0	3.8	1.8	2.2	2.2	2.6
30	20	R	1.4	2.2	1.4	3.2	2.2	2.2	1.5	2.3	2.4	2.1
80	5	S	1.6	0.8	3.2	4.3	3.3	5.1	1.6	2.8	3.1	2.9
80	5	R	1.4	0.9	1.8	2.0	1.5	3.4	1.4	2.5	2.3	1.9
80	20	S	4.8	1.9	5.0	5.6	4.2	4.9	4.3	2.8	5.0	4.3
80	20	R	4.0	1.7	4.1	4.3	3.4	4.3	3.3	2.2	4.4	3.5
L.S.D. (P=0.01)=				0.3			0.3			ns		

[a]Storage rot rating is the distance rot progressed along a cylinder (13 mm diameter × 20–30 mm long) of root tissue. The rating scale was 0, 0 mm; 1, 1 mm; 2, 2–5 mm; 3, 6–10 mm; 4, 11–15 mm, etc.

TABLE 2. The reaction to *Phoma betae*, *Botrytis cinerea*, and *Penicillium claviforme* on sugarbeet roots of different ages at harvest and after storage in 1977

Storage			Storage rot rating[a] of roots from plants grown (days) and inoculated with:									
			P. betae			*B. cinerea*			*P. claviforme*			
Time (days)	Temp (C)	Host reaction	80 days	120 days	160 days	80 days	120 days	160 days	80 days	120 days	160 days	Mean
0		S	1.5	2.8	4.6	4.7	3.9	4.5	3.9	2.9	4.3	3.7
0		R	0.3	2.3	2.7	3.3	2.6	1.4	2.1	2.2	3.4	2.3
30	5	S	2.7	4.4	3.8	3.5	3.8	4.1	2.1	2.6	3.6	3.4
30	5	R	1.8	1.9	2.4	0.9	1.6	2.4	1.6	0.4	3.0	1.8
30	20	S	1.9	3.8	3.0	2.6	4.4	3.9	2.2	2.9	3.7	3.2
30	20	R	1.2	1.7	1.8	1.6	2.4	3.3	1.8	1.6	3.3	2.1
80	5	S	2.4	3.4	2.6	3.2	4.4	3.3	2.6	3.5	2.4	3.1
80	5	R	1.9	0.9	2.2	1.7	3.4	2.6	1.8	1.2	2.5	2.0
80	20	S	6.0	5.0	6.0	6.0	5.0	6.0	6.0	5.0	6.0	5.7
80	20	R	6.0	4.9	6.0	6.0	4.9	6.0	6.0	4.8	6.0	5.6
L.S.D. (P=0.01)=				0.4			0.3			0.3		

[a]Rot rating is the distance rot progressed along a cylinder of root tissue placed on a growing culture of the test fungus. The rating scale was 0, 0 mm; 1, 1 mm; 2, 2–5 mm; 3, 6–10 mm; 4, 11–15 mm.

claviforme also can be determined in roots not subjected to water stress, as in 1976.

This method requires 124 days compared to 254 days for the previous method. There are five advantages of evaluating roots from 80-day-old plants: (i) the smaller roots require less storage space; (ii) the shortened method gains sufficient time for root selection and vernalization (80–120 days), and seed production in the greenhouse before the next growing season; (iii) two cycles of testing and seed production could be accomplished annually in the greenhouse; (iv) storage rot information could be obtained from young, induced roots (stecklings) prior to seed production; and (v) a trial nursery could provide storage rot information before harvest of the main plots.

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