The Effect of Root Dehydration on the Storage Performance of a Sugarbeet Genotype Resistant to Storage Rot

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ABSTRACT

The sugarbeet cultivar American Crystal 2 hybrid B (2B) was superior to the storage-rot-resistant genotype 75P6 in the production of recoverable white sugar per ton (RWST) at harvest, but 75P6 was superior to 2B after the roots had been inoculated with Phoma betae, Botrytis cinerea, and Penicillium claviforme and stored at 10° C in 98% relative humidity for 106 days. The amount of rot in 75P6 was 50% of that in 2B when roots had lost 8-10% of their weight in storage. Dehydrated roots had lower clear juice purity (CJP) and RWST than did turgid roots. Severely dehydrated roots (24% weight loss) of both genotypes did not develop more rot than turgid roots (9% weight loss), but there was a decrease in pol sucrose, CJP, and RWST.

INTRODUCTION

Moisture loss from sugarbeet roots because of drought during the growing season or because of exposure to drying conditions after harvest reportely causes the

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roots to become more susceptible to storage rot. A 9-fold increase in rot during 19 weeks of storage at 10° C was reported for roots that had a 15% weight loss before storage began (5). Another report showed that when roots with a 19% weight loss were injured, there was a 10-fold increase in storage rot compared with a 7-fold increase in uninjured roots (7). Greater rot in the injured roots was attributed, in part, to reduced wound repair capability in wilted roots. Exposure of root sections to drying for 24 hrs increased susceptibility to Phoma betae, and this susceptibility increased more rapidly on wilted sections than on nonwilted sections above 10° C (2). Stored roots rotted more if irrigation during the growing period was restricted, and the benefit of fertilization was nullified when roots were produced under drought conditions (8). Most of the rot was caused by P. betae. Results from the U.S.S.R. further show that cultivars resistant to storage rot maintain higher leaf and root turgor than susceptible roots under drought conditions. There might be a genetic link between drought resistance and storage-rot resistance (9).

The Red River Valley of North Dakota and Minnesota is the largest sugarbeet area in the U.S., and nearly all of that area is cultivated as dryland. Our objective was to determine the effect of water loss from stored roots on rot caused by the major storage pathogens in that region and to see if genetic resistance to rot would reduce sucrose losses under moisture stress.

MATERIALS AND METHODS

Two sugarbeet (Beta vulgaris L.) genotypes were grown for 160 days at the North Dakota Agricultural Experiment Station, Fargo. One genotype was a commercial cultivar, American Crystal 2 hybrid B (2B), and the other was a breeding line, 75P6. Cultivar 2B is susceptible to the storage rot pathogens used here. Line 75P6 was developed at Fargo from the U.S.S.R. introduction VNIS F526 by interpollinating six roots that were selected for resistance to storage rot caused by Phoma betae (Oud.)

Frank. This line also responded with moderate resistance to storage rot caused by Botrytis cinerea L. and Penicillium claviforme Bainier.

Roots were harvested, washed, and divided into four groups of 10 roots each for each of the two genotypes. The roots of group 1 were inoculated and stored in perforated plastic bags. Group 2 roots were stored identically as group 1 but not inoculated. Group 3 was inoculated and stored in open-mesh onion sacks. Group 4 was stored identically as group 3 but not inoculated. The eight treatments were replicated 16 times in a complete randomized block design. Storage was at 10 ± 2^{o} C for 106 days. Relative humidity of circulated air in the storeroom was about 85%, and near 100% within the perforated plastic bags.

Inoculation was done by inserting, with a twisting motion, an 11-mm d cork borer 8-10 mm into the root. The end of the borer had a serrated edge to increase wounding action and was dipped into inoculum before wounding each root. The inoculum consisted of a mixture of conidia from P. betae, P. claviforme Bainier, and B. cinerea L. suspended in a 0.1% water agar.

All inoculated roots were given a rot index based on the distance rot had progressed in both directions from the circular wound site: 0, no rot evident; 1, rot up to 2 mm; 2, rot up to 5 mm; 3, rot up to 10 mm; 4, rot up to 30 mm; 5 rot up to 40 mm (Fig. 1). Rot also was measured by excising the rotted portions from the inoculation site, weighing the rotted tissue, and expressing rot as a percentage of the final weight of the entire root sample. This was done on five randomly selected roots from each bag and the other five roots were used for quality measurements.

Sucrose was measured with a polarimeter by the cold digestion method (3) and adjusted for root weight loss after storage. Clear juice purity (CJP) was determined by using the method described by Dexter and co-workers (4). The data were summarized and statistically analyzed using the SAS-76 computer program (1) on an IBM 370/148

computer.

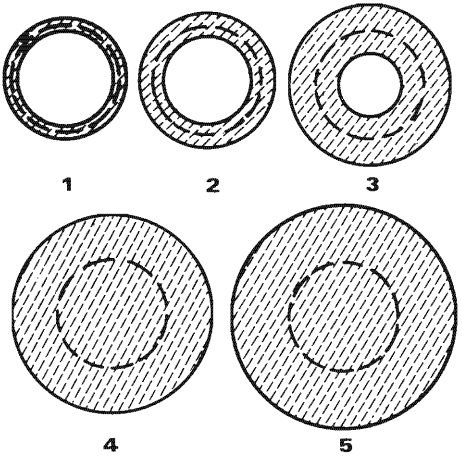

Fig. 1. --Diagram of rot represented by the shaded area in relation to the wound site represented by the broken-line circle, and the rot index number assigned to each class.

RESULTS

Roots that were stored at 10° C in 98% relative humidity in perforated plastic bags for 106 days lost 8 - 10% of their original weight (Table 1). Those stored

Table 1. --The effect of root dehydration during 106 days of storage at 10° C on weight loss and storage rot of a storage-rot susceptible (2B) and resistant (75P6) genotype

	Noninoculated storage Relative humidity, %		Inoculated storage Relative humidity, %	
Genotype	98	85	98	85
		Weight loss, %		
75P6	8 d*	23 a	9 cd	24 a
2B	10 c	22 b	10 c	24 a
		Rot by weight, %		
75P6	---	---	2.1 c	2.5 bc
2B	---	---	5.2 a	4.0 ab
		Rot index		
75P6	---	---	2.4 b	2.8 b
2B	---	---	4.8 a	4.8 a

* Means of 16 replications; means followed by the same letter within each parameter are not significantly (P = 0.05) different by Duncan's multiple range test.

at the same temperature in open-mesh sacks and exposed to circulating air that contained 85% relative humidity lost 20 - 24% of their original weight.

The amount of storage rot in 75P6 was less than 50% of that in 2B (Table 1). The amount of rot within each genotype was not affected by the amount of weight loss during storage. A comparison of the two methods of measuring rot showed a positive correlation (r = .69**).

Cultivar 2B was superior to 75P6 in percentage sucrose, CJP, and recoverable white sugar per ton (RWST) at harvest (Table 2). Noninoculated roots of 2B were

Table 2. --Quality measurements at harvest of a storage-rot resistant (75P6) and susceptible (American Crystal 2 hybrid B) genotype

Genotype	Sucrose content	Clear juice purity	Recoverable white sugar/ton	
	%	%	lbs	Kg/t
2B	14.82 a*	93.84 a	259a	128 a
75P6	13.91 b	91.20 b	229b	113 b

* Means of 16 replications; means followed by the same letter within each column are not significantly different (P = 0.05) by the Waller-Duncan K-ratio method of mean separation.

superior to roots of 75P6 in quality after storage of 106 days at 98% relative humidity (Table 3).

Genotype 75P6 was superior to 2B in all quality measurements after the roots were inoculated and stored at 98% relative humidity (Table 3). At harvest, 2B produced 24 lbs more RWST (11.9 Kg/t) than 75P6 but when infected with storage rot pathogens and stored at 98% relative humidity, 75P6 produced 35 lbs more RWST (17.3 Kg/t) than 2B (Tables 2 and 3). When inoculated and stored under low humidity, the RWST for both genotypes was similar.

DISCUSSION

Genotype 75P6, which has resistance to the storage rot pathogens tested here, expressed this characteristic

Table 3. --The effect of root dehydration and storage rot on the quality of a storage-rot susceptible (2B) and resistant (75P6) genotype during 106 days of storage at 10° C

	Noninoculated		Inoculated	
	Storage Relative humidity, %		Storage Relative humidity, %	
Genotype	98	85	98	85
	Sucrose content, %			
75P6	13.77 b*	13.29 bc	14.23 ab	11.79 d
2B	14.93 a	13.98 b	12.76 c	12.46 cd
	Purity, %			
75P6	88.37 ab	84.40 c	89.42 a	79.30 d
2B	90.99 a	88.03 ab	85.89 bc	80.36 d
	Recoverable white sugar/ton, lbs (Kg/t)			
75P6	211 b (104)	180 c (89)	223 ab (110)	130 d (64)
2B	244 a (121)	213 b (105)	180 c (89)	145 d (71)

* Means of 16 replications; means followed by the same letter within each parameter are not significantly different (P = 0.05) by the Waller-Duncan K-ratio method of mean separation.

favorably not only with less rot than the susceptible cultivar 2B, but also in essentially no loss of RWST when inoculated and stored in high humidity. Conversely, the susceptible cultivar lost 58 pounds of RWST (28.7 Kg/t) during storage. Thus, at harvest, cultivar 2B was superior to 75P6 in yield of RWST but inferior to 75P6 when inoculated and stored in high humidity. Both genotypes suffered a significant loss of 66 - 76 lbs of RWST (32.7 - 37.6 Kg/t) when infected and stored at the lower humidity. The advantage of the genetic resistance possessed by 75P6 was lost when these roots were dehydrated. We report here for the first time that a breeding line possessing genetic resistance to P. betae, B. cinerea, and P. claviforme will suffer a loss in recoverable sucrose comparable to a storage rot susceptible cultivar if the roots are allowed to lose more than 10% of their weight through water loss during storage.

The quality deterioration of dehydrated roots during storage reported here agrees with others (2,5,7,8,9),

but our results show that these losses may not be accompanied by increased rot.

Dehydrated and infected roots of 75P6 did not suffer an increased rot relative to the turgid roots. In fact, there was no change in rot development within each genotype whether dehydrated or turgid. There was a significant decrease during storage in RWST, purity, and pol sucrose in dehydrated, infected 75P6. Moisture loss, coupled with infected tissue, may have caused a sufficient increase in respiration in 75P6 to account for the decrease in sucrose content. There is a general phenomenon that infected resistant plant tissue respires at a higher rate than infected susceptible tissue (6). Therefore, the prevention of root dehydration during storage was more important for the rot-resistant genotype than it was for the susceptible cultivar.

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