IMPACT OF SUGAR BEET ROOT DISEASES ON POSTHARVEST STORAGE

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ABSTRACT

In recent years, the sugar beet (*Beta vulgaris* L.) root diseases, Aphanomyces and rhizomania (causal agents *Aphanomyces cochlioides* Drechal. and beet necrotic yellow vein virus, respectively), have become more prevalent throughout Minnesota and eastern North Dakota. Accompanying any increase in root disease in the field will be an increase in the proportion of diseased roots placed in storage piles. Information on the effects of root disease on initial quality and storability would assist growers and agriculturalists when determining the disease severity that would justify not harvesting a field or if roots from diseased fields should be segregated and processed first. Respiration rate, extractable sucrose per ton, and the formation of carbohydrate impurities were determined in roots exhibiting varying degrees of Aphanomyces or rhizomania symptoms. Respiration rates of roots with moderate or severe Aphanomyces were substantially higher than respiration rates of healthy roots. The concentrations of the invert sugars, glucose and fructose, were also elevated in severely rotted roots, although trisaccharide impurity concentrations were reduced. The higher respiration rates of Aphanomyces infected roots are not only indicative of higher sugar loss but would also increase storage pile temperatures and increase sugar loss in adjacent healthy roots. Further sucrose loss would occur during the processing of rotted roots due to their increased concentrations of invert sugars. Initial observations of the effects of rhizomania on sugarbeet root storage properties suggest that rhizomania is not nearly as detrimental to root storability as Aphanomyces, however, this observation is based on a single year's data. The impact of genetic resistance on storage properties appeared to be negligible as neither rhizomania nor Aphanomyces resistance was associated with higher respiration rates in the absence of disease

INTRODUCTION

In recent years, root diseases have become more prevalent throughout Minnesota and eastern North Dakota. Because of its persistence in soil and the absence of effective control methods, Aphanomyces (*Aphanomyces cochliodes* Drechal.) is especially threatening. Rhizomania (beet necrotic yellow vein virus) was first identified in southern Minnesota in 1996 and has since spread throughout the region. Rhizomania resistant hybrids provide the only practical control for heavily infested sites. Rhizomania resistant hybrids were quickly introduced, in response to the rapid spread of the disease, without knowledge of their storage characteristics. Hybrids with resistance to Aphanomyces have been available for some time and provide some protection when used in combination with fungicides and certain cultural practices (WINDELS, C.E & BRANTNER, J.R., 2002). Resistant hybrids generally are not the most productive in the absence of the disease and disease severity depends upon conditions after planting, making it difficult to predict when resistance will be beneficial. Any increase in the prevalence of root rot in commercial fields will be accompanied by an increase in roots with rot that are placed in storage piles.

In addition to the direct loss of sucrose during postharvest storage, products formed through sucrose metabolism by endogenous sugar beet enzymes or enzymes from pathogenic organisms interfere with sucrose extraction. Among the widely recognized impurities from sucrose degradiation are the invert sugars, glucose and fructose, and raffinose, a trisaccharide. These carbohydrate impurities cause color, crystallization, and filtration problems during processing, increasing the loss of sucrose to molasses. The occurrence of these impurities has been documented in healthy roots but information on the types and quantities of carbohydrate impurities that occur in and accumulate during storage of diseased roots is lacking.

This study was designed to obtain information on the effects of rot severity on initial quality and storability that would assist growers and agriculturalists in selecting hybrids for areas where root diseases are prevalent and in determining the disease severity that justifies not harvesting a field or if roots from diseased fields should be segregated and processed first.

MATERIALS AND METHODS

Three fields near Moorhead, Minnesota were sampled 22 September 2000. Roots from each field were divided into four groups, based upon root-rot severity (primarily Aphanomyces), and stored at 5 C and 95% relative humidity in perforated plastic bags. The four groups were 1) No rot: no visible symptoms of root rot, 2) Russet: small areas of russeting on the root surface, 3) Moderate: up to 25% to 50% of the root surface impacted with rot and slightly deformed roots, and 4) Severe: more than half of the root with active rot and often deformed. Respiration rate was measured 16, 44, 57, and 69 days after harvest. Each sample, consisting of approximately 12 roots, was placed in a sealed bucket with a regulated flow of ambient air. After 24 hours, the CO_2 concentration of air from the exit tube was determined with an infrared analyzer and respiration rate expressed as mg CO_2 /kg roots / hour (BURKE, J.I. et al., 1979). Extractable sugar per ton, sucrose, and carbohydrate impurities were determined 18 and 85 days after harvest. Extractable sugar estimates were based upon sucrose determined polarimetrically (MCGINNIS, R.A., 1982) and clear juice purity (DEXTER, S.T. ET AL., 1967). For the sucrose and impurity determinations a core was removed from the widest portion of the root, frozen in liquid nitrogen, lyophilized, and ground to a fine powder. Gas chromatography was used to determine sucrose, glucose, fructose, and trisaccharide concentrations (LONG, A.R. & CHISM, G.W. 1987).

Roots of six rhizomania and/or Aphanomyces resistant hybrids were obtained from two variety trials in southern Minnesota and one in northern North Dakota in 2001. Yields at one Minnesota site (Degraff, Minnesota) were reduced by rhizomania and perhaps beet soil borne mosaic virus; the other two sites (Clara City, Minnesota and St. Thomas, North Dakota) had no apparent virus symptoms. Respiration rate, sugar, and extractable sugar per ton were measured 18 and 128 days after havest.

Table 1: Storage properties of roots with rot (primarily Aphanomyces) from three fields near Moorhead, Minnesota, 2000.

Days after harvest	Root-rot severity			
	No rot	Russet	Moderate	Severe
	Respiration rate, mg CO_2/kg/hr			
16	5,3	5,9	7,6	21,9
44	4,9	6,0	9,2	25,4
57	4,8	5,4	10,9	19,1
69	4,3	4,7	7,4	21,8
Mean	5,0 a*	5,7 a	8,2 b	22,7 c
	Extractable sucrose, kg/Mg			
18	158 a	155 a	137 b	64 c
85	159 a	162 a	127 b	57 c
	Sucrose, mg/g dry weight			
18	756 a	699 a	692 a	495 b
85	661 a	649 a	616 a	387 b
	Invert sugar, mg/d dry weight			
18	3,93 a	4,31 a	5,03 a	13,40 b
85	3,04 a	2,84 a	3,59 a	10,51 a
	Trisaccharides, mg/g dry weight			
18	5,77 a	6,39 a	4,91 a	3,65 a
85	4,07 a	3,47 a	4,26 a	4,02 a

**Means within a row followed by the same letter are not significantly different, (LSD = 0.10).*

RESULTS

Respiration rates of healthy roots (no rot) and roots with russeting were not significantly different (Table 1). Roots with moderate rot symptoms respired faster than healthy roots but substantially slower than roots with severe rot. Respiration rates for the most diseased roots were 4 times those of the healthy roots and 2.5 times the rate observed for the moderate group. This pattern was observed over four sampling dates, indicating relative respiration rates remain constant when storage conditions are stable.

Sucrose concentrations, on a dry weight basis, 18 days after harvest were 756 mg g^{-1} for the healthy roots compared to only 495 mg g^{-1} for roots with severe rot. The russet and moderate groups had sucrose concentrations of 699 and 692 mg g^{-1}, respectively. This general pattern persisted throughout the 85 days of storage and is reflected in the extractable sugar values in Table 1. Sucrose concentrations of roots with severe rot were 387 mg g^{-1} 85 days after harvest. Extractable sugar concentrations in the severely rotted roots were about 40% of that in healthy roots. Roots classified as moderate had extractable sugar concentrations equal to approximately 80% of the healthy roots. Relative values were similar 18 and 85 days after harvest.

Invert sugar concentrations were significantly elevated in roots with severe root rot. However, concentrations in roots with russeting, or moderate rot did not differ from roots with no rot. Severely rotted roots contained more than three times the invert sugar of healthy roots, 18 days after harvest. Invert sugars appeared to decrease during storage but the decline was not statistically significant. Trisaccharide concentrations, primarily raffinose, were not influenced by root-rot severity or time in storage.

Based upon the 18-day evaluation of roots from the St. Thomas and Clara City variety trials and the 128-day results from Clara City, the introduction of rhizomania resistance was not necessarily accompanied by an increase in storage respiration rate (Table 2). The high 128-day respiration rates and low extractable sugars for St. Thomas demonstrate the negative impact of conventional storage rots and make comparisons with the other two locations meaningless. The lower respiration rates and higher sucrose concentrations observed in the absence of rhizomania could also be associated with environmental factors not related to rhizomania and not the disease per se.

CONCLUSIONS

- Severely infected roots were substantially lower in extractable sugar and had considerable higher respiration rates than healthy roots. Roots with moderate root-rot symptoms also had lower extractable sugar concentrations and higher respiration rates than healthy roots but losses were considerably less than those observed for the severe group. Russeting did not appear to have a negative effect on sugar concentration or respiration. Higher respiration rates would cause temperatures in storage piles to increase, having a negative effect on adjacent healthy roots.
- Invert sugars were elevated in roots with severe rot symptoms. No increase in invert sugar concentrations was observed in russeted or moderately rotted roots. The combination of high invert sugar concentration and low sucrose concentration in the severely rotted roots could cause severe processing difficulties.
- Trisaccharide concentrations were not affected by root-rot severity or time in storage.

Table 2: Storage characteristics (18 and 128 days after harvest) of Aphanomyces and/or rhizomania resistant hybrids from Clara City and Degraff, Minnesota and St. Thomas, North Dakota, 2001.

	Storage Respiration rate (CO_2)		Sugar**		Extractable sugar*	
Location/hybrid	18d	128d	18d	128d	18d	128d
	Mg/kg/hr		G/100g		Kg/Mg	
St. Thomas (Healthy)						
H-7083	5,61	15,98*	168	133	152	86
B-4811	7,66	10,29	162	132	149	106
B-4600	5,82	14,19	172	152	156	112
A-952	6,16	13,16	184	184	167	131
V-46109	6,93	20,30	170	100	156	58
B-3945	6,93	18,43	180	135	164	90
Mean	6,52	15,39	173	136	157	97
LSD (0,05)	0,96	5,79	10	26	10	10
Clara City (healthy)						
H-7083	7,64	5,08	133	119	120	106
B-4811	6,84	5,31	143	127	120	118
B-4600	6,98	6,16	149	133	136	117
A-952	7,08	5,94	151	142	137	128
V-46109	6,92	5,81	141	120	128	109
B-3945	7,40	6,37	148	146	134	121
Mean	7,14	5,78	144	130	130	116
LSD (0,05)	ns	ns	ns	15	13	ns
Degraff (diseased)						
H-7083	9,76	8,28	128	123	117	109
B-4811	8,27	7,57	128	128	116	108
B-4600	9,91	7,77	128	133	114	118
A-952	7,48	5,82	129	109	116	94
V-46109	8,16	9,01	136	120	126	107
B-3945	9,05	9,26	140	127	126	114
Mean	8,78	7,95	131	122	119	108
LSD (0,05)	ns	ns	ns	ns	ns	ns

Hybrid: H-7083 B-4811 B-4600 A-952 V-46109 B-3945

Aphanomyces resistant (B-4811 – B-3945)

Rhizomania resistant (H-7083 – B-4600)

**High respiration rates for St. Thomas 128 days after harvest are due to conventional storage rots - Penicillin, Botrytis, Phoma, etc.*

***Sugar and extractable sugar for 128 days after harvest are adjusted for changes in water content during storage (Based upon weight at 18 days).*

- There does not appear to be a linkage between resistance to rhizomania and storage respiration rate. Development of resistant hybrids with low respiration rates appears feasible.
- The impact of rhizomania on losses in storage is unclear, but considerably less than the effect of severe Aphanomyces.

These conclusions are based upon one year's data from a few environments. Hence, they should be interpreted with caution. The detrimental effects of severe Aphanomyces root-rot seem evident but the impact of light to moderate disease severity is less clear. The impact of Rhizomania is not apparent and confirmation of the trends observed is needed. The results presented here have provided a basis for storage research now in progress.

ACKNOWLEDGEMENTS

John Eide, Nyle Jonason, and Joe Thompson (USDA); American Crystal Ag. Staff – Allan Cattanach, Bill Niehaus, John Prigge, Darin Vettern, Neil Boeddeker, and Donna Aafedt; and Southern Minnesota Ag. Staff – Steve Roehl and Mark Broedehoft contributed to this research. Their input and financial assistance from American Crystal Sugar and the Sugarbeet Research and Education Baord of Minnesota and North Dakota are appreciated.

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