Impact of Rhizomania on Storage Respiration Rate and Sugar Loss

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In the decade since rhizomania (*Beet necrotic yellow vein virus*; BNYVV) was first identified in southern Minnesota, the disease has become a serious threat to sugarbeet production throughout Minnesota and eastern North Dakota. Once the virus is established, rhizomania resistant varieties are the only effective control measure. The rapid spread of the disease required seed companies to respond quickly and in many cases it was necessary to compromise yield, quality, or adaptation to meet the demand for resistant varieties. Growers were faced with a choice of reduced yields if they planted a susceptible variety and the disease appeared or reduced yield and quality if

Table 1. Respiration rate and extractable sugar concentration of susceptible and resistant varieties stored for 30 and 120 days after harvest (DAH) at Crookston and Hendrum, MN, 2002-2003.

Variety Response to BNYVV	2002 Crookston-A	2002 Crookston-K	2003 Hendrum
	mg CO_2 / kg / hour (30 DAH)		
Susceptible	6.10 a*	4.96 b	4.31 c
Intermediate	4.10 cd	4.19 cd	3.65 de
Resistant	3.80 c-e	4.28 cd	3.28 e
	mg CO_2 / kg / hour (120 DAH)		
Susceptible	19.66 a	8.52 c	6.70 cd
Intermediate	15.75 b	4.91 de	4.29 e
Resistant	8.14 c	4.95 de	3.10 e
	Extractable sugar, lbs / T (30 DAH)		
Susceptible	256 e	280 b-d	216 f
Intermediate	264 de	278 cd	246 e
Resistant	307 a	292 ac	300 ab
	Extractable sugar, lbs / T (120 DAH)		
Susceptible	54 f	186 bc	149 d
Intermediate	106 e	219 ab	178 cd
Resistant	239 a	250 a	237 a
	Extractable sugar loss, % (30 – 120 DAH)		

Susceptible	79 a	34 c	31 c
Intermediate	60 b	21 cd	28 cd
Resistant	22 cd	14 d	21 cd

* Means followed by a common letter are not significantly different (LSD $_{0.10}$).

the disease did not materialize and they had planted a resistant variety. Some seed companies attempted to resolve this dilemma by providing varieties that had intermediate levels of resistance, yield, and quality potential. Furthermore, as the prevalence of the disease increased, processors raised concerns regarding the storage of roots from fields with rhizomania. This research was designed to provide information that would assist growers and processors in making decisions that would minimize postharvest losses of roots with rhizomania.

All roots were obtained from American Crystal Sugar Co. strip trials at locations with rhizomania. Two sites south of Crookston, MN were sampled in 2002; the 2003 samples were from a field west of Hendrum, MN. The 2004 samples were from a field east of the Crookston, MN factory, and in 2005, a trial south of Climax, MN was sampled. Each variety was planted in two strips at each location. Three 24-root samples were hand harvested from each strip for determination of storage respiration rate and postharvest sugar loss. Roots were stored in perforated plastic bags at 40^{o} F and high humidity. Half of the roots (12) from each sample were used to measure respiration rate and extractable sugar concentration 30 days after harvest. The same measurements were obtained on the remaining 12 roots 120 days after harvest. Extractable sugar loss was the difference between the 30-day readings and the 120-day readings, adjusted for small changes in dry matter concentration during storage. Percent loss was the actual sugar loss divided by the extractable sugar per ton 30 days after harvest (DAH), expressed as a percent. Only three varieties were available for the 2002 and 2003 trials; an otherwise adapted, rhizomania susceptible variety; a rhizomania resistant variety (Beta-4811); and a variety with intermediate resistance (Beta-4818). Additional varieties were available for the 2004 and 2005 observations.

The difference between the rhizomania resistant varieties and the susceptible variety was greatest at the Crookston-A site in 2002 (Table 1). The respiration rate of the susceptible variety was 1.6 times that of the resistant variety 30 DAH. Respiration rates of all varieties increased during storage and after 120 days in storage the respiration rate of the susceptible variety was 2.4 times that of the most resistant variety. The extractable sugar concentration of the susceptible variety 30 DAH was 256 lbs/ton, but after 120 days only 54 lbs remained; a loss of 202 pounds in 90 days or 2.24 lbs of sugar per ton per day. Extractable sugar loss in the variety with intermediate resistance was 1.76 lbs/ton/day and the resistant variety lost only 0.76 lbs/ton/day. Respiration rates and sugar losses of roots from the Crookston-K and Hendrum sites (Table 1) followed a similar pattern but the differences were smaller. The respiration rate of the resistant variety did not change substantially during storage; however, the respiration rate of the susceptible variety appeared to increase during storage even though storage temperatures were constant for the 120 days in storage and the same for all groups. Daily sugar losses for roots from Crookston-K were 1.04 lbs/ton for the susceptible variety and 0.47 lbs/ton for the resistant variety. Daily losses for roots from Hendrum were similar for all three varieties (0.70 – 0.76 lbs/ton/day); percent loss differences occurred because of differences in extractable sugar concentrations 30 DAH.

Table 2. Respiration rate and extractable sugar concentration of rhizomania resistant and susceptible varieties stored for 30 and 120 days after harvest (DAH), Crookston, MN, 2004.

Hybrid	Variety response to BNYVV	Respiration rate		Extractable sugar		
		30 DAH	120 DAH	30 DAH	120 DAH	loss
		mg CO_2 / kg / h		lbs / T		%
ACH-S	Susceptible	4.64 a*	5.96 a-c	243 d	206 c	15 a
B-3800	Susceptible	4.56 a	5.99 a-c	243 d	215 bc	12 bc
B-4818	Intermediate	4.11 a-c	5.79 a-c	247 cd	217 bc	12 ab
B-1305	Resistant	3.55 cd	3.26 ef	265 bc	240 b	9 b-d
H-2463	Resistant	3.70 cd	2.92 f	282 a	276 a	2 d
H-2469	Resistant	3.55 cd	3.52 ef	274 ab	264 a	4 cd
V-46177	Resistant	3.47 d	3.79 d-f	276 ab	266 a	4 cd

* Means within a column followed by a common letter are not significantly different ($LSD_{0.10}$).

In 2004, the number of varieties examined was increased to seven; four resistant, two rhizomania susceptible, and one variety with intermediate resistance (Table 2). In general, the results were similar to those obtained in 2002 and 2003. Respiration rates of the resistant varieties did not change substantially during storage. In contrast, the susceptible varieties had higher initial respiration rates and respiration rates increased during storage. Sugar losses during storage were low for the resistant varieties, ranging from 2 to 9% with an average of 4.75%, compared to sugar losses of 12 to 15 % for the susceptible varieties. The respiration rate and sugar loss for the variety with intermediate resistance was similar to that observed for the susceptible varieties.

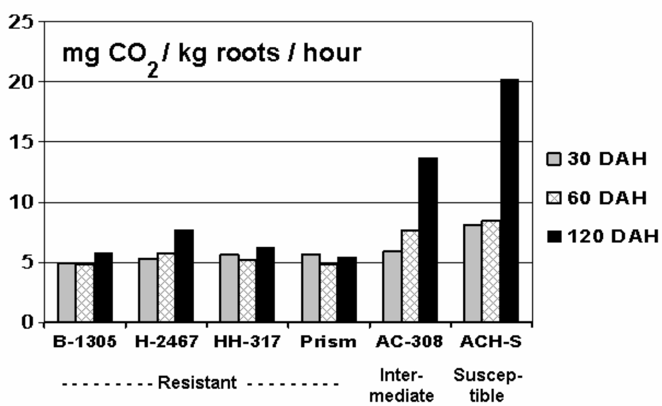

Figure 1. Storage respiration rate of rhizomania resistant, intermediate, and susceptible varieties 30, 60, and 120 days after harvest (DAH), Climax, MN, 2005.

The magnitude of the differences between susceptible and resistant varieties produced at Climax in 2005 in respiration rate and extractable sugar concentration (Figures 1 & 2) approached those associated with the Crookston-A site in 2002. The resistant varieties had slightly lower initial respiration rates than the susceptible variety and the respiration rates of the resistant varieties did not change much during the 120 days in storage (Figure 1). The initial respiration rate of the variety with intermediate resistance (AC-308) was similar to that of the resistant varieties. However, 60 DAH there was a slight but notable increase in the respiration rate of the intermediate variety and by 120 DAH the intermediate and susceptible varieties were respiring at rates 2.2 and 3.2 times the mean of the resistant varieties. Sucrose losses between 30 and 120 days after harvest followed a pattern similar to that observed for respiration rate; a 7.5% sugar loss for the resistant varieties, a 28.5% loss associated with intermediate or partial resistance, and a 52.7% loss for the rhizomania susceptible variety (Figure 2).

The difficulty in predicting economic losses that can be directly attributed to the presence of rhizomania is complicated by the differences among environments observed in these trials. Environmental differences observed in storage response did not appear related to disease severity, based upon visual symptoms, in the field. In regions where avoiding rhizomania is difficult or impossible, resistant varieties are the primary control measure. The production of resistance varieties not only reduces the possibility of extremely low yields at harvest, but may also have a significant positive impact on postharvest storability. If it is necessary to process roots from fields with rhizomania, they should probably be isolated, to the extent possible, to avoid increasing the temperature of nearby healthy roots, and processed as soon as possible to avoid the drastic losses that may accompany the disease. The varieties classified as intermediate in these trials were triploid hybrids, and all the resistant varieties were diploid. This difference in resistance has to do with the way the parental lines were combined and does not preclude the production of highly resistant triploid hybrids in the future. However, the results presented here suggest that high levels of resistance will be required in the future and varieties classified as intermediate, regardless of their makeup, will be of very limited value. In evaluations of the varieties included in these trials from sites with no rhizomania symptoms, there was no apparent association between the presence or absence of rhizomania resistance genes and the storage characteristics of a variety, in the absence of the disease (data not shown). The samples collected for these trials were from fields with uniform rhizomania symptoms and minimal confounding effects from other diseases. However, multiple diseases often coexist in a field and some (*Aphanomyces, Fusarium*) may increase storage respiration rates and sugar losses as much or more than rhizomania did in these trials.

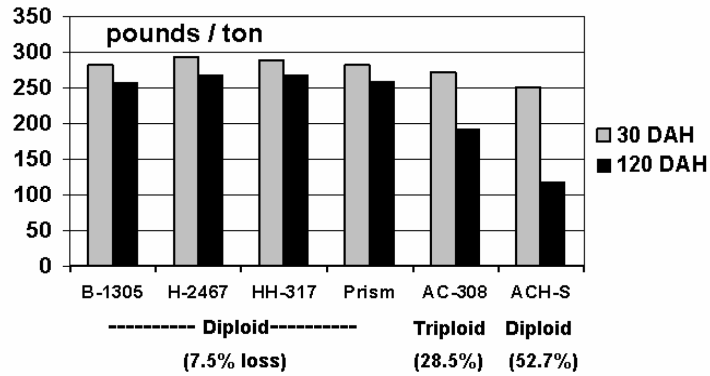

Figure 2. Extractable sugar concentration of rhizomania resistant, intermediate, and susceptible varieties 30 and 120 days after harvest (DAH), Climax, MN, 2005.