IMPACT OF CERCOSPORA LEAF SPOT DISEASE SEVERITY ON SUGARBEET ROOT STORAGE

Karen K. Fugate[1], John D. Eide[1], Abbas M. Lafta[2], and Mohamed F. R. Khan[2,3]

[1]USDA-ARS, Edward T. Schafer Agricultural Research Center, Fargo, ND
[2]Department of Plant Pathology, North Dakota State University, Fargo, ND
[3]University of Minnesota Extension Service, St. Paul, MN

Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola* (Crous et al., 2001), is the most damaging foliar disease of sugarbeet in North Dakota and Minnesota (Khan and Hakk, 2016). Historically, fungicides have been used to control disease symptoms. However, *C. beticola* has developed tolerance to several fungicides that are used against this disease, increasing the likelihood that disease symptoms will develop during production and that roots harvested from CLS-diseased plants will be incorporated into storage piles.

In Minnesota and North Dakota, sugarbeet roots are stored in ventilated or frozen piles for up to eight months. While other production diseases such as Aphanomyces root rot, Fusarium yellows, rhizomania, and rhizoctonia root and crown rot, are known to have a negative impact on storage (Campbell and Klotz, 2006; Campbell and Klotz, 2008; Klotz and Campbell, 2009; Campbell et al., 2011; Campbell et al., 2014), the effects of CLS on sugarbeet root storage properties are not known. It is suspected that roots harvested from CLS-diseased plants do not store as well as healthy roots. However, the effects of CLS on storage properties such as respiration rate, sucrose loss, losses in recoverable sugar, and the accumulation of invert sugars and other impurities that increase sucrose loss to molasses have not been determined.

Research was initiated in 2018 and continued into 2019 to determine the impact of different levels of CLS disease severity on sugarbeet root storage properties after short-term and long-term storage. Roots with varying levels of CLS disease severity were obtained from a field that was inoculated with *C. beticola* and contained plots that received variations in fungicide treatments. After field plots were rated for CLS severity, roots from plots with very low, low, moderate, and severe CLS symptoms were harvested and used for evaluating storage properties after 30, 90 and 120 days in storage.

MATERIALS AND METHODS

Plants with varying severities of CLS were produced in 2018 and 2019 in fields near Foxhome, MN. Plots were six-rows wide (11 ft wide by 30 ft long) with 22 inches between rows and 4.7-inch spacing within rows. In 2018, plots were planted with Hilleshög 9528 sugarbeet seed on 12 May. In 2019, plots were planted with Seedex Cruze on 14 May. Plants were produced using recommended agronomic practices (Khan, 2018) and were inoculated with 5 lb ac^{-1} dried *C. beticola*-infected leaves on 28 June and 12 July in 2018 and 2019, respectively. Varying severity of CLS symptoms were obtained using the fungicide treatments described in **Table 1**, with all fungicides used at their full rates and applied to the middle four rows of each plot. A randomized complete block design with four replicates was used. CLS disease severity was rated using a 1 – 10 scale where 1 indicates an absence of disease symptoms and 10 indicates complete defoliation

Table 1: Fungicide treatments and application dates used to obtain plants with varying severity of Cercospora leaf spot symptoms.

Disease Severity	2018 Production Year		2019 Production Year	
	Fungicide Treatment	**Application Date**	**Fungicide Treatment**	**Application Date**
Lowest	Minerva Duo	07/05/18	Super Tin + Proline + NIS	07/22/19
	Super Tin + Topsin	07/18/18	Super Tin + Proline + NIS	08/01/19
	Proline + Badge SC + NIS	07/31/18	Super Tin + Proline + NIS	08/14/19
	Mankocide	08/16/18	Super Tin + Proline + NIS	08/28/19
	Super Tin + Manzate	08/31/18		
Low	Super Tin + Manzate + Topsin	07/18/18	Super Tin + Manzate Max + Topsin	07/22/19
	Super Tin + Manzate + Topsin	07/31/18	Super Tin + Manzate Max + Topsin	08/01/19
	Super Tin + Manzate + Topsin	08/16/18	Super Tin + Manzate Max + Topsin	08/14/19
	Super Tin + Manzate + Topsin	08/31/18	Super Tin + Manzate Max + Topsin	08/28/19
Moderate	Minerva Duo	07/05/18	Gem	07/22/19
	Super Tin + Topsin	07/18/18	Gem	08/01/19
	Proline + Badge SC + NIS	07/31/18	Gem	08/14/19
			Gem	08/28/19
Severe	untreated		untreated	

and leaf regrowth. The middle two rows of each plot were harvested on 27 September in 2018 and on 10 September in 2019. Roots were washed and roots within a plot were randomly assigned to 10 root samples which served as the experimental unit for the storage study. A 10-root sample from each plot was ground to brei after harvest for the determination of sucrose content, loss to molasses, invert sugar concentration, impurity concentration, and recoverable sugar per ton prior to storage. The remaining 10-root samples from each plot were stored at 5°C (41°F) and 95% humidity in a cold room. Respiration rates of 10-root samples were determined after 30 and 120 days in storage for roots produced in 2018 and after 30, 90, and 120 days for roots produced in 2019. Respiration was determined using a Licor infrared CO_2 analyzer (Campbell et al., 2011). Following respiration rate determinations, samples were ground into brei, and these brei samples were used for determining sucrose content, loss to molasses, invert sugar concentration, impurity concentrations (sodium, potassium, and amino-nitrogen), and recoverable sugar per ton.

PROGRESS REPORT

2018-2019 Storage Study

At harvest, root yield and recoverable sugar per acre were significantly reduced in plots with moderate or severe CLS disease symptoms **(Table 2**). Sucrose concentration and recoverable sugar per ton at harvest were also reduced in roots harvested from plants with moderate and severe CLS symptoms (**Table 3**). Lower sucrose concentration and lower recoverable sugar per ton (RST) after 30 and 120 days in storage were also found in roots from plants with moderate and severe CLS

Table 2: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 27 September 2018 from a field near Foxhome, MN. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4).

CLS severity class	Disease rating	Yield (tons $acre^{-1}$)	Recoverable sugar (lbs $acre^{-1}$)
lowest	3.0 c	30.7 ab	8738 ab
low	3.3 c	33.7 a	9395 a
moderate	6.0 b	27.0 bc	6800 bc
severe	9.8 a	23.3 c	5685 c

symptoms (**Table 3**). The reductions in sucrose concentration and RST in stored roots, however, reflected the lower values for these traits at harvest and were not due to accelerated sucrose loss during storage. Disease severity had no significant effect on root respiration rate after 30 or 120 days in storage or invert sugar concentration at 120 days in storage (**Table 3**). However, a small increase in invert sugar concentration in roots from plants with moderate or severe disease symptoms was observed in roots stored for 30 days.

2019-2020 Storage Study

Like the 2018 field study, root yield and recoverable sugar per acre were reduced for plots with moderate and severe CLS symptoms (**Table 4**). Presently, only respiration rate determinations for roots stored for 30 and 90 days are available, as roots have yet to be stored for 120 days and sucrose concentration, invert sugar concentration, and impurity concentrations will be determined after all tissue samples are collected. For roots stored for 30 and 90 days, however, CLS disease severity had no effect on root respiration rate (**Table 5**).

PRELIMINARY CONCLUSIONS

Data presently available from the 2018-2019 storage study and the ongoing 2019-2020 storage study suggest that Cercospora leaf spot, at any severity level, has little to no effect on sugarbeet root storage properties. However, this conclusion should be considered preliminary until all data from the 2019-2020 storage study have been analyzed and an additional repetition of the experiment is conducted beginning in 2020.

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Table 3: Respiration rate, sucrose concentration, sucrose loss to molasses, recoverable sugar per ton, and invert sugar concentration at harvest and during storage for roots from plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 27 September 2018 from a field near Foxhome, MN and stored for up to 120 days at 5°C and 95% relative humidity. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4). DIS = days in storage.

CLS severity class	Disease rating	Respiration rate		Sucrose concentration			Sucrose loss to molasses			Recoverable sugar per ton			Invert sugar concentration		
		30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS	0 DIS	30 DIS	120 DIS
		- - (mg kg^{-1} h^{-1}) - -		- - - - - - - - - (%) - - - - - - - - - -			- - - - - - - - - - (%) - - - - - - - - - -			- - - - - - - (lbs ton^{-1}) - - - - - - -			- - - (g per 100 g sucrose) - - -		
lowest	3.0 c	2.48 a	2.42 a	16.0 a	15.8 a	15.7 a	1.72 a	1.50 a	1.70 a	285 a	286 a	279 a	1.28 a	0.60 c	3.51 a
low	3.3 c	2.71 a	2.89 a	15.7 a	15.7 a	15.2 a	1.79 a	1.65 a	1.52 a	278 ab	281 a	273 a	0.79 a	0.65 bc	2.10 a
moderate	6.0 b	2.41 a	2.73 a	14.1 b	13.6 b	13.7 b	1.58 a	1.57 a	1.47 a	251 bc	241 b	246 b	1.03 a	0.87 ab	4.42 a
severe	9.8 a	2.76 a	3.10 a	13.7 b	14.0 b	13.5 b	1.59 a	1.62 a	1.47 a	243 c	248 b	241 b	1.00 a	1.00 ab	4.59 a

Table 4: Root yield and recoverable sugar per acre for plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 10 September 2019 from a field near Foxhome, MN. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4).

CLS severity class	Disease rating	Yield (tons acre^{-1})	Recoverable sugar (lbs acre^{-1})
lowest	3.0 c	31.7 a	8709 a
low	3.5 c	30.3 a	8171 a
moderate	5.8 b	25.9 b	6753 b
severe	8.8 a	21.5 c	5467 b

Table 5: Respiration rate after 30 and 90 days in storage for roots from plants with varying levels of disease symptoms due to Cercospora leaf spot. Plants were harvested on 10 September 2019 from a field near Foxhome, MN and stored for 30 or 90 days at 5°C and 95% relative humidity. Means within a column followed by different letters are significantly different based upon Fisher's LSD, with α = 0.05 (n = 4). DIS = days in storage.

CLS severity class	Disease rating	Respiration rate (mg kg^{-1} h^{-1})	
		30 DIS	90 DIS
lowest	3.0 c	2.18 a	3.66 a
low	3.5 c	2.55 a	3.55 a
moderate	5.8 b	2.72 a	3.39 a
severe	8.7 a	2.94 a	3.48 a

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