INTER-ROW CULTIVATION TIMING EFFECT ON SUGARBEET YIELD AND QUALITY IN 2018

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Summary

Field experiments were conducted to determine if cultivation at 1.5 to 2 inches deep at 4 MPH negatively affects sugarbeet root yield and quality. Cultivation did not affect sugarbeet density, root yield, sucrose content, or recoverable sucrose per acre at three environments in 2018.

Introduction and Objectives

Sugarbeet producers have renewed their interest in inter-row cultivation due to the development of glyphosate resistant waterhemp (*Amaranthus tuberculatus)* in Minnesota and North Dakota. However, producers are concerned about how mid-season cultivation affects sugarbeet yield and disease pressure.

Research conducted by Alan Dexter and Joe Giles in the 1980s and 1990s generally demonstrated early-season cultivation has little effect on recoverable sucrose yield, but cultivation later in the season is detrimental to yield and quality (Dexter et al. 2000). Dexter (1983) reported sugarbeet yield tended to increase with up to three cultivations, but decreased after four cultivations. Giles et al. (1987) reported increasing cultivation number from one to four numerically reduced yield in one of two environments. Giles et al. (1990) reported one to three cultivations had no effect on sugarbeet yield, but there was an increasingly negative effect on sugarbeet yield as cultivation number increased from four to seven in one of two environments.

Sugarbeet producers frequently used inter-row cultivation to control herbicide-resistant weeds in 2018 (Peters et al. 2018). Many producers currently consider one to two mid-season cultivation passes a "rescue" strategy rather than a primary weed control method. The objectives of this experiment were to 1) evaluate the effect of inter-row cultivation timing and number of passes on sugarbeet yield and quality and 2) evaluate if inter-row cultivation timing and number of passes increases severity of *Rhizoctonia solani* on sugarbeet.

Materials and Methods

<u>Site Description.</u> Field experiments were conducted in three environments in 2018. The three environments were on producer fields near Glyndon, MN (46°51'52.7"N, 96°31'15.5"W), Hickson, ND (46°42'18.9"N, 96°48'08.1"W), and Amenia, ND (47°00'10.4"N, 97°06'21.9"W). Previous crop grown in fields were soybean, sugarbeet, and wheat at the Glyndon, Hickson, and Amenia fields, respectively. Soil descriptions for each environment can be found in Table 1.

Table 1. Soil descriptions for trial environments in 2018.

Environment	Soil series & texture	Organic matter	Soil pH
Amenia, ND	Bearden & Lindass silty clay loam mix	3.9%	8.0
Hickson, ND	Fargo silty clay	6.0%	7.5
Glyndon, MN	Wyndmere fine sandy loam	2.6%	8.2

<u>Experimental Procedures</u>. The experimental design was a randomized complete block with four replicates. Plots were 11 feet wide (6 rows) and 30 feet long. Treatments were applied every two weeks though the growing season starting June 21 and ending August 16. Treatments were cultivation dates with a maximum of three dates and an untreated control. Inter-row cultivation was performed to the center 4 rows of each plot using a modified Alloway 3130 cultivator (Alloway Standard Industries, Fargo, ND) with 15-inch sweep shovels spaced at 22 inches with a ground depth of 1.5 to 2 inches at 4 MPH.

'Crystal 355RR' sugarbeet seed (American Crystal Sugar Company, Moorhead, MN) was planted 1.25 inches deep at a density of 61,000 (+/- 1,000) seeds per acre in six rows spaced 22 inches apart. Planting dates were May 3, 2018 at Glyndon, May 7, 2018 at Hickson, and May 14, 2018 at Amenia. Sugarbeet seeds were treated with penthiopyrad (Kabina ST, Sumitomo Corporation, New York, NY). Nitrogen, phosphorus, and potassium fertilizer was applied based on spring soil tests and incorporated prior to planting. Weeds and disease were controlled so that crop injury from cultivation could be detected without interference from other yield-limiting factors. Weeds were controlled using glyphosate (Roundup PowerMAX, Monsanto Company, St. Louis, MO) at 32 oz per acre. No more than three glyphosate applications were made at each location and herbicide resistant waterhemp were removed by hand weeding. Root disease pressure from *Rhizoctonia solani* was controlled with soil-applied applications of azoxystrobin (Quadris, Syngenta Crop Protection, Greensboro, NC) at Amenia and Hickson. Disease pressure from *Cercospora beticola* was controlled with foliar applications of triphenyltin hydroxide (Super Tin 4L, United Phosphorus, Inc., King of Prussia, PA), thiophanate methyl (Topsin 4.5FL, United Phosphorus, Inc., King of Prussia, PA), and difenoconazole / propiconazole (Inspire XT, Syngenta Crop Protection, Greensboro, NC).

<u>*Data Collection and Analysis.*</u> Sugarbeet stand counts were collected in the center two rows of each plot prior to the start of cultivation treatments and prior to harvest to determine percent stand mortality throughout the season. Harvest dates were September 17, 2018 at Glyndon, September 11, 2018 at Hickson, and September 18, 2018 at Amenia. At harvest, sugarbeet was defoliated with a four-row topper and harvested with a two-row sugarbeet harvester. The sugarbeet roots harvested from the center two rows of each plot were weighed and a 20-lb sample was analyzed by American Crystal Sugar Company, East Grand Forks, ND for percent sucrose. Sugarbeet roots were visually analyzed for *Rhizoctonia* root and crown rot, but no visual infection was observed from any treatment at any location.

Data was subjected to analysis of variance using the MIXED procedure in SAS 9.4 (SAS Institute, Cary, NC) to test for treatment differences among means at $P \leq 0.05$. Cultivation treatment was considered a fixed effect, while environment and replicate were considered random effects. Environments were combined for analysis when mean square error values between environments were within a factor of ten. Single-cultivation and double-cultivation treatments were subject to regression analysis ($P \leq 0.05$) to detect relationships between cultivation timing and sugarbeet stand, yield, and quality, but no significant relationships were detected.

Results and Discussion

<u>*Field Growing Conditions.*</u> Field planting ranged between May 3 and May 14 across all environments (Table 2), which is typical for sugarbeet production in eastern North Dakota and Minnesota. Season-long precipitation at Amenia was slightly below the 30-year average, while Hickson and Glyndon received slightly above the 30-year average. However, sugarbeet at Amenia still had the greatest sucrose yield of all environments. Hickson received excessive hail on August 26 that destroyed 90% of the crop canopy which likely reduced root yield and sucrose content at harvest. Glyndon received only 0.6 inches of precipitation in the month following planting, which led to an erratic and non-uniform crop stand. Glyndon soil texture was a fine sandy loam with low organic matter, which likely contributed to moisture stress throughout the growing season. Sugarbeets at Glyndon were also noted to exhibit foliar potassium deficiency throughout the season, which was possibly due to inadequate fertilization rate, poor crop uptake, or both.

Table 2. Dates of planting and harvest, previously crop grown, and sugarbeet density at three environments in 2018.

Environment	Planting date	Harvest date	Previous crop	Sugarbeet density [a]
				# per 100 row-feet
Amenia, ND	May 14	September 18	Wheat	185
Hickson, ND	May 7	September 11	Sugarbeet	190
Glyndon, MN	May 3	September 17	Soybean	152

[a] Sugarbeet stand was counted prior to first treatment.

<u>*Sugarbeet Stand Density.*</u> Cultivation did not affect sugarbeet density at any environment in 2018 (Table 3). Environments were analyzed separately for stand mortality because mean square error values between environments were not within a factor of ten. Stand mortality at Amenia was relatively low, ranging from 11% to 21%, but no

patterns were observed. The stand mortality at Hickson was relatively high, ranging from 30 to 40% (Table 3), but the stand mortality was consistent between treatments. The relatively high stand mortality at Hickson is probably due to sugarbeet being the previous crop grown on the field site. Planting sugarbeet into sugarbeet residue highly increases chance of infection from *Rhizoctonia solani* (Windels and Brantner 2008). Sugarbeet stand mortality was not observed at Glyndon (Table 3). Some sugarbeet roots at Glyndon were small and 6 to 8 leaves at harvest, indicating they had emerged mid-season. Sugarbeet were counted a just prior to the first cultivation on June 21, but sugarbeets continued to emerge randomly into the summer at Glyndon, making the stand mortality measurement negative in some treatments.

Table 3. Sugarbeet stand mortality affected by cultivation timing in 2018.

	Stand mortality [a]		
Cultivation timing	Amenia	Hickson	Glyndon
	------------------------%------------------------		
Control	15	32	-14
June 21	20	37	-1
July 5	15	37	4
July 19	20	41	-10
August 2	11	32	-1
August 16	13	30	10
June 21 + July 19	13	31	-7
July 5 + Aug 2	19	36	4
July 19 + Aug 16	21	39	7
June 21 + July 19 + Aug 16	16	37	7
ANOVA	----------------------*p value*----------------------		
Treatment	0.082	0.435	0.848

[a] Percent stand mortality is calculated by multiplying the ratio of harvest stand and pre-treatment stand by 100.

Harvested sugarbeet roots were visually inspected for root and crown rot from *R. solani*, but no infection was observed at any environment. Inter-row cultivation has historically been associated with root and crown rot since cultivation may physically deposit soil onto a beet crown, moving soil-borne pathogens nearer their host. Schneider et al. (1982) reported covering sugarbeet roots with soil via a cultivator moving 8 MPH in mid-August resulted in greater root rot due to *R. solani* in two of three field environments. Windels and Lamey (1998) reported reducing cultivation ground speed reduces chance of infection from *R. solani*. Some soil movement onto beet crowns was observed in this experiment, but the cultivation speed of 4 MPH used in this experiment was possibly not fast enough to cause significant root rot infection in these environments in 2018.

Sugarbeet Root Yield. Cultivation did not affect root yield at any environment (Table 4). Root yields were 37 to 40 tons/acre at Amenia, 16 to 23 tons/acre at Hickson, and 10 to 15 tons/acre at Glyndon. No statistical differences among treatments were measured across environments (P = 0.944). Inter-row cultivation only disturbs soil between the sugarbeet rows and does not significantly affect root growth or yield. Giles et al. (1990) conducted root excavations on sugarbeet in late-July and reported less root development and yield with treatments receiving five to seven weekly cultivations throughout the season in one of two environments. Giles et al. (1990) cultivated to a similar depth of 1.5 to 2 inches, but a ground speed of 3 MPH. Significant root yield reduction was not observed with up to three cultivations in this experiment cultivating 1.5 to 2 inches deep and 4 MPH. The yield loss Giles et al. (1990) reported in one of two environments was likely due a greater number of cultivations (five to seven) as compared to one, two, or three cultivations in the trials conducted in 2018.

Percent Sucrose Content. Cultivation did not affect sucrose content at any environment (Table 4). Sucrose percentages ranged from 15.7 to 16.3% in Amenia, 14.1 to 14.9% in Hickson, and 13.6 to 14.2% in Glyndon, with no significant differences among treatments. Combined analysis tended to demonstrate treatment differences between cultivation number and dates (P = 0.062), but no trends were observed. Regression analysis to determine if sucrose content was affected by cultivation timing was not significant (data not shown). Cultivator shanks traveling between sugarbeet rows during cultivation were observed to cause foliar damage, especially at later cultivation dates. Sugarbeet plants compensate for the foliar damage by producing new leaves, potentially lowering sucrose content, but this data demonstrates no reduction in sucrose content. Foliar damage was also noted from the tractor wheels traveling between plot rows. The tractor wheels in this experiment traveled on the outside of the plot area to remove the effect of the wheels from the results.

Table 4. Root yield, sucrose content, and recoverable sucrose per acre (RSA) affected by cultivation timing averaged across Amenia, Hickson, and Glyndon in 2018.

	Yield Components		
Cultivation timing	Root yield	Sucrose content	RSA
	Ton/acre	%	Lb/acre
Control	24.3	15.0	6,817
June 21	24.1	14.8	6,773
July 5	24.7	14.9	6,934
July 19	23.5	14.9	6,563
August 2	25.4	14.7	6,899
August 16	24.4	14.5	6,529
June 21 + July 19	24.3	14.5	6,679
July 5 + Aug 2	24.7	14.6	6,698
July 19 + Aug 16	23.5	14.8	6,472
June 21 + July 19 + Aug 16	23.5	14.8	6,540
ANOVA	---------------------------------*p value*---------------------------------		
Treatment	0.944	0.062	0.947

<u>Recoverable Sucrose per Acre.</u> Cultivation did not affect recoverable sucrose per acre at any environment (Table 4). Recoverable sucrose per acre (RSA) is a calculation derived from root yield and sucrose content. RSA ranged from 10,600 to 11,700 at Amenia, 4,500 to 6,000 at Hickson, and 2,400 to 3,900 at Glyndon. No treatment differences were measured in the combined analysis ($P = 0.947$). This result was expected since treatment means for root yield and sucrose content were not significantly different (Table 4).

Conclusion

Inter-row cultivation did not affect sugarbeet density, root yield, or quality at any environment in this experiment. This data suggests up to three cultivations performed as late as August 16 will not negatively affect sugarbeet yield. Most producers in 2018 only used cultivation to remove weeds that glyphosate did not control, so it is unlikely that, under current production practices, any sugarbeet producer would cultivate a field more than three times in one season. Most cultivations in 2018 were also done after the sugarbeet canopy closed in mid-July. The effect of inter-row cultivation on yield is likely a complex interaction of cultivation timing, soil type, environmental conditions, disease pressure, cultivation speed, and cultivation equipment.

Sugarbeet producers are concerned about yield loss from inter-row cultivation partially due to the past work done by Dexter and Giles. While the cultivation methods and procedures used in our experiment are similar to what Dexter and Giles implemented in their experiments, our timing of cultivation was different. Dexter and Giles conducted their cultivations on weekly intervals with the same start date, while our cultivations were two weeks apart with staggered starting dates and timings as late as August 16. Furthermore, certain aspects of sugarbeet production that could affect disease pressure are different from the 1980s and 1990s such as diploid genetics, seed treatments, and soil-applied applications of azoxystrobin. Our results show cultivation 1.5 to 2 inches deep at 4 MPH with soil-applied applications of azoxystrobin did not affect sugarbeet yield in 2018, but further research is needed in future years with different ground speeds, cultivator configurations, fungicide applications, and environmental conditions to better determine if cultivation could affect sugarbeet yield.

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