FINDING THE "SWEET SPOT": NITROGEN STRATEGIES FOR VARIABLE SUGARBEET HARVEST TIMINGS

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ABSTRACT

Early sugarbeet (*Beta vulgaris L.*) harvest is a new challenge facing the Michigan sugarbeet industry. Few data indicate how early or how late N can be applied and the subsequent effects on sugar quality. The objective was to evaluate the influence of harvest timing, planter-applied starter fertilizer, and in-season N fertilizer strategies on root yield, sugar quality, and in-season plant growth and development. Studies were blocked by harvest date with treatments arranged in a randomized complete block factorial design with four replications. The main plot factor was harvest date (early and conventional (conv.)). Fertilizer strategy was the subplot factor and split into 1) two rates of starter N fertilizer (0, and 60 lbs. N/acre applied 2x2), and 2) seven in-season N fertilizer strategies consisting of either low (60 lbs. N/acre) or high (100 lbs. N/acre) applied in either early Jun, July, or August. Conv. harvest 2023 increased root yield +17.9 Tons A^{-1} compared to early harvest with root yield increasing on average +1.9 Tons A^{-1} week^{-1}. Starter fertilizer did not influence early harvest root yield, but results were influenced by deficit precipitation (-48%, April- June). Conv. harvest increased root sucrose content +4.3% compared to early harvest. For early harvest, applying nitrogen 1 August as compared to 1 June decreased mean sucrose content -0.5% when starter fertilizer was not utilized. For early harvest 2024 starter N increased root yield +4.4 Tons A^{-1} but had no effect on sugar content. June SD resulted in the greatest yield amongst all the low-rate N treatments increasing root yield +3.5 and +6.2 Tons A^{-1} compared to July and August SD, respectively. Data for 2024 conv. harvest was not completed by this report.

INTRODUCTION

Functioning as a non-sucrose impurity within the beet root, late-applied N decreases sugarbeet sugar content (Campbell, 2002). Therefore, growers tend to apply N earlier in the growing season to decrease the chance of non-sucrose N impurities remaining in the beet root at harvest. Due to sugar processing capacity limitations, earlier sugarbeet harvest is necessary to ensure beet processing is complete by mid- to late-March. Nitrogen strategies for an earlier sugarbeet harvest may differ from a conventional harvest. Although differing each year, the early harvest interval for Michigan often ranges between late Aug. through early October while conventional harvest will initiate mid-Oct. and last until beets are harvested or the piling grounds are at capacity. Harvest date timings are determined by the Michigan Sugar Company which continuously sample throughout the growing season to factor in potential root yield and sugar quality. The optimal N strategy for sugarbeet would be to maximize sugar quality while retaining moderate root yields.

MATERIALS AND METHODS

Field trials were initiated in Richville, MI on a Tappan-Londo-loam soil following corn on 27 April 2023 and 25 April 2024. Soil properties included: 7.7- 8.1 soil pH, 2.1% - 2.5% SOM, 14 – 17 CEC, 14-18 ppm Olsen P, 141-166 ppm K. Main plots were blocked by harvest date (early and conventional). Treatments were arranged in a randomized complete block factorial design with four replications. Fertilizer strategy was split into two rates of starter fertilizer (0 or 60 lbs. N/acre applied 2x2) and seven in-season N fertilizer strategies consisting of either low (60 lbs. N/acre) or high (100 lbs. N/acre) applied in June, July, or August plus a nontreated check. Nitrogen fertilizer treatments included urea ammonium nitrate (28-0-0) for both the starter and side dress treatments. The Jun sidedress treatment was applied via coulter disk injection while the July and August sidedress treatments were applied via Y-drop applicator blended with a urease inhibitor (NBPT). Research plots were 15 ft. wide by 35 ft. long and planted to six rows on 30-inch row spacing with the center two rows acting as the harvest rows. Beet population was 52,000 seeds/acre, and the variety CG049 (i.e., a high tonnage, moderate sugar variety). Composite soil samples were collected at 0-8” prior to planting. Aboveground foliar tissue was sampled prior to applying the Jun sidedress, July sidedress, and the Aug. sidedress. Dry weights were recorded with subsamples analyzed for total N concentration. Preharvest foliar biomass fresh weight was recorded and analyzed for N concentration. Data collection also included normalized difference vegetation index (NDVI), and row fill (%) recorded every two weeks from emergence through row closure. Harvest data included root yield (tons/acre), sugar content (%), recoverable white sugar per ton (lbs./ton), recoverable white sugar per acre (lbs./acre), and economic profitability.

Table 1. Mean monthly and 30-yr. precipitation, Richville, MI, 2023 and 2024

Year	April	May	Jun	Jul	Aug	Sep	Oct
				inches			
2023	3.06	0.98	1.51	5.49	5.91	1.32	2.6
30-yr ‡	3.61	3.59	3.48	3.36	3.49	2.68	2.93
% Change	-15.2	-72.7	-56.6	+63.3	+69.3	-50.7	-11.2
2024	2.76	4.14	3.88	4.27	3.38	1.51	1.85*
30-yr §	3.61	3.59	3.48	3.36	3.49	2.68	2.93
% Change	-23.5	+15.3	+11.5	+27	+3.1	-43.6	-36.8*

RESULTS AND DISCUSSION

The early 2023 growing season was dry with May precipitation at 0.97 inches (72% below the 30-year average) (Table 1). The early season rainfall drought impacted beet establishment and growth. Plants receiving 60 lbs. N/acre starter had a 22% size reduction at growth stage 6-8 LF compared to the plants not receiving any starter fertilizer. Biomass reductions may have been due to saltation from the 2x2 applied starter fertilizer. Saltation symptoms diminished once consistent precipitation began in mid-July with precipitation increasing +63% above the 30-year average. In 2023, harvest date significantly impacted sugarbeet root yield and sugar content (Table 2).

Conventional harvest date yielded +17.9 Tons A^{-1} greater than early harvest and also resulted in a +4.3 % greater sugar content when compared to early harvest. The additional 64 days between harvest dates resulted in a net gain of +1.9 tons A^{-1} and +0.47% sugar $week^{-1}$. Reduced root yields and sugar content are expected outcomes from early harvest sugarbeets in Michigan thus a premium is paid out for early harvest acres.

Table 2. Main effects of harvest date on sugarbeet root yield and sugar content. Richville, 2023

Treatment	Root Yield	Sugar
	—— Tons/acre ——	——— % ———
Harvest Date		
Early 21-Aug	14.4 b	13.8 b
Conv 24-Oct	32.3 a	18.1 a
P > F†	**<0.0001**	**0.0002**

An interaction between starter fertilizer and N SD strategy affected early harvest root yield in 2023 (Table 3A). Without starter application, N SD strategies were similar. However with starter N application, Aug SD low and no SD both decreased root yield compared to remaining treatments. The Aug SD low rate decreased root yield -3 and -3.4 Tons A^{-1} from the June and July low-rate SD treatments, respectively. The August SD low rate was comparable to avoiding a sidedress application altogether. Wet August field conditions may have resulted in some degree of denitrification causing yield reduction with the low August SD treatment as compared to the Aug SD high rate. Across SD strategies, starter fertilizer had little impact on root yield presumably due to lack of early season moisture impacting both growth and N uptake.

Table 3A. Interaction between starter fertilizer and sidedress N strategy on early harvest root yield, Richville, MI 2023.

Early Harvest 2023	Starter N		
	No Starter	60 lbs. N	
	Root Yield		**P>F‡**
Side Dress N	————Tons/acre————		
June SD low	13.9 aA	15.3 aA	**NS**
June SD high	14.2 aA	16.4 aA	**NS**
July SD low	15.6 aA	15.7 aA	**NS**
July SD high	15.3 aA	14.7 abA	**NS**
August SD low	12.7 aA	12.3 bA	**NS**
August SD high	15.2 aA	15.3 aA	**NS**
No SD	12.2 aA	12.8 bA	**NS**
P>F†	**[a]NS**	**0.0808**	

[a] ns, not significant.
† Means in the same column followed by the same lowercase letter are not significantly different at α=0.10.
‡ Means in the same row followed by the same uppercase letter are not significantly different at α=0.10.

An interaction between starter fertilizer and N SD strategy affected conventional harvest root yield in 2023 (Table 3B). Without starter fertilizer, the June SD timing or high rate of July SD timing optimized yield. The August SD timing without starter significantly reduced yield but it is important to note that this SD timing produced greater yield than no SD at all indicating August was not too late to still recover some yield potential. With starter N application, few yield differences occurred amongst N SD strategies indicating starter N effectively minimized yield variability under these environmental conditions regardless of SD timing. This result may impact future N strategies given the year-to-year climate variabilities sugarbeet growers now encounter. Starter N also significantly increased root yield for the low-rate July SD, both rates of August SD, and the no SD treatments. In general, without starter fertilizer SD strategy played a much greater influence on yield potential during the conventional harvest window.

Table 3B. Interaction between starter fertilizer and sidedress N strategy on conventional harvest root yield, Richville, MI 2023.

Conventional Harvest 2023	Starter N		
	No Starter	60 lbs. N	
	Root Yield		**P>F‡**
Side Dress N	———Tons/acre———		
June SD $_{low}$	33.1 abA	35.8 aA	**NS**
June SD $_{high}$	36.9 aA	36.4 aA	**NS**
July SD $_{low}$	29.9 bcB	35.5 aA	**0.0316**
July SD $_{high}$	34.1 abA	34.0 aA	**NS**
August SD $_{low}$	28.6 cB	33.9 aA	**0.0440**
August SD $_{high}$	27.6 cB	33.9 aA	**0.0173**
No SD	22.9 dB	29.8 aA	**0.0104**
P>F†	**<0.0001**	**[a]NS**	

[a] ns, not significant.
† Means in the same column followed by the same lowercase letter are not significantly different at α=0.10.
‡ Means in the same row followed by the same uppercase letter are not significantly different at α=0.10.

Early harvest 2023 sugar quality was also affected by a starter N and SD N strategy interaction (Table 4). Starter decreased sugar content -0.55 and -0.57% for the Jun SD low and No SD treatments, respectively. Without starter application, later applied N decreased sugar content as expected. August SD treatments reduced sugar % compared to June and July SD timings with Aug SD low-rate reducing sugar -0.72 and -0.71% compared to June and July SD low-rate SD strategies, respectively, while Aug SD high-rate reduced sugar -0.22 and -0.21% compared to the June and July high-rate SD strategies, respectively. With starter N application, low-rate July SD increased sugar % compared to remaining treatments. Starter N decreased variability across SD treatments as compared to no starter N possibly due to ~15% greater biomass production resulting in greater tonnage. Late-applied N, especially with early harvest, may not have sufficient time to be translocated and utilized by the plant.

Table 4. Interaction between starter fertilizer and sidedress N strategy on early harvest sugar quality, Richville, MI 2023.

Early Harvest 2023	Starter N		
	No Starter	60 lbs. N	
	Sugar Content		**P>F‡**
Side Dress N	———%———		
June SD low	14.03 bA	13.48 bB	**0.0360**
June SD high	13.73 bcA	13.69 bA	**[a]NS**
July SD low	14.02 bA	14.24 aA	**NS**
July SD high	13.72 bcA	13.56 bA	**NS**
August SD low	13.31 dA	13.63 bA	**NS**
August SD high	13.51 cdA	13.67 bA	**NS**
No SD	14.81 aA	14.24 aB	**0.0210**
P>F†	**<0.0001**	**0.0077**	

† Means in the same column followed by the same lowercase letter are not significantly different at α=0.10.
‡ Means in the same row followed by the same uppercase letter are not significantly different at α=0.10.

No significant interactions or main effects occurred on sugar quality for conventional harvest 2023 with sugars ranging between 17.75 – 18.80%.

For the early harvest 2024 season, starter N increased root yield +4.4 Tons A^{-1}, with no impact on sugar content (Table 5). June SD N strategies produced greatest yield with reductions occurring for both July and August SD timings. June and July SD timings produced similar sugar %'s with reductions in sugar quality occurring with August SD timings. Coventional harvest 2024 data were not available at time of this report. The 2024 growing season was excessively wet May through August resulting in greater root yields but reduced sugar quality as compared to early harvest 2023.

Table 5. Main effects of fertilizer strategy for early harvest sugarbeet root yield and sugar content. Richville, 2024.

Treatment	Early Harvest (August 29, 2024)	
	Root Yield	**Sugar**
	— Tons/acre —	— % —
Starter N		
None	24.5 b	12.9 a
Starter	28.9 a	13.1 a
P > F†	**0.0001**	**[a]NS**
Side Dress N		
No SD	23.3 e	13.49 a
June SD low	30.3 ab	13.31 ab
June SD high	32.3 a	13.03 ab
July SD low	26.8 cd	13.05 ab
July SD high	29.0 bc	13.01 ab
August SD low	24.1 de	12.91 bc
August SD high	21.5 e	12.42 c
P > F	**<0.0001**	**0.0698**

[a] ns, not significant.
† Means in the same column followed by the same lowercase letter are not significantly different at α=0.10.

PRELIMINARY CONCLUSIONS

Vastly different growing conditions impacted N utilization during the first two years of this study and highlight the variability and unpredictability that growers must try to account for each season. The first half of the 2023 growing season (April-June) was extremely dry while the last half (July-August) was extremely wet. The 2024 growing season was opposite to 2023 with a wet early season (April-July) and dry autumn (August-September) soil conditions. Starter N fertilizer was able to reduce some yield variabilities with conventional harvest but also resulted in some degree of additional variability with early harvest 2023 but not 2024. Growers need to have a plan in place at planting time whether acres will be targeted for early or conventional harvest otherwise reductions in sugar quality and losses in revenue from residual N may occur. Results are not intended to highlight the downside or benefit from any single N management practice but rather to gather more data that will allow growers to remain flexible with N management and adjust in-season practices based on variable climate scenarios.