

Determining the Minimum Phosphorus Level for Productive Sugarbeets

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Abstract

For healthy and productive sugarbeets, Amalgamated Sugar recommends soil test phosphorus (P) of at least 20-25 ppm-P in a 0-12-inch soil sample prior to planting. Although this critical threshold range has served us well for many years, we are often questioned by growers about why our P thresholds are so much lower than many of the commercial crop advisor companies that also service our industry. It is not uncommon for these advisors to recommend 100 lb. or more P₂O₅ than we would for the same field. To address this, we established a phosphorus research trial over two years in 2021 and 2022. This micro-plot study evaluated sugarbeet productivity across a range of soil P levels from 5 ppm-P to 65 ppm-P. In addition, we also tested the ability of P-deficient beets to recover yield when amended with P₂O₅ at 2 or 4-leaf stage. Results showed that our current threshold range (20-25ppm-P) is adequate and that further increases in P level do not result in any additional yield or sugar.

Research Objectives

1. Test the adequacy of Amalgamated's thresholds for soil test phosphorus. Evaluate if there is a positive yield response when soil P levels are above 25 ppm-P
2. Measure the ability of P-deficient beets to recover yield following P fertilizer additions at two stages of early plant growth

Materials & Methods

Reducing Experimental Error

- Low fertility sand and sand/soil mix used with all nutrients added back in
- Soil was air-dried and weighed for each bucket
- Fertilizers were carefully measured and thoroughly mixed through the soil in a cement mixer
- Soils were lab tested to ensure adequacy and uniformity of non-P nutrients
- Finely ground triple super phosphate was mixed thoroughly in the top 12 inches for each treatment
- Soils were lab tested post-treatment to ensure accuracy and uniformity of P treatments

Table 1: Experimental design and agronomic details.

	2021	2022
Location	SBR Burley	SBR Burley
Experimental design	Completely randomized	Completely randomized
Treatments	Treatments	Treatments
Deficient-5 ppm-P	Deficient-10 ppm-P	Deficient-15 ppm-P
Deficient-10 ppm-P	Deficient-15 ppm-P	Control-25-ppm-P
Deficient-15 ppm-P	Control-26 ppm-P	P-35 ppm-P
Control-26 ppm-P	P-30 ppm-P	P-45 ppm-P
P-30 ppm-P	P-43 ppm-P	P-65 ppm-P
P-43 ppm-P	Recovery-2	Recovery-2
Recovery-2	Recovery-4	Recovery-4
Recovery-4		
# Treatments	8	8
# Replicates	15	20
Variety	BTS 251N	Crystal A702NT
Pot Size	13"D x 12"H	12"D x 20"H
Potting Medium	fine sand + perlite	50:50 (sand:topsoil)
Irrigation	1.0 gal/hr drippers	1.0 gal/hr drippers
Plant Date	April 20	May 6
Harvest Date	September 10	October 15
Total growing days	143	162

- Field capacity % was measured and optimal soil moisture levels determined
- Soil moisture sensors used, and irrigation scheduled to optimize water
- Crop protection spray program prevented pest and disease incursion
- Careful hand harvesting and processing of each sugarbeet



Photo 1. 2022 trial ready for pre-plant nitrogen and initial wet-up to 80% field capacity



Photo 2. 2022 trial staging and research site.



Photo 3. Sugarbeet emergence prior to thinning.



Photo 4. Soil moisture sensor and sugarbeets on June 13, 2022.



Photo 5. Measuring yield and processing harvested sugarbeets into brei.



Photo 6. 2022 sugarbeets at harvest.



Table 2. 2021 Harvest results. Statistical analysis of variance of mean values for each productivity indicator is shown together with pairwise means comparisons..

Treatment	Root Yield g/beet	Sugar %	Conductivity mmhos/cm	Brei Nitrate ppm
Deficient-5	129.2 c ^e	14.2 c	0.968 a	173.9
Deficient-10	266.2 ab	17.1 a	0.825 ab	162.8
Deficient-15	252.1 ab	17.0 a	0.823 ab	163.4
Control-26	277.1 ab	17.4 a	0.802 ab	168.5
P-30	314.2 a	16.4 ab	0.860 ab	163.3
P-43	274.1 ab	16.6 ab	0.770 b	168.6
Recovery-2	292.0 ab	16.6 ab	0.937 ab	163.8
Recovery-4	200.0 bc	15.7 b	0.811 ab	164.8
P>F	<0.001	<0.001	0.012	0.158 n.s
CV%	23.6	6.2	8.1	2.3

*means followed by the same letter within a column are not different at the $\alpha = 0.05$ probability level



Table 3. 2022 Harvest results. Statistical analysis of variance of mean values for each productivity indicator is shown together with pairwise means comparisons..

Treatment	Root Yield g/beet	Sugar %	Conductivity mmhos/cm	Brei Nitrate ppm
Deficient-10	418.2b ^e	19.3	0.642	179.6
Deficient-15	450.8ab	20.3	0.677	179.6
Control-25	451.9ab	19.8	0.665	179.8
P-35	491.7a	19.6	0.661	180.5
P-45	464.7ab	19.3	0.653	180.2
P-65	485.8a	19.9	0.682	179.7
Recovery-2	497.4a	20.1	0.690	181.3
Recovery-4	469.5ab	19.8	0.629	178.1
P>F	0.002	0.263 n.s	0.630 n.s	0.966 n.s
CV%	5.6	1.7	3.1	0.5

*means followed by the same letter within a column are not different at the $\alpha = 0.05$ probability level

- A shorter growing season but excellent trial quality overall
- Yield loss occurred only at very low 5 ppm-P level
- Soil test P levels from 10ppm-P to 43 ppm-P produced similar yield
- Visual deficiency symptoms only at 5 ppm-P level
- Yield was recovered by P additions at either 2-leaf, or 4-leaf stage
- Sugar % was reduced at 5 ppm-P, and where P-deficiency was treated at the 4-leaf stage
- Sugar % similar for P levels ranging 10-ppm-P to 43 ppm-P
- Sugar % was recovered by P additions at 2-leaf stage only
- Conductivity was no different between treatments
- P levels ranging 5 ppm-P to 43 ppm-P were no different in brei nitrates
- Our current recommendation for P adequacy (20-25 ppm-P) appears accurate

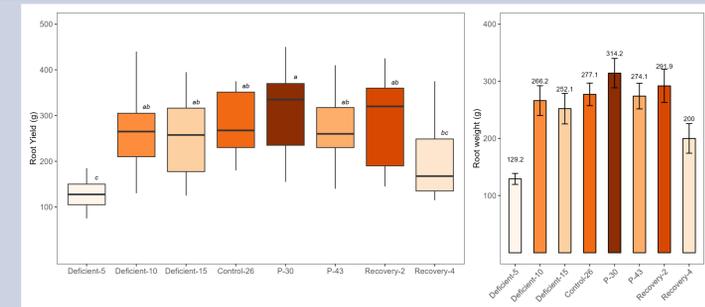


Figure 1. 2021 Yield. Box plot (left) for each treatment with pairwise treatment differences at 95% confidence level. Column plot (right) shows average root yield for each treatment ± standard error.

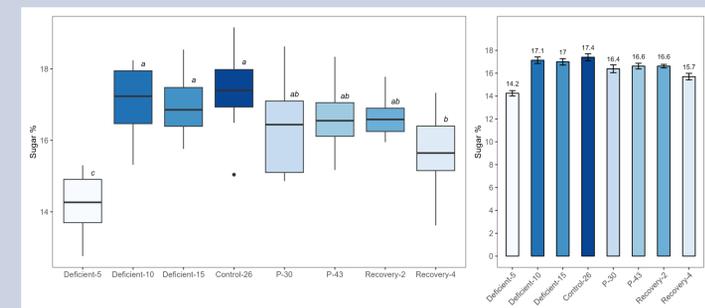


Figure 2. 2021 Sugar %. Box plot (left) for each treatment with pairwise treatment differences at 95% confidence level. Column plot (right) shows average sugar % for each treatment ± standard error.

- A longer growing season with higher yields than 2021. Overall excellent trial quality.
- No difference in yields from 15 ppm-P to 65 ppm-P. Higher levels of soil test P did not result in greater yield
- 10 ppm-P was not low enough to induce deficiency symptoms despite being 10 ppm less than what we would consider minimum adequacy.
- P applied to 10 ppm-P beets at 2-leaf stage caused a significant increase in yield whereas P applied at 4-leaf stage did not. This suggests earlier is better for P application.
- Young sugarbeets responded better to side-dress P at 2-leaf stage than 4-leaf
- Sugar % was high for all treatments. P level had no significant effect on sugar %. Soil test P from 10 to 65 ppm-P resulted in similar sugar %



Photo Panel. 2022 P-treatments at Harvest.

- P level had no significant effect on the sugar quality indicators of Conductivity and Brei Nitrates. All treatments were within levels considered optimal for sugar quality
- No productivity gains were made by increasing available P
- Our current recommendation for P adequacy (20-25 ppm-P) appears accurate

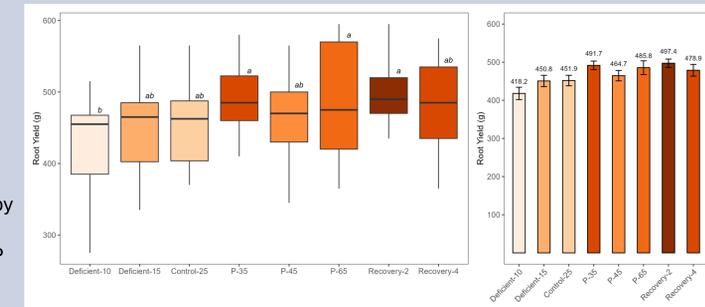


Figure 3. 2022 Yield. Box plot (left) for each treatment with pairwise treatment differences at 95% confidence level. Column plot (right) shows average root yield for each treatment ± standard error.

Conclusions

- The Amalgamated recommended level of 20-25 ppm-P is appropriate as a minimum threshold for soil test P.
- Root yield and Sugar % was not improved by applying P at levels higher than the Amalgamated recommended threshold of 20-25 ppm-P. Levels as high as 65 ppm-P showed no difference in yield to control.
- Root yield and Sugar % was not reduced at levels as low as 10 ppm-P. This is much lower than the Amalgamated recommended threshold of 20-25 ppm-P.
- Sugar quality indicators of brei conductivity and nitrates were not negatively affected by P-levels higher or lower than the recommended threshold of 20-25 ppm-P.
- Yield loss and Sugar % loss only occurred when soil test P was extremely low (5 ppm-P). Even low levels of 10 and 15 ppm-P were not low enough to impact yield or sugar %
- Phosphorus deficiency symptoms were only apparent at the 5 ppm-P level. Symptoms consisted of stunting and slow growth.
- Where P-deficiency existed, yield loss could be recovered by applying fertilizer P at the 2-leaf or 4-leaf stage, though the 2-leaf stage showed greater yield recovery. Sugar % was only recovered by a 2-leaf stage application.
- Phosphorus deficiency occurs at very low soil test P levels of around 5 ppm-P and can be overcome with application of P fertilizer no later than the 2 true leaf stage.