Phosphorus by Nitrogen Rate Trial

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Nitrogen management is a priority for the production of high-quality sugar beets. However, many other nutrients also play a role in plant growth. It is important to understand how the availability of other major nutrients may be impacted by varying levels of nitrogen.

Research Objective

- Provide phosphorus and nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

This trial was conducted as a 3 x 5 factorial with four replications following soybean southeast of Sacred Heart, MN. Soil samples were taken in the fall prior to treatment application (Table 1). The applied nitrogen fertilizer rates were 0, 45, and 115lbs N/A. The phosphorus fertilizer rates were 0, 15, 30, 45, and 60lbs P_2O_5/A. The phosphorus and nitrogen treatments were applied broadcast in the spring and incorporated using a small field cultivator. The nitrogen source was urea (46-0-0), and the phosphorus source was triple super phosphate (0-46-0). The site was planted on April 23rd using Beta 9284. Percent canopy cover ratings were taken in late June and mid-July. Standard practices were used to keep the site weed and disease free. The center two rows of each six-row plot were harvested on October 3rd using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets were used for a quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results for Renville location from fall soil sample in 2023.

Soil test	Sacred Heart
Fall Soil nitrate-N 0-4 ft. (lb N/A)	55
Spring Soil nitrate-N 0-4 ft. (lb N/A)	67
Olsen P 0-6 in. (ppm)	4
K 0-6 in. (ppm)	136
pH 0-6 in. (unitless)	8.1
Organic matter 0-6 in. (%)	5.8

Results

The application of phosphorus and nitrogen did not have an interaction on yield or quality. The application of phosphorus did not impact any quality parameters and only increased yield with the first rate of additional P_2O_5 (Table 2). The use of starter (3 gal of 6-24-6) alone had similar root yield to all other phosphorus treatments at the same nitrogen rate (Table 4). The application of nitrogen also did not have any impact on quality; however, yield had a linear respond to increasing nitrogen rates (Table 3). The percent canopy ratings taken in late June and mid-July were highly correlated with final root yield for nitrogen rates (0.982 and 0.999) but less so for phosphorus rates (0.890 and 0.842).

Conclusions

Phosphorus having a significant impact on root yield was not surprising as the soil sample results indicated very low soil test levels of phosphorus (Table 1). What was surprising was that increasing the rate of phosphorus only improved root yield up to 15lbs of additional phosphate with no further increase in root yield after that rate (Table 2). The response to additional nitrogen over the control was expected and consistent with previous studies when conducted on a site with low residual nitrogen. After sufficiency levels were met there does not appear to be any benefit to increasing the rate of phosphorus if the rate of nitrogen is increased. However, if the phosphorus needs are not met, root yield will be reduced even with high levels of nitrogen. These trials stress the importance of soil sampling and understanding the underlying nutrient levels of a field prior to planting. This trial will be conducted again in 2025 and a combined report will be published with data from multiple years.

Figure 1. Drone image from June 13th showing reduced foliage in plots that were deficient in phosphorus, nitrogen, or both.

Table 2. The effect of increasing P_2O_5 rates on yield and quality averaged across nitrogen rates.

P Rate	Percent Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	17.5	32.7 b	14.8	296.7	9675.6 b	90.6
15	17.6	35.3 a	14.9	298.8	10543.2 a	90.7
30	17.4	35.4 a	14.8	295.1	10444.9 a	90.7
45	17.4	35.1 a	14.8	295.8	10375.2 a	90.8
60	17.4	35.6 a	14.8	295.7	10532.5 a	90.9
Mean	17.5	34.8	14.8	296.4	10314.3	90.8
CV%	1.5	6.8	1.8	1.8	6.1	0.6
Pr>F	0.1945	0.021	14.82	0.4977	0.0081	0.4811
lsd (0.05)	ns	1.9	ns	ns	521.3	ns

Table 3. The effect of fertilizer N on yield and quality averaged across P_2O_5 rates.

N Rate (lbs per acre)	Total N (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	55	17.5	31.4 c	14.9	298.0	9343.3 c	90.9
45	100	17.5	35.5 b	14.8	296.3	10518.1 b	90.8
115	170	17.4	37.6 a	14.8	295.0	11081.5 a	90.6
	Mean	17.5	34.8	14.8	296.4	10314.3	90.8
	CV%	1.5	6.8	1.8	1.8	6.1	0.6
	Pr>F	0.5429	<.0001	0.2402	0.2216	<.0001	0.121
	lsd (0.05)	ns	1.5	ns	ns	403.8	ns

Table 4. The effect of increasing rates of phosphorus and nitrogen analyzed as an RCBD with the addition of a starter fertilizer treatment of 3 gal 6-24-6 mixed with 3 gal of water.

Entry	N Rate	P Rate	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	0	0	17.7	28.9 i	15.0	299.3	8641.8 h	90.7
2	0	15	17.7	33.0 efgh	15.0	300.8	9930.0 efg	90.8
3	0	30	17.5	32.7 fgh	14.9	297.9	9729.9 fg	91.0
4	0	45	17.5	30.8 hi	14.9	298.6	9195.1 gh	91.1
5	0	60	17.3	31.5 ghi	14.7	293.3	9219.6 gh	91.1
6	45	0	17.5	35.0 cdef	14.8	295.4	10332.7 cdef	90.7
7	45	15	17.6	34.1 defg	15.0	299.5	10210.1 cdef	90.9
8	45	30	17.4	35.7 bcdef	14.8	295.0	10535.9 bcdef	90.7
9	45	45	17.3	36.6 abcd	14.6	292.6	10687.3 abcde	90.7
10	45	60	17.6	36.2 abcde	15.0	298.8	10824.6 abcd	90.9
11	115	0	17.5	34.1 defgh	14.8	295.3	10052.3 defg	90.5
12	115	15	17.5	38.9 ab	14.8	296.0	11489.5 a	90.5
13	115	30	17.4	37.9 abc	14.7	292.4	11069.0 abc	90.4
14	115	45	17.5	38.0 abc	14.8	296.3	11243.2 ab	90.7
15	115	60	17.4	39.2 a	14.8	294.9	11553.4 a	90.9
16	45	Starter	17.8	35.7 bcdef	15.1	301.9	10779.1 abcde	90.7
Mean			17.5	34.9	14.8	296.8	10343.3	90.8
CV%			1.4	6.6	1.7	1.8	6.0	0.5
Pr>F			0.1581	<.0001	0.2722	0.285	<.0001	0.7932
lsd (0.05)			ns	3.3	ns	ns	883.6	ns