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USE OF STARTER FERTILIZER TO REDUCE BROADCAST APPLICATIONS OF PHOSPHORUS

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Phosphorus (P) fertilizer is a significant investment in the production of sugar beets and if mismanaged can cause environmental problems. The philosophy of P fertilization varies with individuals and organizations. One philosophy recommends building soil test levels into the upper medium and high ranges followed by annual applications of P fertilizer to replace P removed in the crop and maintain soil P tests. The University of Minnesota recommends annual soil testing to determine soil test P levels and applying recommended P fertilizer rates to optimize production levels. While the university does not recommend building soil test levels, strict adherence to the university recommendations will lead to a gradual build up of soil test P. However, this gradual build up will be accounted for with annual soil testing and P fertilizer recommendations will be adjusted accordingly.

In situations where soil test P levels are in the low category and no P fertilizer has been applied sugar beets will frequently show P deficiency symptoms in the early part of the growing season, but as the season progresses these deficiencies seem to disappear. This suggests that as the sugar beet plant develops, its roots explore more soil and are able to acquire sufficient P. However, if the P deficiency persists for prolonged periods of time during the early growing season, reduced root yields and recoverable sucrose could result (Sims and Smith, 1997 and 1998 SBREB reports; 2001 SSBR). Some growers have reported that three to five gallons of 10-34-0 banded in furrow with the seed at planting yielded satisfactory results without any additional broadcast P fertilizer. Three to five gallons of 10-34-0 supplies 12 to 20 pounds of P_2O_5 A^{-1}. This is considerably less P than recommended rates of broadcast fertilizer that might range from 60 to 80 pounds P_2O_5 A^{-1} in a low P testing soil. This suggests that banded P is more efficiently utilized by the sugar beet plant than broadcast P. Banding reduced rates of P fertilizer compared to broadcast rates will probably not build soil test P levels and thus could be a more environmentally safe management practice. The question is whether it will sustain optimum sugar beet production to allow growers the production levels they need to stay in business.

The objectives of this experiment were to evaluate and compare the sugar beet production levels when reduced rates of P fertilizer are banded in furrow with the seed to broadcast applications of higher rates.

Methods and Materials

A field experiment was conducted at the Northwest Research and Outreach Center near Crookston, Minnesota on a Wheatville loam soil. The experimental design was a randomized complete block design with four replications. A total of 13 treatments were tested in the experiment and included a check with no P fertilizer applied, four rates of broadcast P fertilizer (15, 30, 45, and 60 lbs P_2O_5 A^{-1}), three rates of liquid 10-34-0 fertilizer banded in the furrow with the seed (3, 4, and 5 gals A^{-1}) with no broadcast P fertilizer, three gals 10-34-0 A^{-1} banded in the furrow with 15, 30, and 45 lbs P_2O_5 A^{-1} broadcast P fertilizer, and two rates of dry 11-52-0 fertilizer banded in the furrow with the seed (12 and 16 lbs P_2O_5 A^{-1} similar to the P_2O_5 applied in 3 and 4 gals 10-34-0) with no broadcast P fertilizer. All broadcast applications of P fertilizer were done in the spring and incorporated with a field cultivator prior to planting. All banded P fertilizer was applied down a tube into the seed furrow at planting. All plots were 22 ft wide (12 rows) and 35 ft long. Sugar beet was over planted and thinned by hand at the 2-3 leaf stage. Fungicides, herbicides, and insecticides were applied as labeled to control pest.

In season samplings occurred 40, 61, and 82 days after planting and consisted of hand pulling all sugar beets in a 6 ft length of rows 2, 3, 4, and 5 in each plot. Each sampling event was spatially separated by 2-3 feet to insure adequate plant-to-plant competition in the sampled plants. All plants were separated into root and tops and each was dried at 60^{o} C for 3 days, weighed for dry matter determination, ground to a fine powder in a coffee grinder, and analyzed for total P concentration. In later samplings both the roots and tops were weighed and a subsample was processed as previously described to determine dry matter and P accumulation.

Final harvest was done by machine harvesting rows 9 and 10, weighing the roots, then sending a 10 beet subsample to the American Crystal Analytical Lab in East Grand Forks, Minnesota for tare, sucrose, and impurity analysis.

Comparisons to be made are sugar beet response to broadcast applications of P fertilizer (0-60 lbs P_2O_5 A^{-1}), response to various rates and types of banded P fertilizer, response of 3 gals A^{-1} 10-34-0 with and without broadcast P fertilizer.

Results

Final Yield:

Generally sugar beet root yield and sucrose concentration were lower in the 2002 growing season compared to the previous years of this experiment. Part of this was due to a relatively late planting date (May 15 compared to early May or late April in previous years), delayed emergence due to cold dry conditions, and several heavy rain fall events during critical times of the growing season. Never-the-less, comparisons of treatments are valid.

The P treatments imposed in this experiment had no affect on loss to molasses, which ranged from 0.90% to 1.35% and averaged 1.18% over all treatments. There was also little or no affect from the P fertilizer treatments on net sucrose concentration, which ranged from ranged from 13.1 to 14.2% and averaged 13.6%. The lack of response from either loss to molasses or net sucrose concentration is consistent with results from previous years. It also verifies that most of the differences in recoverable sucrose between the various treatments is due primarily to differences that occurred in final root yield.

Sugar beet root yields increased linearly with increasing rates of broadcast P fertilizer (Table 1 a). However this response to broadcast P fertilizer rates depended on whether P had been banded in the furrow or not as indicated by the significant interaction between the two (Table 1 c).

Table 1. Statistical analysis of final root harvest and total recoverable sucrose in response to broadcast and banded P fertilizer in the 2002 growing season.

Source of Variation	df	Harvested Roots	Recoverable Sucrose
		---------- PR>F$^{\delta}$ ----------	
a. Broadcast P Rates without Banded P fertilizer			
Broadcast P rates	4	***	***
P Rate linear	1	***	***
b. Banded P without Broadcast P Rates			
Banded P	5	***	***
Check vs rest	1	***	***
Dry vs Wet	1	**	ns
Wet linear	1	ns	ns
Wet quadratic	1	Ns	ns
Dry 11.2 vs 16	1	*	ns
c. Combination of Broadcast P and 3 gals 10-34-0 banded P			
Banded P	1	***	***
Broadcast P	3	***	***
P rate linear	1	***	***
Banded by Broadcast P	3	***	*
Band by Broadcast P linear	1	***	**

$^{\delta}$ *, **, ***, and ns represent significance at the PR level of 0.05, 0.01, 0.001, and non significance, respectively.

Sugar beet root yield in the check plot (no P fertilizer) was about 13.5 tons A^{-1} and increased to nearly 20 tons A^{-1} with 60 lbs P_2O_5 A^{-1} broadcast (Fig 1). However, the significant interaction between sugar beet response to rates of broadcast P and banded P is obvious from the total lack of response to the application of broadcast P when 10-34-0 was banded in the furrow with the seed (Fig 1). Three gals A^{-1} of banded 10-34-0 yielded nearly 20 tons A^{-1} when no P fertilizer was broadcast, and additional P applied as a broadcast did not improve the yield. This verifies the improved efficiency of banding P fertilizer relative to broadcasting. Three gals A^{-1} supplies about 12 lbs P_2O_5 A^{-1} and resulted in sugar beet root yield similar to that observed with 60 lbs P_2O_5 A^{-1} as broadcast.

The response of recoverable sucrose to broadcast P rates with and without banded P was similar to the root yield, as would be expected (Table 1, Fig 2). It is apparent that the two variables have a slightly different response to broadcast P rates, especially when 3 gals of 10-34-0 were banded in the furrow with the seed. Keep in mind that recoverable sucrose is a calculated variable using root yield and net sucrose concentration. Therefore differences in response of recoverable sucrose and root yield are associated with the variation in the net sucrose concentration, which was not significantly affected by fertilizer P regardless of its method of application.

The results from the 2002 growing season are similar to what has been observed in previous years. The application of a small amount of P fertilizer in a band down the furrow with the seed produced yields similar to or exceeded those yields obtained with a much larger rates of P applied as a broadcast. The banding of 3 gals A^{-1} of 10-34-0 must be optimizing sugar beet root yields since yields are not further increased when additional P is added as a broadcast. In addition, there is no root yield increase when additional rates of 10-34-0 are banded with the seed (Table 1).

Growers have raised questions about whether dry P fertilizers can be substituted for the liquid 10-34-0. This experiment included two rates of a dry 11-52-0 banded in the furrow with the seed similar to application of liquid 10-34-0. Sugar beet root yields with banded dry fertilizer were similar to the liquid fertilizer, but only at the higher application rates. Table 1 bindicates a significant

difference between liquid and dry banded P fertilizer. This is due to less sugar beet root yield with 11-12 lbs P_2O_5 A^{-1} compared to 16 lbs P_2O_5 A^{-1} as 11-52-0. The root yield difference between these two dry P fertilizer rates was about 2 tons A^{-1} and was significant (Table 1 b). Figure 3 illustrates the sugar beet root yield differences among the various banded P fertilizer sources and rates. As previously mentioned, recoverable sucrose followed similar trends because of the little or no effect of banded P on net sucrose concentration. This was consistent with the 2001 results where 11-52-0 at the 11-12 lbs P_2O_5 A^{-1} rate resulted in yields 1.5 to 2.0 tons A^{-1} less than 3 gals 10-34-0. This years data suggests that banded dry fertilizers are effective, but may require a higher rate than liquid fertilizers.

In-season Growth:

At this time the laboratory and statistical analysis are on going for the in-season sampling of this experiment. It does appear, however, that the sampling of a much larger area and, thus, more plants will allow a greater separation of treatments. In 2001, our in-season sampling was not successful in separating treatments due to large plant-to-plant variation and only 10-12 plants being sampled in each sampling event. In 2002, 30-40 plants were sampled at each sampling event. While the plant-to-plant variability still existed, we think we were able to over come some of that variation by sampling many more plants. We will not have a full analysis done of this data until later this winter.

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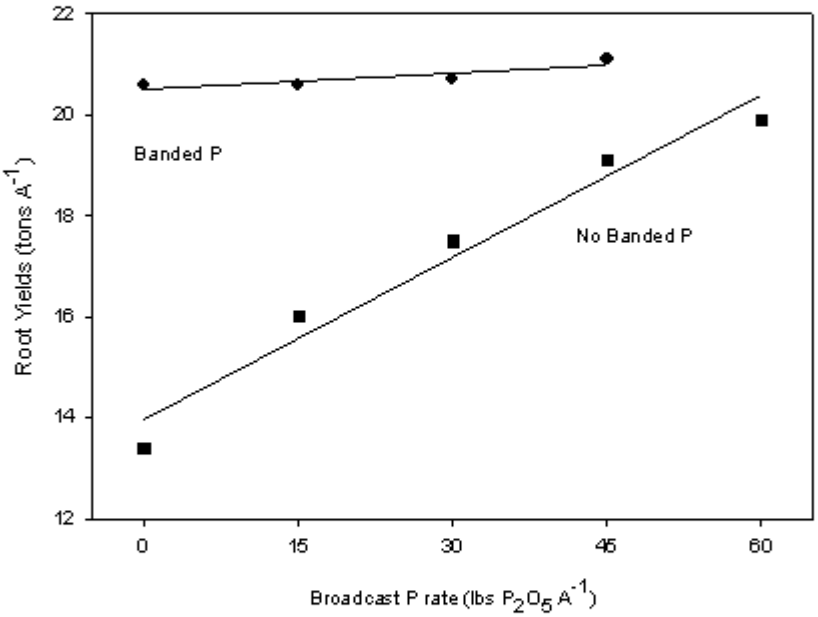
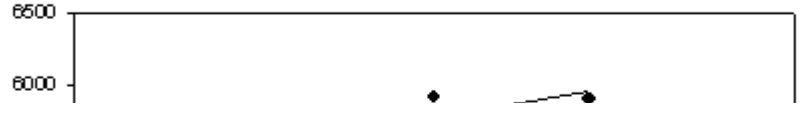


Figure 1. Sugar beet root yield response to broadcast P fertilizer with and without banded P.



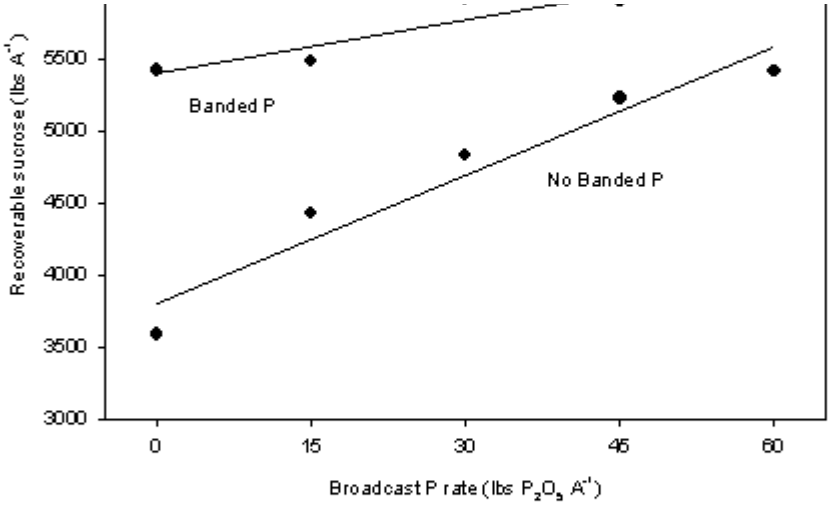


Figure 2. Sugar beet recoverable sucrose response to broadcast P fertilizer with and without banded P

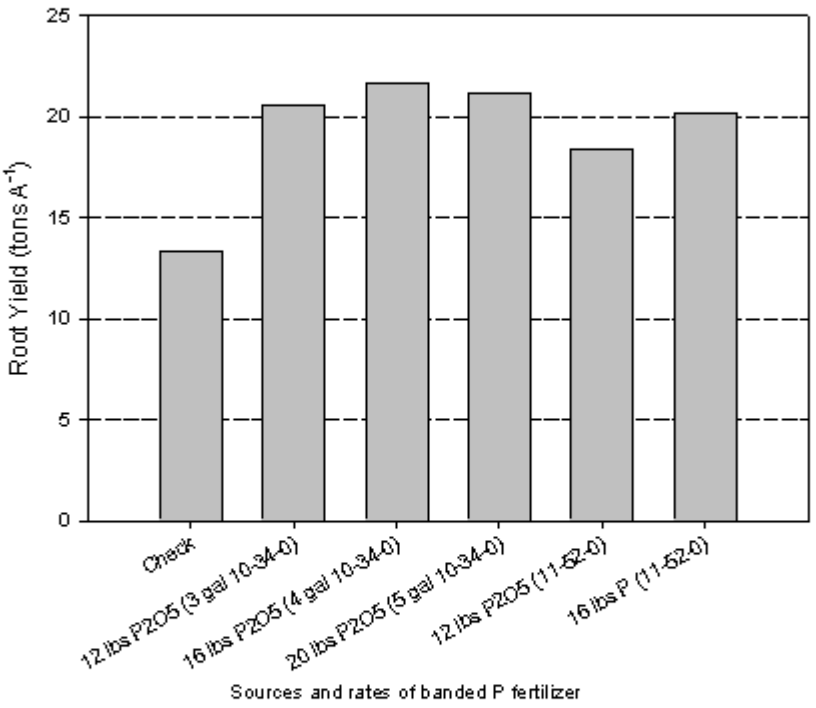


Figure 3. Sugar beet root yield response to various rates and sources of banded P fertilizer.