Minnesota Long-Term Phosphorus Management Trials: The Build Period

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Background and Approach

Phosphorus (P) is an essential nutrient and the second most commonly applied nutrient in Minnesota agriculture. Phosphorus (P) management is critical to reduce environmental risk while sustaining field productivity. Phosphorus management in Minnesota is based on one of two philosophical approaches: Build and Maintain (B&M) and Sufficiency (S). In recent years, it is argued that higher fertilizer applications associated with the B&M approach are necessary to obtain and maintain greater production levels in today's agricultural systems.

Objectives

The objective of this study was to establish long-term experiments in primary agronomic regions of Minnesota to test current and future P management strategies.

PHASE I: Establish at each site replicated soil test P (STP) level treatments ranging from Low, Medium, High, and Very High (V.High), over a period of 4 growing seasons (2011-2014).

PHASE II: Test both fertilizer P strategies (B&M and Sufficiency).

Methods

- Six long-term experiments were located across Minnesota (Fig.1).
  - Each site had a split-plot RCBD with 4 replications.
  - Only Whole plots will be treated in Phase I of the trial.
  - Split-plots will be used in Phase II of the trial.
- Grain yield, P removal, and P inputs were monitored throughout Phase I.
- Soil samples were taken at 0-15 cm soil depth.
- All agronomic practices at each location were customary for the region Only P fertilizer rates varied. Superphosphate (0-46-0) is the only P fertilizer source used at all locations.
- Corn was grown at all sites in 2011, 2012, and 2013 except at Crookston where corn, soybean, and hard red spring wheat were grown, respectively.
- In 2014, soybean was grown at all sites.
- Data analysis was performed using PROC GLIMMIXED procedure (SAS, Institute).

Figure 1. Locations of long-term P trials

Table 1. Soil information for each location

Site	Soil Taxonomy	pH	CCE %	O.M. %
Becker±	Sandy, mixed, frigid Entic Hapludoll	5.2	0.1	1.4
Lamberton	Fine-loamy, mixed, superactive, mesic Calcic Hapludoll	5.4	0.2	3.4
Rochester*	Fine-silty, mixed, superactive, mesic Mollic Haludalf	7.5	0.5	4.3
Waseca	Fine-loamy, mixed, superactive, mesic Aquic Hapludoll	6.0	0.1	4.7
Morris	Fine-loamy, mixed, superactive, frigid Aquic Calciudoll	7.6	1.5	3.9
Crookston§	Fine-silty, mixed, superactive, frigid Aeric Calciaquoll	8.1	2.5	4.8

± Becker site was limed in 2012 to bring soil pH up to 5.8.
* Rochester site was limed just prior to the initiation of the experiment.
§ Crookston and Morris typically use the Olsen STP for P fertilizer recommendations.

Table 2. Soil test phosphorus (P) Interpretation Classes and associated extracted P concentrations used in Minnesota.

Extract	STP Interpretation Class				
	V. Low	Low	Medium	High	V. High
	---------- mg P kg^{-1} extracted ----------				
Bray I-P	0-5	6-11	12-15	16-20	20+
Olsen-P	0-3	4-7	8-11	12-15	16+

Results - PHASE I

P fertilizer was applied to each whole plot to establish a range of STP over 4 growing seasons. Soil test P increased as P fertilizer rate increased (Fig.1), and four different interpretation classes (Low, Medium, High and V.High) were developed for each experimental site by the end of Phase I in the Fall 2014 (Fig.1). The degree to which P fertilizer rates varied STP levels differed among locations within years and in some cases across years within a location. Declining STP levels in Low treatment suggests soil P depletion over time at all sites, except at Lamberton.

At the end of Phase I in 2014, all sites had reached the four established interpretation classes: V.High>High>Medium>Low (Fig.1), and most of them were within the range established for Minnesota, with some exceeding only by a small margin (Table 2).

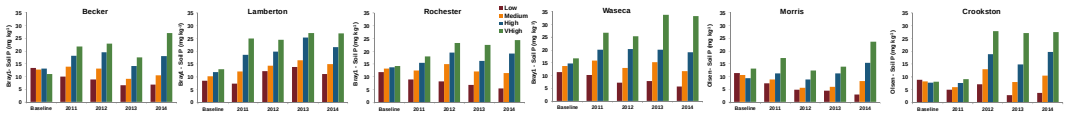

Figure 2. Extractable soil P (mg kg^{-1}) at 0-15 cm measured as Bray-1 for Becker, Lamberton, Waseca, and Rochester, and as Olsen-P for Morris and Crookston for the 4 growing seasons.

Corn was grown at all sites during the first 3 years of Phase I, except Crookston that has only 1yr corn (Fig. 3). Most of the corn sites were responsive to changes in soil P due to P applications, except Lamberton and Rochester that had little or no response to P applications (Fig. 3). Crookston had only one year of corn (2011) with similar corn yield among Medium, High and V.High treatments, but lowest yields in the Low treatments, indicating an overall small response to changes on Olsen-P levels (Fig.3).

Soybean was the crop in the last year of Phase I, and was very responsive to levels of soil P at all sites except Rochester (Fig. 4). The Crookston site had soybean in 2012 and 2014 so both years are represented in the graph (Fig. 4). However, at all responsive sites, there was a STP level above which there was no further yield increase.

Grain P removal was very responsive to the level of soil P at all locations, as interpretation Class soil P went from Low to High or V.High, the amount of grain P removed also increased.

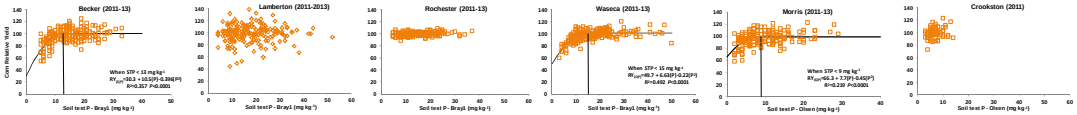

Figure 3. Relative corn yield response to soil test P levels (mg kg^{-1}) for 2011,2012 and 2013 growing season at Becker, Lamberton, Rochester and Waseca, and for Crookston in 2011 growing season. QP= quadratic plateau

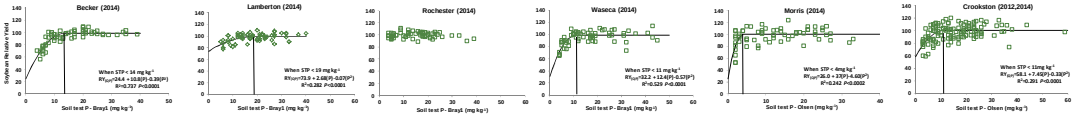

Figure 4. Relative soybean yield response to soil test P levels (mg kg^{-1}) for 2014 growing season at Becker, Lamberton, Rochester and Waseca, and for 2012 and 2014 growing season at Crookston. QP= quadratic plateau

All sites were combined to evaluate the response of relative yield and grain P removal to changes in soil test P–Bray1 (Becker, Lamberton, Rochester, Waseca) or Olsen–P levels (Morris, Crookston) (Fig. 5). Based on relative yield, corn had a weak response to changes on soil test P levels, where soybean showed a strong relationship (Fig. 5). Also, soybean grain P removal had a better relationship with changes in soil test P than corn (Fig. 5).

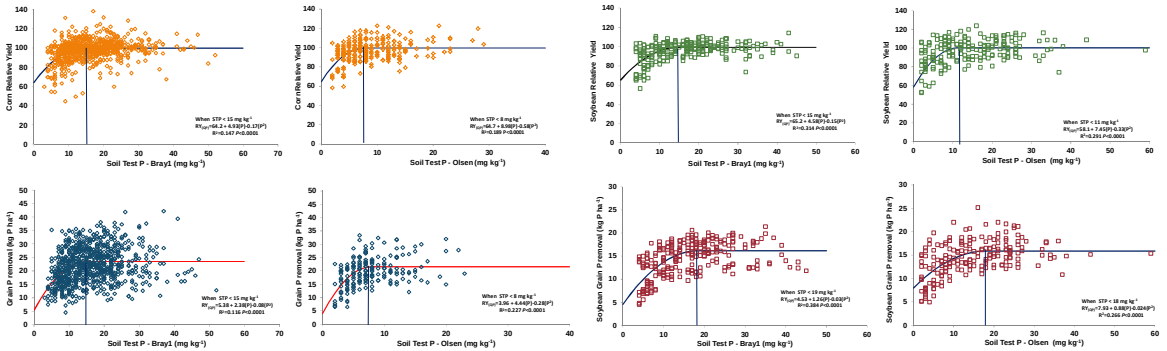

Figure 5. Corn or soybean relative yield and grain P removal response, combined over all years, to changes on soil test P (mg kg^{-1}) measured as Bray-1 (Becker, Lamberton, Rochester, Waseca) or Olsen (Morris, Crookston). QP= quadratic plateau.

Summary

- **All sites reached significant differences among the four established interpretation classes: V.High>High>Medium>Low.**
- **Corn yield response to soil P levels were observed in most sites, except Lamberton and Rochester.**
- **Soybean yield response was significant at all sites except Rochester.**
- **Soybean yield and grain P removal were more responsive than corn to changes in soil P levels due to P fertilization.**

Acknowledgements

This research was partially funded by the Minnesota Agricultural Fertilizer Research and Education Council (AFREC).