Minnesota Long-Term Phosphorus Trial-Phase II: Testing Yield Response and Potential

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Background and Approach

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 overall objective of this study was to establish long-term experiments in primary agronomic regions of Minnesota to test current and future P management strategies. Specific objectives for Phase II of the study are:

- Evaluate corn yield response to applied P under each soil test P interpretation class established over the previous four years.
- Determine if there is a yield potential difference among the soil test P interpretation classes when P fertilizer is applied.

Methods

- Six long-term experiments were located across Minnesota (Fig.1).
- Each site had a split-plot RCBD with 4 replications.
  - Only Whole plots were used in Phase I of the trial.
  - Split-plots were used in Phase II of the trial.
  - Whole-plot= soil interpretation class developed over a 4-yr period of time (Low, Medium, High, Very High).
  - Split-plot= P applied (+P) or no P applied (-P).
- Grain yield and P removal were measured during 2015 growing season.
- 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 2015.
- 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 Very 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 (2014), all sites had reached the four established interpretation classes: Very High > High > Medium > Low (Fig.1), as established for Minnesota, with some exceeding the target range only by a small margin (Table 2).

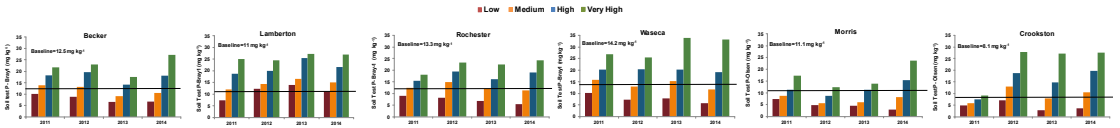

Figure 2. Extractable soil P (mg kg^{-1}) measured as Bray-1 for Becker, Lamberton, Waseca, and Rochester, and as Olsen-P for Morris and Crookston for the 4 growing seasons.

Results - PHASE II

Table 3. Statistical analysis of Grain yield. Effect of soil class, P rate and interactions.

	Grain Yield (Mg ha^{-1})					
Site	Becker	Lamberton	Rochester	Waseca	Morris	Crookston
	P values					
STP Class (C)	0.1109	0.0224	0.0354	0.2114	0.2789	0.2622
P (+P vs -P)	0.0001	0.0019	0.0028	0.0582	0.8826	0.0101
C x P	0.0030	0.1628	0.3080	0.1702	0.3821	0.0123
Slice Effects	P values					
Low	<.0001					0.0009
Medium	0.0064					0.0231
High	0.4690					0.6122
Very High	0.3106					0.7462

- Significant interaction between STP Class and P occurred only at Becker and Crookston.
  - Applied P (+P) increased grain yield in the Low and Medium classes but not in the High and Very High classes (Table 3, Fig 3).
- Both STP Class and P were significant at Lamberton and Rochester (Table 3).
  - Averaged across P, grain yields increased as STP Class went from Low to Very High (Fig 3).
  - +P increased grain yields in all STP Classes. Figure 3 suggests the grain yield increase with +P decreased as STP Class went from Low to Very High. However, this potential Class x P interaction was not significant (Table 3).
- At Waseca, +P tended to increase grain yield over most STP Classes (P<0.10) (Table 3, Fig. 3). This potential increase with +P was consistent at least from STP Classes Low, Medium, and High.
- Neither STP Class nor P had a significant effect on grain yield at Morris (Table 3). Trends that appear in Figure 3 were not significant and suggest this site has considerable variability relative to other sites of this trial.

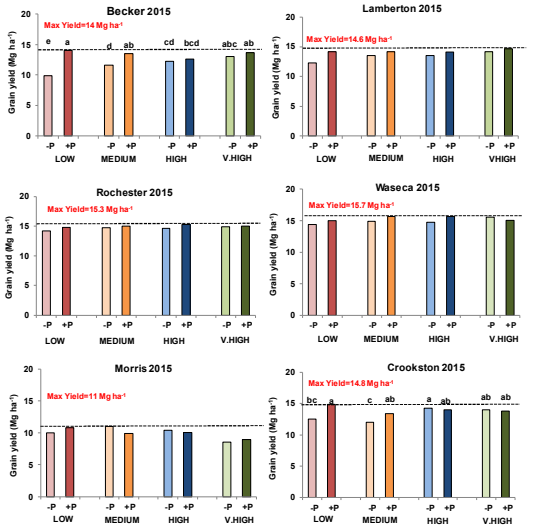

Figure 3. Corn grain yield for 2015 growing season at six experimental sites. Dotted line represent maximum yield at each experimental site. Different letters indicates significant differences at P < 0.05.

The dashed line in each graph of Figure 3 represents the maximum grain yield attained at this site regardless of the specific treatment with that yield.

- At Becker and Crookston, the maximum yield obtained in Low and Medium STP Classes was not different from maximum yields obtained in the High and Very High STP Classes.
- At Lamberton and Rochester, there was little difference among the maximum grain yields obtained within each STP Class.
- At Waseca, there was little difference in maximum grain yield obtained within each STP Class. Maximum grain yield in the Low treatment might have been slightly lower than maximum yield in the other STP Classes.
- At Morris, neither STP Class or P had an effect on grain yield. Figure 3 suggests maximum yield occurred in the Low and Medium STP Class with +P.

Summary

- After 4 years, all sites had an established stair-step range in STP levels that generally corresponded to interpretation classes of Very High > High > Medium > Low.
- Though applied P tended to increase grain yields overall, the impact of the starting STP Class on this response varied among the six sites.
- As long as sufficient P is available, either from fresh P fertilizer or residual P, no evidence was observed that building to a high STP class increased yield potential.

Acknowledgements

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