Sufficiency Level vs. Build and Maintain Approaches to Managing Phosphorus for Crop Production

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Background and Approach

Phosphorus recommendations in Minnesota are based on the Sufficiency approach. Recently, it is argued that Build and Maintain (B&M) approach will support higher corn and soybean grain yields potentials than the Sufficiency (S) approach, however we have no data to support this claim.

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 were:

- Evaluate corn yield and grain P removal 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.
  - Whole-plot = soil interpretation class (STP) developed over a 4-yr period of time (Low, Medium, High, Very High).
  - Split-plot = applied P (+P) or no P (-P).
- Grain yield and P removal were measured during 2015 and 2016 growing seasons.
- All agronomic practices at each location were customary for the region. Only P fertilizer rates varied. Triple superphosphate (0-46-0) was the only P fertilizer source used at all locations.
- Corn was grown at all sites in 2015 and 2016.
- Data analysis was performed using PROC GLIMMIXED procedure (SAS, Institute), considering site, STP class and P fertilizer as fixed effects and block and year as random effects.

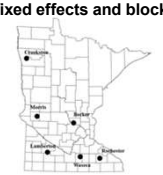

Figure 1. Locations of long-term P trials

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.

Results and Discussion

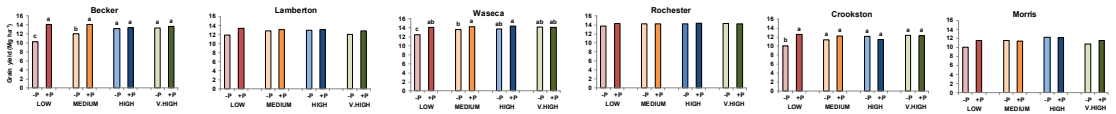

Figure 1. Corn grain yield; average of 2015 and 2016 growing season at six experimental sites. Different letters indicates significant differences at P < 0.05.

–Applied P (+P) increased corn grain yield in the Low and/or Medium STP classes but not in the High and Very High classes (Fig. 1) at Becker, Waseca and Crookston sites.

–Similar grain yields among treatments were observed at Lamberton, Rochester and Morris sites (Fig. 1).

–Application of P in the Low and Medium STP classes resulted in similar yields to those in higher testing P soils with and without fertilizer.

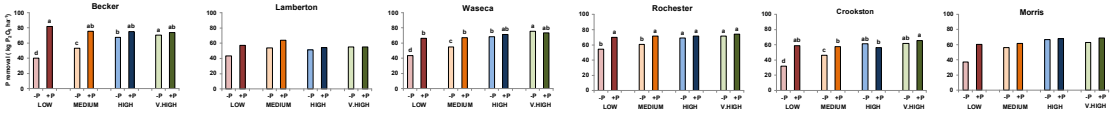

Figure 2. Grain P removal average of 2015 and 2016 corn growing season at six experimental sites. Different letters indicates significant differences at P < 0.05.

–Grain P removal was greater in the applied-P (+P) than noP-applied (-P) in the Low and Medium STP classes at 4 of 6 sites (Fig. 2). Similar to grain yield, no differences were detected in the High and Very High STP classes (Fig. 2).

–At Morris and Lamberton sites, similar trend was observed but differences were not statistically different.

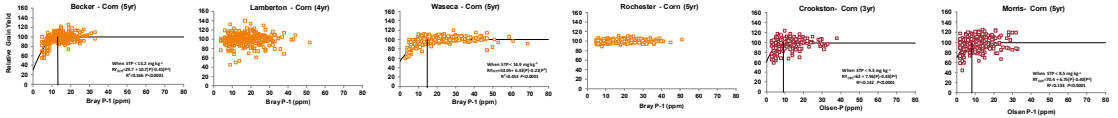

Figure 3. Relative corn yield response to soil P levels (ppm) for 5 growing season at Becker, Rochester and Waseca, 4 for Lamberton, and 3 for Crookston.

– Corn was responsive to soil P changes due to P applications at Becker, Waseca, Crookston and Morris. Lamberton and Rochester had little or no response to P applications (Fig. 3).

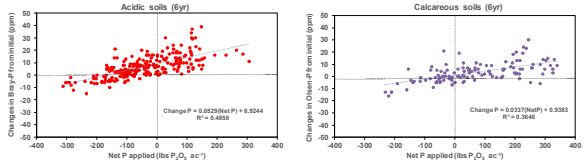

Figure 4. Change in Bray-P or Olsen-P vs net P applied (lbs P_2O_5 ac^{-1} applied in fertilizer – lbs P_2O_5 ac^{-1} removed in grain) after 6 years for acidic (Becker, Lamberton, Waseca, and Rochester sites) and calcareous (Morris and Crookston sites) soils.

After 6 years, when net P addition was 0 (P removed=P applied) a positive net change of 1.5 ppm yr^{-1} and 0.2 ppm yr^{-1} was observed for acidic and calcareous soils, respectively (Fig. 4).

Summary

- Greater response to P application was observed in the Low and Medium STP classes, with little to no response in the High and Very High STP classes.
- Applying P fertilizer annually based on STP level resulted in similar grain yield potential than building and maintaining high STP regardless of P level and soil type.
- Therefore, the Sufficiency approach in Low and Medium STP classes with P application was as productive as High and Very High STP classes with or without applied P fertilizer.

Acknowledgements

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