Minnesota's Long-Term Phosphorus Trial: Phase I

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Introduction

- P management is critical
  - Reduce environmental risks
  - Sustain field productivity
- P fertilizer recommendations vary considerably.
  - Can vary with soil type and crop
  - Can vary depending on who is making recommendation
  - Much of it can be attributed to difference in objective or philosophy
    - Build and Maintain (BM): fertilize soil to a critical STP level then resupplying to the soil what the crop removes
    - Sufficiency (S): fertilizer the crop as needed and rely on soil to supply some of the crop needs
- Early research found BM used more fertilizer than S with no yield benefit.
  - Extensive research in Nebraska (Olson et al, 1982. Agron. J. 74:492-499)
  - Similar trials in Minnesota
- Current production environment:
  - Yields are increasing
  - Soil test P is declining over time
- New questions are being raised:
  - S will deplete soil P reserves?
  - Yields unsustainable with S?
  - Higher yield potential with BM?
- Long-term trials are needed to address some of these questions.

Objective

Establish long-term experiments in primary agronomic regions of Minnesota to test current and future P management strategies.

- Phase I: Establish over a 4 yr. period replicated treatments of various STP levels representing various interpretation classes (Low, Medium, High, and V. High).
- Phase II: Test yield response to applied P fertilizer with each established interpretation class and determine yield potential difference between them.

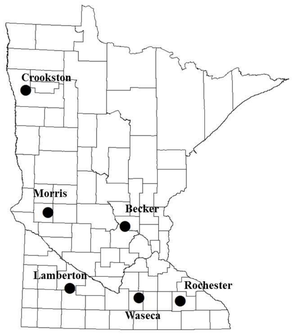

Figure 1. Locations of long-term P trials

Table 1. Soil test phosphorus (P) Interpretation Classes and associated extracted P concentrations used in Minnesota.

	STP Interpretation Class				
Extract	Very 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

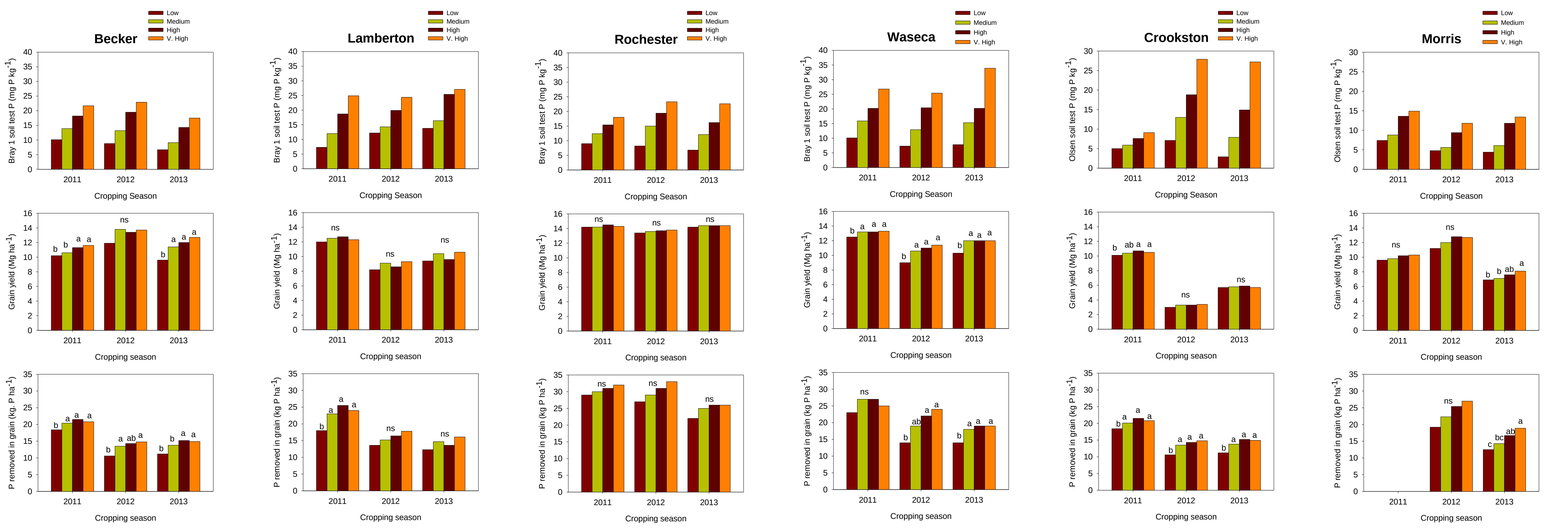

Figure 2. Variation in soil test P (top graphs), grain yield (middle graphs) and P removed in the grain (bottom graphs) associated with the developing soil test P interpretation classes across the first three growing season of Phase I at six locations across Minnesota.

- Statistical analysis of grain yield and P removed in the grain are indicated by letters above the bars. Within a bar cluster, bars with different letters are significantly different at the alpha=0.05 level. Analysis was conducted within each year at each location. Letters of ns indicate no significant differences were found.
- Top graph: Bray I P on the y-axis at Becker, Lamberton, Rochester, and Waseca; Olsen P on y-axis at Crookston and Morris.
- Middle and Bottom graph: All locations planted to corn in 2011, 2012, and 2013 except Crookston where corn was planted in 2011, soybean in 2012, and hard red spring wheat in 2013.

Top graphs: Various quantities of P fertilizer was applied to individual Whole plots in an attempt to establish a range of STP levels. STP increased as P fertilizer rate increased each year. The degree to which P fertilizer rates varied STP levels differed among locations within years and in some cases across years within a location. X-axis is the same for all locations. Note similarities in established STP among some locations and differences among others. Crookston had minimal response to applied P fertilizer in 2011, but was very responsive in subsequent years. Morris STP levels have never reached those of Crookston. Both sites have calcareous soils. Note the increase in STP over years in the Low treatment at Lamberton where no P fertilizer has been applied since before the fall 2010. STP in Low treatment at all other sites suggest soil P depletion over time..

Middle graphs: Grain yield was responsive to the applications of P fertilizer at most sites. However, there was frequently little difference between the Medium treatment and the High treatments. Exceptions were 2011 at Becker. At Lamberton and Rochester, there was no grain yield response to any of the treatments. At Crookston, neither soybean nor hard red spring wheat responded to the treatments.

Bottom Graph: Adding P fertilizer to the Medium, High, and V. High treatments increased total grain P removal in all years at Becker and Crookston, in two of the three years at Waseca, and one of three years at Lamberton and Morris. There was no difference in grain P removal in any year at Rochester.

Methods

- Trials established at 6 locations across Minnesota (Fig 1)
  - Establish a split-plot RCBD with 4 replications at each location.
  - Only Whole plots will be treated in Phase I of the trial
  - Split-plots will be utilized in Phase II of the trial
- Phase I: Establish Whole plot treatments of various range of STP levels representing increasing interpretation classes of Low, Medium, High, and V. High (Table 1)
  - Established Whole plot treatments over 4 yrs. (fall 2010 to fall 2014)
- Monitor grain yield, P removal, and P inputs throughout Phase I
- All agronomic practices will be what is customary at that location and will be practiced over the entire experimental area. Only P fertilizer rates will vary. Superphosphate (0-46-0) is the only P fertilizer source used at all locations.
- All sites grew corn in 2011, 2012, and 2013 except at Crookston where corn, soybean, and hard red spring wheat were grown, respectively.
- In 2014, all locations grew soybean
  - Grain yields and grain P content for the 2014 crop was not available at time poster was made.
- Phase II initiated in Fall 2014 with corn grown in 2015 and 2016.
  - Each Interpretation Class plot will be split into 4 split-plots. One pair of split-plots will be used for 2014-15 trial and the other for 2015-16 trial.
  - One split-plot in a pair will rely on residual P built over the 4 years of Phase I
  - One split-plot will be fertilized with either 170, 102, 34 or 34 lbs. P_2O_5 ha^{-1} in the Low, Medium, High, and V. High treatments, respectively.
  - Test for crop response to applied P and compare maximum yields attained in each interpretation class category

Table 2. Soil information for each of the six locations where trials were established.

			CCE	O.M.	Initial Bray I	Initial Olsen
Site:Soil	Soil Taxonomy	pH	kg Mg^{-1}		mg P kg^{-1}	
Becker: Hubbard ls	Sandy, mixed, frigid Entic Hapludoll	5.2	1		12.5	5.4
Crookston§: Gunclub sicl	Fine-silty, mixed, superactive, frigid Aeric Calciaquoll	8.1	25	48	11.4	9.5
Lamberton: Ves l	Fine-loamy, mixed, superactive, mesic Calcic Hapludoll	5.4	2	34	10.8	6.3
Morris§: McIntosh sl	Fine-loamy, mixed, superactive, frigid Aquic Calciudoll	7.6	15		18.2	11.1
Rochester*: Mt. Carrol sil	Fine-silty, mixed, superactive, mesic Mollic Haludalf	7.5	5	43	13.7	8.6
Waseca: Nicollet cl	Fine-loamy, mixed, superactive, mesic Aquic Hapludoll	6.0	1	47	14.2	6.6

*Rochester site was limed just prior to the initiation of the experiment
§ Crookston and Morris typically use the Olsen STP for P fertilizer recommendations.

- Various site characteristics are being defined throughout the trial period.
- Blank O.M. cells means those analysis values were not available when this poster was developed, but will be available in the coming weeks.
- Initial Bray I and Olsen P are those at the beginning of the trial in Fall 2010. Initially all sites were in the high Low to high Medium interpretation class levels.

Summary

- At each site, replicated plots have been established with varying STP levels that represent the interpretation classes of Low, Medium, High and V. High.
- 2014 data were not available in time for this poster.
- Each site varies in STP responsiveness to increasing levels of P fertilizer that was applied to establish the interpretation class categories.
- Depletion of P (Low) over time reduced corn grain yields and grain P removal at all sites except Lamberton and Rochester.
- Phase II of this trial begins Fall 2014 with corn grown in 2015.

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