Liquid vs Dry Phosphorus Fertilizer Formulations with Air Seeders

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Research Question

The objective of this research is to compare HRSW biomass, P accumulation, and grain yield response to various rates of pre-plant broadcast and starter (banded with the seed) applications of liquid (10-34-0) and dry (11-52-0) P fertilizer sources when the seed is planted in a 4 inch wide bands with an airseeder.

Results

Neither total biomass nor total P accumulation were significantly affected by the experimental factors used in this trial (Table 1). One exception was a significant application method by P source interaction for biomass accumulation at Site S. This exception was caused by a 12% increase in biomass accumulation with starter application of dry P fertilizer compared to the broadcast application, but there was no application method difference with the liquid P fertilizer. The lack of any significant effect at NWROC was surprising because visually we could detect P rate differences early in the growing season. Apparently, by the soft dough stage these differences had been minimized. Averaged across all experimental factors, total biomass was 127 and 140 g DM ft\(^2\) at NWROC and Site S, respectively. At the same respective sites, total P accumulation was 0.144 and 0.194 g P ft\(^2\). Clearly, Site S had greater biomass production, and thus greater P accumulation than NWROC.

Experimental treatment factors primarily affected grain yield and, to a less extent, grain protein (Table 1). At both experimental sites, P fertilizer application method significantly affected grain yield. Starter P increased grain yields compared to pre-plant broadcast applications (Fig 1a and 2a). However, only at NWROC did applied P rates affect grain yield. A significant interaction between P application method and P rate for grain yield at NWROC (Table 1) was primarily caused by the greater yield response to starter P rates compared to broadcast P rates (Fig 1a). Grain protein was reduced with starter applications at NWROC (Table 1 and Fig 3a), which we think was probably due to the strong relative grain yield response to starter applications. Phosphorus source significantly affected grain yield and protein only at Site S (Table 1). Grain yield was 2 to 5 bu A\(^{-1}\) greater with the liquid P source than the dry P source (Fig 2b). At the same time grain protein was reduced 0.1 to 0.2% with the liquid P source (Fig 4b). Though P source was not significant at NWROC, the dry P source tended to produce slightly greater grain yields than the liquid source at lower P rates (Fig 1b), which was the opposite observed at Site S.

Application and Use

Predicting the P fertilizer need for spring wheat production has been difficult and frustrating for many researchers over the last several decades. When a response does occur, it is sufficient to justify the application of P fertilizer and would be costly to the growers had they not applied P fertilizer. But, in most instances, the response to applied P has been minimal at best. The trial discussed here has been no exception. We deliberately searched and found experimental sites with low STP levels to provide the greatest probability of observing a response to P fertilizer. A relatively strong yield response to fertilizer P application occurred in one of the three site years (two each of 2007 and 2008 growing seasons).

In this trial, we used an airseeder with a seed distribution pattern about 4 inches wide. While this may change the dynamics of the proportion of the seed bed planted compared to the normal disk opener grain drill, it appears not to have changed the general effects of P fertilizer management. When a response occurred, there was a strong tendency for a more favorably grain yield response with starter applications compared to a pre-plant broadcast application.

Whether that P should be liquid or dry is not clear from this trial. Results from Site S suggest a liquid source may be more effective, but this is was one of four site years on a mostly non-responsive site. The NWROC site was responsive to P fertilizer application, but source made no significant difference.

Our data would suggest that growers should shop for the cheapest source of P fertilizer for their spring wheat production systems. But, once the decision on the source is made starter applications of that fertilizer should be strongly considered.
Material and Methods

Two field experiments were established in the 2008 growing season. One on the University of Minnesota’s Northwest Research and Outreach Center (NWROC) and another site about 8 miles east by southeast of NWROC (Site S). Soils at both locations have been classified as Wheatville silt loam (coarse-silty over clayey, mixed over smectitic, superactive, Frigid Aeric Calciaquoll). Soil test P levels was 2 ppm at both locations suggesting a high likelihood of a response to the application of P fertilizer at both experimental sites.

A 2 X 2 X 5 factorial treatment design was used with two P sources (liquid 0-0-0 and dry -2-0-0), two application methods (broadcast prior to planting and starter applied with the seed at planting) and five P rates (0, 20, 40, 60, and 80 lbs P2O5 A-1 equivalent). The experimental design was a randomized complete block with four replications. Initial plots were 0 ft wide and 0 ft long, but were later cut back to 0 ft long from the center of each initial 0 ft plot. Broadcast fertilizer was applied just prior to planting by either hand spreading (dry) or using a sprayer mounted on an all terrain vehicle (liquid). Starter fertilizer was applied with a modified airseeder that applied seed and fertilizer in rows 4 inches wide and spaced 10 inches apart.

Hard red spring wheat (Knudson) was planted on April 17 at NWROC and May 5 at Site S. At the soft dough stage, whole plants from one row three feet long was clipped at ground level, dried and processed to determine total biomass and total P accumulation. At physiological maturity, five feet from the center of each plot was harvested with a plot combine. The grain was dried then weighed to determine yield. A sub-sample was used to determine test weight and grain protein via NIR.

Statistical analysis was done using Proc Mixed procedures in SAS 9.1. Differences among the various factors were characterized with slice analysis and targeted single degree of freedom contrasts. Regression lines in the figures included in this report are based on the results of those contrasts.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Currently university P fertilizer management guidelines indicate P rates can be reduced 35 to 50% when banded or applied as a starter at planting compared to pre-plant broadcast rates. If 60 lbs P2O5 A-1 is recommended as broadcast, similar production levels can more than likely be achieved by using 30 to 40 lbs P2O5 A-1 as a starter at planting. Assuming $1 per lbs of P2O5 this is a savings of $20 to $30 per acre. On a 500 acre wheat enterprise, this is a savings of $10,000 to $15,000.

Related Research

Calcium carbonates, common in most soils of northwest Minnesota, tend to tie up phosphorus (P) making it relatively less available for crop production. Many growers maintain soil test P (STP) levels in the medium to high levels, or attempt to do so, by applying relatively large amounts of P fertilizer to ensure against a potential P deficiency in the crop. Currently, this practices is not considered best P management practice by the University of Minnesota because of low economic returns for the amount of P fertilizer applied when STP levels are high, potential environmental consequences of over application of P, and because some soils strongly tie up P and STP hardly change or are difficult to maintain. In recent years, exceptionally high fertilizer costs are forcing growers to reevaluate their P management strategies in order to maintain positive profit margins. In HRSW production, P fertilizer can be either applied broadcast prior to planting or banded with the seed at planting. Banding P fertilizer in HRSW production is frequently recommended because banding reduces the fertilizer-soil contact thus reducing potential for chemical tie up of the P, but also because banding places the fertilizer in a concentrated zone near the plant roots. Banding P fertilizer generally requires less P fertilizer than broadcast applications to obtain similar yields. Peterson et al., (1981) reported that the effectiveness of banded P relative to broadcast P will increase as STP levels decrease. That is, at very low STP broadcast applications require nearly three times the amount of P as banding to obtain the same yield. At low to medium STP levels, broadcast applications require nearly twice as much P as banding. At higher STP levels, there is little difference between application methods, but very little P is generally required at all.

Earlier research in northwest Minnesota has not shown consistent responses to P fertilizer in HRSW production, especially when STP levels are 4 ppm (low category) or higher. This result has occurred regardless of P fertilizer application method of generally
dry P fertilizers. Recent research in Australia found that liquid P fertilizer sources may be more beneficial for wheat production than dry P fertilizer sources on highly calcareous soils (Lombi et al, 2004). The research suggests that dry fertilizer granules draw water from the surrounding soil that brings with it soluble calcium that will tie up the P as the granule dissolves. This appears not to be as large a concern for liquid P fertilizer sources because it is already dissolved. Though soils in northwest Minnesota do not contain nearly the amount of calcium carbonate as those in Australia where this trial was conducted, it did stimulate the question of whether we do not often see a HRSW response to P because we generally use dry P fertilizer.


Recommended Future Research

Future research needs to examine the use, interpretation, and management of soil test P levels for wheat production. Many growers strive to build and maintain the STP levels in the medium to high levels. This suggests that lower STP levels indicate insufficient levels of P for wheat production. If STP levels do reveal soils with insufficient levels of P, then wheat should respond to the application of P fertilizer. Many research projects conducted over several decades by different researchers have observed very few incidents where spring wheat responds to P fertilizer application when the starting STP levels were in the low category. Currently, a strategy is being developed by nutrient management specialists in the University of Minnesota system to reevaluate current P fertilizer management recommendations and how STP should be used in those recommendations. As that strategy is being developed, I would encourage the Minnesota Wheat Growers to consider participating in this work.

Appendix

Table 1. Statistical analysis for the P rate by P source by P application method trial at two experimental sites.

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§***, ***, *, and ns represent significance at 0.001, 0.01, 0.05, and not significant, respectively.
§§App represents broadcast and starter P fertilizer applications. Source represent liquid and dry P fertilizer sources, and P rate represent 5 applied P rates of 0 – 80 lbs P₂O₅ A⁻¹ equivalent.
Figure 1. Grain yield response to applied P rates at NWROC experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

Figure 2. Grain yield response to applied P rates at Site S experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).
Figure 3. Grain protein response to applied P rates at NWROC experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).

Figure 4. Grain protein response to applied P rates at Site S experimental site when applied as either a starter at planting or pre-plant broadcast (a) or using a dry or liquid P fertilizer source (b).