PHOSPHORUS AND ORGANIC ACID BONDING ENHANCES UPTAKE EFFICIENCY AND YIELD RESPONSE IN CROP PLANTS

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ABSTRACT

Phosphorus (P) fertilizer is essential for crop production, but reductions are warranted to conserve resources and minimize environmental impacts. Several lab, glasshouse, growth chamber, and field studies have been performed over the past seven years with a new P fertilizer (Carbond P; CBP; Land View Fertilizer, Rupert, ID, USA) in calcareous, low OM soil. This paper will be a review of a portion of that data. Studies comparing CBP to ammonium polyphosphate (APP) and monoammonium phosphate (MAP) applied to soil show season-long increases in P solubility for CBP in many soils. Glasshouse and field studies with maize (*Zea mays* L.), dry beans (*Phaseolus vulgaris* L.), potato (*Solanum tuberosum* L.), sugarbeet (*Beta vulgaris* L.), and wheat (*Triticum* spp.) resulted in significantly greater yields and/or crop quality in 19 of the 41 studies—with no negative responses at what would be considered low to moderate rates of CBP. Low rates of CBP show increases in biomass and P concentration when compared to APP and MAP at similar rates. The effect largely disappears at high rates. When examining only trials with low soil test P (<20 mg kg^{-1} Bicarbonate extractable P for potato and <12 mg kg^{-1} for all other crops), greater responses occurred in nearly every trial for CBP over APP when comparing low rates of these materials—showing an increase in P use efficiency. The average yield increases were 11% and P uptake increases were 14%. Carbond P is an enhanced efficiency fertilizer that often increases yields and crop quality and almost always increases P uptake in plants compared to traditional fertilizers when applied at low rates on calcareous soils with relatively low soil test P.

MATERIALS AND METHODS

P Solubility

Ammonium polyphosphate (APP; 10-34-0), mono-ammonium phosphate (MAP; 11-52-0), and Carbond P (CBP; 7-24-0) were applied as a concentrated band at 8 cm below soil surface in 15 cm tall soil columns packed with alkaline sand, calcareous sand, or calcareous loam soil. Two application rates (20 or 80 kg P_2O_5 ha^{-1}) were applied to each soil and compared to an unfertilized check with six replicates. Soil was packed in columns to bulk density similar to native soils (~1.65 g cm^{-3}). The mobility of P was evaluated at 24, 48, 110 and 365 days by leaching each column with two pore volumes of water. The leachate was then analyzed for total P concentration (ICP) and evaluated statistically by ANOVA (SAS software).

Field Crop Response

APP and CBP were applied and incorporated to potato, dry bean, sugarbeet, silage corn, and wheat with 11, 4, 3, 19, and 4 site years, respectively. Application rates were 22 kg P_2O_5 ha^{-1} for potato and 11 kg P_2O_5 ha^{-1} for other species. The bicarbonate extractable P was 13-28 mg kg^{-1} for potato and 6-18 mg kg^{-1} for other species. Potato yields were determined as US No. 1, sugarbeet as extractable sugar tonnage, silage corn as 30% adjusted relative moisture for above ground biomass cut at 10 cm above soil, and wheat and dry bean yields determined as grain weight. Tissue P was determined by nitric-perchloric digestion and ICP analysis and evaluated statistically by ANOVA (SAS software).

RESULTS AND DISCUSSION

P Solubility

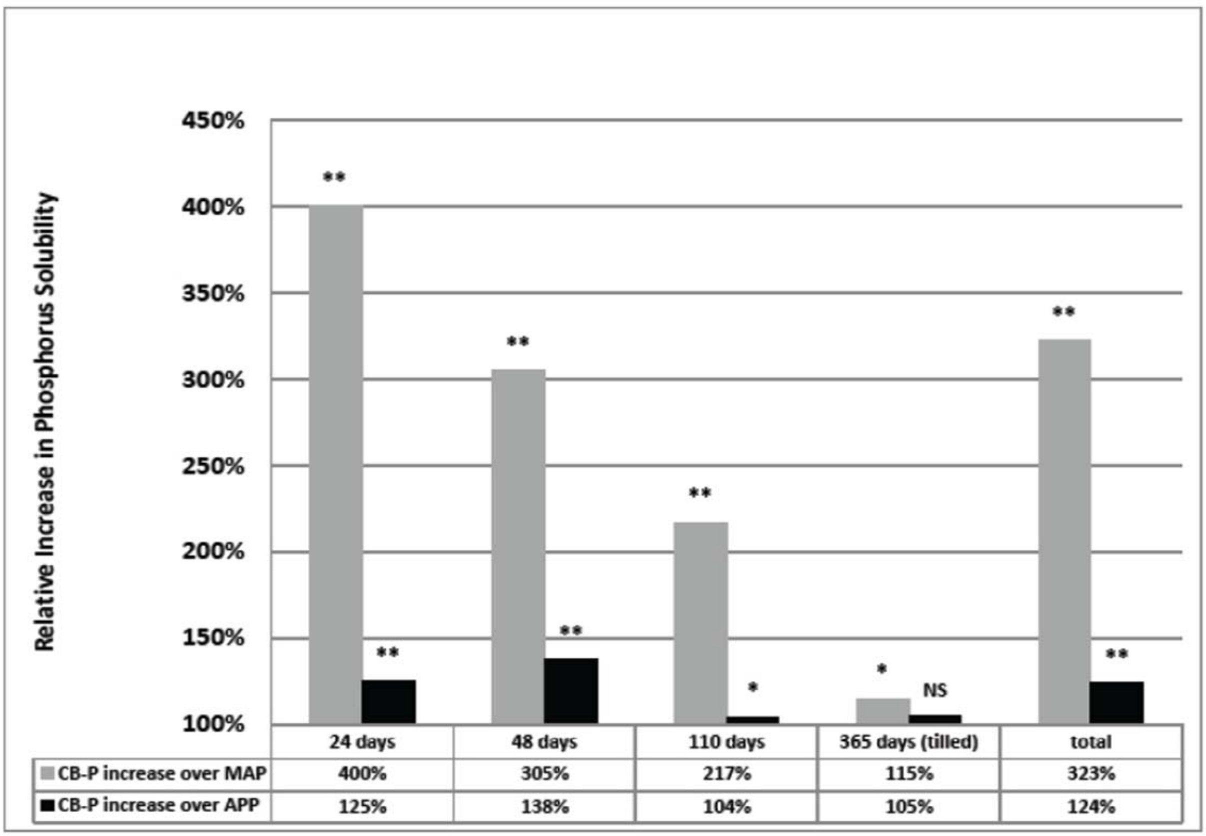

Fig. 1. P Solubility - Relative increase in P solubility to an unfertilized control with application of CBP compared to APP and MAP in a banded application to three soils at two P rates (results are combined across rates and soils). Increase in P solubility for CBP over APP/MAP is signified by "NS" = not significant, "*" = significant at $P < 0.05$ and "**" significant at $P < 0.01$.

There were no significant fertilizer rate or soil type interactions with fertilizer source and, therefore, the results were averaged across these parameters to examine differences by fertilizer source. Leachate from CBP treated soils in banded applications consistently had significantly greater P concentration than other fertilizers for all dates except MAP at 365 days (Fig. 1; Hill, 2013). Similar results were found when the fertilizers were broadcast applied in an otherwise identical study, albeit the magnitude of the differences were not as great (Hill, 2013). The CBP is more soluble than APP and MAP over the course of growing season.

Field Crop Response

A consistent increase of P concentration in plant tissue was measured when fertilized with CBP over APP across five crops (Fig. 2). An increase was also noted for crop yields using CBP compared to APP with all five crops (Fig. 2).

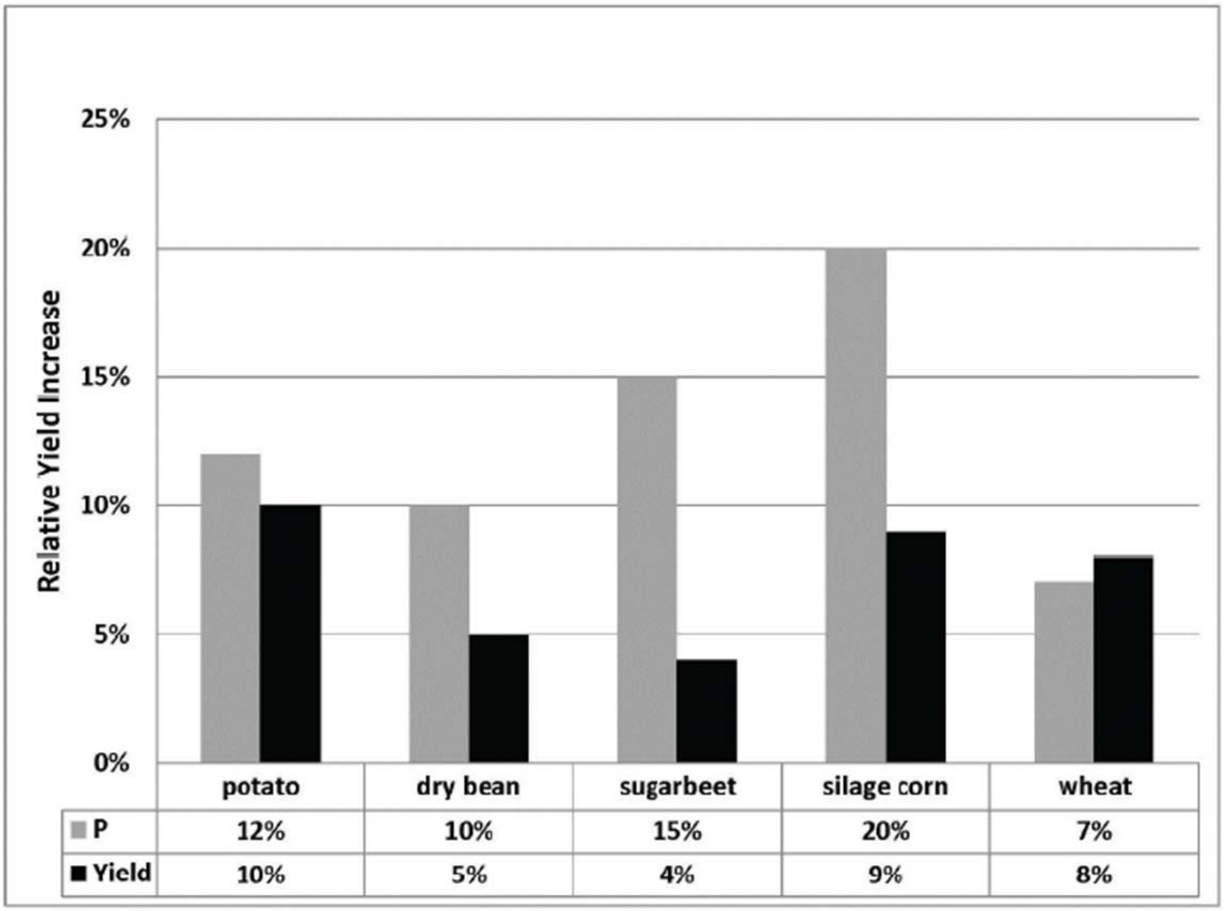

Fig. 2. Field Crop Response - Increase in crop yield/quality and P concentration for CBP compared to APP at 11 kg P_2O_5 ha^{-1} for all crops except potato, which was applied at 22 kg P_2O_5 ha^{-1}. All differences are significant at $P < 0.05$. (note: additional higher rates were applied, but CBP did not show a consistent advantage over APP at the higher rates and the data is not shown here)

When evaluating individual fields, there were significantly greater yields and/or crop quality in 19 of the 41 studies—with no negative responses at what would be considered low to moderate rates of P. Low rates of CBP show increases in biomass and P concentration when compared to APP and MAP at similar rates. The effect largely disappears at high rates. This is not surprising, as available P levels supply adequate nutrition, one would not expect further yield increases. If enough APP or MAP, which are proven fertilizer sources, are added to a crop then adding more would not result in further yield increases once the yield plateau is reached. The same would be expected of CBP—more P in the plant is not a benefit once the plant's needs are met. It is apparent, however, that CBP achieves the yield plateau with a lower rate of P than APP or MAP in calcareous soils. In fact, there is some evidence that yields declined at high rates of CBP—possibly due to a P induced micronutrient (likely Zn or Mn, but also possibly Cu or Fe).

The average yield increases across all trials were 8% and P uptake increases were 14%. When examining only trials with low soil test P (<20 mg kg^{-1} Bicarbonate extractable P for potato and <12 mg kg^{-1} for all other crops), greater responses occurred in nearly every trial for CBP over APP when comparing low rates of these materials—showing an increase in P use efficiency.

CONCLUSION

The organic acid-P manufactured fertilizer, Carbond P, is more soluble and mobile than ammonium polyphosphate. Increases in early season glasshouse grown maize biomass and P concentration, uptake, and efficiency were observed consistently at the lowest rates of fertilizer applied to calcareous soils. The effect disappeared or even was reversed at moderate to high rates. Further work needs to be done in field studies on neutral and acid soils.

REFERENCE

Hill, Michael W. 2013. Improving phosphorus use efficiency through organically bonded phosphorus. Brigham Young University thesis.

PROCEEDINGS

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Volume 11

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