PHOSPHORUS AND ORGANIC ACID BONDING IMPACTS AT VARYING SOIL pH

Trenton A. Blair, Curtis J. Ransom, Paul Hosford, Jeffery D. Svedin, Lloyd Sutton, Adam Winchester, Karen Manning, Tyler J. Hopkins, and Bryan G. Hopkins
Plant and Wildlife Sciences Department
Brigham Young University, Provo Utah

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 six years with a new P fertilizer (Carbond P; CBP; Land View Fertilizer, Rupert, ID, USA) mostly in calcareous, low OM soil. 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, dry beans, potato, sugarbeet, alfalfa, wheat, and bluegrass resulted in enhanced yields and/or crop quality in 23 of the 45 studies. In this study, three glasshouse trials were conducted with maize grown in a sandy loam soil modified to be either calcareous, alkaline non-calcareous, acid, or neutral pH with each constructed soil type receiving four rates of P using CBP or APP compared to an unfertilized control. A soil by fertilizer source interaction was observed with most measured parameters. Phosphorus resulted in increased biomass, plant height, and total P uptake, especially for CBP at the lowest two rates (10 and 20 kg ha^{-1}). Biomass was similar for CBP and APP at the highest rates. Stem width consistently increased with CBP greater than APP at all rates. 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.

METHODS

Four soils were constructed using a non-calcareous, alkaline sandy loam from Rupert, ID, USA modified as follows:

*4.5 pH – adjusted by leaching with pH 4.5 water until target pH was reached,
*6.8 pH – adjusted by leaching with pH 6.8 water until target pH was reached,
*8.0 pH – alkaline soil (this is the original, unmodified soil),
*8.2 pH – addition of CaCO3 on a 12% mass/mass basis.

Ammonium polyphosphate (APP; 10-34-0) or Carbond P (CBP; 7-24-0) were applied 5 cm (2 inch) to the side and 5 cm below eventual seed placement at four rates of 11, 22, 44, and 88 kg P_2O_5 ha^{-1} (10, 20, 40, and 80 lb ac^{-1}) compared to an unfertilized control) for each of the four soils. Nitrogen was balanced across all treatments.

Glasshouse studies were performed at Provo, UT, USA between February 2013 and February 2014. Three maize (DeKalb DKC30-20 hybrid) seeds were planted per pot (pot size = 30.5 cm height x 10.2 cm diameter) and eventually thinned to one plant per pot.

The maize was irrigated with water adjusted at same pH as soil to maintain target pH. After 42 days, shoot height and stem width were measured and then shoot and root biomass and tissue P concentration determined. Statistical analysis was accomplished by ANOVA (SAS software, Cary, NC, USA) with mean separation (Duncan).

RESULTS

Among other differences, a significant soil by fertilizer source interaction was observed. Maize fertilized with CBP had significantly greater biomass at the two lowest rates for both acid and calcareous soils (Fig. 1). The high rate resulted in higher significant biomass for the acid soil only—where the APP seemingly had a negative fertilization effect, possibly due to a P induced micronutrient deficiency, but CBP showed no such effect. A similar trend was evident for non-calcareous alkaline soil.

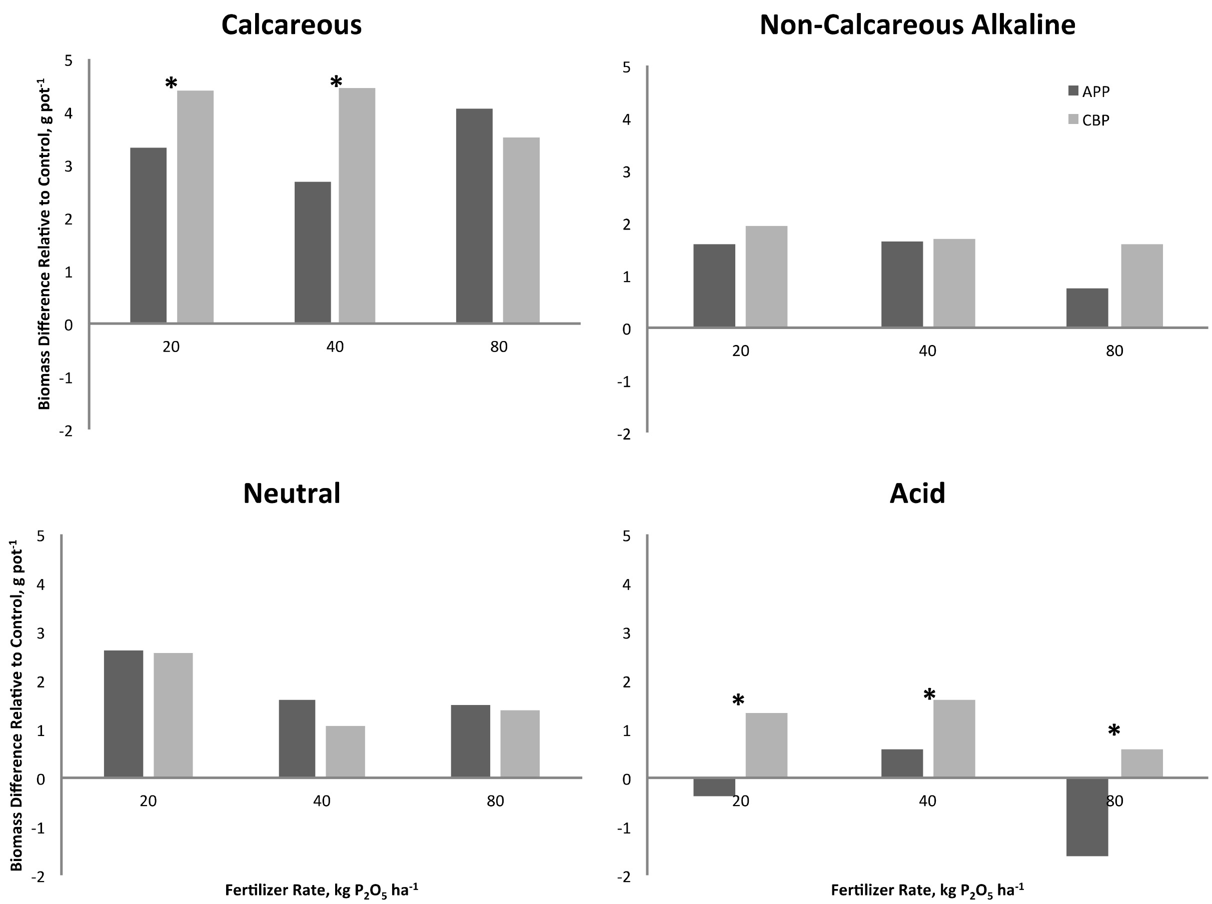

Figure 1. Maize biomass for a glasshouse fertilization study with ammonium polyphosphate (APP) and Carbond P (CBP) relative to an unfertilized control for a sandy loam soil adjusted to be acidic (pH 4.5), neutral (pH 6.8), alkaline (pH 8.0), or calcareous (pH 8.2 with 12% lime). "*" = CBP and APP were significantly different from one another in soil and rate shown

Maize fertilized with CBP had significantly greater stem width at the 2 highest rates for both the acid and calcareous soils (Fig. 2). The low rate also resulted in a significantly greater stem width, but for the alkaline and calcareous soils only.

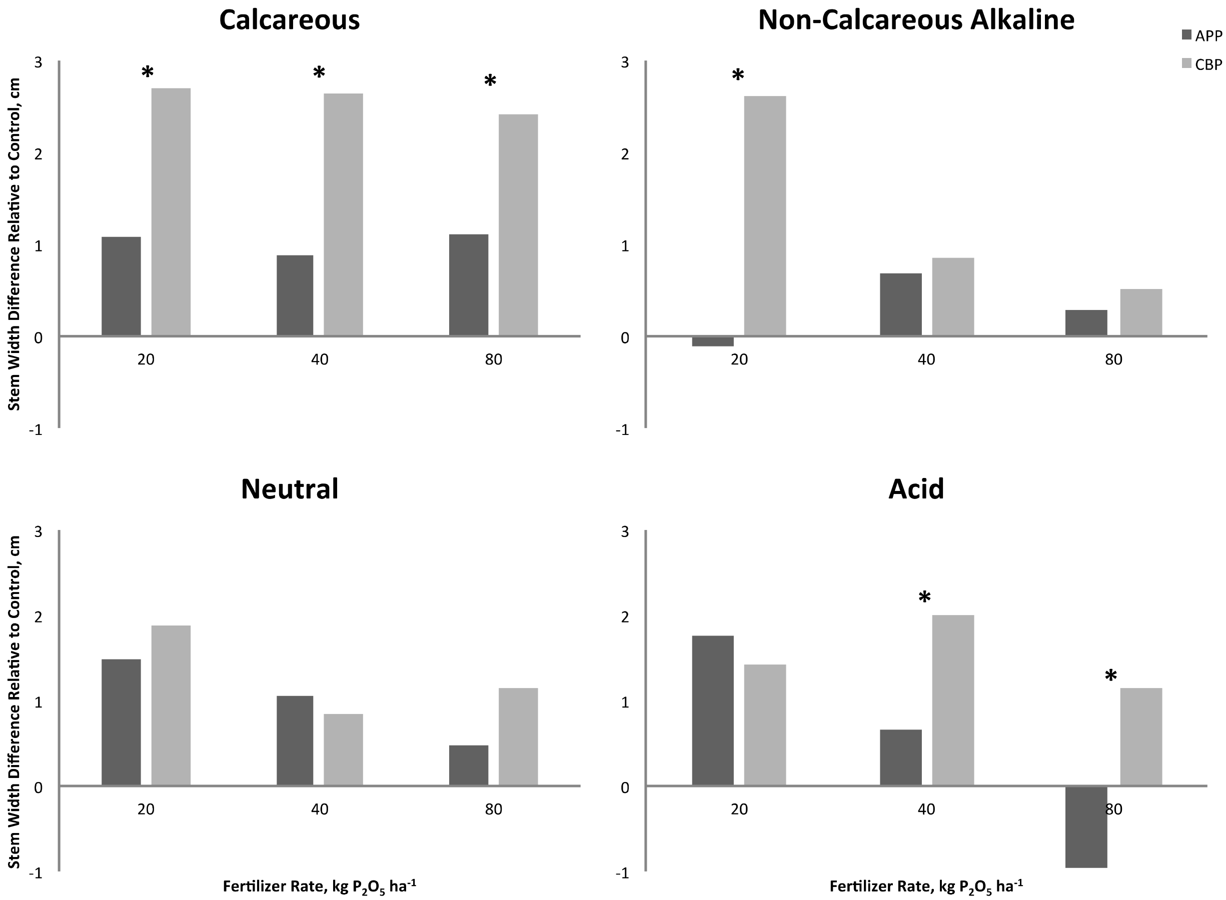

Figure 2. Maize stem width for a glasshouse fertilization study with ammonium polyphosphate (APP) and Carbond P (CBP) relative to an unfertilized control for a sandy loam soil adjusted to be acidic (pH 4.5), neutral (pH 6.8), alkaline (pH 8.0), or calcareous (pH 8.2 with 12% lime). "*" = CBP and APP were significantly different from one another in soil and rate shown

Additionally, maize fertilized with CBP resulted in significantly taller plants for acid, neutral, and calcareous soils at low rate. The highest 2 rates also resulted in significantly taller plants, but only for the acid soil (data not shown).

DISCUSSION

Increases in early season glasshouse grown maize biomass and stem width were observed at the lowest of rates of fertilizer applied across acid, alkaline, and calcareous soils. The effect was less evident at higher rates. Previous studies also showed P concentration, uptake, and efficiency increased at the lower rates.

The binding of the P with the organic acids in this product has been shown to be relatively more soluble and plant available. However, if P fertilizer rates are high there is an expected plateau where adding more P is not beneficial. Thus, utilizing technology which enhances P solubility is more likely to result in differences when compared to traditional P sources when applied at low P rates—which is mostly consistent with the findings in this and other studies performed with CBP.

In addition, most of the work performed to date with CBP has been done with crops growing in calcareous soils—where P solubility is known to be relatively poor compared to neutral soil. Similar results would likely be expected in acidic soils where P solubility is also low compared to neutral soils. The results of this study largely are in line with these known principles of P solubility and plant availability—with the neutral soil showing the least response and the acid and calcareous soils most responsive. The alkalinity by itself did not seem to have as large of an impact as did the presence of free excess lime in the calcareous soil when comparing CBP to APP. It is well documented that P solubility is greatly reduced in acid and calcareous soil. This, combined with the findings of this study and other similar studies, show that use of CBP is most likely to be beneficial at these pH/lime extremes and at lower rates of P fertilization. It is also worth noting that, as expected, the impact of added P was greatest for the calcareous soil when comparing fertilized to the unfertilized control.

REFERENCES

Hill, M.W. Improving Phosphorus Use Efficiency Through Organic Bonded Phosphorus. Thesis, Brigham Young University. December 12, 2012.

Ransom, C.J., Hill M.W., and Hopkins, B.G. Improving Phosphorus Use Efficiency with Carbond P and Dicarboxylic Acid Polymer (Avail) Fertilizer Additives. Pages 149-154 in Idaho Potato Conference. January 20, 2011.

Summerhays, J.S. Effectiveness of Phosphorus Fertilizers in Hydroponics and Glasshouse Settings with Moderate and High Organic Matter Soils. Thesis, Brigham Young University. August 9, 2012.

PROCEEDINGS

OF THE

WESTERN NUTRIENT

MANAGEMENT CONFERENCE

Volume 11

MARCH 5-6, 2015
RENO, NEVADA

Executive Committee
Galen Mooso, Simplot, 2014-15 Chairman
Joan Davenport, Washington State University, 2014-15 Vice Chairman
Jim Walworth, University of Arizona, 2014-2015 Secretary

Program Chair
David Tarkalson
USDA - ARS
3793 N 3600 E
Kimberly, ID 83341
(208) 423-6503
David.tarkalson@ars.usda.gov

Coordinator
Phyllis Pates
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
ppates@ipni.net