Phyto-Extraction of Phosphate Rocks in Organically Managed Soils

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Introduction

- Organically managed soils have been found to become deficient in plant-available phosphorus (P) over time[1]
- Phosphate rock (PR) may provide the external source of P needed if the rock can be dissolved in the soil to release plant-available P
- Dissolution of PR in Ontario soils is unlikely due to high pH and Ca content[2]
- Certain plant species can create ideal soil conditions for PR dissolution in the rhizosphere, thus providing the potential for PR use in alkaline soils (Figure 1)
- Buckwheat (*Fagopyrum esculentum*) has an enhanced ability to take up P from PR compared to other plants through root exudation of protons[3]
- PR with high carbonate substitution in the apatite mineral and small grain size will also enhance the effectiveness of PR in soils[4]

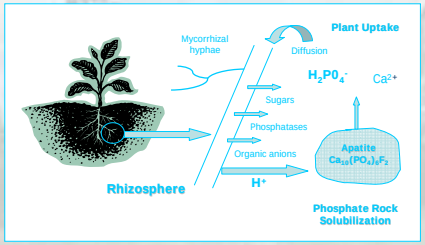

Figure 1 Simplified model of the dissolution of phosphate rock in the rhizosphere

Goal and Objectives

Goal

- To determine if buckwheat can utilize P from PR in alkaline soils

Objectives

- To evaluate P uptake of buckwheat as affected by phosphate rock
- To evaluate the relative effectiveness of different PR to supply P to buckwheat compared to MAP and TSP

Figure 2 Map of field sites located in Southwestern Ontario

Materials and Methods

Sites

- Located on a conventional dairy farm and on two certified organic dairy farms in Southwestern Ontario (Figure 2)
- Selection was based on low[5] initial $NaHCO_3$-extractable P soil test levels (Figure 3)
- The experiment was arranged as a two factorial (P source and application rate) randomized complete block design with four replicates

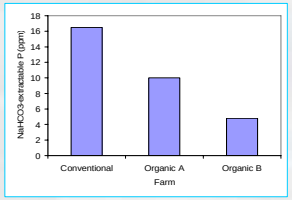

Figure 3 Initial $NaHCO_3$-extractable P in the top 15 cm soil on the field sites

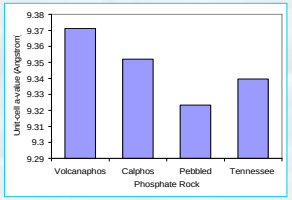

Figure 4 Degree of carbonate-substitution in the PR as determined by x-ray diffraction

Phosphorus Treatments and Buckwheat

- PR were analyzed for reactivity using XRD (Figure 4)
- Low unit-cell a-values indicate higher carbonate substitution and therefore higher reactivity of PR[4]
- Calphos, Volcanaphos and Spanish River Carbonatite PR were applied on the organic sites
- In addition to the above PR, Pebbled PR, Tennessee PR, and soluble fertilizers, MAP and TSP were applied on the conventional site
- P treatments were applied at three rates on 5m x 3m plots
- Buckwheat was seeded on all plots after PR application and harvested after 7 weeks of growth
- Total P of the above-ground plant material was analyzed
- Buckwheat residues were returned to half of each plot to assess their mineralization in the 2005 field season (Figure 5)

Preliminary Results

- Averaged over the three farm sites, P uptake (kg P ha^{-1}) of buckwheat due to Calphos was 40, 49, and 83 % greater than the control at application rates of 100, 400, and 800 kg P ha^{-1}, respectively (Figure 6)
- On the conventional farm, the differences in P uptake in buckwheat due to Calphos, MAP, and TSP were insignificant at the low P rate (Figure 7)

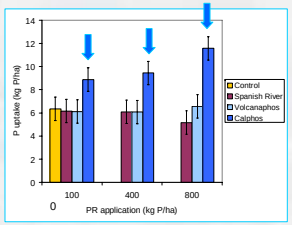

Figure 6 Effect of phosphate rock and rate on the P uptake of buckwheat averaged over three field sites. Bars indicate standard errors (1.01) and arrows indicate significant differences ($p<0.05$) compared to the control.

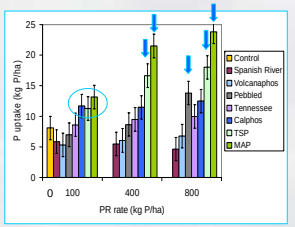

Figure 7 Effect of P treatment and rate on the P uptake of buckwheat on the conventional field site. Bars indicate standard errors (1.92) and arrows indicate significant differences ($p<0.05$) compared to the control. The circle indicates no significant difference among treatments.

Conclusion

- In seven weeks of growth, buckwheat was able to utilize P from the Calphos PR and Pebbled PR only
- Despite having the lowest unit-cell a-value, Pebbled PR performed better than Calphos only at the highest application rate, likely due to particle size
- Further work will examine the effects of the buckwheat residues on the P uptake of a subsequent ryegrass crop

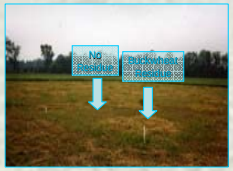

Figure 5 Buckwheat residue on half of each plot

References

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3. van Ray, B. and van Diest, A. 1979. *Plant and Soil* 51(4) 577-589.
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5. Soil test P (STP) < 10 ppm considered low, STP < 20 ppm considered medium for buckwheat according to OMAF (1997) Publication 296 Field Crop Recommendations, Toronto, ON.

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