Ability of a Green Manure Crop to Increase Availability of Organic Phosphorus Fertilizers

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Background

- Maintaining soil phosphorus (P) fertility represents a challenge for organic producers in the northern Great Plains (NGP) because of high pH, calcareous soils that limit P availability.
- P sources, such as rock phosphate (RP) and bone meal (BM) are sparingly soluble in calcareous soils and do not readily become plant available, especially when surface applied.
- Plant available P in organically managed soils generally declines over time, therefore it is essential to establish reliable strategies to maintain soil fertility and sustain crop yields.[1,2]

Introduction

- Green manure (GM) crops and organic fertilizers represent two approaches for improving soil P fertility in organically managed cropping systems in the NGP.
- Select GM crop species are capable of influencing P uptake by extracting P from calcium bound sources through plant mediated mechanisms like root exudation and acidification of the rhizosphere.[3,4]
- GM crops capable of mobilizing P may increase P incorporated into residue and release plant available P through mineralization.
- In a dual phase greenhouse experiment, GM crops were first fertilized with organic fertilizers and then a spring wheat crop was seeded into the GM residues.

Goals

- Develop long-term sustainable P management strategies for organic production in the NGP
- Evaluate the potential of GM crops to enhance P bioavailability of RP and BM

Specific Objectives

- Compare P uptake of GM crops fertilized with RP and BM to a conventional fertilizer, monocalcium phosphate (MCP)
- Evaluate effect of fertilized GM crop residues on P uptake of a subsequent grain crop

Methods – Green Manure Phase

- Experiment arranged in a randomized complete block design with 4 replicates (Fig. 1).
- Pots (15 cm diameter x 12.5 cm) were filled with 2,200 g low soil test phosphorus (Olsen P = 4 µg g^{-1}) calcareous loam soil (Fig. 2).
- Buckwheat (*Fagopyrum esculentum* cv. Mancan), spring pea (*Pisum sativum* L.), spring wheat (a crop control; *Triticum aestivum* cv. Hank) and a non-crop control (fallow) were seeded and banded (Fig. 2) with RP (0-3-0), BM (5-10-0) and MCP at rates equivalent to 0, 10 and 25 kg ha^{-1} available P.
- Pots were fertilized with 100 mg N kg^{-1} soil as NH_4NO_3 and maintained near field capacity.
- Crops were harvested at anthesis.

Figure 1. Green manure crops in greenhouse.

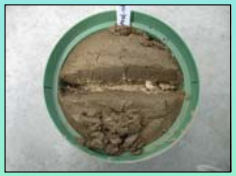

Figure 2. P fertilizers banded at 5 cm depth. Crops seeded parallel to band.

Methods – Wheat Phase

- Crop residues dried, returned to pots and incorporated into the soil (Fig. 3)
- Spring wheat (cv. Choteau) seeded to all pots 3 weeks after residue incorporation (Fig. 4)
- Wheat harvested at anthesis and analyzed tissue for total P.

Figure 3. GM crop residues returned to pots and incorporated into soil.

Figure 4. Spring wheat seeded to all pots.

References

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Results and Discussion

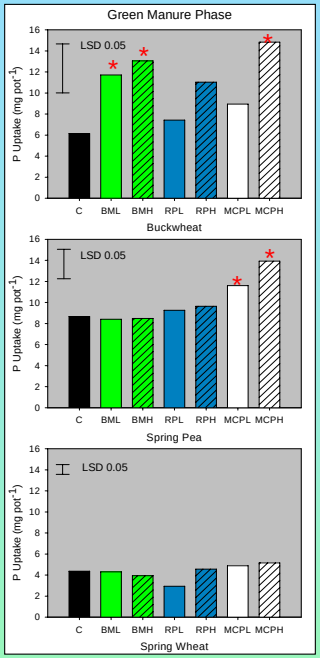

Figure 5 . Mean P uptake for crops in GM Phase. C=Control (0P), L and H=10 and 25 kg P ha^{-1} , respectively; BM=bone meal; RP=rock phosphate and MCP=monocalcium phosphate. Statistical analysis for GM crop completed individually by crop. Starred bars indicate statistical significance from the 0P control for that crop ($p<0.05$).

Green Manure Phase

- Buckwheat significantly enhanced P uptake of BM over the 0P control ($p=0.05$) and utilized BM as well as the more soluble MCP (Fig. 5).
- Spring pea was less effective at mobilizing RP or BM when compared to MCP where P uptake was significantly increased at the high level ($p=0.05$) compared to the 0P control (Fig. 5).

Wheat Phase

- P uptake of the subsequent wheat crop was overall highest in the fallow treatment compared to all other GM treatments (Fig. 6). P uptake based on previous crop treatment followed the order, fallow>wheat=buckwheat>spring pea.
- P uptake in the wheat crop following buckwheat was significantly higher ($p<0.001$) than following spring pea (Fig. 6).
- Regression analysis (Fig.7) indicates P uptake of wheat crop is not positively correlated with P uptake of the GM crop; however this may reflect the increased level of P sequestered in the buckwheat and spring pea crop residue combined with a short residence time for residue mineralization (3 weeks at seeding; x weeks at termination).

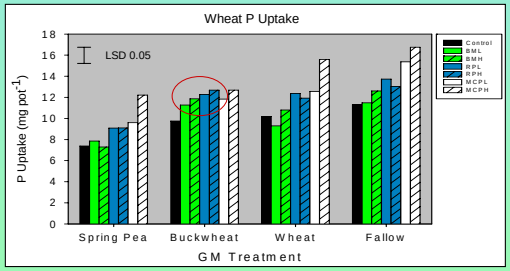

Figure 6. Effect of GM treatment on wheat crop P uptake. Statistical analysis concurrent with all treatments. Circle indicates statistical significance of buckwheat-RP and BM treatment compared to spring pea-RP and BM ($p<0.001$).

Conclusions

- These results demonstrate that buckwheat can measurably enhance P availability of a less soluble organic fertilizer over that of spring pea.
- However, the decreased ability of spring pea to effectively mobilize RP or BM may reflect the use of nitrate as the N source in this study, thereby negatively impacting biological N fixation and rhizosphere pH of the pea[5].
- As legumes are an integral component of organic soil fertility in the NGP, it is essential to determine if common legume GM crops, without external N input, can increase the availability of organic P fertilizers.
- A two year companion field study in an organically managed NGP cropping system is in progress.

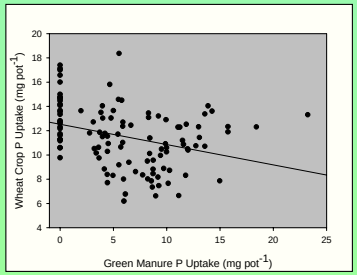

Figure 7. Regression analysis of P uptake in wheat crop as a function of GM P uptake ($R^2 = 0.10$, $p<0.001$).