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organic SCIENCE CLUSTER 3

The effects on soil biology, soil chemistry, and water quality of amending organically managed soils with struvite

2023 Submitted by Dr. Kim Schneider and Dr. Henry Wilson

Organic grain and forage producers need to alleviate nutrient deficiency in a variety of soil types with low availability of soil phosphorus (P), while avoiding non-renewable P sources. The European Commission Directorate General for Agriculture and Rural Development Expert Group for Technical Advice on Organic Production (EGTOP) has announced that struvite produced utilizing the Pearl process is in compliance with Organic Principles. The Pearl process results in a product which has consistent P content and can be crystallized from human and livestock wastewater streams with allowed organic processing aids. This form of struvite is noted as deserving of fair evaluation as an allowed synthetic in organic systems. It is extremely low in heavy metals and salts and as a recycled source of P, struvite has potential to substitute for non-renewable sources, while reducing the amount of P transported downstream to surface waters at risk of eutrophication.

Recycling P from wastewater for use as fertilizers can contribute to the circular economy for P. Struvite recovered from municipal wastewater is a sparingly soluble fertilizer that has been recommended as a suitable P source for organic production, where soil P deficiencies can be particularly severe. Optimizing the use of struvite fertilizer in such systems requires greater understanding of its effects on crop performance, soil P dynamics, and soil organisms such as arbuscular mycorrhizal fungi (AMF).

Objectives

The objectives of our research were to evaluate the agronomic and environmental implications of struvite application in different soils, at different rates, and spatial scales of research (pots, plots, field trials).

Methods

Plot-scale field trials were conducted at an organically managed site near Libau, MB. A three-year trial was conducted testing different rates of struvite application on the yield and P uptake of wheat, flax and alfalfa-based forage. A complementary pot trial using two soils contrasting in pH and texture, but both having low soil test P was also conducted using alfalfa as a test crop. In both the field and the pot trial, the impact of struvite application on arbuscular mycorrhizal fungi (beneficial fungi that colonize the plant roots and are known for assisting with P uptake) were assessed. In tandem with the pot trial, an incubation study was also conducted, investigating the fate and availability of added struvite and monoammonium phosphate to soils in the absence of growing plants. Finally, field scale small watershed studies were conducted to compare the impact of fertilizing a field with struvite on runoff water quality the following spring.

Joanne Thiessen Martens harvesting wheat from the field trial in 2018

Results and Conclusions

Field studies on an alkaline clay soil demonstrated increases in yield and P uptake for organic spring wheat and alfalfa–grass forage, whereas flax showed no response. Forage response to struvite increased in the second and third years after struvite application, demonstrating the potential of struvite as a multi-year P source.

The soil incubation study using the same alkaline clay and a contrasting neutral-pH soil showed that struvite solubility was delayed relative to monoammonium phosphate, and that P concentrations in water-extractable and Olsen P pools were affected by soil type and P application rate. After incubating struvite-amended soils for only a few days, the study revealed unexpectedly high labile soil P water extractable P concentrations. This contradicts what is known about struvite, but may be explained by sample grinding increasing P solubility in struvite or by the very high P rates tested in this study.

The pot experiment on alfalfa in the same soils showed no differences between struvite and monoammonium phosphate on alfalfa performance, further supporting its use as a P fertility amendment for alfalfa-based forage. At the highest application rate, struvite showed a small inhibitory effect on root colonization with mycorrhizal arbuscular fungi, but to a lesser extent than with conventional P fertilizer, indicating the potential of struvite to have less of an impact on this group of fungi.

Overall, this research shows that struvite is an effective P source for some crops, even in calcareous high pH soils, but that struvite dissolution and transformation processes vary with application rate and soil type.

Incubation pots in the walk-in incubator

Soil sample from incubation at first sampling date with struvite granules

Future Research Needed

A closely related knowledge gap pertains to the extractability of struvite P in standard agronomic and environmental soil tests and implications for the relevance of these tests for struvite-amended soils. Sample preparation including sample grinding could also significantly affect the solubility of struvite in water and should be further explored. The impact of struvite grain size also needs further investigation.

Optimizing use of struvite fertilizer in cropping systems will require additional knowledge of fertilizer management practices such as application rates, placement, and timing of application under field conditions, which have received very little attention to date. Understanding the roles of environmental conditions such as temperature and moisture in interaction with crop- and soil-related processes in struvite dissolution, transformation, and P uptake processes is also necessary.

The evidence for multi-year crop P supply in the present field study highlights the need to investigate the effects of struvite management practices over periods longer than a single growing season and with a range of crop types and sequences.

Alfalfa just before cut 3 (with Joanne Thiessen Martens)

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