Mosaic
AgriSight®
TRUSTED CROP NUTRITION EXPERTISE℠
ISSUE 26: 2025

Utilizing Cover Crops to Enhance Soil Phosphorus Availability

- Many different species of cover crops can help make P more available to cash crops.
- Cover crops can't replace P fertilizer applications!
- Cover crops can help improve PUE and support 4R nutrient stewardship.

Cover crops have become a strategic tool for farmers because of their ability to prevent erosion, improve soil health, sequester carbon, and improve soil structure. For these reasons, cover crop acreage has steadily increased by approximately 800,000 acres annually in North America over the past decade[1]. While many think of nitrogen when cover crops are discussed for their contribution to nutrient cycling, cover crops can also be a strategic tool for managing phosphorus (P) availability. Some species of cover crops improve the availability of P by making it plant available or by relocating it in the soil profile closer to the crop root zone. Regardless of method, the outcome is the same, greater immediate and longer-term phosphorus cycling has benefits in agricultural systems.

The Role of Cover Crops in Phosphorus Cycling

Phosphorus is an essential, yet often limiting, nutrient for crop growth due to its limited availability in some soils. Phosphorus is taken up by crops as phosphate from the soil, but soil phosphate readily binds with iron (Fe), calcium (Ca), and aluminum (Al) forming insoluble mineral compounds in the soil. The P in these compounds is not accessible to crops, however several species of cover crops have the natural ability to unbind phosphate from these mineral compounds.

Utilizing cover crops as part of a phosphorus management program aligns with 4R nutrient stewardship, which emphasizes applying nutrients at the Right source, Right rate, Right time, and Right place while incorporating conservation practices as a complimentary practice to fertilization. Cover crops can help increase phosphorus use efficiency (PUE) by scavenging and accessing residual phosphorus, making it more available for subsequent cash crops while minimizing phosphorus losses to the environment[2]. By integrating cover crops into on-farm nutrient management strategies, farmers optimize their phosphorus investment, improve soil health, and support sustainable agricultural systems (Fig. 1).

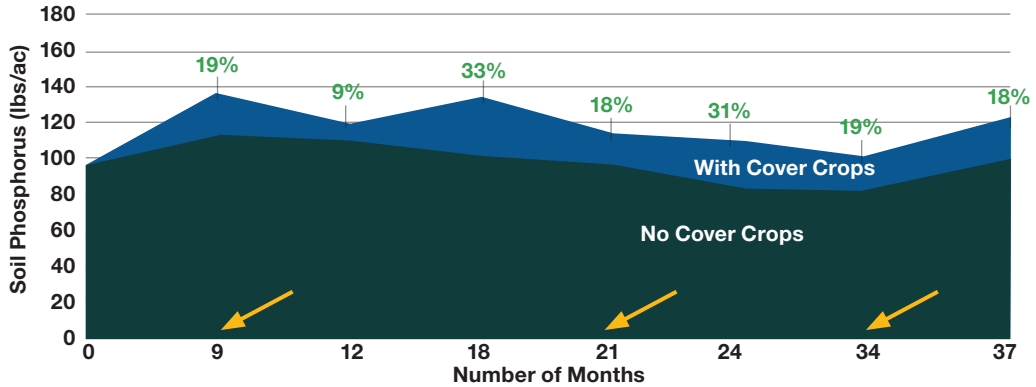

Figure 1: The benefits of cover crops on soil P values were consistently higher at the end of the cover crop growing period (yellow arrows) and 3 months into the cash crop growing cycle. This indicates that cover crops make P more available in the soil even before the nutrients in the cover crop biomass are released back into the soil[3].

Mechanisms of Phosphorus Mobilization by Cover Crops

Cover crops achieve phosphorus mobilization primarily through three key root interactions with the soil. These include:

1. **Root Exudation of Organic Acids:** Certain cover crops, like those in the *Brassicaceae* family, release organic acids from their roots that help dissolve P bound to soil particles, converting it into forms that plants can utilize. These organic acids can also chelate cations that tie up phosphate, which increases phosphate availability within the soil.
2. **Accessing Deep Soil Phosphorus:** Many cover crops develop deep root systems capable of drawing phosphorus from lower soil layers. When the cover crop decomposes, phosphate pulled from lower soil horizons is released into the upper soil layers, making it accessible for shallower-rooted crops in the next rotation[4].
3. **Soil Microbiome Stimulation:** Many species of cover crops can form symbiotic relationships with mycorrhizal fungi, which extend the root system's ability to access phosphorus. Cover crop roots can also stimulate microbial activity, which enhances the mineralization of organic P into inorganic forms taken up by plants.

Selecting Cover Crop Species for Increasing Phosphorus Availability

Integrating cover crops to enhance phosphorus availability requires strategic selection based on soil P levels, soil and mineral characteristics, the type of cash crops being grown in rotation, and management goals. Several cover crop species have shown distinct capabilities in mobilizing phosphorus. Their efficiency varies based on root structure, decomposition rate, and interaction with different P sources found throughout the soil.

Brassicas: Actively growing brassicas release organic compounds via root exudates that alter soil chemistry and make phosphorus more available in the rhizosphere. Tillage radishes for example, have shown to lower inorganic P soil test values, and since they decompose rapidly and release their nutrients back to the soil quickly, this has a benefit for the following crop. Studies also show that tillage radishes can effectively access and redistribute some labile and moderately labile P, making it an ideal cover crop for systems where soil P is present but not crop available[5].

Buckwheat: Buckwheat is renowned for its ability to solubilize soil bound phosphorus. Its dense and fibrous root system exudes citric and oxalic acids, which solubilize phosphorus compounds, converting them into forms that are more accessible to other plants. With a C:N ratio that is almost ideal for soil microbes, buckwheat residue breaks down quickly and effectively cycles the nutrients that it has taken up back to the next crop in rotation.

Legumes: While primarily thought of for their nitrogen fixation, legumes can also be an effective tool for improving phosphorus availability. The deep root system of common vetch can access deep soil phosphorus and release it to the soil surface when the vetch cover crop dies and decomposes[2]. Common vetch can also release both mineral bound, and organic pools of P in upper soil layers that are ordinarily unavailable to crops. Other legumes such as red clover, cowpea, and hairy vetch secrete organic acids via their roots to mobilize mineral bound phosphorus. Those same root exudates promote beneficial mycorrhizal associations that enhance phosphorus uptake.

Oats and Rye: Oats and rye have fibrous root systems that can explore a significant volume of soil, as well as access phosphorus in lower soil layers[4]. Oats are also known to be one of the best cereal grains at supporting mycorrhizal fungi that aid in phosphorus uptake[2]. Oat residue has a high C:N ratio, providing P release over a longer duration, often into the next growing season.

Cover Crops Role in Phosphorus Sustainability

Cover crops are not a replacement for regular inputs of phosphate but can be a complimentary way to supplement P applications. Growers can select from many different cover crops that offer unique P-mobilizing benefits suited to different agricultural systems. Cover crops can improve soil health and contribute to integrated nutrient management practices that align well with 4R nutrient stewardship. As the agricultural industry seeks to balance productivity and environmental stewardship, cover crops hold significant promise for bolstering sustainability, and PUE within farming systems.

References:

1. Wallander, S., Smith, D., Bowman, M., and Claassen, R. 2021. Cover Crop Trends, Programs, and Practices in the United States. EIB 222, U.S. Department of Agriculture, Economic Research Service.
2. Nelson, N.O., et al. 2023. Agronomic and economic implications of cover crop and phosphorus fertilizer management practices for water quality improvement. *Journal of Environ. Qual.* 52:1:113-125.
3. Tubaña, B., Forestieri, D., Fultz, L.M., and Mite, J. 2020. Cover Cropping Enriches Soil: Many factors cause nutrient contributions to vary. LSU College of Agriculture, AgCenter.
4. Janegitz, M. C., Helene Martins A.R., and Rosolem C.A. 2017. Cover crops and soil phosphorus availability. *Communications in Soil Science and Plant Analysis.* 48.10.
5. Soltangheisi, A., et al. 2020. Cover cropping may alter legacy phosphorus dynamics under long-term fertilizer addition. *Front. Environ. Sci.* 8:13.

The Mosaic Company ▪ 101 East Kennedy Blvd. ▪ Suite 2500 ▪ Tampa, FL 33602 ▪ www.CropNutrition.com