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Radish plus rye treatment in fall.

Radish plus rye treatment in spring, showing dead radish tubers.

COVER CROPS

Can Radish Cover Crops be Used to Manage Soil Phosphorus?

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Introduction

By now, most farmers have heard of cover crops and the benefits they can provide. Farmers who choose the practice of cover crops are now basing their decisions on a whole "menu" of benefits, or ecosystem services. Beyond protecting soil from erosion, farmers also plant cover crops to compete with weeds, disrupt pest cycles, increase carbon capture, retain soil moisture, provide livestock forage, stimulate soil biology and to cycle and retain soil nutrients — or any combination of those. Of the functions listed, nutrient cycling and retention are of particular interest in areas where water quality is a resource concern.

Oilseed radish is a cover crop popular for its "biological tillage," but perhaps an equally important function that radish provides is the ability to "scavenge" soil nutrients such as nitrogen (N) and phosphorus (P), retain them in the field, and release them for a subsequent crop. Field trials have found evidence that radish develop symbiotic relationships with soil biology near their tubers and increase the availability of soil P for the following crop. While it makes sense that these functions could make radish a valuable tool for managing soil P, it is not straightforward because the process timing is unpredictable. This is partly because radish is an annual plant with a very low carbon to nitrogen ratio (C:N), meaning it winterkills under freezing temperatures and decomposes rapidly in spring. Because of this rapid and unpredictable process, it is unclear whether soil P that is scavenged and mobilized by radish will benefit the following crop directly.

Cereal grains such as oats or (winter) cereal rye are also popular cover crops because of their soil health and nutrient retention benefits. With higher C:N they take much longer to decompose than radish and retain nutrients for longer in the spring. The goal of this project was to test whether mixing radish with cereal grain helps to retain soil nutrients long enough to benefit a subsequent crop compared to radish planted alone, and whether it makes a difference if the cereal grain is a winter-killing or winter hardy species.

What We Did

For this project, we focused primarily on soil phosphorus. Plots were established at three sites with silt loam soils near

Lafayette, Indiana. The cover crop treatments were radish (alone), radish + oats, and radish + cereal rye, and there was a no-cover crop control treatment. All treatments were randomized and replicated three times. Cover crops were planted with a no-till drill in late August. Plant available P was measured using Mehlich-3 P — the method commonly used by commercial laboratories for reporting P on routine soil tests. Soil samples were collected from each treatment in both fall (November) and spring (April) and divided into six sub-samples — row position (Figure 1): root zone (near the radish tuber), and buffer zone (away from the tuber), and soil depth: 0-1 inch, 1-4 inch, and 4-8 inch. Cover crop biomass samples were collected in November to measure above- and below-ground biomass production and P accumulation for all treatments, and again in April for the cereal rye (winter surviving) treatment only.

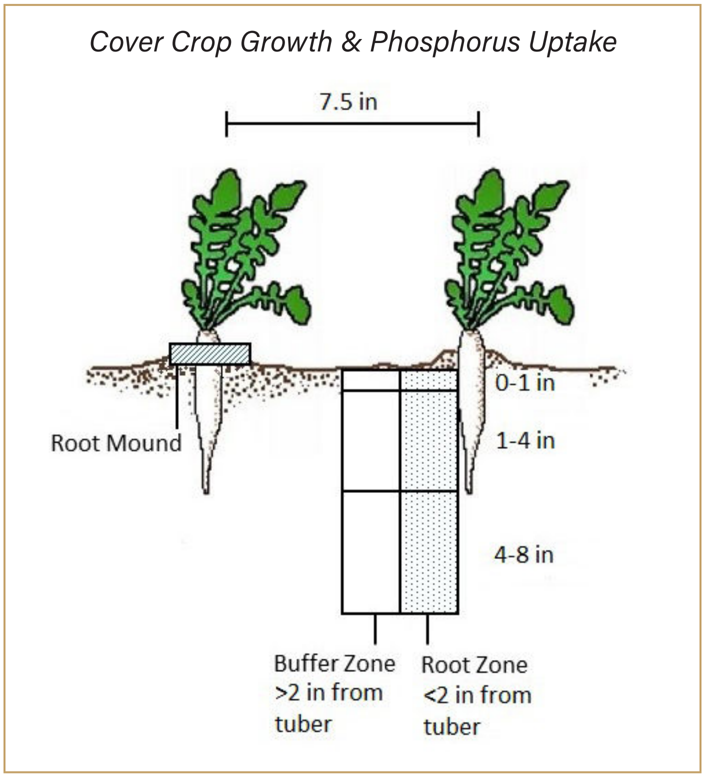

Figure 1. Soil sampling diagram showing row position and depth increments.

For this study, cover crops were planted at a time consistent with cover crops following a small grain harvest. Planted the last week of August, there was substantial fall growth of cover crops. Total biomass growth ranged from 1,606 to 4,640 lbs dry matter (DM) per acre, depending on the site. Amount of above-ground growth averaged 2,260 lbs DM/acre for radish, 3,033 lbs DM/acre for radish + oats, and 2,525 lbs DM/acre for radish + rye (Figure 2). The average height of each species was 13 inches for radish, 21 inches for oats and 14 inches for rye.

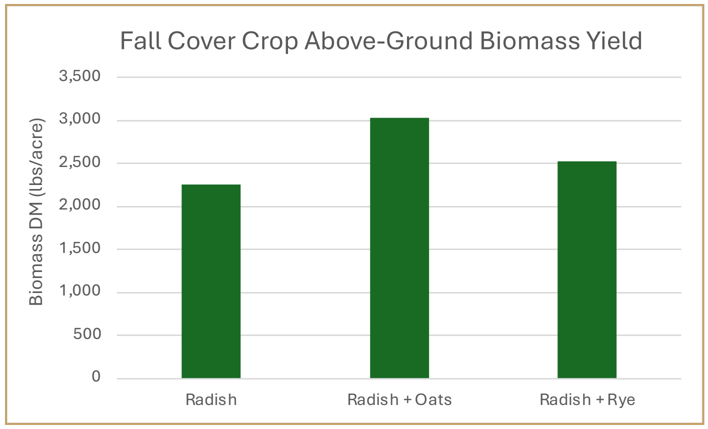

***Figure 2.** Above-ground biomass yield for cover crops measured in Nov.*

These above-ground biomass quantities reflect what a farmer would observe on the field in fall. But there is even more biomass production when factoring below-ground growth (Figure 3), which is of equal importance for many cover crop functions, including nutrient uptake.

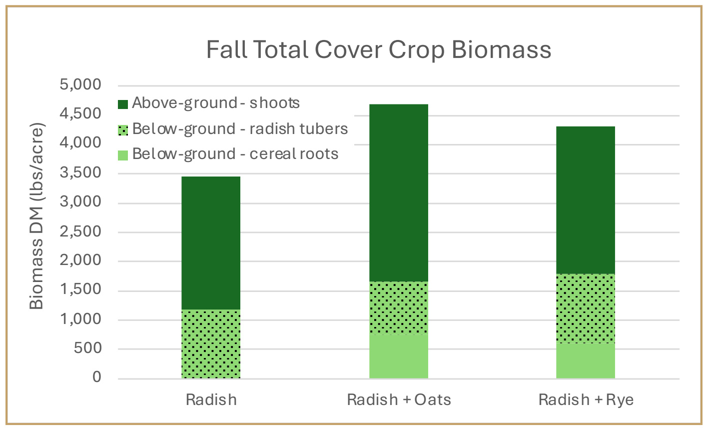

***Figure 3.** Above- and below-ground biomass yield for cover crops measured in Nov.*

On average, 60% of the total biomass produced across all treatments was above ground, and 40% was below ground. The total above- and below-ground cover crop biomass contained from 12.4 to 14.2 lbs P/acre in fall. Two of the treatments completely winter-killed after fall sampling, and only the rye in the radish + rye treatment remained alive through winter and resumed growing in spring. While oats provides quicker cover in the fall than rye, rye makes up for dead and decomposed cover in the spring.

Soil Phosphorus Levels from Cover Crops

When soil samples were averaged across row position, depth and time, plant available P was left unchanged by cover crops. This indicates that a standard soil fertility test composited across an entire treatment or field would detect no change in plant available P from cover crops, thus a modification of P fertilization recommendations would not be warranted. However, when soil samples were divided for analysis, the following effects were observed for each sub-sample:

- By row position — there was more plant available P in the root zone, near the radish tuber, than in the buffer zone, especially in the fall.
- By depth — there was more plant available P at 0-1", near the soil surface, than at 1-4" or 4-8" depths.
- By row position, depth, and time — in spring, the 0-1" depth still had greater P in the root zone compared to the buffer zone, while lower depths no longer had differences between the two zones.
- By treatment and time — in spring, the radish alone had greater plant-available P than the control. The radish-oats and radish-rye plots were intermediate but not statistically different than either radish alone or the control.

What do these results suggest?

The overwhelming majority of researchers who have studied soil P in field settings over the years have agreed that soil P is dynamic, difficult to measure and prone to stratification near the soil surface. And while some modest effects of cover crops on plant-available P were observed in this study, radish grown with or without cereal grains largely did not disrupt the typical characteristics of soil P, at least with one year of cover crop growth. The lone exception is that springtime plant-available P is higher near the radish row at the soil surface than away from the row.

In effect, what we observed is that cover crops did not necessarily create more available P, but rather moved it around, accumulating it in certain spots. These P "hot-spots" may provide a nutrient management opportunity, where farmers can utilize precision planting technology to plant cash crops directly into previous radish rows, making use of accumulated plant available P. There is also a responsibility to manage these hotspots to avoid the risk of nutrient losses via erosion from biologically tilled soil.

What does this mean for my farm?

The entire menu of ecosystem services provided by cover crops should be considered when making management decisions. It is advisable to base decisions on benefits that are more predictable, such as biological tillage of radish or the promotion of soil aggregation by cereal grains. Cycling of soil nutrients such as P should possibly be lower on the list due to its unpredictability. At best, cycling of nutrients should be treated as an ancillary benefit of cover crops. If the primary goal is to manage soil P in areas where P is a major resource concern, then cover crops should not be the sole solution, but rather a part of the solution. The best strategy for nutrient retention will likely involve multiple conservation practices, where cover crops are enhanced by other complementary practices.

Full Paper:

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