The Benefits of Using Cover Crops

FUTURE GENERATION AG
Building Soil Health With Cover Crops

Future Generation Ag, LLC (FGA) is a cover crop seed and services provider that was formed out of a passion to help you, the farmer, pass on an inheritance of healthier soils to the next generation. Farmers all over the world are recognizing the key role that cover crops need to play in bringing soils back to life, and our team is here to help you provide and utilize cover crop solutions.

The Future Generation Ag team, with over 12 years of combined experience in the cover crop seed industry, is focused on helping you benefit from our extensive knowledge and industry experience and to provide farmers across the United States with more than just seed.

The team has had the unique experience of working with growers in every state, within a large range of climates and soil-types, and in a large variety of crop rotations. We understand the many variables that go into selecting the right cover crop for your operation, and make it our goal to help equip you with the knowledge, tools, and cover crop seed that will boost yields and increase the health of your soil.

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Benefits

General Cover Crop Benefits

Most cash crops and many of the feed crops farmers produce today have a limited life span. While the more common cash crops can provide good soil cover during their life spans, soils are typically left exposed to the elements between harvesting one year and planting the next. With no crop growing in the soil, water from rain and snow melt can etch away soil on the surface, and leach away nutrients that remain from previous crops.

Seeding a cover crop between cash crops adds surface biomass that helps protect soil from erosion. Roots from the cover crop take up free nutrients from the soil and sequester them in the new biomass produced by the cover crop, where they remain until the cover crop is terminated and soil bacteria begin breaking down biomass the following spring.

Benefits that mean something to everyone

Besides helping reduce losses of soil and nutrients, cover crops add organic matter and encourage the growth of beneficial mycorrhizae in the soil. Through plant material remaining on the surface and root channels opened deep into the soil, cover crops can even slow run-off and increase the water-holding capacity of the soil.

Cover crops need to be part of an overall program, rather than just an afterthought and another production cost. When growers manage their cover crops as carefully as they do their cash crops, they'll see improved overall performance and profits from their total crop production program.

Overview

What Cover Crops Can Do for Growers and Communities

Erosion control is the cover crop benefit most frequently cited by growers, but increasing crop production profits is the most frequently desired. Growers may notice some benefits from cover crops in the first year of use, while other benefits may accrue over several years. In either case, an investment in time and resources is required to experience these benefits.

The table below lists 16 different possible benefits of cover crops and groups them into five general categories. Some of these groupings are subjective, but the list provides a good starting point for a discussion.

	ENVIRONMENTAL		LONG TERM PROFIT	SHORT TERM PROFIT	
COVER CROP BENEFITS	Protect Soil	Protect Water Quality	Improving Soil	Improved Production Efficiency	Increased Yield
Erosion wind/water	✔	✔	✔		✔
Nutrient capture/release		✔		✔	✔
Reducing nitrate loss		✔		✔	✔
Fixing N				✔	✔
Breaking compaction			✔	✔	✔
Increasing rooting depth			✔	✔	✔
Suppressing nematodes				✔	✔
Forage production		✔		✔	✔
Increasing soil organic matter			✔	✔	✔
Breaking disease cycles				✔	✔
Weed suppression	✔			✔	✔
Changing soil microbiology		✔	✔	✔	✔
Drought protection			✔	✔	✔
Water infiltration			✔	✔	✔
Nutrient relocation		✔	✔	✔	✔
Habitat for beneficial insects				✔	✔

Erosion Protection

There are two main types of soil erosion:

- **Wind erosion**
- **Water erosion**

Any living cover crop with a significant canopy or substantial residue from a terminated cover crop can provide a barrier to wind erosion. The amount of erosion protection increases with the volume of biomass produced above ground and within the top layers of the soil surface.

Many cover crops are well suited for reducing soil erosion from both wind and water. To help control water erosion, we recommend a mixture of radish with either Annual Ryegrass or small grains like Winter Forage Triticale or Oats, keeping in mind that cover crops that winterkill will provide less erosion control in the spring than those that survive the winter.

WIND EROSION

WATER EROSION

Photo courtesy Tualatin Soil and Water Conservation District, Hillsboro, OR

Understanding Soil Erosion

It may be easy to see soil erosion in bad years, but smaller amounts of soil loss often go unnoticed.

Saving good soil is easier than building it
Improving soil properties typically takes years. On the other hand, simply protecting the good soils they already have from erosion can often lead to faster benefits from cover crop use than trying to build new soil.

Figure 1 shows an estimate of soil loss for Iowa in 2007. Considering there are about 23 million acres of row crop in the state, the 10 million acres with losses above 5 tons/acre illustrate a major problem in that wet year.

It is difficult to predict losses in years that are more extreme, but having the cover crop protection in place will result in a benefit.

Table 1 (below) shows the impacts of cover crops in reducing erosion on fields that are not considered high risk because of the low slope and no-till management. There are benefits from saving soil with a cover crop that are often overlooked because certain areas or fields are not classified as high risk for erosion.

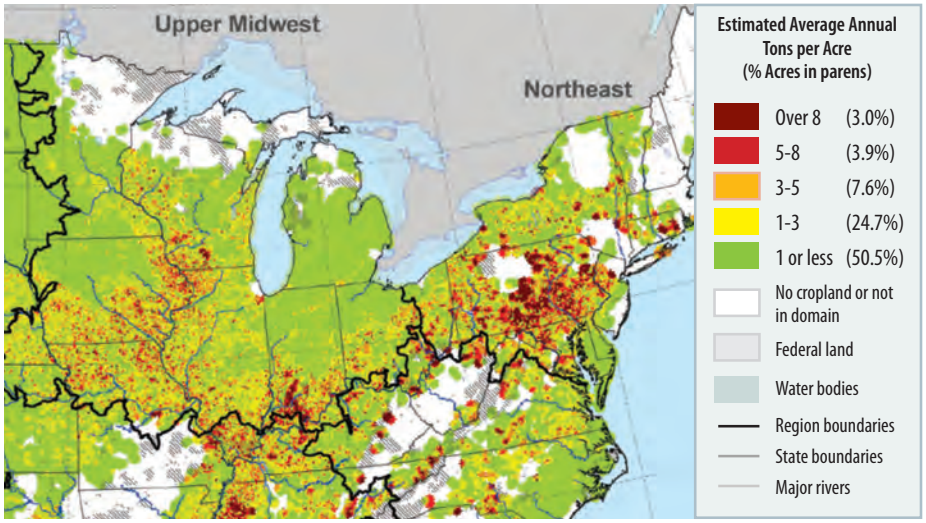
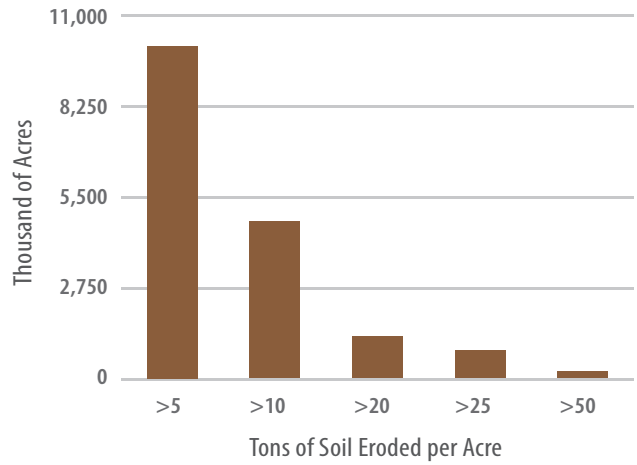


Figure 1. Millions of acres in Iowa eroded at more than 5 tons per acre – the so-called "sustainable" rate – in 2007



Saving the soil can give bigger and faster benefits than building the soil.

Table 1. Estimates of cover crop erosion benefits on moderate slopes on no-till systems

CORN-SOYBEAN ROTATION *NT, spring anhydrous, 5% slope, 150 ft slope length, Ames, IA*			
Without Rye Cover Crop = **2.1 t/A/yr**	With Rye Cover Crop = **1.2 t/A/yr**	> 40%	Erosion Reduction
CONTINUOUS CORN SILAGE *NT, spring anhydrous, 5% slope, 150 ft slope length, Ames, IA*			
Without Rye Cover Crop = **4.8 t/A/yr**	With Rye Cover Crop = **1.9 t/A/yr**	> 60%	Erosion Reduction

Nutrient Capture & Release

All growing plants take nutrients from the soil and sequester them in organic matter on or near the soil surface. Any crop residue remaining on the field after harvest or grazing is eventually processed by soil microorganisms and nutrients are released (or mineralized) in the soil.

Besides providing a protective cover for the soil, extending the growing season with cover crops allows the capture and release of more nutrients as the soil warms and microbes are again actively breaking down residue the next spring and or summer.

Non-legume cover crops and nutrients

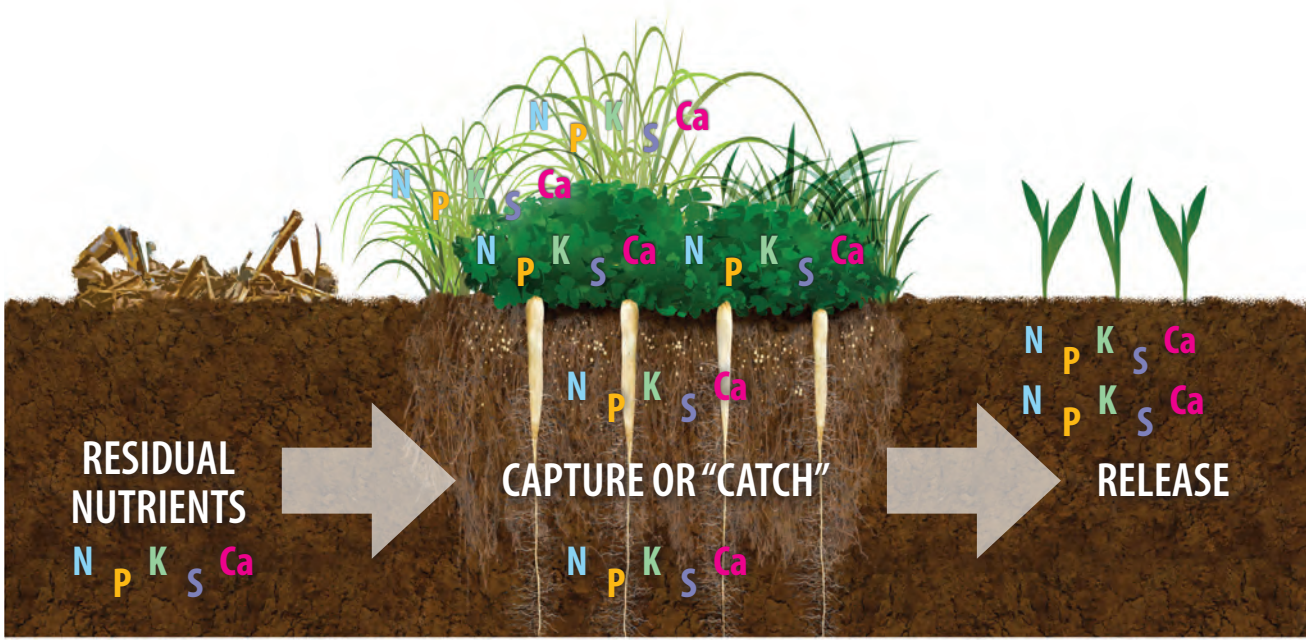
Because all growing plants take up nitrogen (N), the cover crop doesn't have to be a legume to provide an N credit for a future crop. Examples of non-legume cover crops include radish, Annual Ryegrass and Winter Forage Triticale.

Sealing the leaks, recycling nutrients

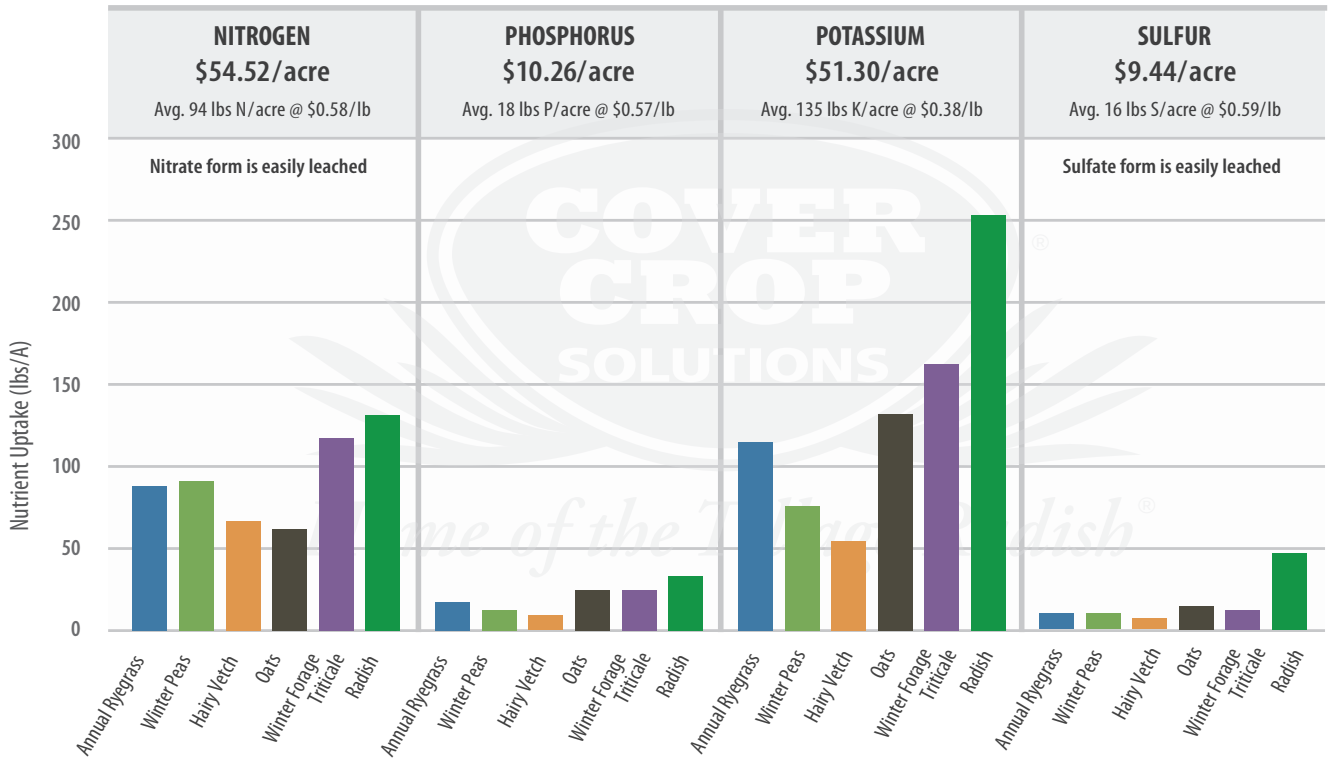
Nutrients like nitrogen in the nitrate form and sulfur in the sulfate form can be easily lost by leaching. However, a cover crop can take up and hold those nutrients and release them in the spring.

The deeper the root system of the cover crop, the more leachable nutrients like nitrate and sulfate can be recycled. Nutrients not lost to leaching are nutrients you don't need to purchase next season.

Nutrients like P and K are not generally lost from the soil, except by soil erosion (which cover crops can mitigate), but only a small amount of these nutrients are in an available form.



Fall Nutrient Uptake



Data from replicated plots planted after wheat in Holtwood, PA (Trial 2014-1-35).

The graph above shows nutrient uptake and projected fertilizer value (a potential nutrient credit) from various cover crops grown in research in 2014.

Nutrient credits from cover crops

While the concept of a nutrient credit for cover crops is not yet widely accepted in the academic world, nutrients taken up by cover crops are often scavenged from deep in the soil. Nitrate and sulfate are highly water soluble and often lost to leaching, or are moved deep into the soil, out of reach of the roots of future crops. Nutrients saved from leaching or moved back up into the normal rooting zones for cash crops are then available for future crops.

Nutrient release tied to breakdown

The majority of cover crops will break down quickly enough for the majority of nutrients to be released for the next grain crop. Some nutrients can still be leached or tied up in the soil depending on many factors, so a full credit shouldn't be assumed.

Good growing conditions enhance benefits

In general the better the growing conditions, the more a cover crop will grow and the more nutrients will be taken up. Available heat units, soil moisture and available nutrients are some of the key factors that will influence cover crop growth and nutrient concentration.

Radish in Central Iowa

Planted: Sept. 11, 2013 Sampled: Nov. 11, 2013

32 lbs N	@	$0.58/lb	=	$18.56/A
5 lbs P	@	$0.57/lb	=	$ 2.85/A
29 lbs K	@	$0.38/lb	=	$11.02/A
6 lbs S	@	$0.59/lb	=	$ 3.54/A

Reducing Nitrate Loss

Cover crops can be more effective at reducing nitrate losses from crop fields than other reduction strategies, such as lowering N application rates, installing tile filters, and constructing wetlands.

Government programs are available in many areas to provide cost share to growers using cover crops because they are proven to reduce nitrate losses by leaching and runoff.

Cover crop type and management

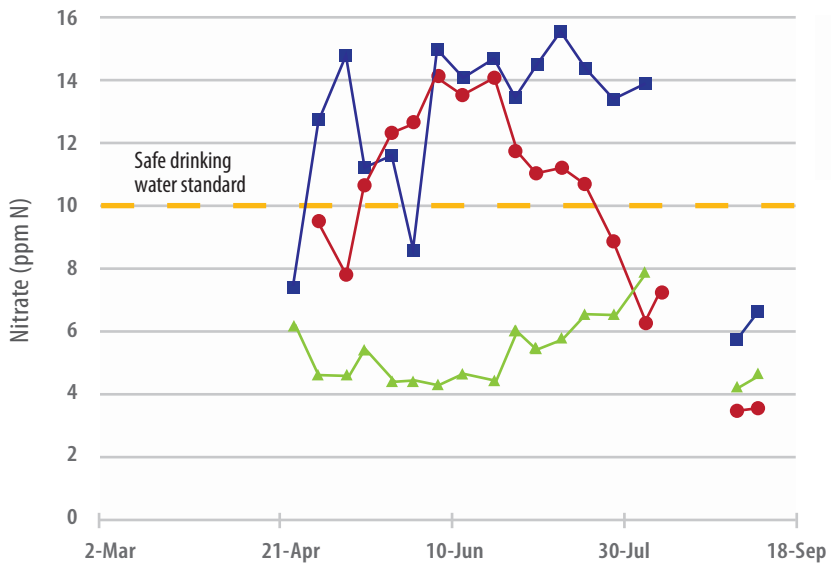
Nitrate retention in the soil can be increased by selecting the proper cover crop, timely planting, and terminating the cover crop at a time that matches residue breakdown (nutrient release) with nutrient uptake by the following crop.

Three main ways cover crops can help

1. Properly managed cover crops extend the time that actively growing plants can take up and hold nutrients.
2. They make use of soil moisture, potentially reducing the amount of excess moisture in the soil, and so may reduce nutrient losses from leaching.
3. They capture nitrate at lower levels in the soil profile which might be lost before the next season's crop can use it and relocate it closer to the soil surface.

Notice the tile line running at a time when there is no growing crop in the field to catch the nitrates that are being lost through the tile line.

2014 Drainage Water Nitrate Concentration From Corn Production



Source:

Tom Kaspar USDA-ARS, National Laboratory for Agriculture and the Environment, Ames, Iowa

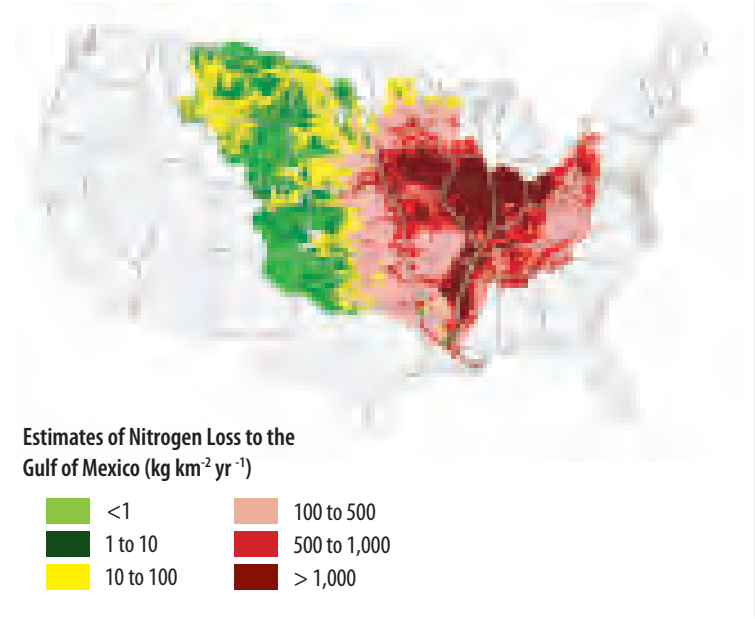
KEY POINTS

1. The blue line shows that where normal N fertilizer rates were used for corn production and no cover crop was grown before planting, nitrate levels in water were above the safe drinking water standard.

2. The red line shows that where no N fertilizer was used for corn production for two years and no cover crops were grown in the off season, nitrate levels in water were still above the safe drinking water standard in the summer.

3. The green line shows that where normal N fertilizer rates were used during corn production and cover crops were grown, nitrate levels were never above the safe drinking standard.

   This is a key reason that cover crops are the focus of so many environmental programs.



A BIG PROBLEM

The Mississippi River and its tributaries drain a significant portion of the U.S. Nitrate (as well as phosphate) carried into the Gulf of Mexico via this watershed contributes to hypoxia (the Dead Zone), where low oxygen levels inhibit sea life.

The darker red areas on the map on the left represent the areas of the Mississippi watershed where more nitrate is lost from farm fields. Cover crops can help farmers address this issue by retaining N in the field.

Source:

National Research Council. *Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico*. Washington, DC: The National Academies Press, 2009.

Fixing N

Through symbiotic relationships with soil bacteria, legumes have the ability to capture nitrogen from the air and store it in plant tissue, which can reduce the need for applied fertilizer for the next crop.

Warm Season Legume

Cover crop legumes like Sun Hemp (*Crotalaria Juncea L.*) can fix more than 100 lbs N/a if planted during a warm part of the season such as in prevented planting conditions or following wheat.

Cool Season Legumes

Cover crops like Crimson Clover, Hairy Vetch, and Winter Peas will grow in cooler conditions than corn or soybeans so they can take up and fix N throughout the fall and until spring termination.

If a significant amount of N is already present, legume crops will take up the available N from the soil rather than expend the energy required to fix larger amounts of N through symbiosis. This combined uptake and retention of N from the soil can still result in a N credit for the next year.

Legume plant matter contains more N than grasses and will typically break down faster, releasing N and other nutrients faster. Importantly, *legumes are fixing N and utilizing N even if you don't see nodules in the roots.*

GROWING CONSIDERATIONS

Legumes typically require use of a species-specific bacterial inoculate for optimal N fixation.

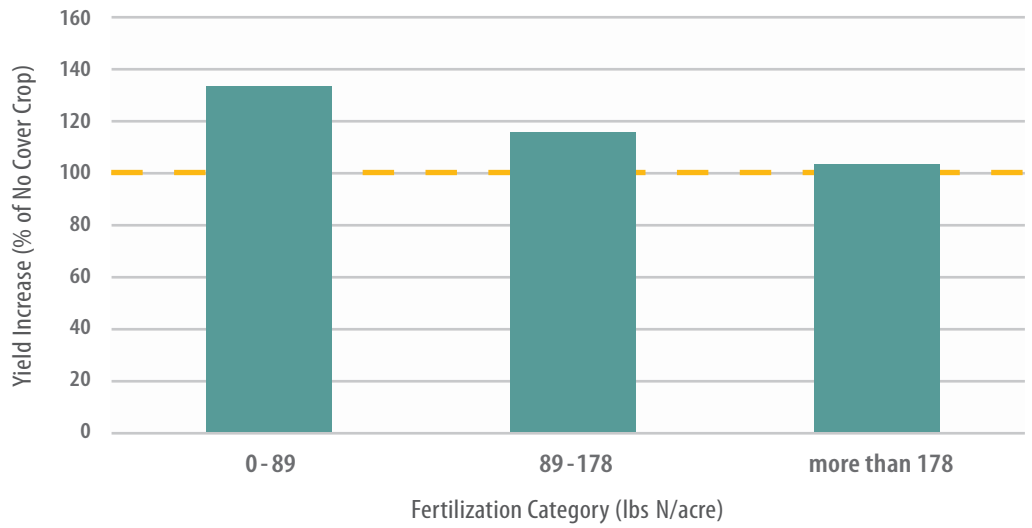
The more growth, the more N uptake and N fixation. Some corn and soybean rotations may not permit adequate time for optimal cover crop growth.

Be aware of the planting window to assure winter hardiness. Plants that are too small or too large of plants are not as winter hardy.

Sun Hemp N nodules at 26 days growth.

Nitrogen nodules are more widely dispersed in the fine roots of this Crimson Clover grown in a research root tube.

Corn Yields Following Legume Cover Crops at Three Nitrogen Fertilization Categories



Summary of 82 observations

Source:

Adapted from Miguez and Bollero. Crop Science. 45:2318–2329 (2005).

KEY POINTS

1. To capitalize on the nutrient credit value from a legume cover crop, you may need to adjust your N fertilization rates.
2. When N rates were reduced, corn yields were significantly higher in plots where legume cover crops had previously been grown than in plots where no legume cover crops had been planted.

Example of Crimson Clover

After 34 days of fall growth

Notice the root mass in the picture on the left. Roots had grown 24 inches into the soil in the rooting trial containers. Pulling the plants up does not show the entire rooting mass. Nodules present on the roots are shown above.

Breaking Compaction

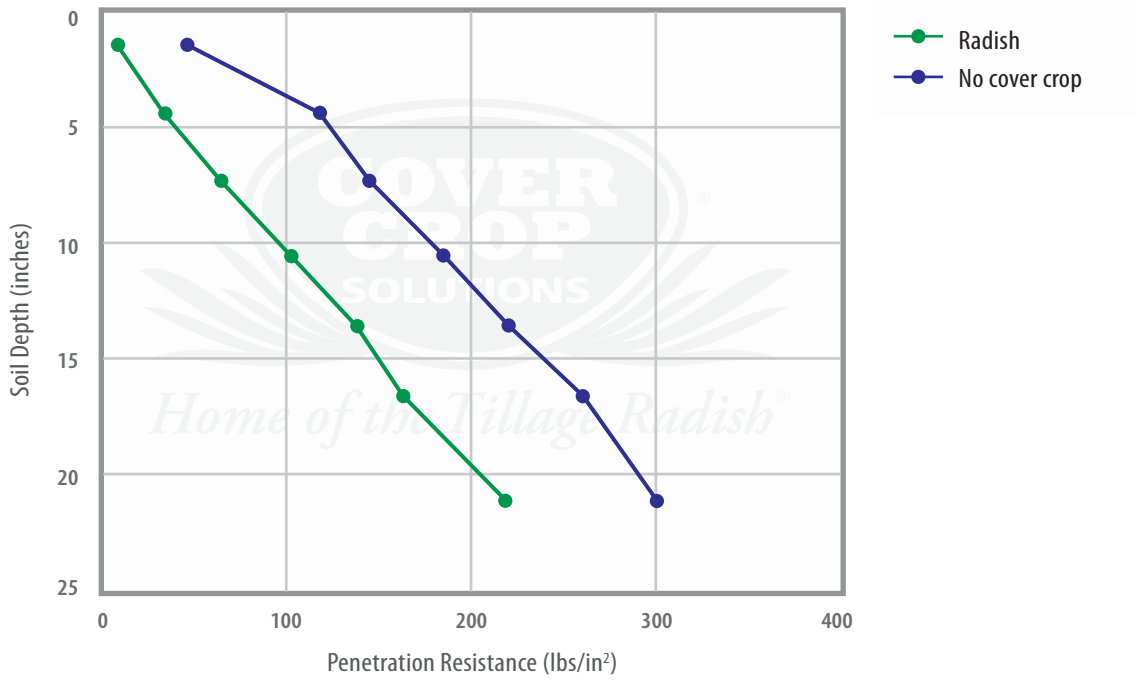
Some soils have a compacted layer that may hinder rooting nutrient uptake by cash crops like corn and soybeans. Many cover crops have the ability to root far deeper than the shanks on a deep ripper and can leave root channels behind that can be used by roots of future crops.

While many cover crop species have been selected for their aggressive and deep-rooting capabilities, root growth takes time. If compaction alleviation is a motivating benefit, farmers should be prepared to plant their cover crop six to 10 weeks before the first killing frost.

The three mechanisms for breaking compaction are:

1. Certain cover crops have roots that can reach deeper than some cash crops.
2. Some cover crops have roots that can penetrate compacted soils better than some cash crops.
3. Cover crops grow in a different time window than cash crops. Often there is additional moisture in the soil during the fall, which allows the cover crop roots to penetrate soil layers that are impenetrable during the dry summer months.

Soil Penetrometer Resistance with and without Cover Crop



KEY POINTS

1. Cover crops can help "loosen" a soil. The figure above illustrates the difference in how easy it was to push a penetrometer into the soil. The green line shows that the soil was "looser" for all depths measured in the soil following the radish cover crop, when compared with plots without a cover crop (blue line).

2. This study shows only data for the top 2 ft. of soil. Since cover crop roots can reach much deeper than that, they can impact soil density – or compaction – at depths below most tillage operations.

   See page 17 for effects of cover crops on root growth of subsequent crops.

Increasing Root Depth

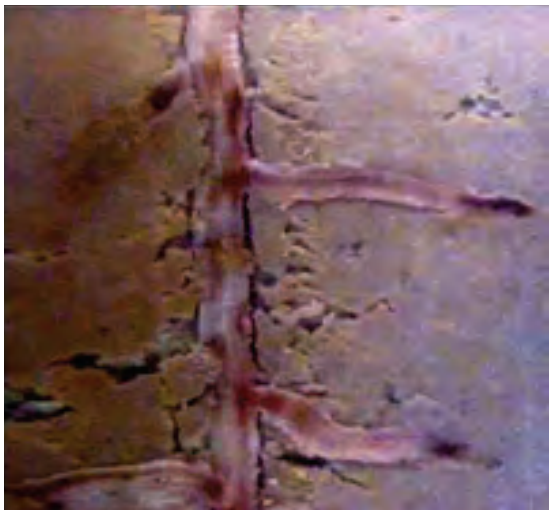
Cover crop roots may grow deeper than cash crops, even in soils not known to have a significant compaction layer.

The benefits from cover crops rooting through soil layers are:

1. Creating root channels that roots from future crops can use to reach deeper to get additional water and nutrients.
2. Cover crop roots that reach deeper can bring nutrients from deep in the soil closer to the surface where they are more accessible to following cash crops.
3. Open root channels left behind by cover crops can increase water infiltration, which can result in increased water storage for the future crop.
4. As your soil health improves, you may see an increase in earthworm activity. These earthworms will also work to open up root channels for your cash crops.

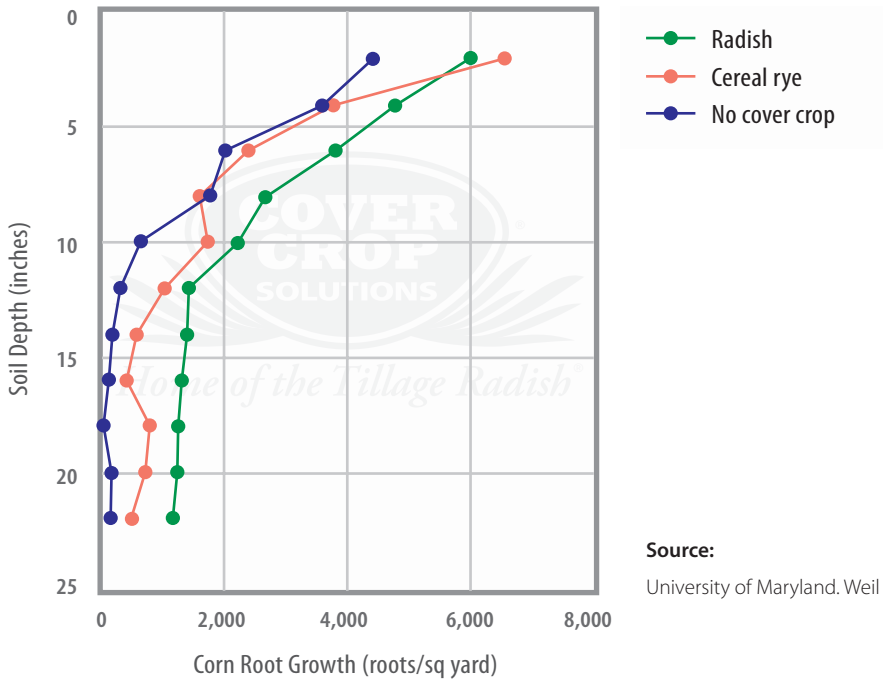
3 May, Canola Root

17 July, Soybean Root



The photos above show a channel that was created after a canola cover crop root decomposed. This same channel was then used by the subsequent soybean crop.

Corn Roots Following Cover Crops



Source:
University of Maryland. Weil and Chen. 2007

This data represents the means of 12 cores (3 cores per replication) in sandy soil at the University of Maryland Hayden Farm, near Laurel, MD.

KEY POINTS

1. Cover crops can help increase the root growth of crops that follow them. This has been confirmed in a number of research trials. The graph above, from a 2007 University of Maryland study, shows the increase in corn roots in the top 2 ft. of soil from the plots where cover crops were grown. More roots at lower depths mean more nutrient and water uptake.
2. The green line shows data documenting a major increase in root growth in corn that followed radish. The red line shows the increase in corn roots following a cereal rye cover crop.

Suppressing Nematodes

Nematode pests, like Soybean Cyst Nematodes (SCN), can cause significant yield loss in many areas of the Corn Belt. Adding cover crops to the cropping program can disrupt the life cycle of nematodes that thrive in a two-year corn/soybean rotation.

Research on how cover crops suppress nematodes is still in early stages. Here are four main methods:

1. **Non-Host Cover Crop**
   - **a.** By selecting a cover crop that is not a host, you can keep nematode pressure lower than with cover crops that are hosts.
   - **b.** Displacing weeds that can serve as nematode hosts (such as Henbit) with cover crops that are not hosts will reduce SCN pressure.
2. **Biofumigant**
   - **a.** Cover crops with higher sulfur content (brassicas) tend to have more glucosinolates which can break down into isothiocyanates, natural chemicals that can kill live nematodes.
   - **b.** Incorporation of the leaf tissue into the soil is usually required for significant control.
   - **c.** This practice is more common in sugar beets and potato production.
3. **Hatch and Starve**
   - **a.** Some nematodes deposit their eggs in cysts (i.e., soybean cyst nematode). Eggs protected by the cyst can remain viable for up to 10 years.
   - **b.** Some cover crops can encourage egg hatching even though they are not hosts for the nematodes.
   - **c.** In order to trigger egg hatch in the fall, there would have to be significant cover crop growth before the soil temperature cools to 50º F.
4. **Increasing Natural Predators**
   - **a.** Nematodes are part of complex soil biology.
   - **b.** There are predators of nematodes in the soil biology mix.
   - **c.** Adding cover crops can stimulate biological activity in the soil which can increase the activities of nematode predators.

Soybean Cyst Nematode

Soybean cyst nematodes (SCN) are a problem that seem to be increasing in soybean production. The data below, from a University of Illinois study, illustrate the impact of using cover crops in a corn/soy rotation.

KEY POINTS

1. Four sites monitored over two years shows a significant reduction in SCN egg count in plots where cereal rye and annual ryegrass cover crops were used.
2. Each treatment was replicated three times in each of the four sites.
3. Both cover crops showed a major statistically significant reduction in the egg count.
4. The mode of action (i.e., the mechanism by which the cover crops reduce egg count) has not been determined, but the two sites in soybeans after two years of the study had a yield increase following the cover crops that support the benefit of reducing the SCN egg count.

Effect of Cover Crops on Nematode (SCN) Egg Population

Site	No Cover Crop	Cereal Rye	Annual Ryegrass
	SCN EGGS		
1	7533	717 *	117 **
2	3650	320 *	0 **
3	1559	722 *	386 *
4	1202	390 *	279 *

* Significant 0.05
** Significant 0.01

Source: Mike Plumer, University of Illinois

Effect of Reduction in Nematode (SCN) Egg Population on Soybean Yield

Site	No Cover Crop	Cereal Rye	Annual Ryegrass
	Bu/Ac		
1	48.9	53.8 4.9 *	55.6 13.7 *
2	48.2	52.3 4.1 *	60.6 25.7 *

No yield information is reported for sites 3 and 4, since they were in corn during this year of the study and SCN does not impact corn yields.

* % Increase over control

Another Way Cover Crops Can Pay Back Directly

Forage Production

Cover crops can provide a good supply of forage with adequate growing time and proper management.

To optimize forage production:

1. Decide whether forage is needed in the fall or the spring, and make sure there is adequate growing time to develop the forage desired.

2. Increase the seeding rate and ensure adequate fertility. Ratios of different species in mixtures may need to change with increased seeding rates. Single species of grasses may need to be added to existing mixes to boost the volume of forage that is produced.

3. For optimal grazing performance, limit the amount of radish in a forage mix to no more than 2 lbs per acre.

4. When seeded after corn or soybean harvest, the most likely use for cover crop forage will be grazing. Cooler fall temperatures result in slow growth and poor drying conditions that usually make a hay or silage harvest difficult.

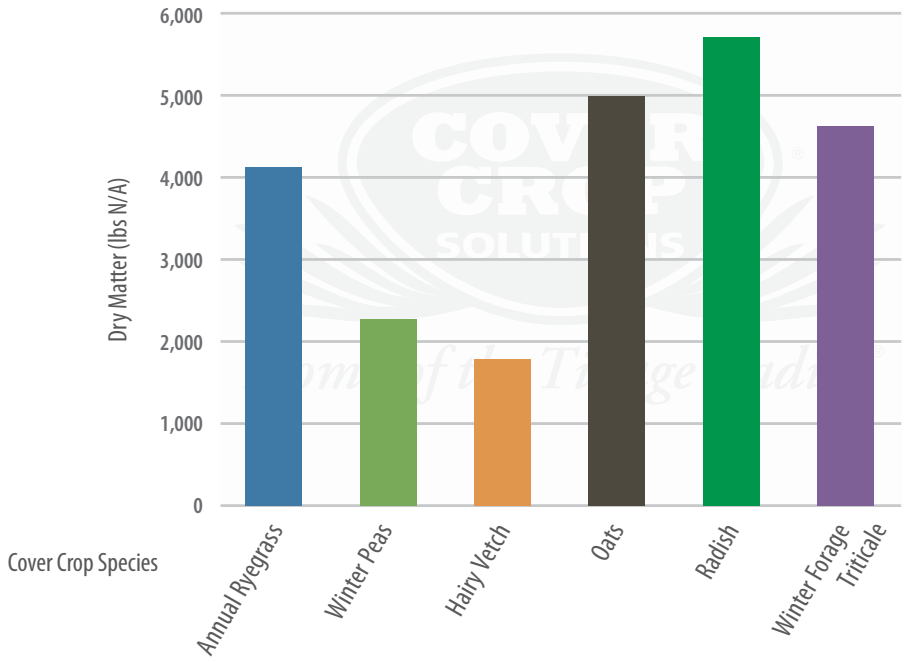
5. A spring forage harvest may also be possible if there is enough time for growth before planting the next crops.

6. If corn stalk grazing is a normal part of your program, interseeding cover crops into standing corn before harvest will allow more growth for improved overall digestibility and a longer fall grazing period.

7. Select the appropriate species for the time and type of grazing desired. For example, seeding Annual Ryegrass or Winter Forage Triticale will enhance nutritional value of feed when grazed in the fall, and may also allow early spring grazing or an early forage crop before weather is warm enough to plant cash crops.

8. Radish can greatly increase feeding value and total forage yield for fall grazing.

Dry Matter Production for Six Cover Crops



Cover crops can generate significant quantities of biomass that can be used as a forage. Below is an example showing the amount of cover crop growth for six different cover crops measured in the fall.

Data shown above are from cover crops grown in replicated plots following wheat harvest, sampled before the first killing frost in 2014 at Holtwood, PA.

Cover Crops That Overwinter Can Be Great Spring Forage

For cover crops that overwinter, there can be significant spring growth if the cover crop is permitted to grow long enough. The example below shows the forage value of Annual Ryegrass, as evaluated in a 2012 Penn State University Forage Trial.

The soil fertility program was designed around maintenance applications of phosphorus and potash to meet the soil test requirements. Plots received 30 units of N in the fall, 100 units of N at green-up in the spring, and 50 units of N after each cutting.

		DM Yield (tons/acre)				First Cutting				Average First and Second Cuttings			
SPECIES	**VARIETY**	Cut 1	Cut 1	Cut 3	**Total**	CP %	ADF %	NDF %	30-Hr NDFd	CP %	ADF %	NDF %	30-Hr NDFd
Ryegrass /Diploid	Tillage RootMax®	1.87	1.92	1.28	**5.07**	22.8	27.3	42.2	52.0	17.1	28.2	50.1	54.0

Planted September 19, 2011.
First cutting on April 26, 2012.
Second cutting on May 25, 2012
Third cutting on June 20.

Increasing Organic Matter

Soil organic matter is one of the best predictors of how good a soil is for crop production. Cover crops can increase soil organic matter (SOM) content over time, by capturing carbon and adding it to the soil through roots and shoots.

Increasing Nutrient Availability

1. Each 1% of SOM contains about 1,000 lbs N/a.
2. A very general rule of thumb is that 2% of the N in the OM is released each year, or about 20 lbs N/a.
3. Each 1% of SOM would increase available P by about 2 lbs of P (4.5 lbs of P_2O_5).
4. There is negligible K released from OM.
5. Each 1% of SOM would increase available S by about 2.5 lbs.

Water Benefits

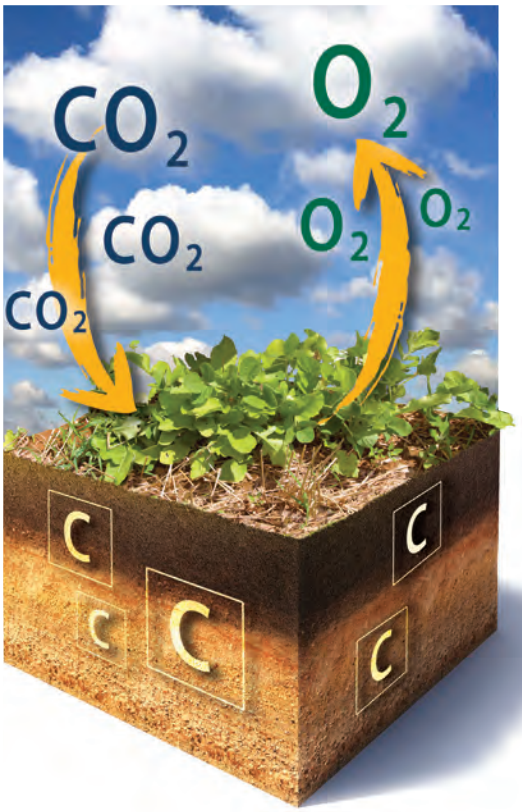
1. It's estimated that each 1% increase in SOM increases water holding capacity by about 1 acre inch. (An acre inch the volume of water from an inch of rain on an acre of soil, or about 28,000 gal.)
2. Increasing SOM can increase water infiltration rates which means more water can be stored in the soil rather than running off the surface.

Source: Tom Kaspar, USDA-ARS, Ames Iowa.

Other Benefits

1. Increasing SOM increases soil aggregation and helps decrease soil compaction.
2. Roots of most cover crops are often only 20-40% of the biomass produced above ground.
3. Under good growing conditions, radish can produce more root growth than shoot growth.

Cycle of Adding Organic Matter



Growing plants take in carbon dioxide (CO_2) and release oxygen (O_2) to the atmosphere while storing carbon (C) in organic matter in the soil.

Long-Term Gains in Soil Organic Matter

Increased soil organic matter is one of the long term improvements many growers say they want when using cover crops. It seems straight forward that growing cover crops adds more plant material that is not being taken off the field and should therefore increase the organic matter.

Soil samples from the top 2 inches of soil for treatments with and without a cereal rye cover crop in a corn silage-soybean rotation after 10 years.

TREATMENT	Soil Organic Matter (%)	Particulate Organic (ppm)	Potential N Mineralization (ppm)
CEREAL RYE	5.65 a	8.8 a	49.6
NO COVER CROP	4.93 b	6.1 b	35.8

Source: Tom Kaspar, USDA-ARS, Ames Iowa.

KEY POINTS

1. Ten years of cover crop use resulted in an increase of 0.72% organic matter in the top 2 inches of soil.
2. The cereal rye cover crop "increased" total soil organic matter (SOM) content in the top 4 inches of soil (not the 2-inch sample reported above) from 4.8% to 5.3% (or a 0.5% change in SOM).
3. Detecting a 0.5% change in organic matter content of soil is extremely difficult because of the variability in soil samples and the length of time it takes to produce a measurable change.

Also:

1. There was a 38% greater particulate organic matter in these plots.
2. There was a 48% greater potential N mineralization.

CAUTION

This study involved the collection of more than 400 soil samples collected in an area that measured less than 4 acres. Use caution when interpreting or monitoring changes in organic matter over time that are based on samples collected as part of a "normal" farm soil testing program.

Breaking Disease Cycles

Cover crops can influence the microbial community in the soil, and can help suppress some of the soil-borne disease cycles.

Some of the key ways cover crops can influence disease cycles are:

Improving the Soil Physical Environment

1. Some pathogens thrive in wet soil conditions. Cover crops can help alleviate wet soils by increasing water infiltration rates in the soil or by taking up excess moisture during wet periods.
2. Some cover crops, like oats, have been shown to decrease the incidence of diseases like white mold and "Sudden Death Syndrome."

Increasing Soil Organic Matter

1. This can increase biological control by feeding antagonists of the undesired pathogens.
2. Increased organic matter also means a better food supply for desirable soil microbes, which then compete with undesirable pathogens for resources.
3. Growth of friendly microorganisms can produce anti-microbial chemicals which can inhibit pathogens.

Cover Crop Residue

This can create a physical barrier between the soil and the crop. White mold is an example of a fungal disease that a mulch can help prevent in soybeans.

Impacts of Cover Crop Treatments on Diseases in Spring Planted Soybeans

TREATMENT	SCN Change in Egg Counts (100 cc)	SDS	Foliar	Grain Yield (bu/a)
FALLOW (no winter crop)	**+589 a**	**25.2 a**	**157.7 a**	**65.4 b**
COVER CROP (rapeseed)	**- 313 b**	**16.8 b**	**103.9 a**	**67.5 ab**
GREEN MANURE (rapeseed)	**+691 a**	**5.5 c**	**37.1 b**	**69.6 a**

Means followed by the same letter are not significantly different according to the LSD test at P = 0.05.
In this study, green manure was incorporated into the soil, and the cover crop was not incorporated.

Source: J. Bond. Southern Illinois University, Carbondale.

Cover Crops and Disease Cycles

There are many disease control or suppression benefits from cover crops reported in vegetable production research. Research on the influence of cover crops in disease cycles in grain farming is more limited.

Cover crops and disease

To date, most of the studies done with cover crops were not designed to help understand a specific mechanism that may influence disease cycles. One exception is a study (not shown here) that shows planting into a heavy cover crop mulch helps prevent development of white mold.

ILLINOIS EXAMPLE

The two tables on this page report observations made from cover crop studies done in Illinois. These are not comprehensive trials, but do illustrate that there are ways that cover crops can help reduce disease pressure.

Figure 1 shows some reduction in Sudden Death Syndrome (SDS) by some cover crops.

Figure 2 illustrates some reduction in rhizoctonia diseases.

Given the relatively new interest by researchers in documenting disease impacts with cover crops, we can expect to see a lot of new information coming in the future years that will likely show how cover crops can add to the growers' bottom line.

Figure 1. Effects of cover crop treatments on soil suppression of SDS *(Fusarium Virguliforme)*

FARM	Cover Crop	Disease Severity
WIU	Canola	2.1 A
	Rye	2.0 A
	Fallow	2.0 A
	Mustard	2.0 A
	Rape	1.1 B
HUNT	Fallow	2.5 A
	Rape	1.6 B
	Rye	1.6 B

Means followed by the same letter were not significantly different according to the LSD test at a = 0.05.

Source: Measurements from University of Illinois at Urbana-Champaign and Western Illinois University, 2012.

Figure 2. Effects of cover crop treatments on soil suppression of *Rhizoctonia Solani*

FARM	Cover Crop	Disease Severity
AYERS	Fallow	1.5 A
	Rye	0.8 B
WIU	Fallow	1.5 A
	Canola	0.9 AB
	Mustard	0.7 B
	Rye	0.5 B
	Rape	0.4 B

Means followed by the same letter were not significantly different according to the LSD test at a = 0.05.

Source: Measurements from University of Illinois at Urbana-Champaign and Western Illinois University, 2012.

Weed Suppression

Cover crops provide a ground cover that, when properly managed, can reduce weed establishment and reduces the need for herbicides.

For best results in controlling or suppressing weeds, cover crops should be:

1. Established before weeds get established or weed seeds germinate.
2. Planted densely enough to compete with weeds.

FALL

Control Mechanisms from a Living Cover Crop

1. Creates shade that discourages weed establishment. This is sometimes referred to as a smother crop.
2. Out-competes weeds for shallow soil moisture, preventing weed germination/establishment.
3. Temporarily ties up nutrients, making them unavailable for weed uptake.
4. Releases chemicals that prevent germination or hinder weed growth. Often referred to as allelopathic effect.

SPRING

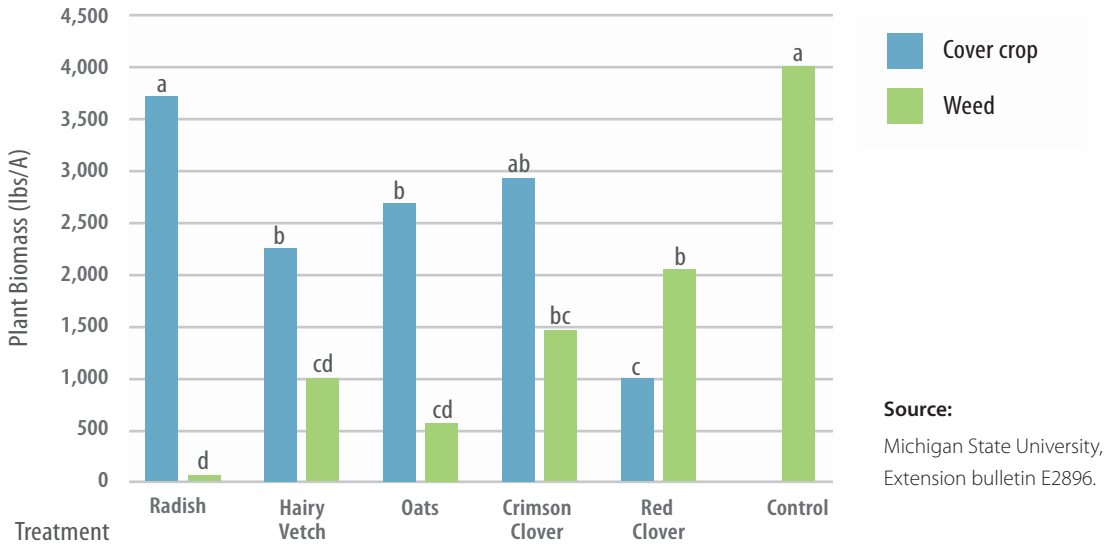
Control Mechanisms from Cover Crop Residue

1. Mulch effect that limits sunlight penetration to the soil and so helps prevent weed seed germination.
2. Decomposing residues release chemicals that prevent germination or hinder growth of some weed species (allelopathy).

Bird's eye view detail of Radish foliage residue (also shown above) in winter and early spring.

Weed Suppression is Maximized in Extended Growing Periods

Figure 1. Plant biomass for cover crops and weeds following snap beans



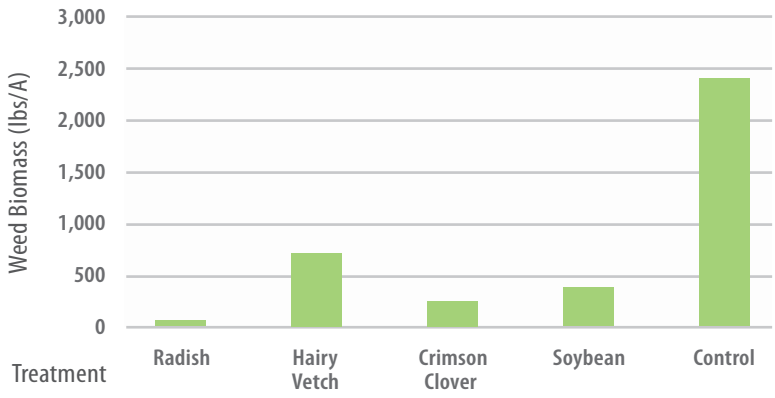
Source:
Michigan State University, Extension bulletin E2896.

The primary way cover crops can help suppress weeds is by creating a dense cover growth that out-competes weeds.

KEY POINTS

1. The study in **Figure 1** shows that there is typically less weed growth as the amount of cover crop growth increases.
2. For fall cover crop growth, oats and radishes often have the fastest initial growth with adequate moisture and soil fertility.
3. Clovers and hairy vetch are usually slower to grow in the fall, but they can overwinter in some areas and provide a thick matte in the spring.

Figure 2. Fall weed suppression by cover crops following winter wheat



Note:
Lower numbers indicate greater weed suppression

Source:
Michigan State University, Extension Bulletin E2907.

KEY POINTS

1. The longer the growth period for a cover crop, the more time there is for weed suppression benefit to develop. **Figure 2** shows that with the longer the time interval after wheat harvest, cover crops provided more than an 80% reduction in weed biomass.
2. The radish provided the largest weed suppression of the different treatments reported.

Changing Soil Microbiology

Cover crops can be used to improve or alter the soil environment and microbial community.

Changes can improve subsequent crop performance, but may result in detrimental effects if cover crops are not managed properly.

Ways Cover Crops Affect the Microbial Community

1. **Provide food to increase microbial activity**
   Plant organic matter and exudates from cover crop roots provide food for many different bacteria and fungi in the soil. This food source helps increase the overall microbial population and activity in the soil, which will increase competition with undesirable pathogens.

2. **Become a host for beneficial organisms or a non-host for specific pathogens**
   Mixing up cover crop species, and especially planting a mixture, will help diversify the microbiology present in the soil. The diversification and stimulation of the microbiology will help counter the presence of a specific pathogen.

3. **Alter soil properties, like bulk density and rate of water infiltration/drainage**
   The microbial community is affected by the amount of air in the soil. A saturated soil is a less desirable environment than a well drained soil. One result of improved water infiltration/drainage is increased microbial activity that will release more nutrients and create an environment in which pathogens like root rot are not as prevalent.

There are millions of microorganisms in a healthy, functioning soil community.

Measuring Microbial Activity

The soil depends upon the biological activity for many purposes, such as breaking down residues into compounds that feed plants, insects and other soil biology. The types of plants, growth period, and tillage practices all have a big impact on the soil biology.

A key metric

It is impossible to quantify the total amount and types of microorganisms in the soil. One indicator of this is a test that measures the dehydrogenase activity in the soil environment. Dehydrogenases are a class of soil enzymes. They exist only in the cells of living microorganisms and play a key role in many biological processes, like the decomposition of organic matter, which results in the release of soil nutrients.

Figure 1 shows that using an oat cover crop increased the soil dehydrogenase activity compared to the fallow/weed plots.

Another test that provides insight into biological activity is the Fluorescein diacetate (3',6'-diacetylfluorescein [FDA]) test. Simply explained, the more the FDA is broken down by the soil, the more fluorescein is produced and can be measured. More fluorescein means more biological activity.

Figure 2 shows the correlation between reduced weed growth and increased biological activity in the soil.

There are a number of other tests that can be used to assess various aspects of the soil biology. However, it is difficult to find good direction for interpreting these tests and making the results into a useful guide for detailed crop management. Growers need more information on how to apply such data to topics like nutrient management and disease issues.

Figure 1. Soil dehydrogenase activity

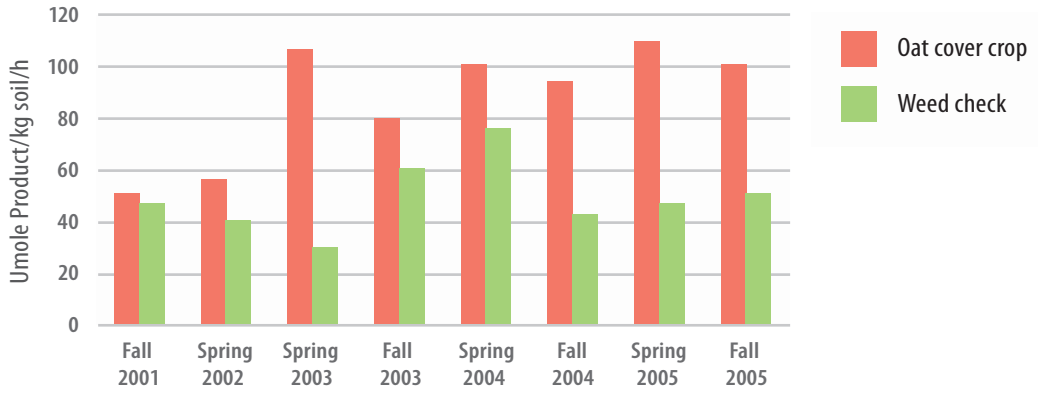
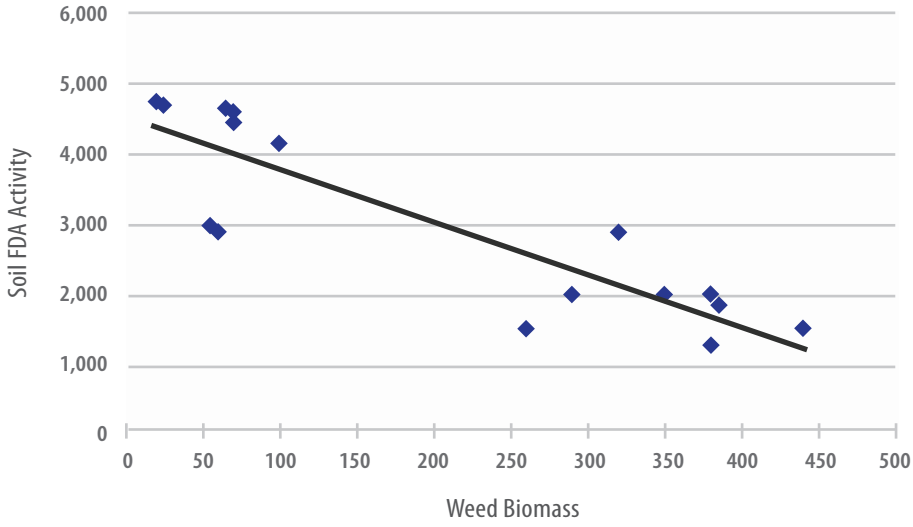


Figure 2.



Source for both Figures:

Kremer, R.J. *Alternative management for winter annual weeds and improved soil quality*. North Cent. Weed Sci. Proc. 60:39.

Drought Protection

An important benefit of properly established cover crops is their ability to help increase moisture availability for a subsequent crop.

How Cover Crops Help Increase Water Availability for Subsequent Crops

1. Cover crops can provide a mulch layer that reduces soil moisture evaporation by keeping the soil cooler.
2. Roots from cover crops can increase water infiltration, which means less water runs off the field, and more is stored in the soil.
3. Cover crops can help increase the rooting depth of subsequent crops, which can lead to more moisture uptake from lower in the soil profile.
4. Over time, cover crops can increase soil organic matter, which, in turn, can increase the soil's water-holding capacity. Each 1% increase in soil organic matter can retain the equivalent of about an additional inch of water, or about 28,000 gal. per acre.

GROWING CONSIDERATIONS

Because cover crops do use soil moisture, they could create a soil moisture deficit while actively growing in dryer soils. If soil is overly dry as the cash crop planting date approaches, terminating the cover crop early is recommended.

DEALING WITH MULCH

On the other hand, a heavy mulch can prevent moisture from evaporating from a wet soil If soil is overly wet nearing cover crop termination time, delaying termination may actually help to dry the soil. A dead cover crop on wet soil may not allow timely planting. In this case, terminate only the area that can be planted before the next expected rain.

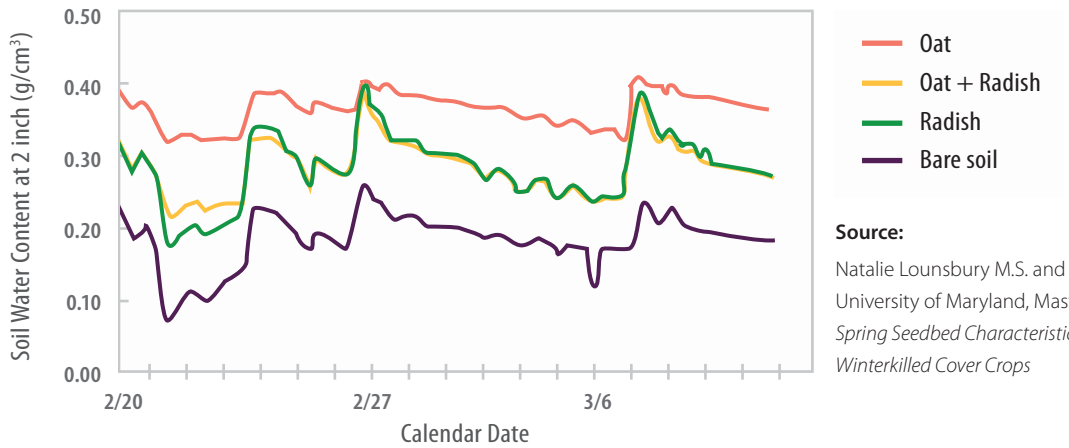
Increased organic matter in the soil acts like a sponge, soaking up and holding excess water, reducing moisture losses by surface runoff and by leaching downward through the soil.

Soil Moisture with Winter Terminated Cover Crop

There is often a concern that a cover crop will deplete soil moisture instead of increasing it. For many areas of the country, this fear is heightened near the time of planting a cash crop.

Figure 1 below illustrates the soil moisture in the top two inches just before planting. Each of the cover crops showed a higher soil moisture than the fallow plots. This is due in part to the winter kill of the cover crops selected. The oats provided a higher soil moisture level that was likely due to a thicker mat that served as a mulch. It is also interesting to the see that the differences in the moisture between the plots stayed fairly consistent regardless of how soon the measurements were made after a rainfall.

Figure 1. Moisture in the top two inches of soil



Source:

Natalie Lounsbury M.S. and Dr. Ray Weil, University of Maryland, Master's Thesis, *Spring Seedbed Characteristics After Winterkilled Cover Crops*

Figure 2. Soil moisture differences from cover crop and tillage treatments

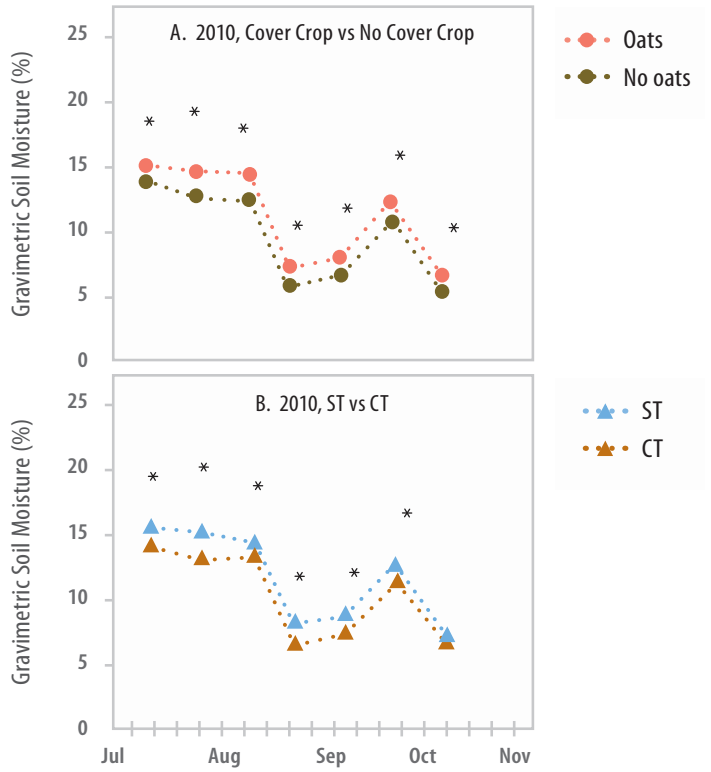


Figure 2 shows soil moisture differences in a Michigan study that compared both cover crops and tillage systems. The study showed that an oats cover crop increased moisture in the top 8 inches of the soil throughout the season. It also showed that the differences were roughly the same as the differences between strip tillage (ST) and a conventional tillage (CT) system.

The asterisks mean statistically different between the two treatments.

Source:

Haramoto et al. 2012. Hort Science 47:1596-1602.

Water Infiltration

Cover crops can increase water infiltration in a number of ways

1. A cover crop, either growing or with surface residue, will slow down water runoff and increase water infiltration.

2. Root channels created at the surface give a direct way for water to enter the soil. This is especially true for the radish. (See photo below.)

3. Deeper rooted cover crops can open channels further into the soil, resulting in deeper infiltration of the water, which allows more of the water to be stored in the soil for the next crop.

4. Over the long term, increasing the organic matter in the soil will also increase both the water infiltration rate and the water holding capacity of the soil.

Winter terminated radish leaves voids in the soil surface which can improve water infiltration into the soil. Tuber length varies, but the radish taproot has been measured to 6 ft. and more.

Infiltration Example

The graphs on this page are results from a Georgia study after three years of growing a corn and sorghum rotation with different cover crops. One of the measurements they made was water infiltration in each plot after sprinkler irrigation.

Figure 1 clearly shows that water infiltration was higher in plots where a hairy vetch cover crop had been seeded than in plots without a cover crop.

Figure 2 illustrates that water infiltration rate was higher in plots with hairy vetch than in those that were in winter wheat or fallow.

Possible reasons for the differences

The speculation is that the difference in cover crops could be due to the difference in canopy architecture.

Wheat has a more upright architecture when compared with the sprawling structure of the hairy vetch.

The hairy vetch matte provides a barrier between rain drops and the soil, reducing their ability to create surface compaction. This results in an increase in water infiltration.

Figure 1. Infiltration rate as a percentage of the sprinkling rate (1.6 in/hr) on a gravelly clay loam soil

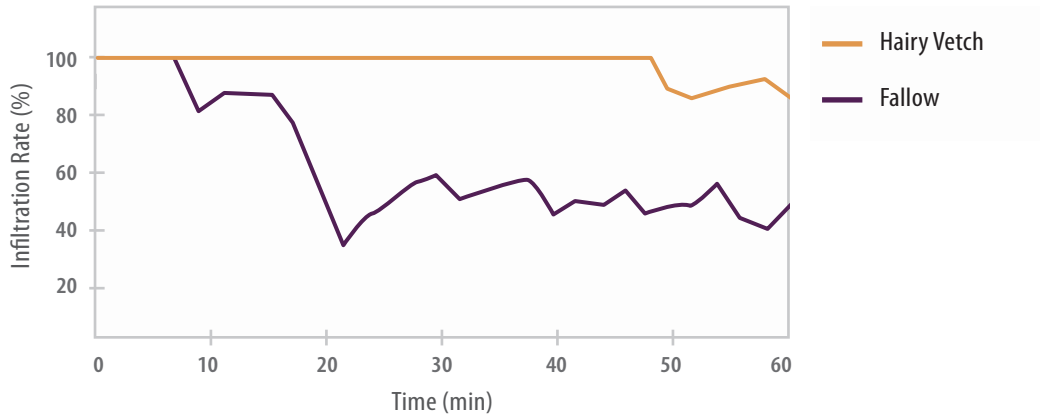
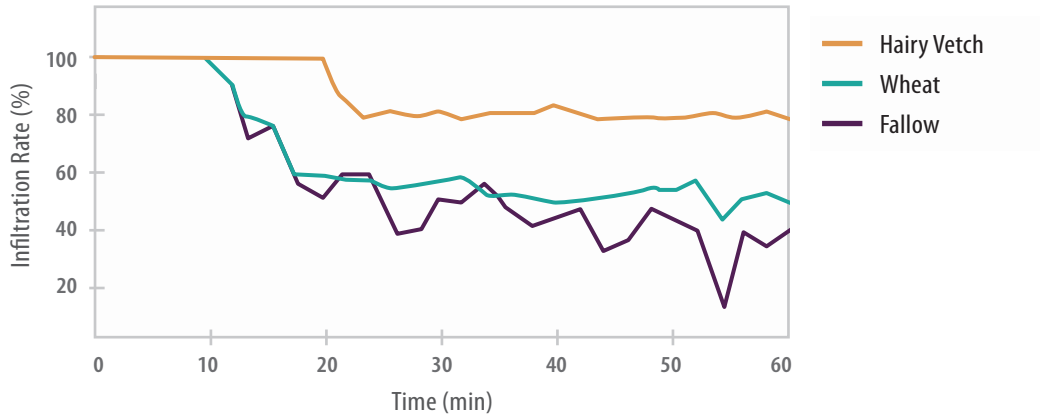


Figure 2. Infiltration rate as a percentage of the sprinkling rate (2.7 in/hr) on a sandy clay loam soil



Nutrient Relocation

Cover crops can improve nutrient uptake of future crops by bringing nutrients up from lower depths of the soil profile to a more shallow depth where they are more accessible to subsequent crops.

All About The Roots

Many cover crop species have roots that reach deeper than those of some cash crops, so they can pull nutrients from depths lower than the cash crop can reach.

A deep rooting cover crop can capture nutrients like nitrate and sulfate, which leach easily, from lower depths in the soil and relocate them in plant material nearer to the soil surface, preventing them from being leached into ground water or lost through tile drainage.

Nutrient Uptake Enhanced

In addition to scavenging nutrients, cover crop root exudates can increase nutrient availability for uptake by subsequent crops. Having cover crop roots growing for more months out of the season and at lower depths in the soil can increase nutrient availability for the next crop.

A root pit showing cover crops like radish can reach below six feet.

Figure 1 (on the right) shows that radish was able to take up the residual nitrate in the soil profile down to five feet.

KEY POINTS

1. The nitrate form of nitrogen is easily lost with leaching rain. If the cover crop had not relocated the nitrate from the soil profile to the plant tissue, it could have been lost before the next season's crop could establish roots to reach and use it.

2. Moving nitrate from the lower depths to nearer the soil surface and storing it in plant residue for release during the next growing season can result in both economic and environmental benefits.

Figure 1. Soil nitrate remaining by soil depth as affected by cover crops

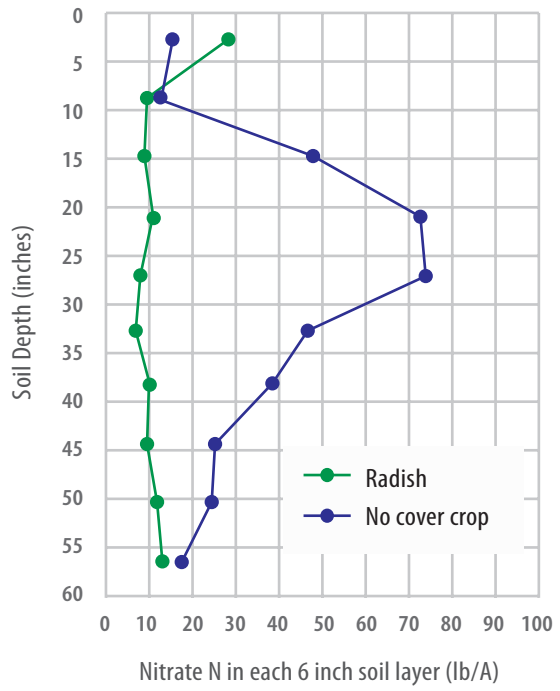


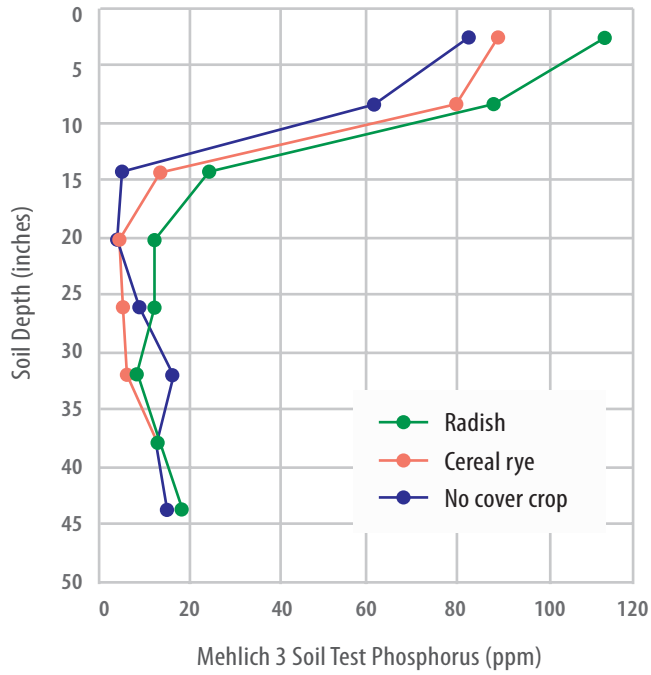
Figure 2 is from a Maryland study on phosphorus (P) availability, which looked at plots with different cover crops and fallow soil and compared the P concentrations at different soil depths to below three feet.

KEY POINTS

1. The study showed that both cereal rye and radish increase the P availability in the surface foot of the soil. Radish achieved the largest increase in P availability.

2. Although these soils would not be considered deficient, the increase in availability in the surface foot of soil is considerable. When soil tests show building soil P is necessary, it generally requires 15-25 lbs of P fertilizer to increase soil availability by 1 ppm.

Figure 2. Phosphorus availability by soil depth as affected by cover crops



Source:
Weil, University of Maryland