Cover Crop Basics

Third Edition

Meet the contributors behind the Third Edition of Cover Crop Basics. Their diverse experiences and expertise bring a wealth of knowledge and unique insights.

Cher Gillson, GO Seed Sales & Marketing
With over a decade of agri-business experience, the past five in the seed industry, Cher's ongoing drive to learn and teach is guided by her passion to help farmers innovate to create positive change in their operations and increase their profits. Contributions: Lead Editor and Content Curator, *Breaking Down Nitrogen, Revolutionizing Cover Crop Systems, Unlocking the Power of Legumes, Dr. Josh White: Getting the Most from Legume Cover Crops*

Dr. Shalamar Armstrong,
Associate Professor of Soil Conservation and Management, Purdue University
Dr. Armstrong is an esteemed environmental soil scientist/conservation agronomist. His research program investigates the agronomic, environmental, and economic impacts of current and emerging regenerative agricultural practices. Contribution: *Revolutionizing Cover Crop Systems*

Rick Clark, Farm Green
Rick Clark is a 5th generation farmer from Williamsport, IN. The main goal on his farm is to build soil health and achieve balance with Mother Nature. Rick is building a system that will be viable and profitable for generations to come.
Contribution: *Farming For Profit*

Dr. Shannon Cappellazzi, GO Seed Director of Research
Dr. Cappellazzi is one of the country's most highly respected scientists in the field of soil health analysis. After her degree in animal science, Shannon turned to soil science to explore the intersection of fertility and microbiology. She now focuses on providing data to help producers realize the benefits of soil health systems. Contributions: *Breaking Down Nitrogen, Soil Health Assessments Part 1, 2, and 3*

Dr. Josh White, Forage and Cover Crop Variety Testing Manager,
Mississippi State Univeristy
Dr. White is a specialist in the field of plant and soil sciences. His role involves conducting research and providing educational resources to farmers and agricultural professionals. His expertise helps in improving forage production systems and cover crops, which are essential for overall farm sustainability. Contribution: *Dr. Josh White: Getting the Most from Legume Cover Crops*

Jerry Hall, GO Seed President
Jerry began working on a research farm when he was 13, eventually majoring in agricurtural economics at Oregon State Universtiy. In 2000, he co-founded Grassland Oregon and has been instrumental in breeding and bringing to market numerous high-performing and high-value varieties of turf, forage, and cover crops. Contribution: *What's Next for Cover Crops?*

Cover cropping is more than covering bare soil.

It's understanding how the plant performs above ground,

And how the roots interact with the microbial communities below ground.

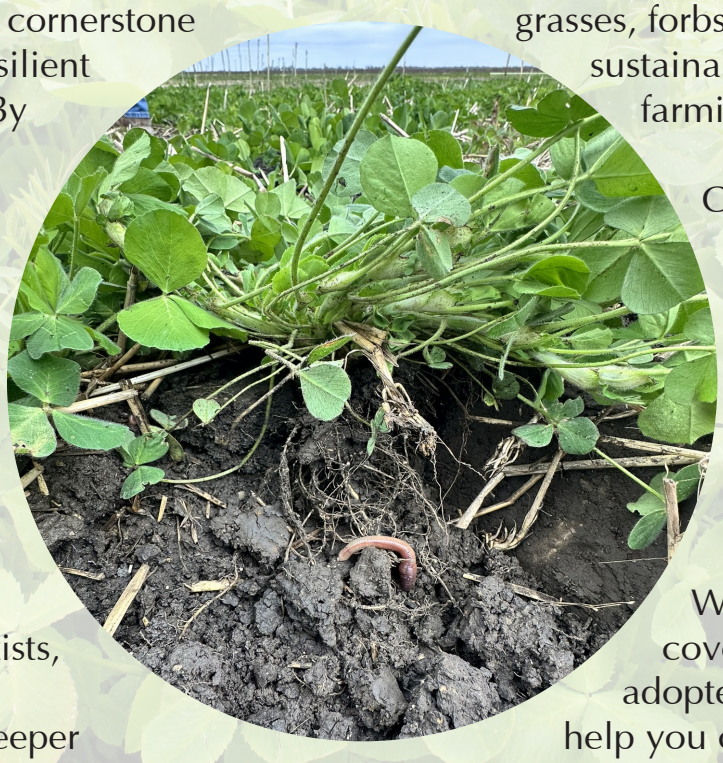
It's the manifestation of human ingenuity in science and agriculture,

And the preservation of our planet for the future.

-Cher Gillson

Cover crops are not merely supplemental elements, but fundamental pillars of profitable agricultural ecosystems. Healthy soils are the cornerstone of productive and resilient generational farms. By nurturing soil health through the strategic use of cover crops, farmers are improving their soil structure, enhancing water retention and infiltration, and lowering input costs.

Farmers, plant scientists, and soil scientists continue to gain a deeper understanding of the sophisticated interactions between plants, soil, and microorganisms. This new knowledge will help us to harness the power of legumes, grasses, forbs, and brassicas to create sustainable and profitable whole farming systems.



Cover Crop Basics, Third Edition, demonstrates how healthy soils are the backbone of healthy crops and how cover crops are the key to unlocking the soil's potential.

Whether you're new to cover crops, or a pioneering adopter, this guide is sure to help you continue on your journey to a climate resilient farm.

Breaking Down N

The Carbon to Nitrogen (C:N) ratio is a crucial aspect of understanding how organic matter breaks down and releases nutrients in the soil. When considering cover crops, the C:N ratio plays a significant role in determining the rate and efficiency of decomposition.

C:N Ratio and Decomposition
A cover crop with a low C:N ratio means there is a lower carbon content relative to nitrogen. This means that N is more likely to become available quicker.

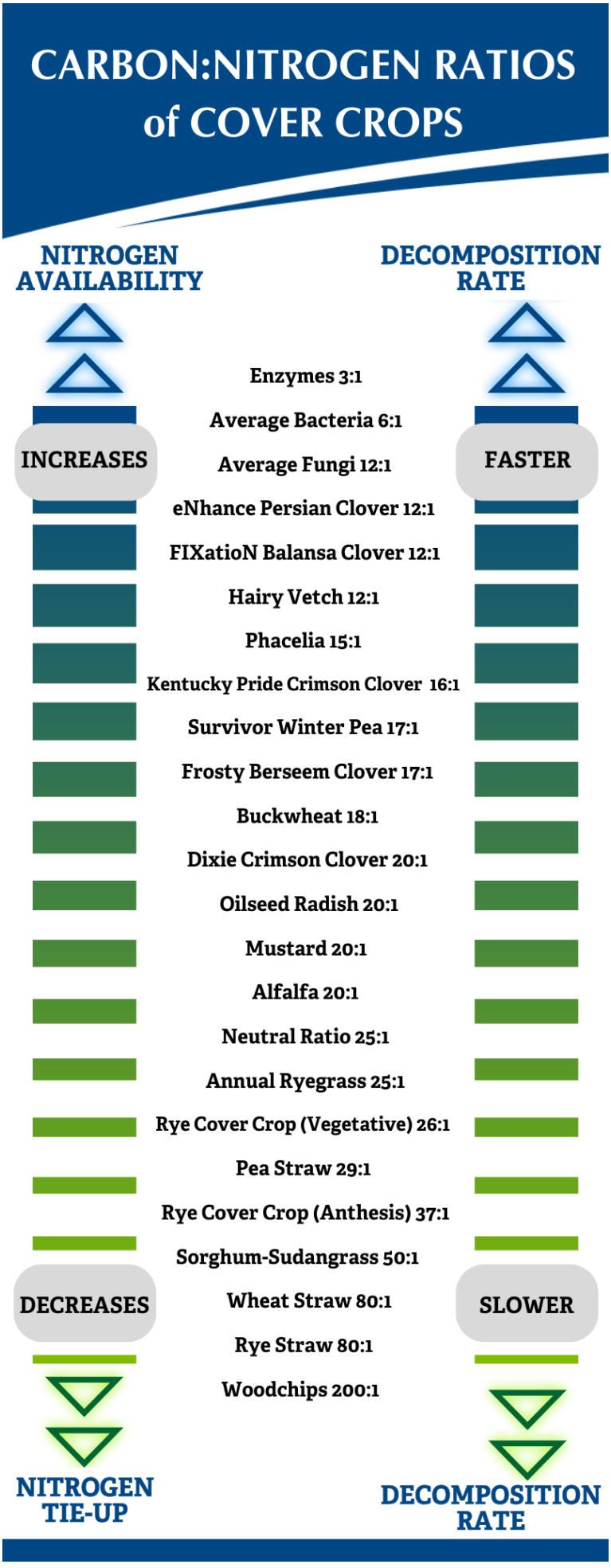
Billions of organisms in the soil take part in the continuous process of organic matter decomposition. They require both carbon and nitrogen for their growth and reproduction. Microorganisms break down organic matter with a high C:N ratio more slowly because they need to acquire additional nitrogen to balance the excess carbon.

Nutrient Availability
During decomposition, microorganisms consume organic matter for energy and growth, breaking it down into simpler compounds. This process releases nutrients stored in the organic matter, such as nitrogen, phosphorus, potassium, and micro-nutrients.

Organic matter with a high C:N can cause temporary nitrogen immobilization or nitrogen tie up. Microbes keep any nitrogen they can find within their body while they scavenge for what they need to build structures or make new cells. This means there is less nitrogen available for crops. This can result in increased soil organic carbon and may also require additional nitrogen fertilizer application. However, the lower the C:N ratio the more nitrogen becomes available as microorganisms die or release excess nitrogen back into the soil through mineralization.

Low C:N ratio cover crops decompose more quickly, resulting in a more immediate release of nitrogen and other nutrients.

Understanding these dynamics can help farmers optimize nutrient management to successfully integrate cover crops.



Revolutionizing Cover Crop Systems: An Interview with Dr. Shalamar Armstrong

In the world of regenerative agriculture, cover crops are gaining traction as a method to enhance soil health and boost crop yields. Dr. Shalamar Armstrong's groundbreaking research is at the forefront of this movement. His work delves deep into the intricacies of cover crop systems, aiming to balance ecological advantages without decreasing yields. Here we discuss Dr. Armstrong's research and its implications for modern farming.

Understanding the Basics: Goals and Challenges

Dr. Armstrong's research focuses on developing high-performing cover crop systems designed to prevent soil and nutrient loss while promoting nutrient efficiency. He emphasizes, "Our goal is to maintain environmental benefits while managing for competitive yields, which is crucial for farmers."

One of the early challenges Dr. Armstrong faced was with cereal rye, a commonly used cover crop. Initial experiments revealed a 6-13% reduction in corn yield following cereal rye. "We took thousands of plant samples throughout the corn's life-cycle, with and without the cereal rye, to understand nutrient uptake patterns. We discovered that 60-75 days after terminating the cereal rye, there was a significant reduction in the nitrogen available to the corn, leading to reduced yields," Dr. Armstrong explained. (Figure 1)

Dr. Armstrong fed the cereal rye a nitrogen that he could track through the plant, the soil, and into the corn at different growth stages; V5, V10, and harvest. Overall, he found that the cereal rye only releases about 10% of what it takes up. To overcome the yield lag from cereal rye, farmers would need to apply more nitrogen, which is not a sustainable conservation practice.

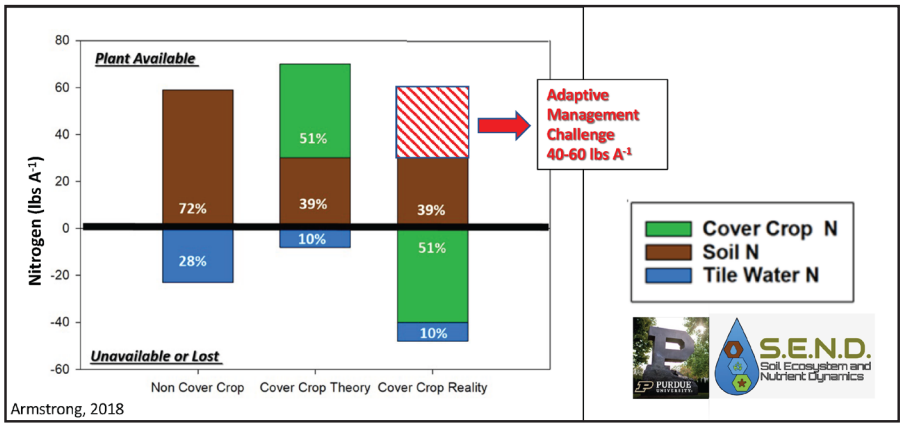


Figure 1. Changes In Soil Nitrogen Availability During the Life Cycle of Cereal Rye. Measuring forms of nitrogen through the system, we see more nitrogen taken up by cereal rye that remains unavailable to the following corn crop, leading to an adaptive management challenge, yield lag.

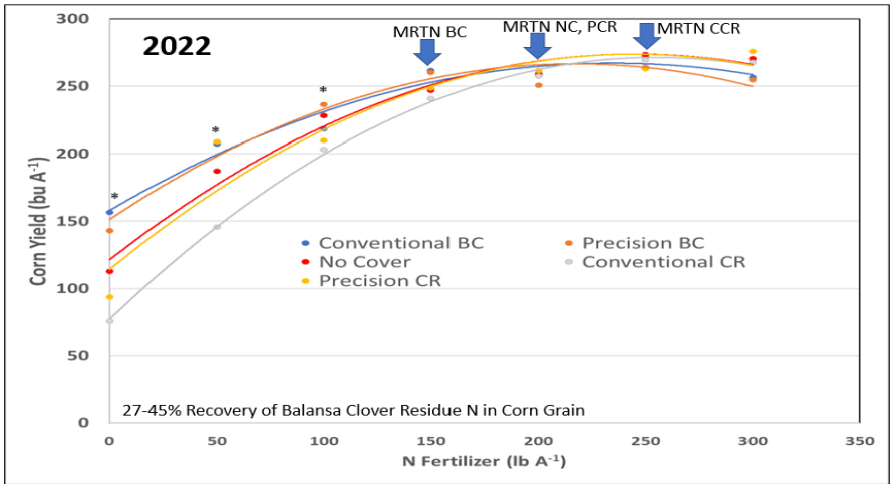


Figure 2. The Maximum Return to Nitrogen (MRTN) given specific synthetic fertilizer rates for FIXatioN Balansa Clover (BC) and Cereal Rye (CR) planted with either precision row spacing or conventionally planted.

The FIXatioN Balansa Clover Advantage

This revelation prompted Dr. Armstrong to explore alternatives, leading to significant findings with FIXatioN Balansa Clover. Unlike cereal rye, Balansa clover has a low carbon-to-nitrogen (C:N) ratio, making it more efficient at releasing nitrogen. "Balansa clover significantly increased soil nitrogen over a short amount of time, translating into better yields with less fertilizer," Dr. Armstrong noted. (Figure 2)

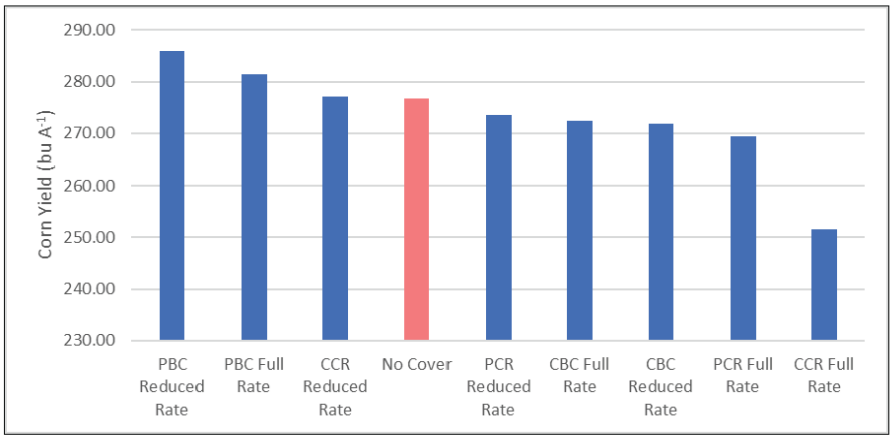


Figure 3. Corn yield in 2022 in southern Indiana. First letter stands for Precision (P) or Conventional (C). BC is Balansa Clover, CR is Cereal Rye. Reduced of full rate refer to the cover cop seeding rate.

Understanding the corn's N uptake requirements, timing of the available N from the FIXatioN Balansa Clover became crucial. Dr. Armstrong experimented with both planting "green" and planting "brown-green". Brown-green planting involved terminating the Balansa cover crop two-weeks before planting corn to allow the clover to begin decomposition and make the clover's N available to the corn at the V6 to V10 stage.

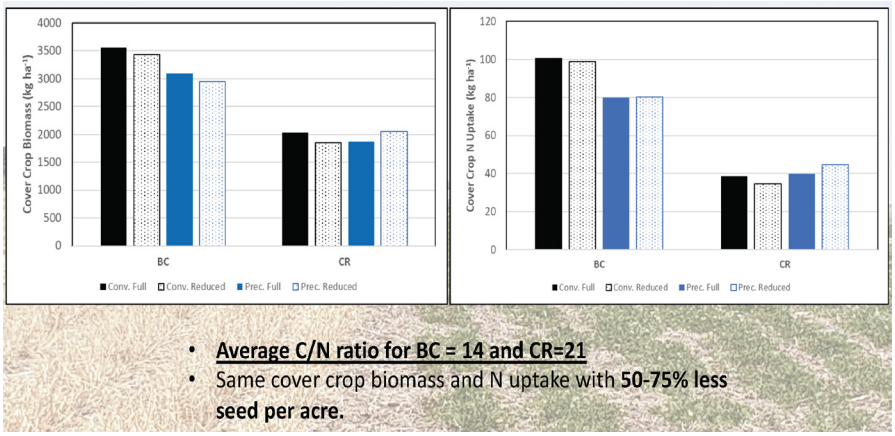


Figure 4. Cover crop biomass in southern Indiana in 2022 by planting type (conventional and precision) and seeding rate (full or reduced), comparing FIXatioN Balansa Clover (BC) and Cereal Rye (CR).

In the 2022 trial, both conventionally and precision planted Balansa clover, at a reduced seeding rate (2.5 lbs. per acre), yielded 250 bushels with only 150 lbs. of synthetic N per acre added. (Figure 3) FIXatioN Balansa Clover allows farmers to achieve competitive yields with less applied nitrogen per acre, compared to the 200-300 lbs. needed for a non-cover crop or cereal rye. Including the cost of FIXatioN Balansa Clover seed and termination management, this reduction in synthetic fertilizer can increase profits by $20-70 per acre.

FIXatioN Balansa Clover's two year average of dry matter biomass reached 4,780 lbs. per acre, with a nitrogen content of 137 lbs. Cereal rye had an average dry matter biomass of 2,567 lbs. per acre with nitrogen content of 53 lbs. What's more, the biomass was not significantly different when FIXatioN was planted at a reduced seeding rate, which can further reduce costs. (Figure 4)

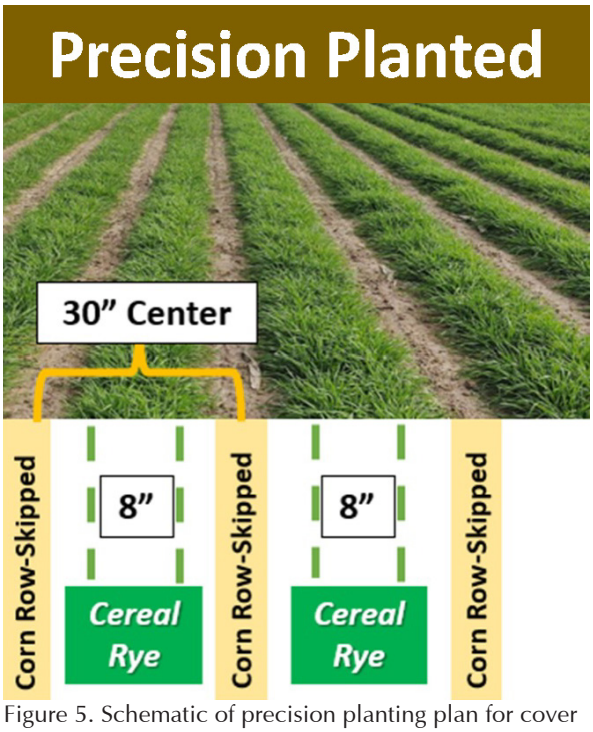


Figure 5. Schematic of precision planting plan for cover crops and corn on 30" centers.

Precision Planting: Enhancing Efficiency

Precision planting has been another crucial aspect of Dr. Armstrong's research. By planting cover crops in specific patterns to minimize competition with cash crops, farmers can improve both the biomass and nitrogen efficiency of their cover crops. (Figure 5) "Precision planting involves planting cover crops in strips with designated gaps for corn, which reduces negative reactions between the two when the corn seed is planted," Dr. Armstrong explained.

Figure 6. Growth state of FIXatioN Balansa Clover in southern Indiana, with attention to explosive growth through April, demonstrating why delaying termination increases benefits from increased biomass and N accumulation.

Precision planting was especially important in drought years. The gap row made it so the corn didn't compete with the cover crop for soil moisture. This allowed the clover to continue to put on biomass without depleting the soil moisture for the cash crop. (Figure 6)

"Ultimately, our goal is to make these practices the norm, benefiting both farmers and the environment," Dr. Armstrong stated. "There are long-term soil health benefits, protection from erosion, and a financial benefit. Farmers can spend less time and money for the same yield. Who wouldn't do it?"

Dr. Armstrong's research is not just about improving yields; it's about creating sustainable, economically viable farming practices. As he puts it, "The initial learning curve and investment can lead to substantial long-term benefits, both economically and environmentally. The inclusion of FIXatioN Balansa Clover could be vital in the production of low carbon intensity corn due to its ability to generate an N credit and its carbon capturing potential."

Dr. Armstrong measuring FIXatioN Balansa Clover biomass in Champagne County, IN on April 27, 2023.

Dr. Armstrong recognizes that there is still significant work to be done. His research has primarily focused on agricultural practices in southern Indiana, and is now expanding into northern climates, aiming to optimize planting dates for these regions. He emphasizes the importance of involving entomologists in his research to address pest management challenges.

Another critical aspect of his future research involves quantifying the balance of nitrogen loss in agricultural systems. While there is an understanding of nitrogen uptake from corn residue of balansa clover, further research is needed to comprehend gaseous nitrogen losses, quantifying when and how much loss occurs, and to develop strategies to manage these losses effectively.

Dr. Armstrong's research is sure to add valuable, practical knowledge to generations of farmers in the now and in the future, ensuring more sustainable, profitable, and productive agricultural practices.

Research Collaborators: Dr. Amir Sadeghpour, Southwestern University and Dr. Andrew Margenot, University of Illinois.

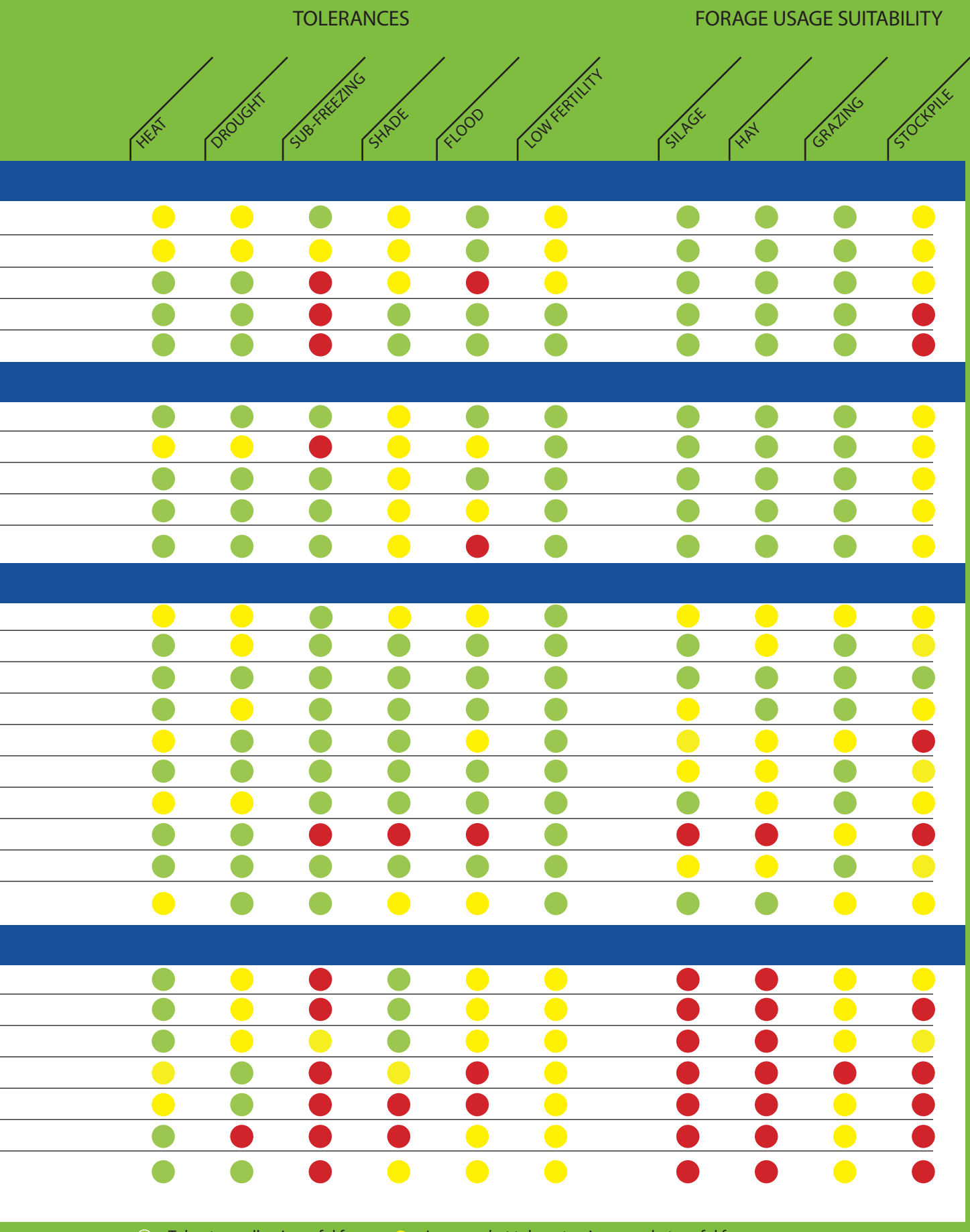
COVER CROP MORPHOLOGY

SPECIES/VARIETY	LIFESPAN	ROOT STRUCTURE-ROOT ELONGATION	C:N RATIO
GRASSES			
Lonestar Diploid Annual Ryegrass	A	FIBROUS - 🟡	25:1
Tetrastar Tetraploid Annual Ryegrass	A	FIBROUS - 🟢	25:1
Pearl Millet	A	FIBROUS	30:1
Sorghum-Sudangrass	A	FIBROUS	50:1
GRAINS			
Barley	A	FIBROUS	80:1
Oat	A	FIBROUS	70:1
Rye	A	FIBROUS	80:1
Triticale	A	FIBROUS	80:1
Wheat	A	FIBROUS	80:1
LEGUMES			
eNhance Persian Clover	A	TAP 🟡	15:1
FIXatioN Balansa Clover	A	TAP - 🟡	12:1
Frosty Berseem Clover	A	TAP - 🔴	17:1
Kentucky Pride Crimson Clover	A	TAP - 🟡	16:1
Hairy Vetch	A	TAP	12:1
AberLasting Kura x White Clover	Pw	RHIZOME - 🔴	15:1
Dynamite Red Clover	B/P	TAP - 🔴	20:1
Sunn Hemp	A	TAP	44:1
Domino White Clover	P	TAP	15:1
Survivor Winter Pea	A	FIBROUS 🟢	17:1
BRASSICAS & FORBS			
Driller Radish	A	TAP - 🟢	20:1
Carwoodii Radish	A	TAP - 🟢	20:1
Purple Top Turnips	A	TAP	20:1
Bio-fumigation Mustard Mix	A	TAP	20:1
Dwarf Essex Rape	A	TAP	20:1
Buckwheat	A	FIBROUS	18:1
Phacelia	A	FIBROUS - 🟢	15:1

Lifespan: A= Annual; B=Biennial; P=Perennial

○ = Fast to reach maximum root depth 🟡 = Average speed to reach maximum root depth

🔴 = Slow to reach maximum root depth



○ = Tolerates well or is useful for ● = Is somewhat tolerant or is somewhat useful for

● = Is not tolerant or should not be used for

COVER CROP USAGE

SPECIES/VARIETY	SEEDING DEPTH	POUNDS ACRE DRILLED**	POUNDS ACRE BROADCAST**	pH RANGE	SOIL TEXTURE GROUP
GRASSES					
Lonestar Diploid Annual Ryegrass	0.25″ – 0.50″	15–20	25–30	5.0 – 8.0	fine to medium
Tetrastar Tetraploid Annual Ryegrass	0.25″ –0.50″	15–20	25–30	5.0 – 8.0	fine to medium
Pearl Millet	0.50″–1″	20	30	5.5 – 7.5	fine to medium
Sorghum-Sudangrass	1″	35	50	6.0 – 8.5	all
Sudangrass	1″	35	50	6.0 – 8.5	all
GRAINS					
Barley	0.75″–1″	40–55	60–75	6.0 – 8.5	medium
Oat	0.75″–1″	40–55	60–75	4.5 – 8.0	all
Rye	0.75″–1″	40–55	60–75	5.0 – 7.0	medium
Triticale	0.75″–1″	40–55	60–75	5.0 – 7.0	medium
Wheat	0.75″–1″	40–55	60–75	5.0 – 7.0	medium
LEGUMES					
eNhance Persian Clover	0″ - .025″	5 - 8	8 - 10	5.0 – 8.0	all
FIXatioN Balansa Clover	0″ - .025″	5 - 8	8 - 10	4.5 - 8.5	fine to medium
Frosty Berseem Clover	0.25″ - 0.5″	15 - 20	20 - 25	5.0 - 7.8	fine to medium
Kentucky Pride Crimson Clover	0.25″ - 0.5″	15 - 20	20 - 25	4.8 - 8.2	fine to medium
Hairy Vetch	0.5″ - 0.75″	15 - 20	25 - 30	5.0 - 7.0	coarse to medium
AberLasting Kura x White Clover	0″ - 0.25″	3 - 5	7 - 10	5.5 - 7.5	fine to medium
Dynamite Red Clover	0.25″ - .05″	8 - 10	12 - 15	6.0 - 7.5	fine to medium
Sunn Hemp	0.75″	12 - 15	—	5.5 - 8.5	coarse to medium
Domino White Clover	0″ - 0.25″	4 - 5	8 - 10	5.8 - 7.8	fine to medium
Survivor Winter Pea	1″ - 1.5″	40 - 60	—	5.5 - 7.0	medium
BRASSICAS & FORBS					
Driller Radish	0.25″ - 0.5″	5 - 8	10 - 12	6.0 - 7.5	fine to medium
Carwoodii Radish	0.25″ - 0.5″	8 - 10	12 - 15	6.0 - 7.6	fine to medium
Purple Top Turnips	0.25″ - 0.5″	2 - 3	4 - 5	5.5 - 7.0	fine to medium
Bio-fumigation Mustard Mix	0.5″	5 - 8	10 - 12	5.5 - 8.0	fine to medium
Dwarf Essex Rape	0.5″	5 - 8	10 - 12	5.5 - 8.0	fine to medium
Buckwheat	0.5″	25 - 30	35 - 40	5.0 - 7.0	all
Phacelia	0.25″	5 - 7	8 - 10	6.5 - 7.8	fine to medium

* Denotes specific variety not tested but species is considered a poor host or non-host

** Recommended seeding rate should vary by seed size, with a target number of seed per given area

	NEMATODE RESISTANCE					USE BEFORE				
	COLUMBIA ROOT KNOT	NORTHERN ROOT KNOT	SOUTHERN ROOT KNOT	SOYBEAN CYST NEMATODE	SUGARBEET CYST NEMATODE	CORN	COTTON	RICE	SOYBEAN	WHEAT
		*								
		*								
				Non-Host						
				Non-Host						
				Non-Host						
					*					
Controls										

● = Is resistant or recommended ● = Is somewhat resistant or ok for use

● = Do Not Use for this purpose

Soil Health Assessments, Part 1: Comparisons

Healthy soil should be the consistency of chocolate cake.

Soil health is the continued capacity of the soil to function as a vital living ecosystem that sustains life. The principles of land management for soil health are maximizing living roots, keeping soil covered, increasing diversity, minimizing disturbance, and integrating livestock when possible.

The more we learn about soil, the clearer it becomes that it's the organisms living underground that control changes to the system. These principles help the soil organisms to maximize its capacity to cycle nutrients, infiltrate and hold water, resist erosion, provide healthy habitat, store carbon, and suppress pests and diseases.

Traditional soil tests are based on soil chemistry and soil physics. The results can help producers determine if they have nutrient limitations and how much fertilizer they should apply. Soil health tests are meant to evaluate how the soil's biology is influencing its chemical and physical characteristics, and its ability to function as a living system.

Soil health assessments add another layer to testing. They indicate changes in soil function influenced by land use and management practices.

Soils are highly variable because they develop in place, over time, due to the climate, organisms, landscape position, and the types of minerals they are derived from. This variation does not mean one soil is good or bad, but they will have different advantages and challenges. A soil in a hot dry desert does not have the same capacity to store carbon or hold water as a soil in a temperate wet prairie.

These differences in place-based soil characteristics are why comparative analysis is a key component in interpretation of soil health assessments. It helps to assess one field relative to another. This may be two neighboring fields with different management or the same field over time.

"Bookend samples" for each soil type you will be working with on your farm are recommended. The goal of bookend sampling is to find soil with the lowest and highest potential health you can expect.

To locate your "low bookend", find an area where the soil has never benefited from positive soil health practices. For the "high bookend", find an area that's had minimal disturbance and has grass or a mix of perennial plants covering the soil. It should be darker, soft to the touch, smell rich, and teem with life.

Send the two bookend samples along with your farmed ground samples on that same soil type to your chosen lab. Once assessed, compare the results of your farmed ground relative to the test results from your two bookends. This will show you how far you have come and have an idea of what your goal could be to maximize your soil's potential.

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LEGUMES

Legumes are essential in many cover crop systems because of their nitrogen-fixing abilities. Nitrogen is stored in their above ground biomass. When the biomass decomposes it enriches the soil and reduces the need for synthetic fertilizers. They can also enhance soil structure, promoting better water infiltration and aeration. Moreover, legumes act as dynamic accumulators, drawing up nutrients from deeper soil layers and the atmosphere, making them available for subsequent crops.

BALANSA CLOVER

Trifolium michelianum

Balansa clover is a legume used as a cover crop in agricultural systems. It's native to the Mediterranean region but has been widely introduced and cultivated in various regions worldwide.

Balansa clover is a low-growing, spreading plant, forming a dense mat of foliage close to the ground, assisting in weed suppression. It is adaptable to a wide range of soil types, and even standing water. It can also tolerate moderately acidic to alkaline soil pH levels.

Like other legumes, it has the ability to fix atmospheric nitrogen through a symbiotic relationship with nitrogen-fixing bacteria (rhizobia) present in its root nodules. This capability enhances soil fertility and reduces the need for synthetic nitrogen fertilizers in cropping systems.

FIXatioN Balansa Clover's massive biomass suppresses weeds and excels at nitrogen fixation.

FIXatioN Balansa Clover is tolerant of standing water and will continue to grow.

RECOMMENDED VARIETY

FIXatioN Balansa Clover has the only patented cold tolerant balansa genetics in the world. It represents a tremendous improvement over other varieties which are susceptible to frost. Potentially the most cold-tolerant annual clover in the world, FIXatioN has survived down to -5° F with no snow cover, and at -15° F with.

Thriving in challenging growing conditions, including waterlogged soils and pH's from 4.5-8.5, makes it more versatile than crimson clover. The hollow stem is ideal for crimping to terminate.

FIXatioN features as much as 200% more biomass than competing balansa varieties, storing a higher percentage of nitrogen in it's leaves. This makes it the #1 nitrogen fixing annual clover.

A C:N ratio of 12:1 allows rapid nutrient cycling which quickly benefits the following crop.

Key Benefits

BERSEEM CLOVER

Trifolium alexandrinum

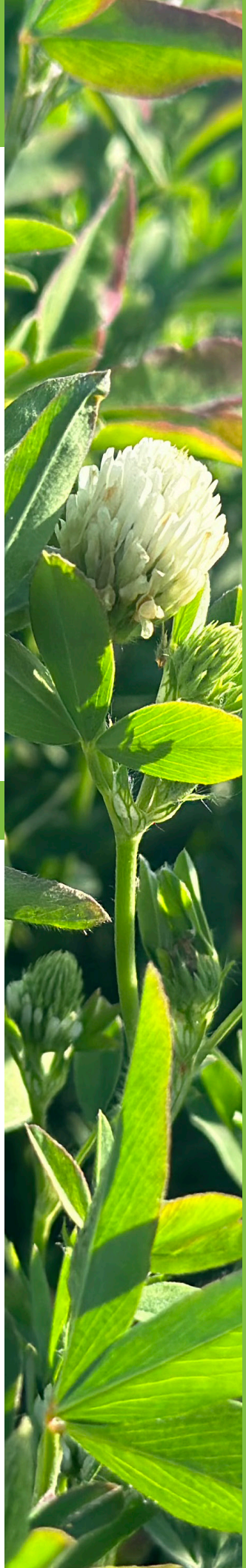
Berseem clover is valued for its versatility, adaptability, and multiple agronomic benefits, making it a popular choice for cover cropping, forage production, and soil improvement in various settings.

Well-adapted to a variety of soil types, beseem thrives in sandy, loamy, and clay soils. Historically, it prefers well-drained soils with a pH range of 5.8 to 7.8, tolerating slightly alkaline conditions. However, recent advancements in breeding have maximized it's potential.

Berseem clover produces ample, attractive flowers that are rich in nectar and pollen. These flowers are appealing to a variety of pollinators, including bees, butterflies, and other beneficial insects.

Frosty Berseem Clover's increased cold tolerance means big benefits for colder climates.

A non-bloating legume, Frosty Berseem Clover is suitible for all classes of livestock and wildlife.



RECOMMENDED VARIETY

FROSTY Berseem Clover

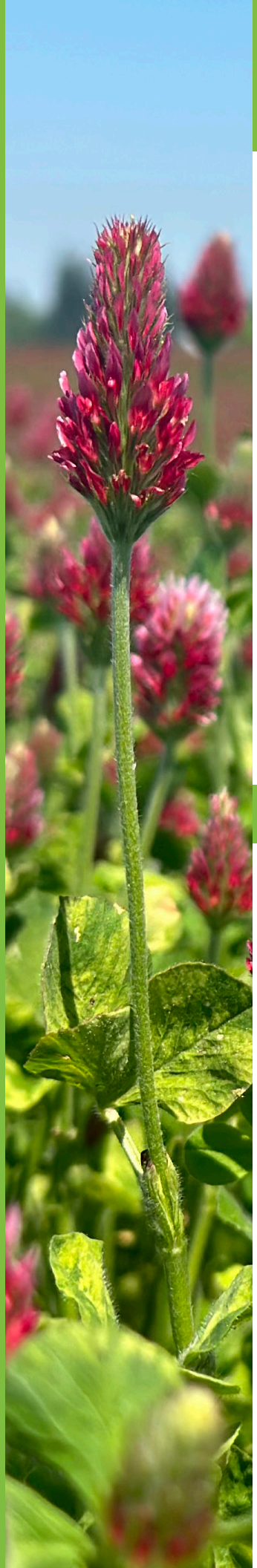
Thanks to the patented cold-tolerance of Frosty Berseem Clover, farmers in northern climates can now benefit from this powerhouse legume, which can survive down to 5° F with snow cover.

Frosty Berseem Clover is capable of producing large amounts nitrogen, reducing the need for synthetic fertilizer. It's aggressive root system pulls up additional nutrients from deep in the soil to make them available to the following crops.

As a grazed cover crop, Frosty is capable of creating up to 7,500 tons of highly nutritious, non-bloating dry biomass per acre.

Maturing later than other varieties provides a longer window for termination, making it a great choice for prevent planting.

Key Benefits



CRIMSON CLOVER

Trifolium incarnatum

Crimson clover serves as a valuable cover crop with numerous benefits for ecological systems. One of its primary advantages is as a natural weed suppressor, inhibiting the growth of unwanted plant species. Its dense growth habit and rapid establishment help smother weeds, reducing competition with cash crops.

Attracting beneficial insects, such as ladybugs, it can also help naturally control pest populations, reducing the need for chemical pesticides.

Its extensive root system improves soil structure, promoting better water infiltration and retention. Crimson clover is often utilized in crop rotation systems to replenish nitrogen levels through its ability to fix atmospheric N. This nitrogen enrichment enhances soil fertility, reducing the need for synthetic fertilizers in subsequent crops.

New genetics have improved root architecture to fix more nitrogen.

Advancements in breeding have increased cold tolerance in some varieties.

RECOMMENDED VARIETY

KENTUCKYPRIDE Crimson Clover

Kentucky Pride Crimson Clover is unique among other crimson varieties as it's extremely cold tolerant. Bred for more prostrate initied growth, the leaves and tillers initially grow lower to the ground giving it improved winter survivability.

With up to four times the biomass of Dixie Crimson Clover and 25% deeper roots, Kentucky Pride leads the way in crimson's ability to suppress weeds.

The plants above ground growth stores the majority of nitrogen it holds. Maturing two weeks later than other common varieties, Kentucky Pride has time to increase its biomass before flowering. This results in up to three times more N fixing opportunity than Dixie Crimson Clover.

If allowed to go to seed, this annual clover will reseed itself, making it an excellent addition to pastures, orchards, and vineyards.

Key Benefits

PERSIAN CLOVER

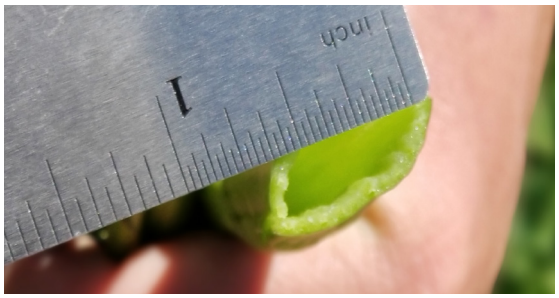
Trifolium resupinatum var Majus

Persian clover is a member of the legume family renowned for its adaptability to diverse climates and soil types. It's important to note that the Persian clovers that grow in the wild in the southeastern US states are not the same subspecies as "*var Majus*", which has a greatly different growth habit.

Recent genetic improvements in some breeding programs have produced a Persian clover that is exceptionally frost tolerant, later maturing, and has increased nitrogen fixing abilities.

The deep, fibrous roots penetrate compacted soil, enhance soil structure, and increase water infiltration and holding. The vibrant blossoms attract pollinators and wildlife equally with their sweet aroma.

Large leaves increase above ground biomass.



Hollow stems add to palatability and ease of termination.

RECOMMENDED VARIETY

eNhance PERSIAN CLOVER

eNhance Persian Clover is the only Persian clover bred with the ability to withstand temperatures as low as -15° F with snow cover.

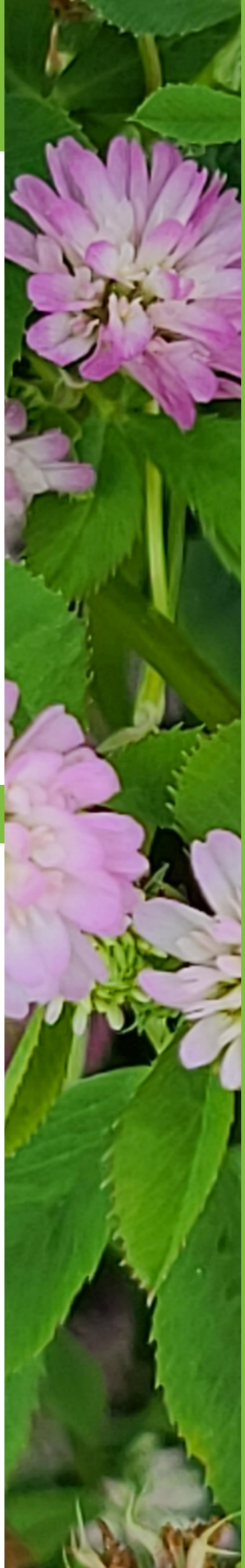
It has rapid stem elongation allowing it to "keep up" in a diverse blend. It can tolerate sandy soils, standing water for short amounts of time, and soil pH between 5.0-8.0.

Advanced seedling vigor allows eNhance to establish at a similar rate as cereal rye.

This variety has a large, hollow stem which adds to the palatability for livestock and wildlife, and lends to easy termination.

Additionally, eNhance Persian Clover can fix up to 150 lbs of nitrogen per acre, making it an excellent addition to any cover crop mixture.

Key Benefits



WINTER PEA

Pisum sativum

Winter peas provide multiple benefits as an additional crop rotation. They excel at nitrogen fixation, reducing the need for synthetic fertilizers while improving soil fertility.

The dense foliage acts as a protective layer, preventing erosion, reducing soil temperature and evaporation, while suppressing weeds. This natural weed control lessens the need for herbicides, fostering environmentally sustainable farming practices and reducing chemical input costs.

Winter pea's deep root system enhances soil structure. By maintaining soil structure and moisture levels, they create a conducive environment for subsequent crops, promoting healthier root development and potential for improved yields of the cash crop.

Survivor Winter Peas provide a habitat and food source for beneficial insects.

The dense foliage of Survivor Winter Pea shades out weeds, inhibiting their establishment.

RECOMMENDED VARIETY

SURVIVOR
Cold Tolerant Winter Pea

Survivor Winter Pea was bred for increased cold tolerance and early spring green-up, out performing other common winter pea varieties.

It's quick establishment acts as a natural weed suppressant while sending roots deep down into the soil to improve water infiltration and holding capacity.

An impressive nitrogen producer, up to 200 lbs per acre, and a low C:N ratio of 17:1, Survivor Winter Peas are quick to recycle their nutrients and organic matter to increase overall nitrogen availability.

The viney plants grow thin, hollow stems that reach to 4' long and have curled tendrils that are able to climb nurse crops.

By providing a habitat and food source for beneficial insects, winter peas can contribute to natural pest control and enhance the overall biodiversity of agricultural ecosystems.

Key Benefits

HAIRY VETCH

Vicia villosa

Hairy vetch establishes a dense mat of vegetation, suppressing weed growth and erosion while improving soil structure through its extensive root system.

It attracts pollinators and enhances soil microbial activity, fostering a healthier soil ecosystem. It can thrive in diverse climates and soil conditions making it a valuable asset for farmers.

Its dense foliage acts as a natural mulch, conserving soil moisture and moderating soil temperature, especially beneficial during periods of drought or extreme weather events. Hairy vetch protects soil from nutrient leaching and erosion during fallow periods, contributing to long-term soil conservation efforts.

Hairy vetch is an excellent pollinator attractant.

The hairy vetch vines grow and climb with ease.

CARBON = WATER

Carbon increases soil's water holding capacity. Carbon makes up approximately 50% of your soil's organic matter. Each percentage of organic matter represents nearly 30,000 gallons of water holding capacity per acre.

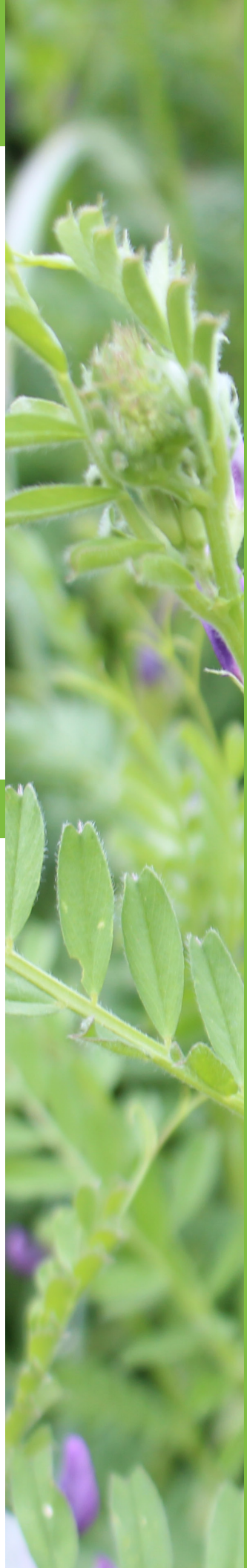
Soil health practices can both increase a soil's ability to hold water and a soil's ability to drain water. This is due to the formation of soil aggregates and pores (void spaces) of various sizes.

Small-sized pores hold water tightly and keep it in the system. Large pores allow water (as well as gas and organisms) to move more freely through the soil.

Cover crops increase carbon inputs, food for the organisms, that then build stable aggregates.

Therefore, increasing soil carbon increases water drainage and water holding capacity.

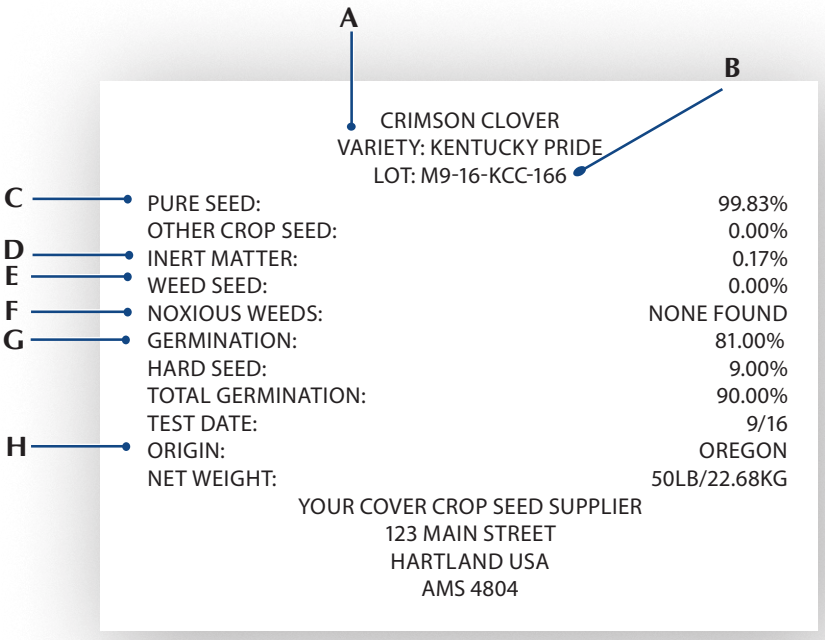
Photos are from the same farm on the same day after a heavy April rain. Above: perennial grassland. Below: wheat fallow system.



KNOW YOUR SEED

Purchasing seed that has been tested and labeled in accordance with the Federal Seed Act is crucial for ensuring the quality and authenticity of the seed you're buying. This act mandates that any seed sold for commercial use must be tested for purity, germination rates, and the presence of noxious weeds. The seed labels must accurately reflect these test results, providing buyers with essential information to make informed decisions.

Avoid bin-run or unlabeled seed, as it bypasses required testing and you have no guarantee of what you're actually getting. Adding unlabeled seed to your system can have long term consequences such as introducing new weeds, increasing negative pests and disease, or poor germination.



Coated and raw, Kentucky Pride Crimson Clover seed.

A - VARIETY: Indicates the type of seed along with the name of the genetic variety. If the variety is not known, or it's open-source material, it will be listed as VNS (Variety Not Stated or Variety Unknown). VNS varieties are unreliable as performance is unknown

B - LOT: A unique number used to track a specific batch or quantity

C - PURE SEED: Indicates, by weight, the percentage of the seed ingredient listed

D - INERT MATTER: The content of material that is not seed weight such as chaff or stems

E - WEED SEED: The amount of weed seeds present

F - NOXIOUS WEEDS: Indicates, by weight, the number and kinds of weeds per pound that must be identified and listed by name, unique to each state and country

G - GERMINATION: The percentage of seed that will germinate for each ingredient (refer to the "Test Date" to see how current the information is). Germination may include a hard seed count which adds to the overall germination total

H - ORIGIN: Indicates where the seed was produced

UNLOCKING THE POWER OF LEGUMES

It's widely known that legumes have a symbiotic relationship with soil bacteria, known as rhizobia. When clover seeds germinate, their roots release compounds that attract and allow infection by rhizobium bacteria. Each legume species can associate with several different rhizobia, but not all rhizobia fix nitrogen at the same rate. To get optimal nitrogen additions, they must be properly inoculated with specie specific rhizobia.

The rhizobia enter the root hairs. In response, the plant forms small nodules along its roots to house the bacteria. These nodules act as tiny nitrogen-fixing factories. The root nodules persist for the legume's lifetime, transforming atmospheric nitrogen to plant available nitrogen while the plant is actively growing and photosynthesizing. The plant stores this nitrogen in the above-ground plant biomass. The greater the biomass, the greater the nitrogen stored. Some species can store more nitrogen in a pound of biomass than others. When the legume dies or is terminated, the plant biomass is decomposed by soil microbes, releasing the nitrogen fixed by the rhizobia into the soil for use by subsequent crops.

Nitrogen fixing nodules on FIXatioN Balansa Clover.

Professor Dr. John Jennings of the University of Arkansas System Division of Agriculture, Little Rock writes, "Most of the N is found in the top growth of the plant with a smaller amount in the crown, roots and nodules. Estimates for perennial legumes show that about 75-80% of the plant's N content is in the top growth. Texas A&M research showed that in crimson clover (a winter annual clover) about 90% of the total N was in the top growth and only 10% in the roots."*

Understanding that a significant portion of the fixed nitrogen is transported up into the clover's above-ground biomass - the stems, leaves, and flowers, gives us a greater understanding of how to maximize N from the cover crop. FIXatioN Balansa Clover, Frosty Berseem Clover, eNhance Persian Clover, and Survivor Winter Pea are known for substantial nitrogen additions because of their abundant leafy growth.

The stored nitrogen stays trapped until the clover begins to decompose after termination. To capture the maximum nitrogen contribution from the above-ground growth, terminate annual legumes at bloom stage. As the plant matter breaks down, it will slowly release the sequestered nitrogen for use by your subsequent crop.

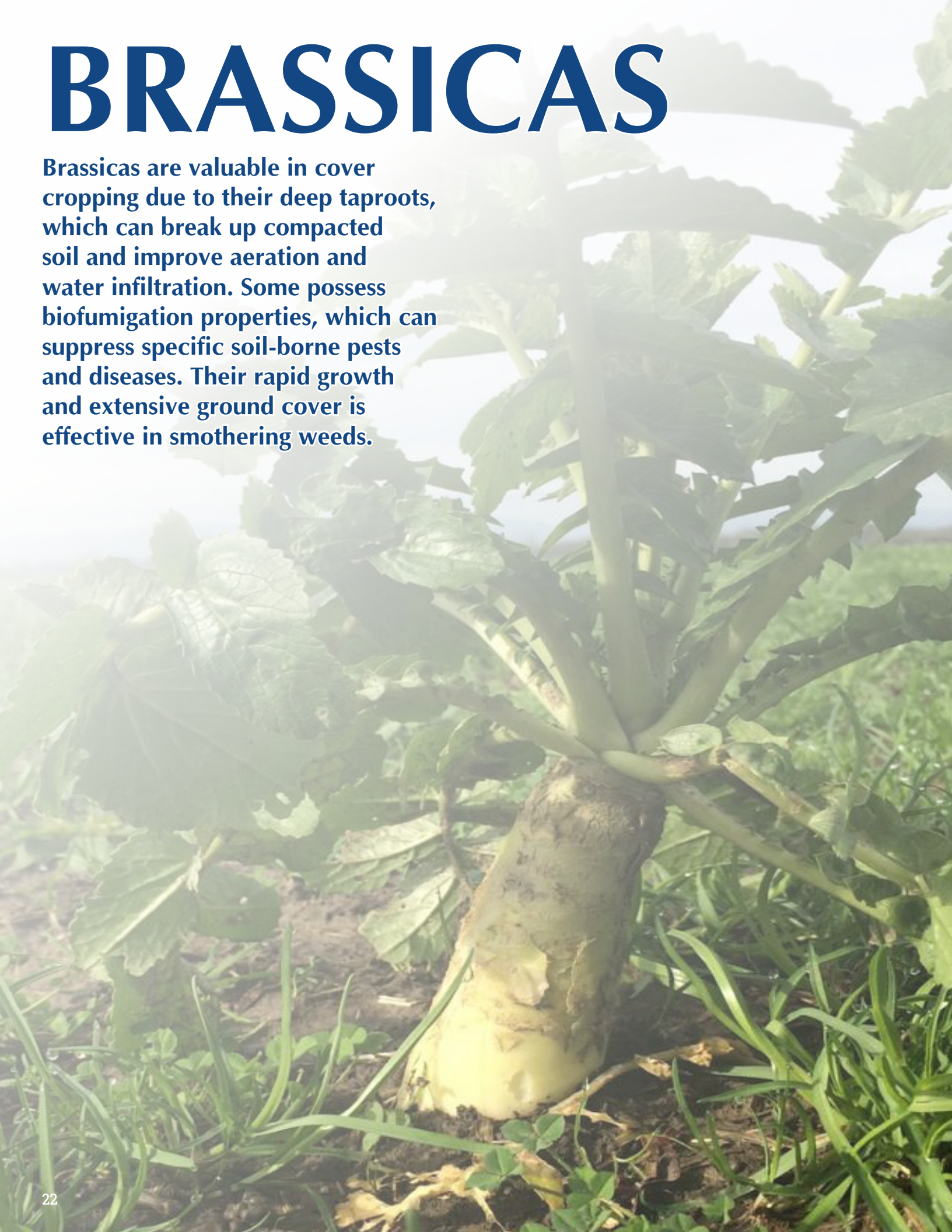
Removing the above ground biomass of the legume cover crop for hay or silage will reduce a significant amount of nitrogen that the cover crop could have fixed. Leaving the residue and planting green into it could maximize the benefits to your cash crop. Dr. Jenning's notes, "To release the fixed N in clovers for use by other forages, the topgrowth must be recycled through grazing animals or through plant decomposition. When hay is harvested, most of the N is removed from the field."

With proper management, legumes can be excellent nitrogen sources and extremely beneficial cover crops for improving soil fertility in your cropping systems.

* Jennings, J. (n.d.). Value of nitrogen fixation from clovers and other legumes (FSA2160). University of Arkansas Division of Agriculture Cooperative Extension Service.

BRASSICAS

Brassicas are valuable in cover cropping due to their deep taproots, which can break up compacted soil and improve aeration and water infiltration. Some possess biofumigation properties, which can suppress specific soil-borne pests and diseases. Their rapid growth and extensive ground cover is effective in smothering weeds.



DAIKON RADISH

Raphanus sativus

Daikon radish is known for its large, elongated white root, which can push through soil hardpans. It has been known as a "tillage radish" because it can penetrate compacted soil layers, break up hard-pans, and improve soil structure. This helps to enhance soil aeration, water infiltration, and root penetration for subsequent crops.

It's vigorous growth provides excellent ground cover, reducing soil erosion caused by wind and water. It scavenges nutrients from the soil, particularly N, P, and K, which it stores in its roots and foliage. As it decomposes, these nutrients are released back into the soil, enriching it and providing fertility.

The dense canopy formed by daikon radish foliage can reduce the need for herbicides by shading the soil thus suppressing weed growth and competition.

The easy to manage Driller Daikon Radish provides both environmental and financial benefits.

The canopy of Driller Radish reduces herbicides needed by shading the soil and suppressing weeds.

RECOMMENDED VARIETY

DRILLER
DAIKON TYPE RADISH

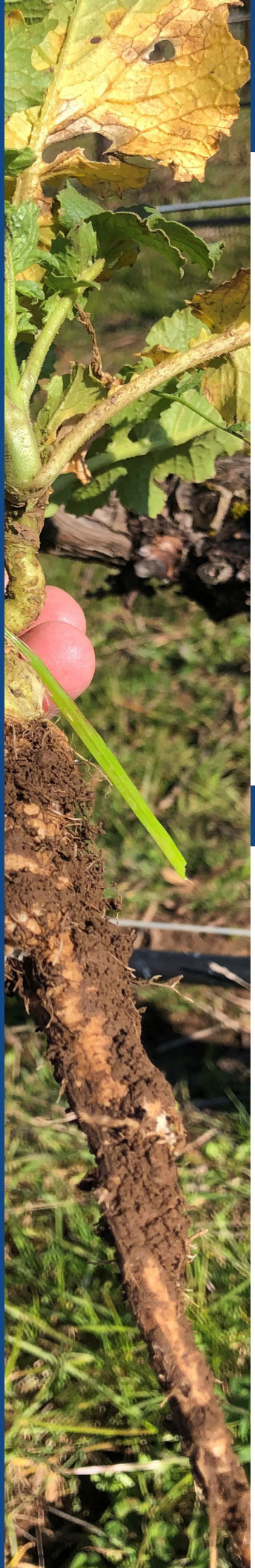
Driller Radish (daikon type) is quick to establish and generates large amounts of biomass, both above and below ground. It was bred for an enormous taproot, which can reach depths of 30 inches or more.

When Driller's taproot hits a soil compaction zone, it "bio-drills" through and opens up the soil for increased water infiltration, root channels, and air.

Driller Radish is an excellent catch crop, especially in its ability to capture nitrogen. As it decays, microbial activity increases in the soil. This decaying organic matter provides food for earthworms, fungus, and microbes. As the organisms cycle the nutrients mined from below, they are returned to the soil and become available to the subsequent crop.

Driller Radish (daikon type) will winterkill when temperatures drop into the low 20°'s F.

Key Benefits



NEMATODE CONTROL RADISH

Raphanus sativus

A nematode controlling radish, also known as a nematicidal radish, refers to certain cultivars of radish that possess properties capable of controlling specific nematode populations in the soil.

These radish varieties are bred or selected for their ability to suppress specific nematodes, which are microscopic roundworms, that can be detrimental to plant health and productivity. This suppression may involve affecting nematode mobility, interfering with their ability to feed, or even causing mortality in some cases.

Care should be taken when selecting a nematode controlling radish as some can actually act as hosts and increase the undesirable nematode population.

Carwoodi Nematode Control Radish has branching taproots.

The dense canopy of Carwoodi Nematode Control Radish can assist with weed suppression.

RECOMMENDED VARIETY

CARWOODI
Nematode Control Radish

Nematode controlling radish are bred to provide maximum control for targeted species of nematodes. Carwoodi is effective at controlling Columbia, Northern, and Southern Root Knot nematodes.

Carwoodi Nematode Control Radish releases a biochemical from its roots that stimulates cyst nematode eggs to hatch prematurely. The nematodes then attach to the radish root but are unable to adequately feed. Because the radish does not provide the nutrition they need, the nematodes either die or do not reproduce.

It is critical that nematode controlling radishes are not planted in mixes with species that are known or suspected of being a nematode host.

Carwoodi's branching taproot is also effective for breaking up soil compaction.

Key Benefits

WHITE MUSTARD

Brassica alba or Sinapis alba

White mustard has several environmental benefits. Biofumigant properties in some varieties can suppress soil-born pathogens and pests, potentially reducing the need for chemical pesticides.

White mustard can improve fertility by producing a large amount of biomass per acre and scavenging nitrogen and sulfer from the soil.

It also suppresses weeds by shading them out and producing chemicals that act against weeds and pests.

With roots reaching a depth up to 6' deep, white mustard improves water management by improving infiltration and moisture holding ability of the soil.

It is sensitive to cold temperatures and winter-kills at about 25° F.

Later maturing varieties are the easiest to manage as it delays going to seed.

DWARF ESSEX RAPE

Brassica Napus

Dwarf Essex Rape is a specific variety of oilseed rape that has been used as a cover crop and forage for over a century.

As its name suggests, it is characterized by its compact, low-growing stature compared to traditional oilseed rape varieties. Dwarf Essex Rape offers rapid establishment, dense foliage, and deep root penetration.

A palatable, high-energy and protein forage crop, it can be used for winter grazing by livestock and deer.

Its canopy shades the soil, reducing moisture loss and inhibiting weed growth, making it effective for weed suppression.

The powerful fibrous roots break through hard-pans to enhance soil structure, water infiltration, and erosion control.

Like some other brassica cover crops, it exhibits biofumigation properties that can help suppress some pests and disease.

Dr. Josh White:
Getting the Most from Legume Cover Crops

For the past six years, Dr. Josh White and his team at the Forage Variety Testing Program at Mississippi State University have been conducting cover crop research trials. Their efforts have included estimating nitrogen availability of different species and different varieties of cover crops, their forage quality, and the long-term benefits of cover crops. These trials which are open to seed company participation, aim to foster the adoption of cover crops in the southeastern US.

The Importance of Timing

One of the critical findings from Dr. White's initial studies (2019-2021) is the significance of cover crop termination dates. "Delaying termination until at least April 15th is crucial for economical biomass production of legumes in Mississippi," Dr. White explained. Some of the legumes more than doubled their biomass in just 15 days. However, many corn producers in Mississippi terminate their cover crops around March 15, limiting the cover crops' potential N contribution to the following cash crop.

Allowing the cover crop to grow to bloom stage maximizes the N in legume biomass which is then made available to the next crop by soil microbes, reducing the need for synthetic fertilizers. (Table 1)

Cash crop planting dates, often more cultural than necessity-driven, also play a crucial role in cover crop success. April 1st marks the period when clovers start growing vigorously in a typical year in Mississippi. "Farmers need to produce enough clover biomass to justify seed costs and reduce synthetic nitrogen and herbicide needs," Dr. White stated. Waiting to terminate cover crops until April 15th is essential to reap these benefits. He added, "Delaying termination enables a higher rate of nitrogen cycling and long-term soil health improvements."

Species and Variety Differences

Dr. White's research has also uncovered significant differences between species and varieties of cover crops. "Within clovers, there are substantial maturity differences between varieties," he noted.

Table 12. Dry matter yields of cover crop varieties at three termination dates in Newton.

Variety	Species	March 15 termination	April 1 termination	April 15 termination
		lb/A	*lb/A*	*lb/A*
Vivant	Turnip	1846	1478	2456
Jackpot	Turnip	404	938	2046
Aerifi	Radish	256	256	389
Fixation	Balansa C.	981	2170	2711
Frosty	Berseem C.	1222	2950	3736
Enhance	Persian C.	563	1357	3112
Driller	Radish	115	130	315
Survivor	Winter Pea	1084	1457	2557
Dynamite	Red C.	656	1696	3194
Q	Red C.	749	1573	3930
Purple Top	Turnip	955	1406	2886
Essex Rape	Rape	419	948	1646
Mean		771	1363	2415
LSD (0.05)		585	943	1587
CV		40	39	38

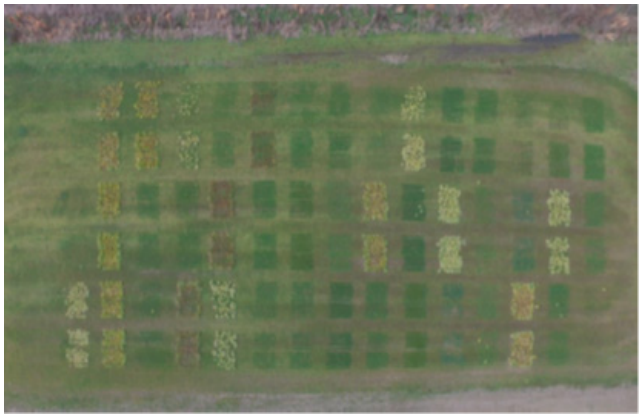
Planted: 10/7/20
Soil: Prentiss Sandy Loam
Cereal rye was not planted at Newton due to lack of seed to plant all replications.

Table 1. Dry matter yields of cover crop varieties by termination date, used with permission from Dr. White in the Mississippi Cover Crop Variety Trials, 2021. Note, legumes terminated on March 15 have sizably less biomass compared to April 15 termination.

Later maturing varieties like eNhance Persian Clover, Frosty Berseem, and FIXatioN Balansa Clover offer higher forage quality and lower lignin content compared to earlier maturing varieties. "Since biomass correlates with nitrogen storage, later-maturing varieties provide more opportunity to put on growth, potentially increasing sequestered N. We continue to study the timing and availability of this nitrogen to help farmers reduce input costs," Dr. White emphasized. "There is also potential to use these cover crops as hay or grazing before termination. I'm a big fan of the low-bloat potential of Frosty Berseem Clover hay, and it regrows so quickly that it returns to its pre-hay harvest state within 15 days."

Long-Term Trials and Soil Health

In another trial, Dr. White's team uses a repeated measure experimental design system, maintaining the same cover crop variety over three years, followed by corn. "This approach will help us understand how the soil microbiome changes with consistent cover crop usage," Dr. White explained. The trial aims to determine whether rotating cover crops annually or maintaining the same cover crop over time is more beneficial for soil health, microbial community shift, and cash crop yield. He adds, "There is evidence, that despite observing limited corn yield improvement on poorer soils, there is a definite shift in the microbial population under different cover crop inclusions. This shift may eventually lead to more available N for the cash crop over time."



Cover crop treatments (above) followed by corn (below) at Mississippi State University.

Additional Benefits of Cover Crops

Beyond nitrogen supply, cover crops offer numerous benefits, including potential to reduce herbicide usage, improved water infiltration, increased carbon sequestration, and moderating soil temperature and water evaporation. Dr. White encourages farmers to view cover crops as a long-term investment. "It may take a couple of years to see significant improvements, the benefits—such as healthier soil, reduced input costs, and potential additional income from hay crops—are considerable," he said. It's important that producers recognize that the financial and environmental advantages accrue over time.

Conclusion

Dr. Josh White's insights and research underscore the importance of thoughtful cover crop management for regenerative agriculture. By considering factors like termination dates, species and variety differences, and long-term soil health benefits, farmers can make informed decisions that enhance their productivity and sustainability.

Dr. White at Mississippi trial plots.

Soil Health Assessments, Part 2: Indicators

The choice of soil health indicators depends on the information needed and how it will be used. This may vary based on your level of experience, specific questions, or production challenges.

At a minimum, it's recommended to measure soil organic carbon, CO2 burst, and aggregate stability. This recommendation aligns with the recently published works from the Soil Health Institute's North American Project to Evaluate Soil Health Measurements.

The *soil organic carbon* test measures the total feed potentially available to the microbes, the *CO2 burst* indicates if the microbes are using the carbon, and *aggregate stability* indicates whether they are building structural diversity and resilience out of that carbon. This minimum suite of soil health measurements, compared to your bookend samples, will demonstrate whether a soil is moving toward regeneration generally.

Soil Organic Carbon (SOC)
Many soil organisms are heterotrophic, which means they get their energy and food from consuming organic materials. Without carbon they don't have the building materials to make new cells or the energy for carrying out all processes, functions, and ecosystem services that happen in the soil. Think of soil organic carbon representing all the fuel (microbial food) that could possibly be used to power the system. It's important to get carbon back into the soil so microbes can function, thereby allowing producers to reduce inputs and increase profits.

A dry combustion test is the most accurate method but if your soil lab doesn't have this ability, most labs can measure "organic matter (OM) by loss on ignition," which will provide nearly the same result. About 50% of organic matter in the soil is carbon so you can convert results from OM to SOC. Soil organic carbon comes in many forms and it should cycle in and out of the system, being broken down and built back up.

CO2 Burst Test
Heterotrophic microbes breathe out CO2 as a byproduct of their metabolism, just like humans. To get an indication of microbial activity in your soil, your lab can use an incubation called a "CO2 burst test" (also called potential carbon mineralization or respiration). The CO2 burst test involves wetting a dry soil sample which triggers a burst of carbon dioxide that is measured over 24 hours. Not all the carbon coming from this test is a direct result of immediate microbial activity, but it's highly indicative of the activity level and microbial biomass in the soil.

FAQ: "Wait, why is a high CO2 respiration rate a good thing, I thought this was all about keeping carbon in the soil?"

Farmer's need to add carbon to their system so that organisms can perform healthy functions. A highly active microbial community in the soil often emits more carbon than a low activity soil. However, while the organisms are using carbon, they are also gluing particles together, opening pore spaces, and cycling nutrients. As they

Taking soil samples with a probe.

do this, some carbon gets stuck between mineral particles and can stay for a long time.

Additionally, by restoring soil functions, the fuel and chemical use needed to produce a healthy crop can be reduced, further improving a host of environmental conditions.

High CO2 from lab incubation is indicative of highly active microbes, indicating healthy soil function. Highly functional soils use and trap carbon, and soil with high carbon creates a positive feedback cycle that subsequently needs less inputs. A high CO2 burst can mean higher profits.

Carbon within the soil is constantly transforming, moving in and out of the system. The goal is to add more carbon to the system than is lost, thereby regenerating the health of the system. The CO2 burst test is highly responsive to farming practices and gives an early indication that your soil organisms are at work.

Aggregate Stability

Aggregates are groups of sand, silt, and clay sized particles stuck together through chemical attraction and organic binding agents. They can be root hairs or fungi that are physically gathering soil particles, or bacterial exudates, and gluing them together. This creates void spaces called "pores" which provide habitat, a place for water to move into and through, and space for gases and nutrients to be exchanged. Highly stable aggregates are often found in soils with high organic carbon, ample roots, and many kinds of biological organisms, each doing their part to build their homes.

Aggregate stability epitomizes the usefulness of a soil health test because it's a physical measurement, influenced by soil chemistry, and varies based on many levels of biological interactions. It's related to the soil functions of erosion resistance, water infiltration and holding, greenhouse gas regulation, and habitat diversity. It is highly recommended for any soil health assessment. This test has often been cost prohibitive but check with your lab to see if they can do the "SLAKES" test. It is quick and easy, and if your lab can't do it, you can download the app and do it yourself.*

When interpreting the results of soil health assessments the tests are often considered to be in the "more is better" category. This simply means high numerical values are better. There is a considerable effort to catalog, baseline-bookend samples throughout the US for various soil and climate zones. Until this catalog, or soil health atlas is readily available, continue to use your own bookend samples to interpret these soil health indicators.

*App developed by The Soil Health Institute and The University of Sydney.

Cont. on Page 38

GRASSES

Grass in cover crops contribute to soil stability by holding it in place with their dense root systems. They also enhance biodiversity, providing habitat for beneficial insects and microorganisms. Moreover, grasses demonstrate a great ability to increase soil organic carbon, providing essential feedstock needed for a thriving microbial community and climate resilience.

CEREAL RYE

Secale cereal

Cereal rye is often planted late in the fall and provides winter cover, which helps protect the soil during periods of heavy rainfall or snow-melt.

Its extensive root system can penetrate compacted soils, improving soil aeration and water infiltration. Additionally, cereal rye is known for its allelopathic properties, where it releases chemicals that inhibit the growth of competing weeds and other plants.

Cereal rye is characterized by its rapid growth, winter hardiness, and ability to tolerate various soil conditions. Once established, It can thrive in both temperate and Mediterranean climates and is tolerant of drought conditions. Cereal rye has a remarkable ability to scavenge and hold onto nitrogen, preventing it from leaching into groundwater.

Cereal rye can help to increase soil organic carbon.

TRITICALE

X Triticosecale

Triticale is a hybrid grain crop derived from crossing wheat and rye. It combines the beneficial characteristics of both parent species, exhibiting rapid growth, strong root development, and excellent winter hardiness.

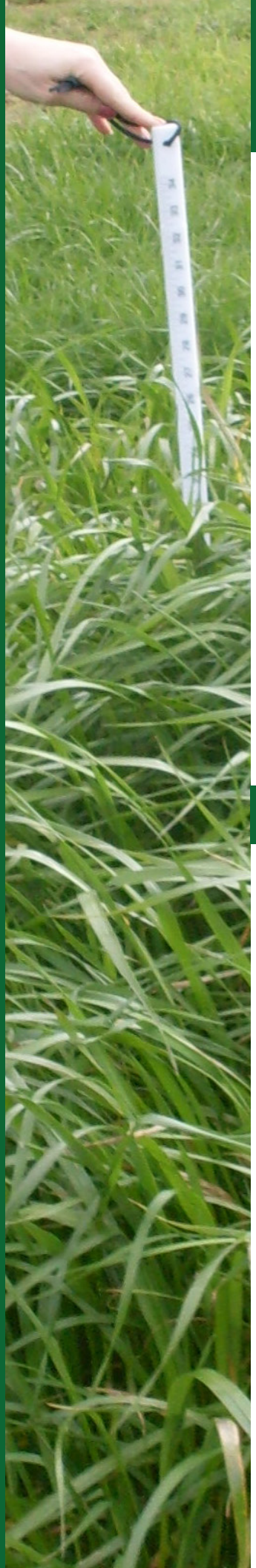
Triticale's robust root system helps prevent soil erosion, improves soil structure, and enhances water infiltration. Additionally, triticale can scavenge excess nutrients from the soil, helping to mitigate nutrient runoff.

Triticale can contribute to healthier soil and reduce the risk of disease buildup in crop rotations.

Its dense canopy suppresses weed growth, providing effective weed control throughout the growing season.

Triticale can function as both a fall-planted cover crop and a spring-planted cover crop, offering flexibility in rotations.

It can be grazed during the fall and winter months, providing supplemental feed while still providing the benefits of a cover crop.



ANNUAL RYEGRASS

Lolium multiflorum

When considering using annual ryegrass for cover cropping, identify your goals, then choose between a diploid or tetraploid. Diploid ryegrass has two sets of chromosomes per cell, while tetraploid ryegrass has four, thus changing their growth habits, palatability, and resilience. Both are excellent nutrient scavengers, with a dense, deep root structure that can thrive even in low pH environments.

Diploid ryegrasses have smaller seeds and plant features, leading to a denser stand that is more competitive with weeds and can handle wetter conditions.

Tetraploid ryegrass seeds are larger and heavier, which helps them germinate more quickly and have success when overseeding. They have wide, upright leaves and are less suitable to coarse soils. Tetraploids are more sensitive to cold temperatures than diploids.

Lonestar Annual Ryegrass provides dense ground cover, choking out weed competition.

Tetrastar Annual Ryegrass is high in Water Soluble Carbohydrates (WSC) making it very palatable.

RECOMMENDED VARIETY

ANNUAL RYEGRASS LONESTAR SUPERIOR FORAGE

Lonestar is a diploid annual ryegrass bred for greater cold tolerance which provides a wider opportunity for use as a cover crop.

It has increased germination speed, strong disease resistance, and superior erosion control from both wind and rain events.

Lonestar's impressive root system can scavenge nitrogen, phosphorous, and other beneficial minerals from deep in the soil, preventing leaching into waterways.

TETRASTAR
TETRAPLOID ANNUAL RYEGRASS

As a tetraploid annual ryegrass, Tetrastar has excellent seedling vigor, resulting in quick growth.

It can be used as a companion with legumes, acting as a nurse crop, protecting them from extreme weather.

Tetrastar is an effective catch crop and it's extensive root system works to reduce soil erosion, while breaking up compacted soils.

It's valuable forage during winter months for livestock and deer.

TURF GRASS

Turf serves as a resilient perennial cover crop, offering multifaceted benefits to vineyards, orchards, berries, and drive-rows.

Dense root systems effectively anchor soil, curbing erosion and enhancing soil structure and fertility through aeration and organic matter decomposition. This makes turf an excellent option for high-traffic areas that see repeated passes of heavy equipment.

Turf acts as a natural weed suppressant, minimizing the need for herbicides and manual weeding while providing a lush, green aesthetic that enhances outdoor spaces.

Additionally, its ability to absorb storm water mitigates runoff, aids in temperature regulation, and supports biodiversity by offering habitat and food for various beneficial insects.

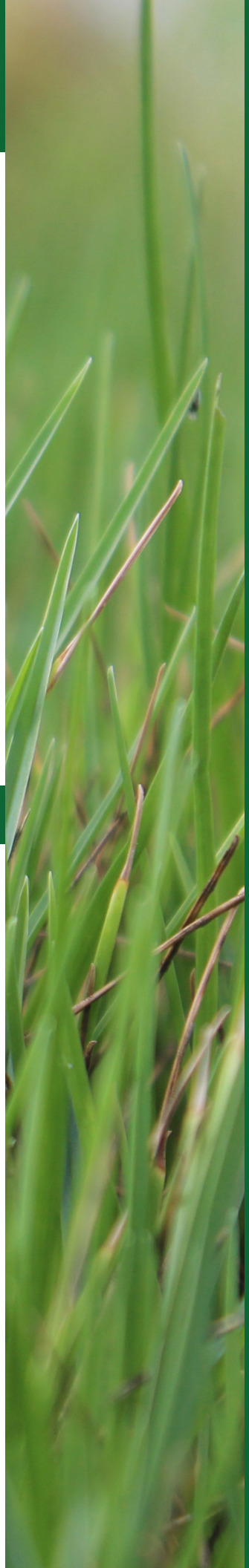
Turf is a versatile and sustainable choice for diverse landscapes, where it contributes to improved air quality, noise reduction, and overall environmental health. It is insufficient for grazing animals and should not be used as fodder.

RECOMMENDED TYPES

Turf Perennial Ryegrass has a dense, fibrous root system that helps to stabilize soil, preventing erosion, especially on sloped terrain or in areas prone to heavy rainfall. It forms a thick, competitive turf that shades the soil surface, inhibiting the germination and growth of weeds.

Turf Tall Fescue is known for its deep root system, which allows it to access water from deeper soil layers during dry periods. This drought tolerance makes it an excellent choice for areas with limited irrigation or in regions prone to periodic water scarcity. Once established, it exhibits good resilience to heavy traffic and machinery, making it suitable runways, vineyards, drive-rows, and roadside verges.

Turf Kentucky Bluegrass forms a dense, lush turf that provides excellent ground cover and erosion control. This makes it particularly suitable for use on slopes, banks, and other areas vulnerable to soil movement. Kentucky bluegrass will go dormant in cold temperatures, but will green up as spring brings warmer weather.



FARMING FOR PROFIT

Rick Clark, Farm Green

As a 5th generation farmer from Williamsport, Indiana, I've seen firsthand how industrial farming techniques can degrade the soil over decades and the cost of trying to mimic a healthy soil with fertilizer, pesticides, and herbicides. My 7,000-acre farm had been tilled extensively with heavy input applications since the 1880s. But about 15 years ago I was driven by the need to defend my soil from erosion. I decided to make a radical change towards regenerative practices.

Soil teeming with life.

The core principles driving my transformations are: minimize disturbance to the soil, avoid chemicals, maximize diversity of plant life, keep living roots in the ground as many days as possible, armor the soil with cover crops, adapt practices to the unique context of your land, integrate livestock when possible, and stay committed through the transition.

It hasn't been easy, but the results speak for themselves. My soil has shifted to a fungal-dominated system with extensive networks of arbuscular mycorrhizal fungi - the communication backbone for the entire soil microbial biome. The earthworm counts, nutrient availability, water infiltration rates, and aggregate stability have all dramatically improved.

Diversity is key to building soil health. I plant multiple species of cover crops like cereal rye, winter peas, grasses, brassicas, and clover to feed the diverse microbial communities. I've even started planting multiple cash crops together in the same fields. The diversity above ground feeds the diversity below ground.

Instead of fighting Mother Nature with intensive tillage and chemicals, I work with her. I've eliminated synthetic fertilizers by growing nitrogen-fixing legume mixtures and relying on the nutrient cycles, and I've cut herbicides by planting cereal rye mixtures to suppress weeds.

This transition challenged me to be flexible, patient, and open to constant learning and adjustments. There were years I had to sacrifice some yield to build long-term soil health. But the financial payoff has been worth it - my profits have increased as I've completely removed expensive inputs from my system.

"If you are not uncomfortable with what you are doing, then you are not trying hard enough to change."

In my land cover cropped with cereal rye and FIXatioN Balansa Clover I took 2x2' samples of the above ground biomass and sent it to the lab to analyze its nutrients on three different dates in the spring.

I was blown away to see how the nitrogen content had doubled with the clover from June 4 to June 8! By letting it grow just four more days, the cover crop biomass was able to put on an additional 140 lbs of nitrogen, 40 lbs

phosphorus, and over 200 lbs of potassium. That translated to roughly $595 worth of nutrients. I reduced my fertilizer bill and now focus my entire fertility program on supporting the biological capacity of the soil.

While conventional farming aims to maximize yield through external inputs, regenerative practices optimize soil health and overall profitability. This approach restores balance with nature to create a fertile, resilient system that can sustain my family's farm for generations.

I'm proud to be a farmer, but I'm most proud of how I farm - working in harmony with the land instead of exploiting it. The path hasn't been easy, but the validation comes in the life teeming in my soil and the promising future for my grandchildren's inheritance.

If you're considering a transition to regenerative practices, **start small with humble patience**. Be willing to be uncomfortable and go against conventional wisdom. Carefully observe what works for your unique soil context. Most of all, commit to being a faithful steward of your soil's health. The rewards will extend far beyond your farm to a more sustainable food system.

I challenge my readers to plant their cover crop, wait as long as possible to terminate, measure the nutrients in their biomass, and reduce their nitrogen applications by half the N sequestered. Watch your profits continue to grow as your soil benefits from the ongoing gifts provided by cover cropping.

Rick Clark is available for private consultations and speaking engagements. Visit www.farmgreen.land for more information.

Rick Clark on his 5th generation family farm in Williamsport, Indiana.

Rick Clark, Farm Green
"The Power of FIXatioN Balansa Clover"
Trial Data Collected 2020

Cost of FIXatioN Balansa Clover per acre: $33.00
Input saving per acre: $334.33
Return on Investment (ROI) per acre: $301.33

	N lb/acre	P2O5 lb/acre	K2O lb/acre	Biomass lb/acre
MAY 20, 2020	75	30	138	3,800
JUNE 4, 2020	114	56	213	6,800
JUNE 8, 2020	262	97	444	12,700
POST TERMINATION JULY 24, 2020	52	15	24	5,400
ANNUAL INPUT SAVINGS AT JUNE 8, 2020 TERMINATION	$217.46	$88.27	$288.60	

Cost during trial in 2020: N= $0.83 lb, P2O5 = $0.91lb, K2O = $0.65lb
C:N Ratio of FIXatioN Balansa Clover is 12:1 resulting in a rapid breakdown of organic matter and return of nutrients to soil.

Rick Clark, Farm Green
"The Power of Cereal Rye"
Trial Data Collected 2020

Cost of Cereal Rye per acre: $29.00
Input saving per acre: $352.11
Return on Investment (ROI) per acre: $323.11

	N lb/acre	P2O5 lb/acre	K2O lb/acre	$ Per Acre
12" Rye	82	32	133	$181.17
18" Rye	120	44	213	$278.09
28" Rye	134	64	281	$352.11
Dead Rye	84	64	65	$170.21
Annual Input Savings at 28" Termination	$111.22	$58.24	$182.65	

Cost during trial in 2020: N= $0.83 lb, P2O5 = $0.91lb, K2O = $0.65lb
C:N Ratio of Cereal Rye at anthesis is 37:1 resulting in a slower breakdown of organic matter and return of nutrients to soil.

FORBS

Forbs, often overlooked in cover cropping, play a crucial role in enhancing soil health. With their deep root systems and ability to tolerate drought conditions, forbs excel as cover crops. They act as nutrient scavengers, enriching the soil and promoting its fertility. Additionally, many forbs are top producers of nectar, further highlighting their importance in agricultural ecosystems.

PHACELIA

Tanacetifolia

Phacelia stands out for its rapid growth and drought tolerance. It can enrich the soil structure through its deep-rooted system. This makes phacelia particularly valuable in organic and sustainable farming practices, where minimizing the need for synthetic herbicides is paramount.

Its extensive root network helps in improving soil health by enhancing nutrient retention and promoting aeration.

Phacelia's vibrant flowers attract pollinators and beneficial insects, thus contributing to biodiversity and supporting overall ecosystem balance.

A prolific bloomer with prolonged flowering period, phacelia can contribute to increased honey yields.

BUCKWHEAT

Fagopyrum esculentum

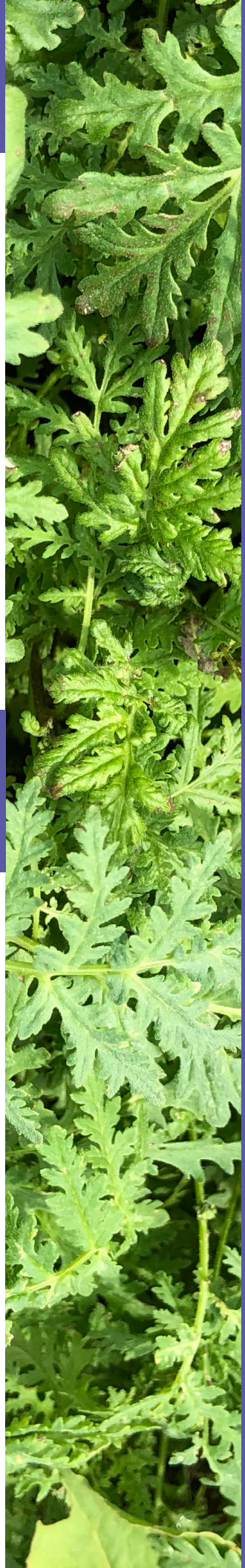
Buckwheat can have positive spillover effects on nearby crops by increasing pollinator populations.

Buckwheat serves as an exceptional cover crop, renowned for its rapid growth, dense foliage, and allelopathic properties that suppress weed growth effectively. Buckwheat's shallow white blossoms attract beneficial insects that attack or infest aphids, mites and other pests.

Buckwheat's short growth cycle allows for quick incorporation into crop rotation systems.

Its ability to thrive in high temperatures stems from its adaptability to a wide range of environmental conditions. Even during periods of intense heat stress, buckwheat can continue to grow vigorously.

Buckwheat's abundant blossoms, which produce copious amounts of nectar and pollen, serve as a valuable food source for bees, butterflies, and other beneficial insects.



Soil Health Assessments, Part 3: Sampling

Timing
When considering sampling time, consistency is key. Many biologically focused test results differ when taken at different times of the year. Changes in soil temperature and moisture influence biological processes and production. Rather than a specific day of the year, it's best to consider your timing relative to the cropping system. If you delayed planting because the soil was too wet to get in the field, you will also want to delay your soil sampling plan.

For spring planted crops, try to take soil health sample roughly one month after planting your cash crop. If this recommendation isn't possible for your production system, you can also take samples before you make a change in management, and stick to sampling around that time of year.

Location
There are two primary strategies used for typical soil sampling, either by grid sampling or by management units. Regardless of the method that meets your management style, abnormal areas such as a small depression or cow pies should be avoided for your general sampling.

Grid sampling involves drawing straight lines to separate your field into regular repeating cells. This method is often used in precision agriculture and can give a high-resolution understanding of variability within your field. However, it is typically not recommended for soil health assessments unless you are going to make a change in your biological management at that scale.

Separating the field by management units is recommended for soil health sampling. Divide the land by both landscape position and management history for sampling. In one grazed pasture, the hilltop would be a separate management unit from the area on the hill slope. If you also had crop land on that same hilltop, it would be yet another sample. It is recommended to take 10-20 subsamples to be mixed into one composite sample. Each sample should represent the average of the whole management unit.

Sampling Method
Using a sharpshooter shovel and a soil knife, called a hori hori, to take samples is effective when focusing on aggregate stability. It is more time-consuming than using a probe, but it has a couple of advantages. Number one, you can learn a lot by getting down and interacting with your soil, and you will inevitably make observations about its condition. Number two, you don't create artificial soil clods that can skew aggregate stability measurements.

Sample handling is important when it comes to soil health measurements. Biological measurements change as a result of heat and moisture. If you can't ship your samples right away, keep them cool in a fridge.

"To know where you are going, you have to know where you have been." As you start, or dig deeper in your soil health journey, gather the data to prove to yourself on the hard days that the changes you are making will help your farm thrive for generations to come.

This article has been abbreviated from the original version. For the full article and a comprehensive list of soil labs, scan QR:

Taking a soil sample with a hori hori.

What's *Next* for Cover Crops?

The use of cover crops has long been practiced in many traditional farming systems around the world, however, it wasn't until the early 20th century that scientific research began to systematically study cover crop species, seeding rates, and management strategies.

Over the decades, land-grant universities and agricultural research stations have trialed hundreds of cover crop varieties and mixtures suited to different climates and cropping systems. This research has unlocked a deeper understanding of their numerous benefits, both above and below ground.

As environmental concerns and interest in regenerative agriculture have grown, so too has adoption of cover cropping. Across the United States, acres planted to cover crops have steadily increased, with programs providing cost-share assistance to incentivize the practice on both conventional and organic operations.

While still underutilized in most regions, cover crops are becoming a more mainstream practice as part of a whole farming system. One item to keep an eye on for the future are perennial cover crops.

Perennial cover crops are presently being evaluated at several sites across N. America for use in corn and/or soybean rotations. The introduction of perennial cover crops won't be suitable for all operations. It requires a greater initial monetary investment and could potentially be detrimental to row crop yields in drought years.

Falcata Alfalfa

Perennial Turf Grass

White Clover

However, the pros may greatly outweigh the cons. Perennial cover crops don't need to be replanted annually, resulting in long-term savings. They could work in areas that lack a long enough growing season to establish an annual cover crop.

With living roots in the ground year-round, it could lead to greater carbon sequestration and nitrogen additions. Depending on the perennial selection, they have the potential to add opportunities for integrating livestock in row crop farms.

RegenPGC is a project being led by individuals at Iowa State University, University of Wisconsin-Madison, University of Missouri, Kansas State University, The Land Institute, and Corteva Agriscience. This perennial ground cover research is evaluating Kentucky bluegrass, *Poa bulbosa*, and Tall Fescue species.

GO Seed is working with individuals at Michigan State University, Ohio State University, South Dakota State University, and Bennett Ag Research Corp, evaluating AberLasting DoubleRoot clover and one of GO Seed's proprietary falcata alfalfa varieties. The research is focusing on effective agronomic management of these varieties in a continuous corn system.

Although cover crop adoption rates increase annually, survey based estimates indicate only 5.47% of the US cropland utilized cover crops in 2022. There is much still to be done by plant breeders, research scientists, and producers to find novel solutions for growing concerns.


Cover crop research and breeding combines science and tradition to create climate resilant farms.
www.gocovercrops.com