Cover Crop Basics

Fourth Edition



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



Cher Gillson, GO Seed Sales & Marketing

Cher works in Sales and Marketing at GO Seed, where she writes and develops educational content based on research in cover crops, forage systems, and plant breeding. Her work focuses on translating technical information into clear, useful resources for growers and the seed industry. Gillson also serves as President of the Oregon Forage & Grassland Council and was recognized by Seed World as one of its Top 10 Next Generation Leaders.



Dr. D. Raj Raman, Iowa State University

Dr. Raman is a Morrill Professor of Agriculture & Biosystems Engineering at Iowa State University. His research has encompassed waste management, insect detection, and technoeconomic modelling of bioprocessing systems. Since 2017, he has worked closely with Dr. Ken Moore (Distinguished Professor of Agronomy) on perennial groundcover (PGC) approaches for corn and soybean production systems. Raman earned a PhD in Agricultural and Biological Engineering from Cornell University and a BS degree in Electrical Engineering from The Rochester Institute of Technology.



Dr. Shui-zhang Fei, Iowa State University

Dr. Fei is a Professor of Grass Genetics and Breeding in the Department of Horticulture at Iowa State University. His research uses genetics and molecular tools to better understand and improve important agronomic traits in grasses, including tolerance to environmental stresses. His work spans economically important species such as perennial ryegrass, creeping bentgrass, and switchgrass, with a broader focus on grass development, adaptation, and crop improvement. Fei earned his Ph.D. from the University of Nebraska–Lincoln and teaches courses in crop genetics and perennial grass growth and development.



Jerry Hall, GO Seed President

Jerry is President of GO Seed and has more than 45 years of experience in the seed industry. His career has spanned plant breeding, research, seed production, procurement, and business leadership, beginning as a research technician in 1979. Hall co-found GO Seed and has been serving as president since 2000, where he has helped guide the development and commercialization of elite turf, forage, and cover crop varieties. He holds a degree in agricultural economics from Oregon State University.

Cover cropping begins with intention.

It's choosing species for the challenges they are meant to solve,

And combining them into systems that work with purpose.

It's creating habitat for pollinators, resilience within the soil, and value across the farming system.

It's turning research into practical solutions,

And building healthier agricultural systems for generations to come.

—Cher Gillson

Cover crop research is giving farmers better tools to make more informed decisions in the field.

As university trials, breeding programs, and on-farm research continue to expand, we are learning more about how genetics influence establishment, winter survival, maturity, root development, biomass production, forage quality, and stress tolerance.



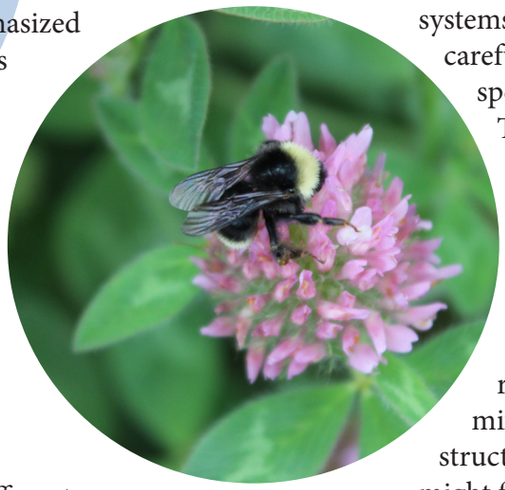
That research is making one thing increasingly clear: species alone does not tell the whole story. Varieties matter.

Just as you select a corn hybrid or wheat variety for your environment and production goals, cover crop varieties should be matched to your planting window, region, and intended outcome.

In Cover Crop Basics 4th Edition we focus on what current research is teaching us about those differences and how they translate to the field. The goal is to help farmers discover better genetics, stronger data, and practical management decisions to build more reliable cover crop systems and get more from every acre.

FROM SPECIES TO SYSTEMS:
Breeding Cover Crops for Solutions

Early cover crop adoption emphasized familiar, single-species solutions for general soil improvement, but today's advancements in plant breeding and our growing understanding of above- and below-ground interactions are driving more sophisticated, purpose-built systems. As research, breeding, and on-farm experience have expanded, it has become increasingly clear that different species and varieties provide different functional benefits. Today, many are beginning to approach cover cropping as a prescriptive, systems-based management tool, utilizing carefully curated genetics designed to address specific agronomic or ecological challenges. This approach can be thought of as cover cropping for solutions. Rather than planting a single "common" variety or a generic mix and expecting broad benefits, modern cover crop systems rely on synergistic combinations of plants that perform complementary roles to achieve targeted outcomes. Some mixtures are designed to improve soil structure or supply nitrogen, while others might focus on erosion control, managing pests such as nematodes, or supporting beneficial insects.

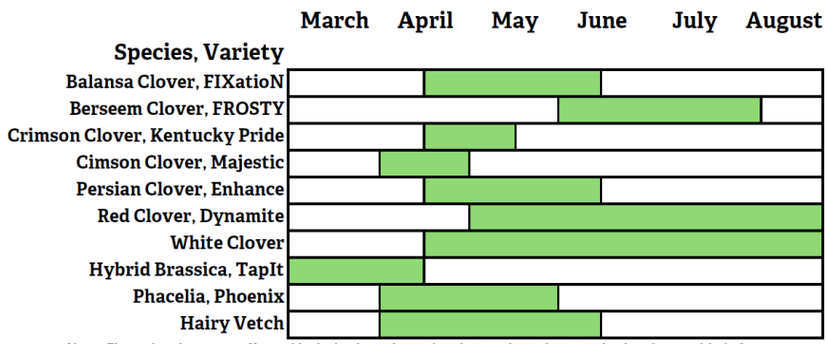


The following two examples illustrate how this concept is being applied in practice: cover crop mixtures used to support pollinators within forage systems and short-term cover crop mixtures used to improve soil conditions in sod production systems.

PASTURES FOR POLLINATORS

Pollinators play a critical role in agricultural ecosystems. Animal pollinators are responsible for the reproduction of roughly three quarters of the world's flowering plants and about 35 percent of global food crops. According to the U.S. Fish and Wildlife Service, insect pollination contributes more than $34 billion annually to U.S. agricultural production. Despite their importance, many pollinator populations face increasing pressure from habitat loss and limited floral diversity across agricultural landscapes.

Pasture and forage systems can help address this challenge when they include flowering species with staggered bloom periods. Individual plant species typically flower for only a portion of the season. By combining species with different bloom windows, as is done in "Pastures for Pollinators", pastures can provide nectar and pollen across a longer period of time.



Note: Flowering dates are affected by latitude and growing degree days. As a result, the above table is for relative bloom representation. For best use, shift the entire chart based on known bloom periods in your area.

Legumes are particularly valuable in these systems because they attract pollinating insects while also contributing nitrogen to the soil. Several clover species provide complementary flowering periods. Crimson clover often blooms early in spring, followed by balansa clover, which produces abundant blossoms during mid-spring.

Persian clover and berseem clover extend flowering into late spring and early summer. Later in the season, red clover and white clover continue to provide nectar and pollen resources. Red clover's deeper blossoms are especially well suited to bumble bees, while white clover produces smaller flowers that can be accessed by a wider range of pollinators. Brassicas can also contribute to pollinators. Turnips, when allowed to mature and flower, produce clusters of yellow blossoms that attract bees and other beneficial insects.

Together, these species create a pasture system that produces forage for livestock while also providing a sequence of blooms that supports pollinators throughout the growing season.

Cover Crop Rx: SOD

The same principle of functional plant diversity can also be used to address soil challenges in sod production systems. Harvesting sod removes a large portion of plant biomass and can leave soils compacted and depleted of organic matter. Sod producers are realizing they need a short-term cover crop between turf plantings to restore soil function before the next crop is planted.

One example is the use of Cover Crop RX: SOD, that includes eNhance Persian Clover and TapIt Hybrid Brassica during the fallow period between sod harvest and replanting. Persian clover establishes quickly and contributes biologically fixed nitrogen to the soil, while the hybrid brassica develops deep taproots that help penetrate compacted layers and recycle nutrients from deeper in the soil profile.



An example of Cover Crop RX: SOD in rotation with sod crops.

These species can grow rapidly in the limited window between sod crops, producing both root biomass and surface residue that improve soil structure and nutrient cycling. The combination of fibrous and taproot systems helps create channels in the soil that improve water infiltration and root penetration for the following turf crop.

As the use of cover crop mixtures expands, it is also important to recognize that variety selection matters. Not all mixtures provide the same benefits in every system. Certain species may host plant pathogens or increase populations of pests such as plant-parasitic nematodes if they are poorly matched to the cropping system. Others may compete with the following crop for moisture or nutrients if they are not properly managed. For this reason, cover crop mixtures are most effective when they are developed and evaluated using agronomic research and local field experience.

When carefully designed, however, mixtures that combine complementary plant traits can serve as powerful management tools. By matching varieties to specific production goals, growers can integrate researched systems that improve soil function, support beneficial insects, and enhance overall resilience within agricultural landscapes.

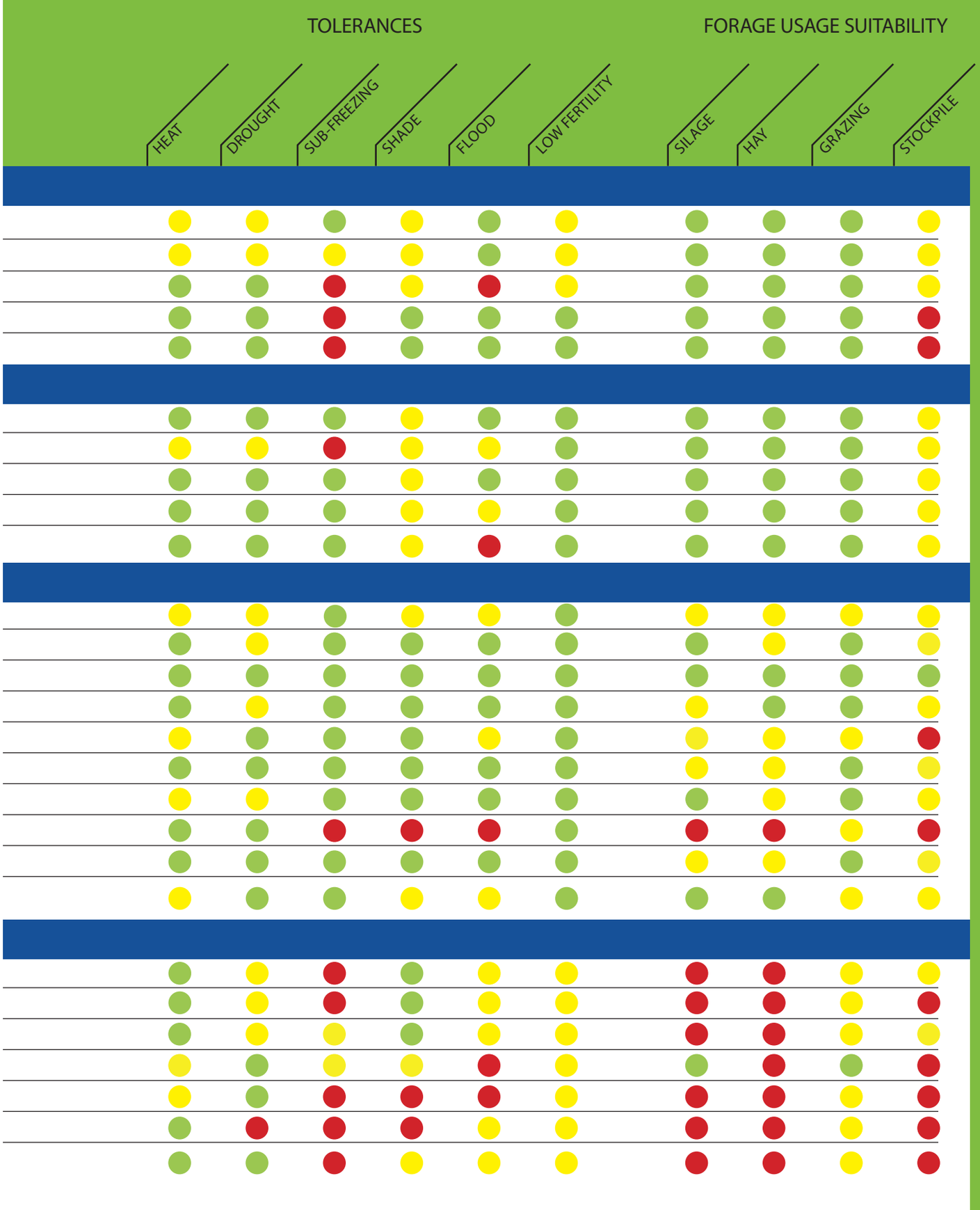
COVER CROP MORPHOLOGY

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	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
TapIt Hybrid Brassica	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


TOLERANCES
FORAGE USAGE SUITABILITY
HEAT
DROUGHT
SUB-FREEZING
SHADE
FLOOD
LOW FERTILITY
SILAGE
HAY
GRAZING
STOCKPILE
= 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
TapIt Hybrid Brassica	0.25″	2 - 3	4 - 5	5.5 - 7.0	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
Under Evaluation
= Is resistant or recommended
= Is somewhat resistant or ok for use
= Do Not Use for this purpose

Breaking Down N

The Carbon to Nitrogen (C:N) ratio is a crucial factor of understanding how organic matter breaks down and releases nutrients in the soil. 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 likely to become available sooner.

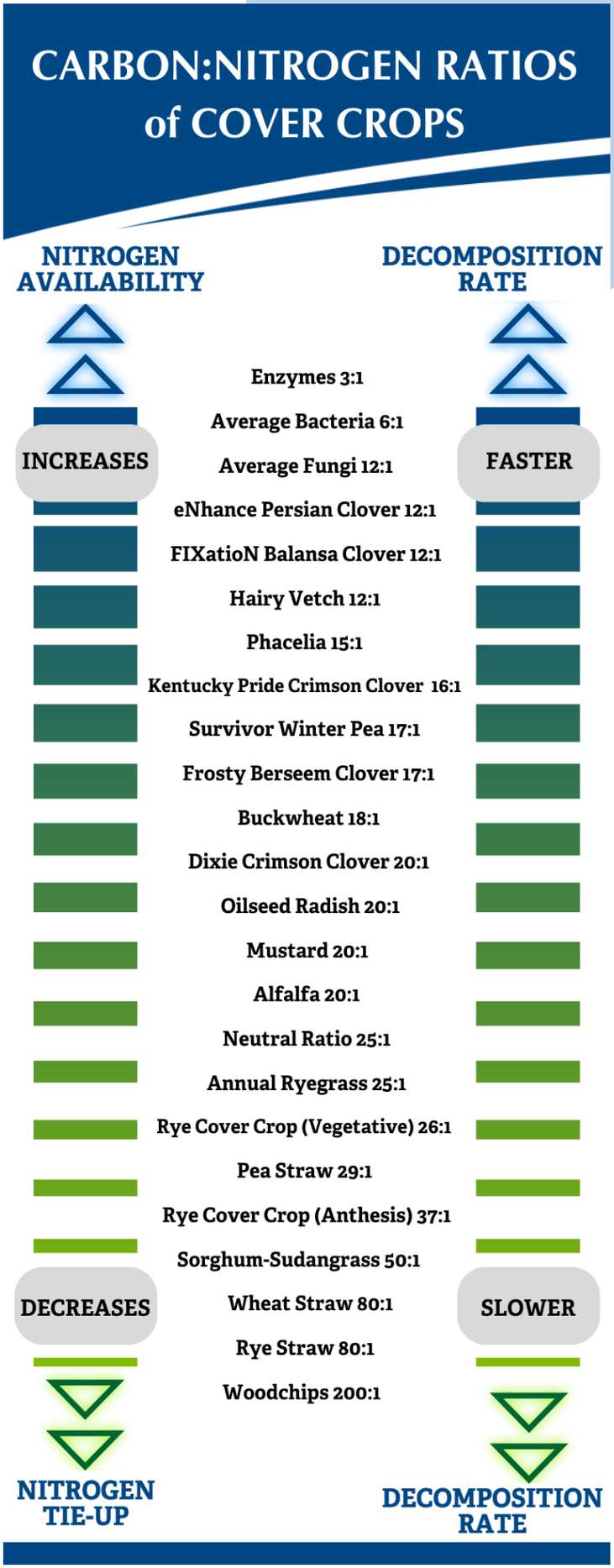
Billions of organisms in the soil take part in the continuous process of organic matter decomposition. They require both carbon and nitrogen for their growth and reproduction. Microorganisms break down organic matter with a high C:N ratio more slowly because they need to acquire additional nitrogen to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





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 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 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 large biomass suppresses weeds and excels at nitrogen fixation.



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

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. Possibly 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 ranges 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 subsequent 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 many settings.

Well adapted to a variety of soil types, berseem 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 its 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 suitable 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.

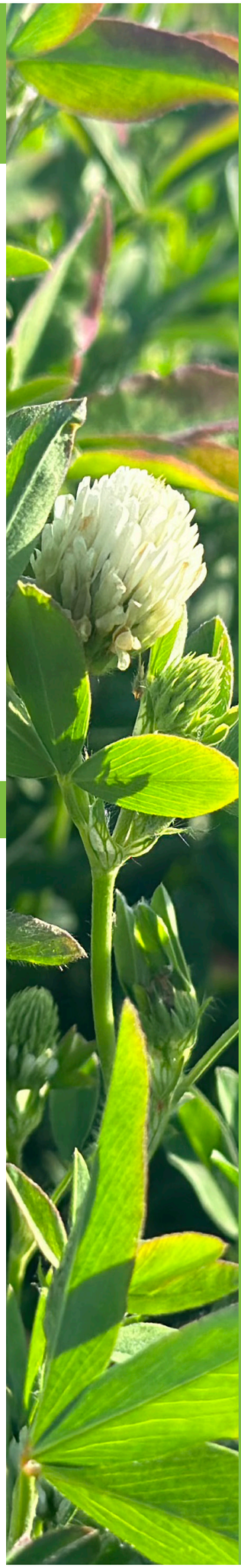
Frosty Berseem Clover is capable of producing 180lbs of nitrogen per acre, reducing the need for synthetic fertilizer. Its aggressive root system draws additional nutrients from deep in the soil to make them available to the following crops.

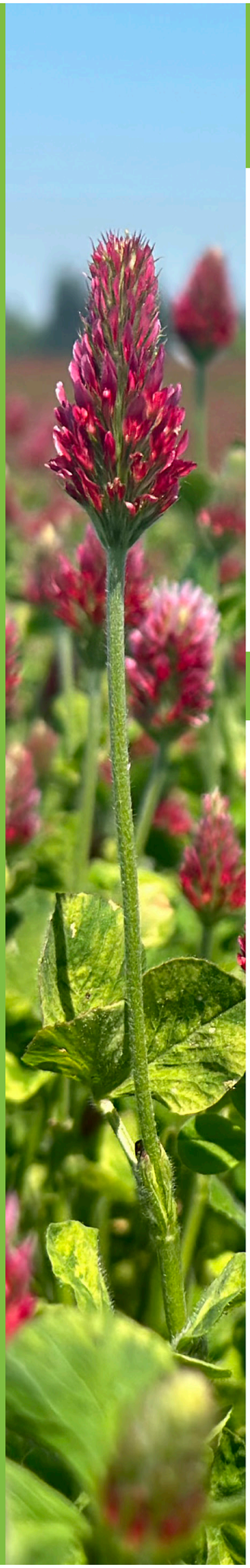
As a grazed cover crop, Frosty is capable of creating up to 7.5 tons of highly nutritious, non-bloating dry biomass per acre.

Later maturation 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 is a versatile cover crop that suppresses weeds through rapid establishment and dense growth. It also attracts beneficial insects that can help naturally reduce pest pressure.

Its extensive root system improves soil structure, water infiltration, and moisture retention. As a legume, crimson clover fixes atmospheric nitrogen, helping replenish soil fertility and reduce fertilizer needs for subsequent crops.



New genetics have improved root architecture to fix more nitrogen.



Advancements in breeding has increased cold tolerance in some varieties.

RECOMMENDED VARIETY

KENTUCKYPRIDE Crimson Clover

Kentucky Pride Crimson Clover was bred for improved cold tolerance, with a prostrate growth habit that helps protect plants through winter.

Compared with Dixie Crimson Clover, it can produce up to four times the biomass and develop roots 25% deeper, supporting strong weed suppression.

Its later maturity also extends vegetative growth, allowing more time to build biomass and fix nitrogen. If allowed to mature and set seed, Kentucky Pride can naturally reseed in pastures, orchards, and vineyards.

Key Benefits



Majestic Crimson Clover

Majestic Crimson Clover was selected for strong winter survival, rapid spring growth, and high biomass production.

In Ohio trials, it maintained 100% spring stand and cover, while Tennessee trials showed strong early-season canopy development and up to 2.5 tons of combined April–May biomass.

Majestic also released up to 50 pounds of nitrogen per acre during spring growth. Its combination of winter resilience, quick canopy development, and nitrogen contribution makes it well suited for weed suppression, soil protection, nutrient cycling, and forage use.

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 wild in the southeastern 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.

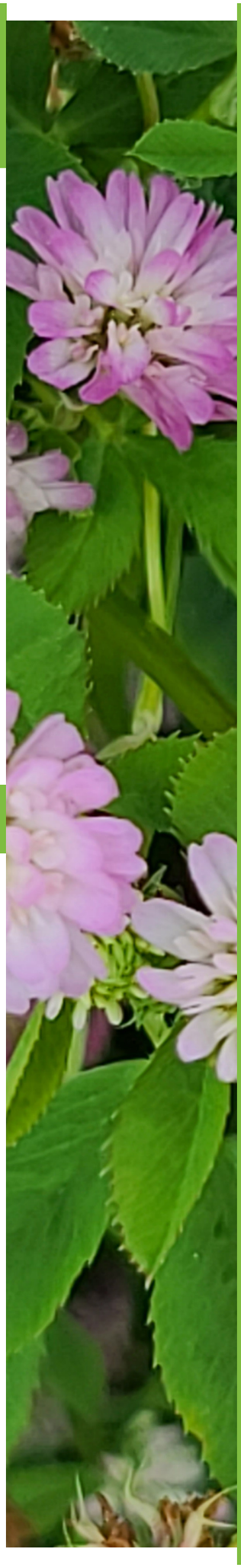
Advanced seedling vigor allows eNhance to establish at a similar rate as cereal rye.

This variety has a large, hollow stem that 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 reduces the need for herbicides, fostering environmentally sustainable farming practices.

Winter peas deep root system enhances soil structure. By maintaining soil structure and moisture levels, they create an environment for subsequent crops that promotes 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.

SURVIVOR
Cold Tolerant Winter Pea

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

Its quick establishment acts as a natural weed suppressant while sending roots deep 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 habitat and food source for beneficial insects, winter peas can contribute to natural pest control and enhance 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.

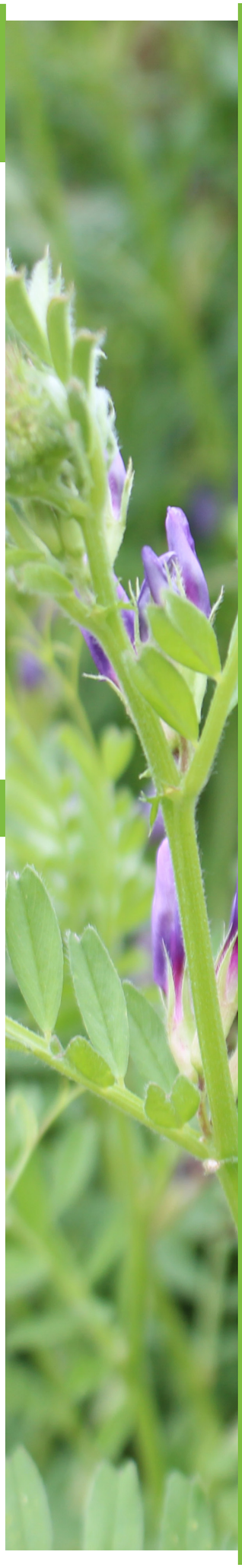
Its dense foliage acts as a natural mulch, conserving soil moisture and moderating soil temperature, especially beneficial during periods of drought or extreme weather events. Hairy vetch protects soil from nutrient leaching and erosion during fallow periods, contributing to long-term soil conservation.



Hairy vetch is an excellent pollinator attractant.



The hairy vetch vines grow and climb with ease.



CARBON = WATER

Carbon increases the water holding capacity of soil. Carbon makes up approximately 50% of 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 which then build stable aggregates.

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



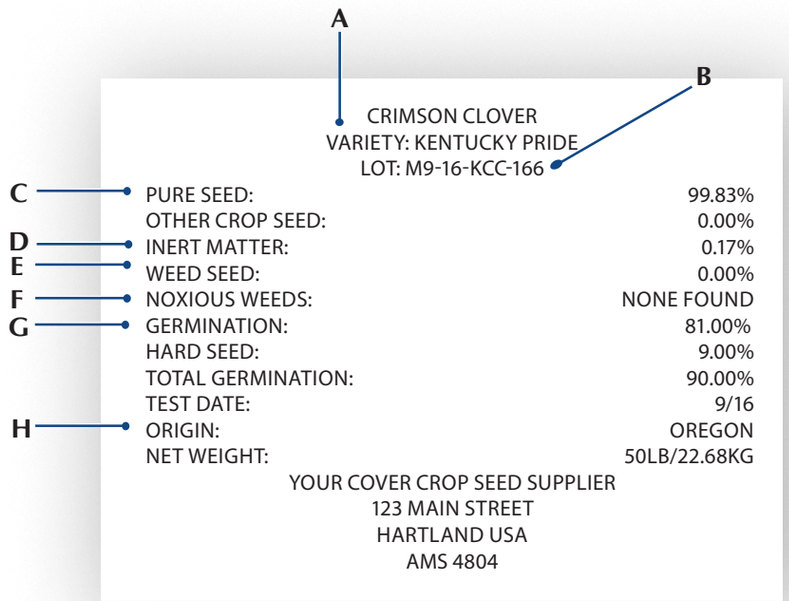
Photos are from the same farm on the same day after a heavy April rain. Above: perennial grassland. Below: wheat fallow system.



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 to provide buyers with essential information to make informed decisions.

Avoid bin-run or unlabeled seed, as it bypasses required testing so 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: The percentage, 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: 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: The location where the seed was produced

Glucosinolates in Cover Crops:
Understanding the Chemistry That Can Drive Soil Function

The brassica plants in your field carry a chemical arsenal. Most farmers don't know which weapon they're deploying or why it matters enormously for root health and soil biology.



Carwoodi Nematode Control Radish

Farmers treating glucosinolates as a single thing is the same mistake as treating all pesticides as interchangeable. There are over 120 distinct glucosinolate compounds, each with a different biological target, breakdown product, and effect on your soil. Lumping them together leads to wrong planting decisions. The current conversation around brassica cover crops focuses almost entirely on the species (radish, mustard, turnip) without asking which specific compounds those plants may produce, what part of the plant they are present, and at what concentrations.

Compound identity is one of the major factors influencing whether a cover crop suppresses pests, supports beneficial organisms, or affects the establishment of a following cash crop.

The good news: once you understand the three compound families and specific compound tied to the root biomass, you can make planting decisions that can help reduce or even replace some fungicide and nematicide applications. The species determine the practical management choice, while the glucosinolate composition helps explain differences in performance.

The Three Glucosinolate Families
All glucosinolates share the same core chemical structure, a glucose molecule attached to a sulfur-containing group. What makes each compound unique is the side chain attached to that core. Those side chains fall into three families, each with distinct biological activity.

FAMILY	EXAMPLE COMPOUNDS	KEY PLANT SOURCES	PRIMARY PEST TARGET
Aliphatic	Glucoraphanin, Sinigrin, Gluconapin	Broccoli, Mustard, Canola/ Rapeseed	Fungal pathogens, some insects
Indole	Glucobrassicin, Neoglucobrassicin	Cabbage, Kale, Brussel Sprouts	Insect feeding deterrent, herbivory defense
Aromatic	Gluconasturtiin, Glucotropaeolin	Watercress, Nasturtium, Turnip	Root-Zone nematodes, soil-borne pathogens

Key Distinction: The active defense chemical isn't the glucosinolate itself, it's the breakdown product. When plant tissue is damaged (by tillage, freeze-kill, or pest chewing), an enzyme called myrosinase splits the glucosinolate into isothiocyanates (ITCs), nitriles, or thiocyanates. The ITC produced by gluconasturtiin, phenethyl isothiocyanate (PEITC), has demonstrated strong biofumigation activity.

Not all brassica cover crops deliver the same effect. Each glucosinolate family produces a different breakdown product with a different mode of action.

Aliphatic ITCs can inhibit fungal growth and disrupt spore germination. Sinigrin from mustard releases allyl-ITC, documented to suppress Rhizoctonia and Verticillium when incorporated at high biomass rates.

Indole ITCs are less volatile with shorter soil persistence. Their primary role is above-ground insect deterrence, they interfere with feeding behavior and larval development in caterpillar species.



TapIt Hybrid Brassica Root

Aromatic ITCs are highly volatile and may move deeper through the soil profile under favorable conditions. PEITC (phenethyl isothiocyanate) is a naturally occurring ITC derived from the glucosinolate gluconasturtiin. Some turnips and rapes accumulate gluconasturtiin as the dominant compound in their roots, making them the most relevant field crops for delivering this ITC into the soil profile.

Gluconasturtiin: The Root Compound Farmers Underestimate
Gluconasturtiin is the dominant glucosinolate in the aromatic family and is found at high levels in the roots of some turnips and rapes (Brassica rapa and Brassica napus), as well as in watercress (Nasturtium officinale) and garden nasturtium (Tropaeolum majus). Unlike aliphatic glucosinolates that concentrate in leaf tissue, gluconasturtiin loads heavily into root tissue, exactly where soil-borne pest and fungal pressure occurs.

In some turnips and rapes grown as cover crops, roots accumulate gluconasturtiin as the dominant compound. This means the root mass isn't just storing carbon, it is capable of depositing a concentrated aromatic biofumigant payload directly into the subsoil when it decomposes or is incorporated.

The glusonasturtiin breakdown mechanism:

- Step 1 – Cell disruption: Tillage, freeze-kill, or pest feeding ruptures root cells, bringing gluconasturtiin into contact with the enzyme myrosinase.

- Step 2 – Hydrolysis: Myrosinase cleaves the glucose-sulfur bond, releasing PEITC as volatile gas.

- Step 3 – Soil diffusion: PEITC can move through soil pore space. At concentrations achieved from high-biomass roots, it can be lethal to nematode eggs, suppressive to Pythium, and inhibitory to Fusarium germination.

- Step 4 – Dissipation: PEITC can degrade within 2-4 weeks under the right field conditions, leaving little to no residue concerns for the following cash crop if incorporation timing is managed correctly.

Critical Considerations - High Root Concentrations
High gluconasturtiin levels in roots create a double-edged situation. When some turnips and rapes with large root mass decompose in wet, cool soils without proper incorporation, PEITC can accumulate in the soil solution at phytotoxic concentrations, suppressing germination of small-seeded cash crops planted too soon after termination.



A field of Driller Daikon Type Radish.

The practical rule: allow a minimum 3-4 week window between brassica termination or incorporation and planting of small-seeded crops (carrots, small grains, brassica vegetables). Corn and soybean are often more tolerant and can follow within 2-3 weeks. Soil temperature above 50F accelerates PEITC breakdown and reduces risk.

Which Plants Carry Which Compounds
Not all brassica cover crops deliver meaningful biofumigation. Compound concentration can vary dramatically by species, variety, and by growing conditions. Below is a practical breakdown of the most agronomically relevant species, the gluconsinolate they emphasize, and where in the plant that compound is stored.

PLANT	DOMINATE GLUCOSINOLATE	FAMILY	PRIMARY STORAGE TISSUE	KEY ITC RELEASED
Daikon Radish	Glucoraphasatin	Aliphatic	Root	4-MTBITC (Raphasatin)
Brown/Oriental Mustard	Sinigrin	Aliphatic	Seeds & stems	Allyl ITC
Canola/Rapeseed	Gluconapin	Aliphatic	Seeds	But-3-enyl ITC
Kale/Cabbage	Glucobrassicin	Indole	Leaves	Indole-3-carbinol
Watercress	Gluconasturtiin	Aromatic	Leaves & stems	PETIC
Garden Nasturtium	Glucotropaeolin	Aromatic	Leaves	Benzyl ITC
Some Turnips & Rapes	Gluconasturtiin	Aromatic	Roots	PETIC

Practical Takeaway: Root-zone nematodes or Pythium? Introduce turnips and rapes with gluconasturtiin in their roots as an active ingredient, that will release PEITC into the subsoil. Above-ground leaf-chewing insects? Kale or cabbage interplanted as a trap crop leverages indole glucosinolates. Soil-borne fungi broadly? Try mustard with high sinigrin content. Incorporated at high biomass it is an established tool.

How Glucosinolates Can Help Reduce Reliance on Chemical Inputs
Biofumigation with high-glucosinolate cover crops is not a fringe concept. The key is matching the right compound to the target pest.

- **Nematodes**: PEITC from gluconasturtiin can disrupt nematode neuromuscular function. Root lesion nematode (Pratylenchus) and root knot nematode (Meloidogyne) egg hatching is suppressed at PEITC concentrations achievable from 3-5 tons/acre of fresh brassica biomass (some turnips and rapes) incorporated at peak root mass.

- **Soilborne fungal pathogens**: Allyl-ITC from sinigrin (mustard) and PEITC can interfere with fungal membrane function and other cellular processes.

- **Wireworm and soil insects**: Volatile ITCs in the soil profile can deter egg-laying and larval feeding by wireworm species. The effect is concentration-dependent and requires adequate soil moisture for gas diffusion.

- **Weed suppression** (secondary benefit): ITC breakdown products inhibit small-seeded weed germination, the same phytotoxicity risk noted for cash crops is an asset against winter annual weeds when managed correctly.



Nematodes are microscopic plant-parasitic roundworms that infect roots, reducing plant growth and yields.

Three Moves Beyond Cereal Rye Monoculture
Cereal rye is a valuable cover crop, but it does not contribute glucosinolate-derived biofumigation. Farmers relying exclusively on cereal rye for pest management are leaving a biological tool on the shelf. Here are three specific, implementable alternatives.

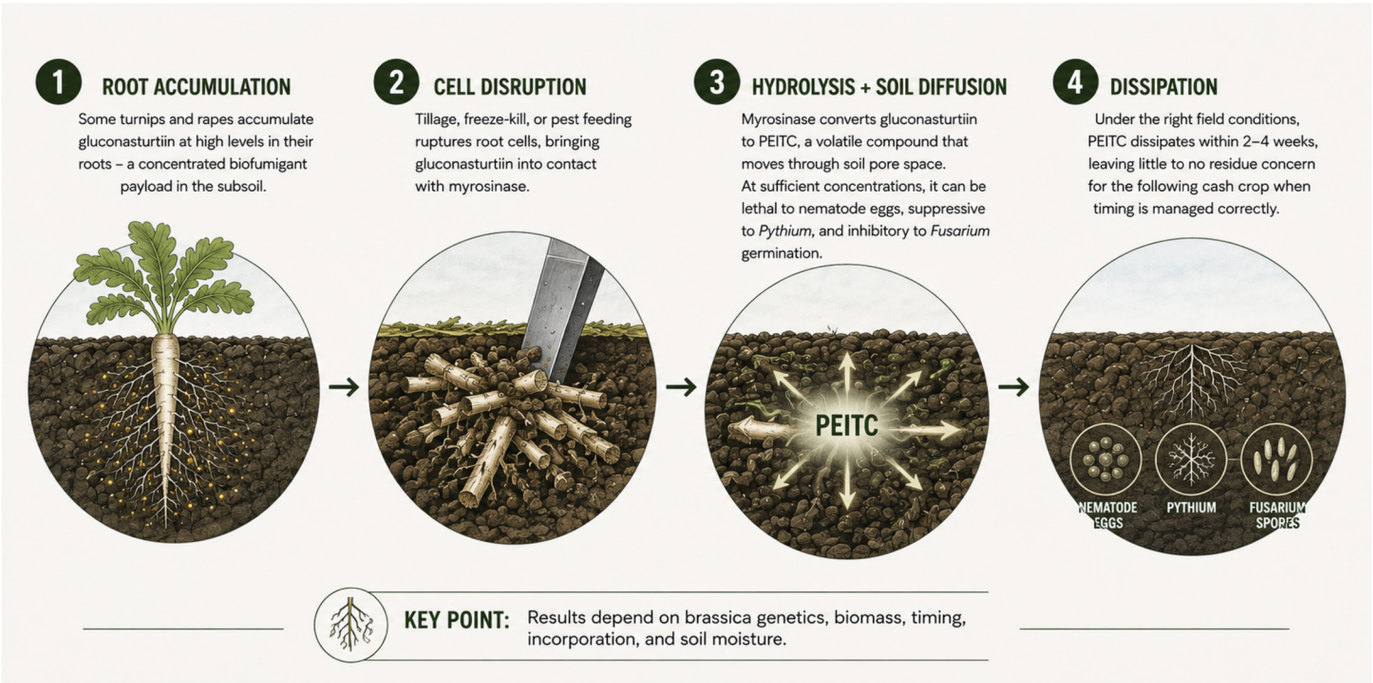
1. Use some turnips or rapes ahead of nematode-susceptible crops for PEITC delivery
    a. Specific species and varieties confirmed to carry gluconasturtiin as the dominant root glucosinolate. Seed at recommended rates in late summer (6-8 weeks before first frost). Allow roots to develop maximum mass before termination. Wait 3-4 weeks after kill before planting corn, soybeans, or potatoes. Target fields with documented root lesion or root knot nematode history. This is an active population-reduction tool, not a proven strategy, timed to your cash crop rotation.

2. Use brown mustard incorporation ahead of high-value vegetable of berry crops
    a. Seed brown mustard at 12-15lb/ac, allow growth to early flowering (maximum sinigrin concentration), then flail-mow and immediately incorporate with a disc or incorporation tillage pass within 30 minutes of chopping. Prompt incorporation is non-negotiable. PTIC and allyl-ITC volatilize rapidly and are lost to the atmosphere if tissue sits unincorporated. Seal the service with irrigation or rain within 24 hours to trap gas in the soil profile.

3. Add a gluconsinolate-containing species to your existing cover crop mix, strategically
    a. For farmers not ready to go all-in on a brassica monoculture cover-crop, adding a gluconasturtiin dominate turnip or rape variety at low seeding rates into a cereal rye or oat mix can deliver root-zone biofumigation activity while retaining the erosion control and biomass benefits of the cereal base. Confirm with your seed dealer which specific brassica genetics they have in their lineup are confirmed for gluconasturtiin dominance in the root. Not all turnips and rapes qualify.

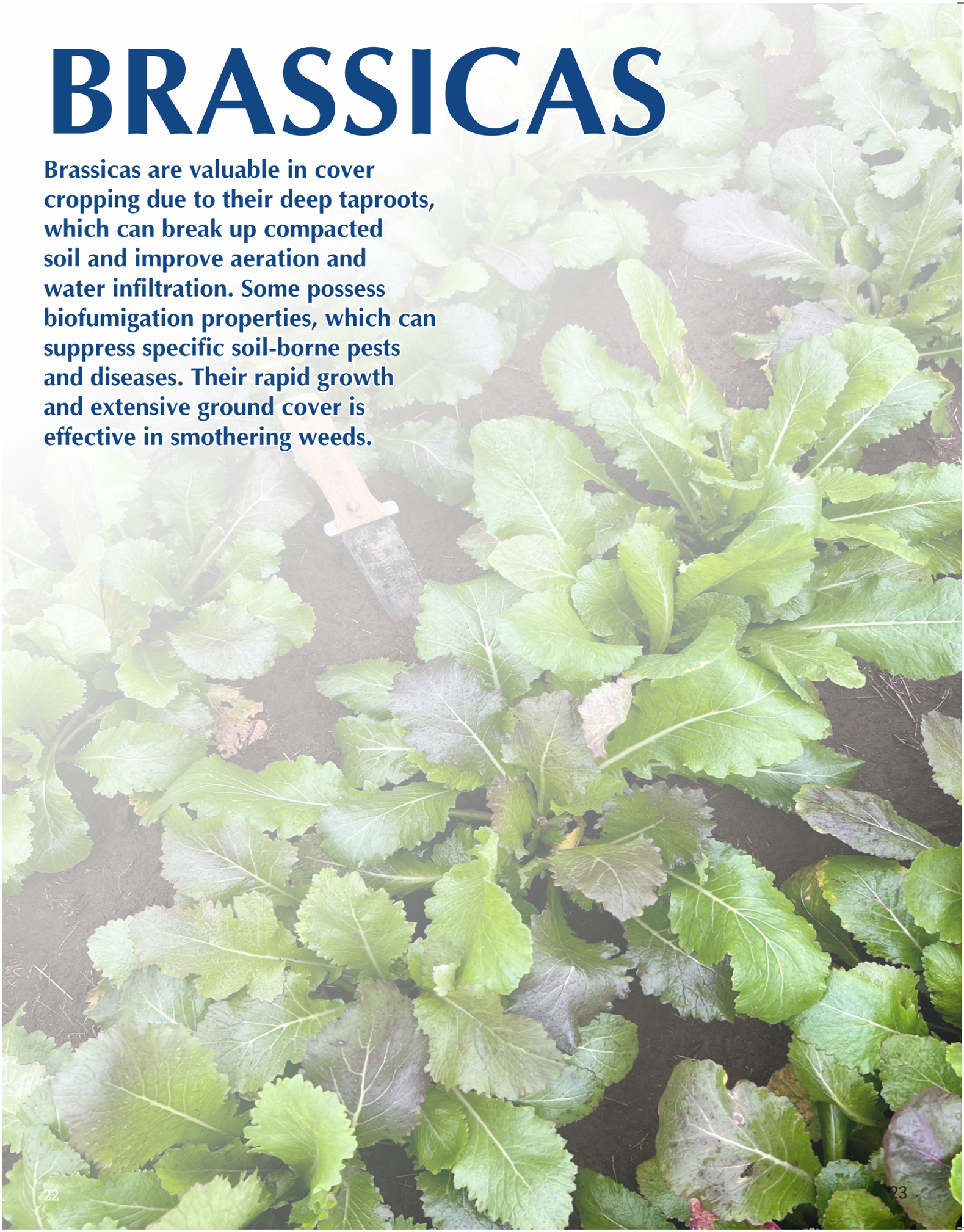
The Bottom Line
Ask two questions: What is the primary pest pressure in this field? And what cash crop follows? The answers determine which glucosinolate compound is needed, and therefor which variety to use. Treating all brassicas as interchangeable "biofumigators" is leaving agronomic performance and results as risk.

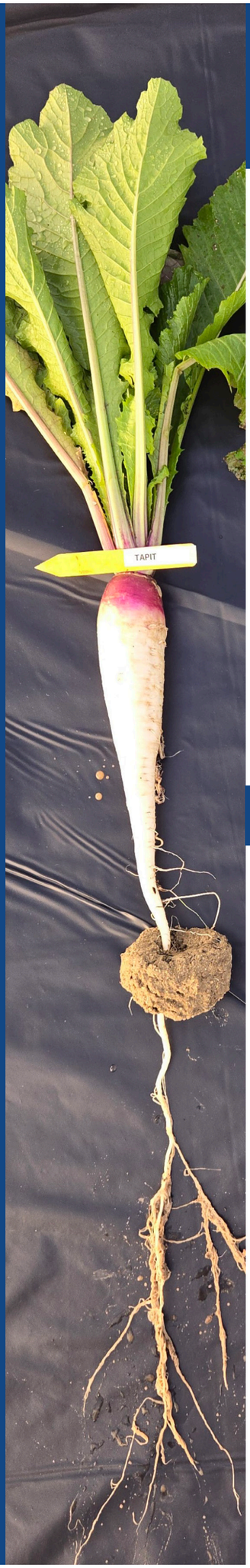
UNDERSTANDING GLUCONASTURTIIN IN THE ROOT ZONE



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.





HYBRID BRASSICA

Brassica rapa x (Brassica rapa x Brassica napus)

Brassica species have long been valued in cover crop systems for their rapid growth, deep rooting, and ability to improve soil structure. Through traditional plant breeding and careful selection, breeders develop plants with complementary characteristics, such as strong root architecture, rapid fall growth, or improved stress tolerance, and then select the best-performing offspring over multiple generations.

Crossing brassica species allows breeders to bring together strengths that rarely exist in a single plant. By combining genetics from multiple brassica types, breeders can develop varieties with more powerful taproots, greater biomass production, and improved resilience in difficult soil conditions. The result is a plant bred with purpose, designed to function as a biological tool that improves soil structure, captures nutrients, and supports more productive cropping systems.



High leaf biomass increases capacity to capture more atmospheric carbon and convert it into organic matter.



Upright leaf architecture of TapIt Hybrid Brassica doesn't shade out other plants in a mixture.

TapIt Hybrid Brassica was bred for a strong taproot that can bust through dense compaction layers that can't be reached by other brassica types. TapIt features one of the fastest root elongation speeds of all crops, with roots reaching a 36" depth in as little as 28 days.

The leaf architecture was selected to intentionally emerge from the crown in a very upright angle, allowing TapIt to be used without the fear of shading out the other species in a mixture.

With 138,000 seeds per pound, this is an extremely economical compaction relief solution on a per acre basis, while making it ideal for aerial or drone seeding where small, lightweight seed and even distribution matter.

By improving soil structure, TapIt Hybrid Brassica gives subsequent crops greater access to nutrients and water deep in the soil profile. It has survived down to -9°F with snow cover 0° F without.

TapIt's roots contain a high level of gluconasturtiin. (see article on page 19)

Key Benefits



DAIKON RADISH

Raphanus sativus

Daikon radish has long been valued as a versatile cover crop for improving soil function and nutrient cycling. Its fast-growing taproot penetrates the soil profile, creating natural channels that enhance water infiltration, aeration, and root exploration for subsequent crops.

As the root decomposes, it leaves behind biopores that support microbial activity and help build soil structure over time. Daikon is also highly effective at scavenging residual nutrients, particularly nitrogen, from deeper soil layers and recycling them back to the surface, reducing nutrient loss.

In fields with moderate compaction, its vigorous root growth can help loosen soil and initiate biological soil improvement while providing valuable fall biomass.



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 its enormous taproot, which can reach depths of 30 inches or more in moderately compacted soils.

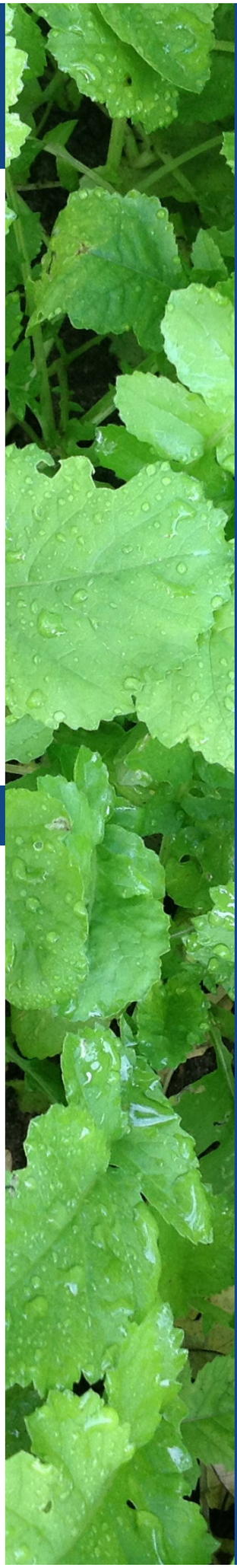
When Driller's taproot hits a mild soil compaction zone, it can open up the soil for increased water infiltration, root channels, and air.

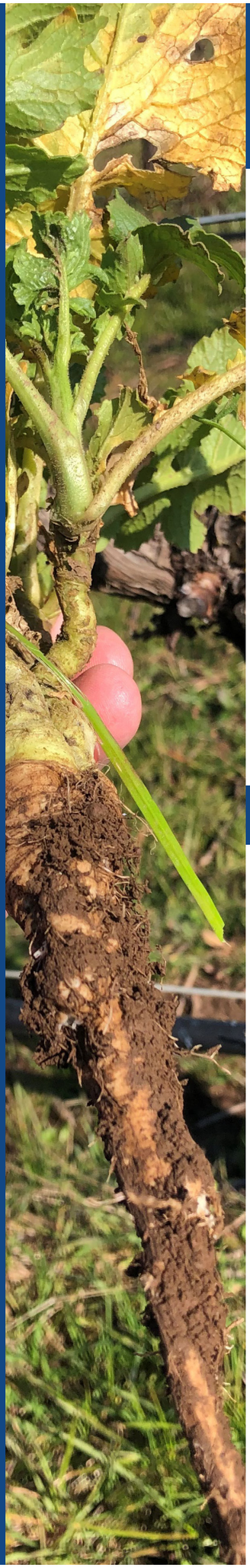
Driller Radish is an excellent "catch crop", especially in its ability to capture nitrogen. As it decays, microbial activity increases in the soil. This decaying organic matter provides food for earthworms, fungus, and microbes. As the organisms cycle the nutrients mined from below, they are returned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

Driller Radish will winterkill when temperatures drop into the low 20° F.

Key Benefits







NEMATODE CONTROL RADISH

Raphanus sativus var. oleiformus

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, 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 is bred to provide maximum control of 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 sulfur 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 retention of the soil.

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



Later maturing varieties are the easiest to manage because of the delayed seed maturation.

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.

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

The powerful fibrous roots enhance soil structure, water infiltration, and erosion control.

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

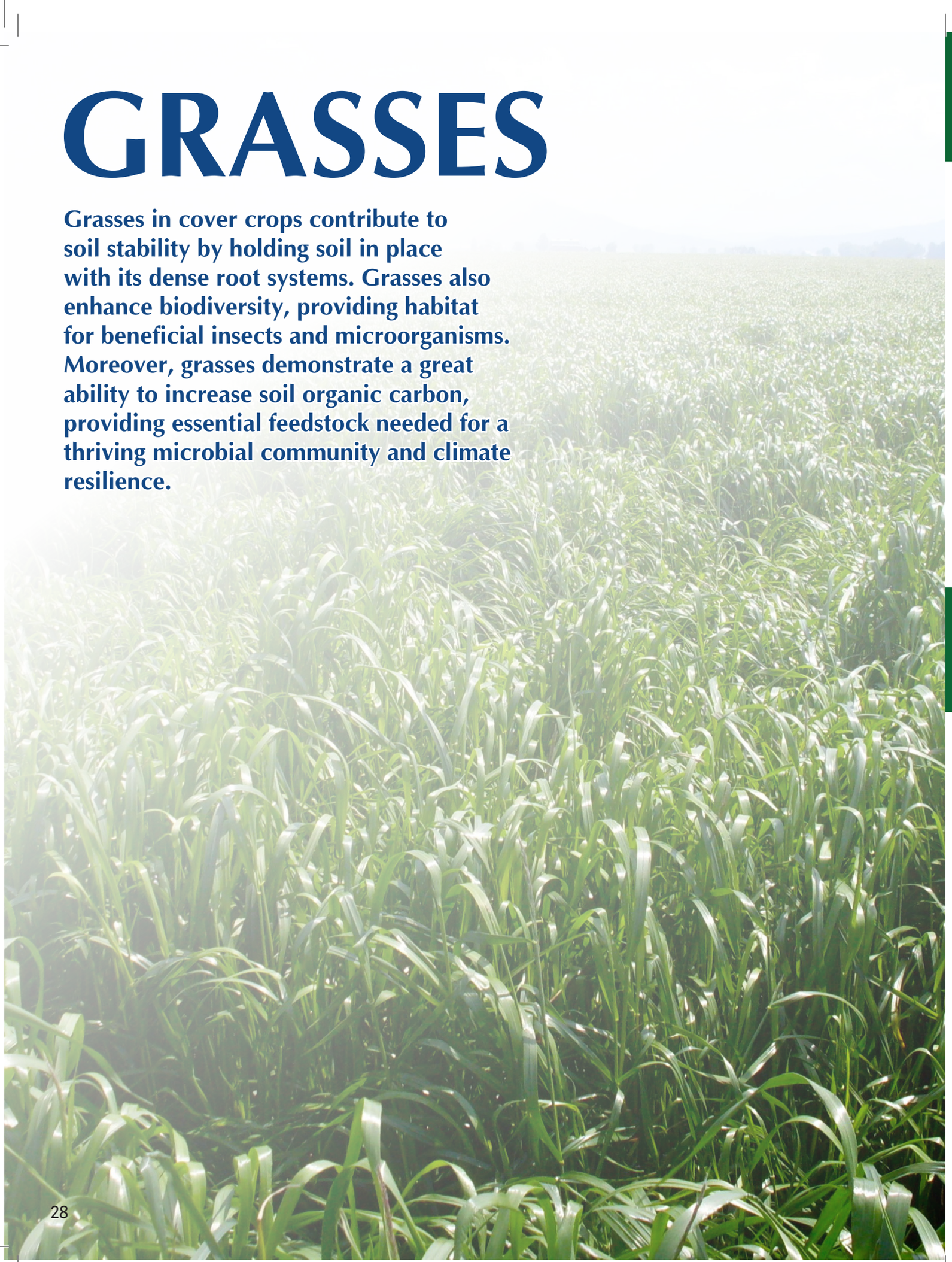


A palatable, high-energy and protein forage crop, it can be used for winter grazing by livestock and deer.



GRASSES

Grasses in cover crops contribute to soil stability by holding soil in place with its dense root systems. Grasses 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, can thrive in both temperate and Mediterranean climates and is tolerant of drought conditions. It 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 successfully when overseeding. They have wide, upright leaves and are less suitable for 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.

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.

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, leading to 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 also valuable forage during winter months for livestock and wildlife.

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 for 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.

Perennial Groundcover: Cover Crops That Stay

Annual cover crops have proven value, but planting, terminating, and managing them year after year can add cost and complexity. What if a cover crop could be planted once and left to do its work season after season? Professor Ken Moore asked that question nearly 20 years ago, and today Researchers Dr. Raj Raman and Dr. Shui-Zhang Fei of Iowa State University are part of a team helping explore that possibility through RegenPGC, a USDA-NIFA-funded project studying perennial groundcovers that can remain in place for years while corn and soybean crops grow alongside them.

Rethinking the Cover Crop Cycle

Perennial groundcover, or PGC, is a low-growing perennial established once and maintained alongside a cash crop for multiple seasons. It is not harvested. Instead, its purpose is to provide continuous ecosystem services, including holding soil in place, reducing nutrient leaching, and keeping living roots in the ground between cash crops.

The concept sounds simple, but making it work requires careful balance. A successful groundcover must be vigorous enough to establish and persist, but not so competitive that it reduces cash crop performance.

In the upper Midwest corn and soybean systems where RegenPGC is focused, researchers anticipate that PGC will work best with a defined crop-growth zone of approximately 15 inches, maintained through strip tillage.

The groundcover occupies the area between rows, while management keeps it from encroaching into the crop zone. Ideally, it becomes dormant naturally as corn begins growing or can be temporarily suppressed without killing the perennial stand.

The goal is essentially to create a system in which the cover crop knows when to grow and when to get out of the way.



Corn grown with Radix Hybrid bulbosa (RHb).

Finding the Right Groundcover

Much of the work by Dr. Raman, Dr. Fei, and the broader RegenPGC team centers on finding groundcovers that can persist without competing with the cash crop. Two species have emerged as leading candidates.

Turf type kentucky bluegrass was the first groundcover Professor Moore and his students successfully grew

alongside corn without reducing grain yield. It offers relatively inexpensive seed and creates an erosion-resistant root mat capable of persisting for a decade or longer.

More recently, Radix Hybrid bulbosa (RHb) has shown even greater promise. Dr. Fei and his students brought RHb into the project after earlier trials produced promising results. RHb naturally goes dormant in late spring, establishes more readily under dry conditions, and has been less likely to compete with corn or cause yield loss. Its primary limitation is stand longevity, although researchers believe management and breeding improvements could extend persistence beyond five years in corn-soybean rotations.

That natural dormancy is especially important. A groundcover that shuts down as the cash crop begins its most competitive growth period could reduce the management required to keep the two crops compatible.



Corn grown with Turf Kentucky Bluegrass.

Making Perennial Cover Pay

Persistence also changes the economics of cover cropping. If an RHb stand costs $60 per acre to establish but remains productive for five years, the annual seed cost falls to about $12 per acre before machinery, fuel, and labor. Researchers have used glufosinate to suppress RHb during corn production, although suppression may not be necessary during soybean years. Future breeding could potentially produce varieties that enter dormancy earlier, reducing or even eliminating the need for chemical suppression.

The Road Ahead

Perennial groundcovers are not yet a plug-and-play practice. The RegenPGC team describes the technology as being in the developmental “valley of death”: proven enough to show promise, but not yet supported by the agronomic data, economics, and risk-management tools needed for widespread adoption.

Researchers are now building the acre-years of field data needed to evaluate PGC as an insurable practice while refining management of current groundcovers. At the same time, breeders, including Dr. Fei, are working on next-generation groundcovers, such as Poa secunda, that could offer improved risk and cost profiles.

PGC will not fit every field or cropping system. Questions surrounding persistence and insurability still need to be answered. But the concept offers an intriguing possibility: a low-cost, minimal effort way to provide nearly continuous living roots year round.

As research and breeding advance, perennial groundcover could fundamentally change what it means to keep working farmland covered, becoming part of how the next generation farms.

THE ROLE OF FORBS IN COVER CROP SYSTEMS

Forbs are becoming an increasingly important part of cover crop programs as growers select species for more specific functions. These herbaceous broadleaf plants can contribute to nutrient cycling, soil biological activity, weed suppression, pollinator resources, and seasonal ground cover. The term forb describes a growth form rather than a single plant family. Cover crop forbs represent a broad and varied group of plants, with differences in rooting, growth habit, flowering period, nutrient use, and environmental adaptation.

One of the most visible contributions of flowering forbs is their ability to provide nectar and pollen. Agricultural landscapes can have periods when relatively few plants are flowering, particularly before or after cash crop bloom. Species that flower during these gaps can provide food resources for bees, butterflies, and other beneficial insects.

Their contribution also extends below ground. Root systems differ among species in depth, density, and chemistry. Active roots capture nutrients and release carbon compounds into the soil, supporting microorganisms in the rhizosphere. As plant residues decompose, nutrients contained in the tissue can cycle back into the soil system.



Phacelia combines cool-season growth, fine rooting, nutrient capture, and abundant flowering. It has been studied as a nitrogen catch crop because of its ability to take up residual soil nitrogen that might otherwise be vulnerable to loss. Its flowers also provide nectar and pollen resources for pollinators and other beneficial insects.

Buckwheat is known for speed. It germinates rapidly, develops a canopy quickly, and can be useful when the available growing window is short. Its fast growth helps cover the soil and compete with weeds. Buckwheat can also acquire phosphorus from soil pools that may be less accessible to some crops and cycle those nutrients through plant residue. Because it is frost sensitive and can set seed quickly, termination timing is important.

Camelina fills a different seasonal niche. Although botanically a member of the brassica family, it can serve many of the same functional roles as other flowering broadleaves. Camelina can establish in fall, survive winter conditions in many regions, and resume growth early in spring. Its early flowers can provide nectar and pollen when relatively few other plants are blooming, while its winter growth maintains soil cover and living roots.

Timing Shapes the Opportunity

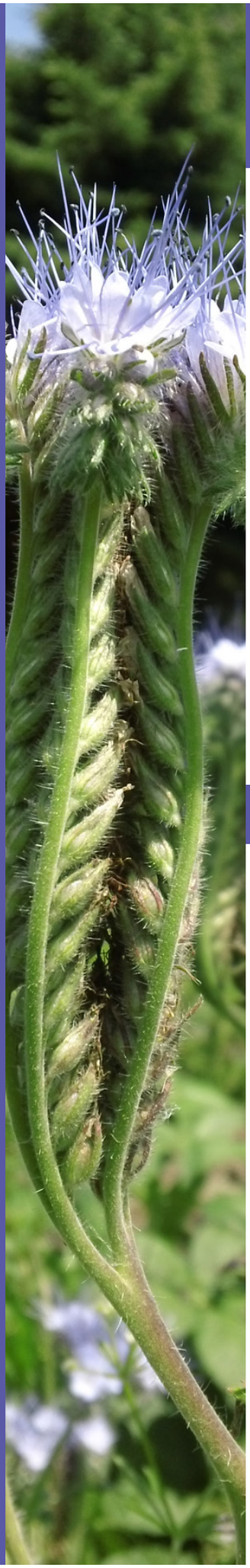
The value of a forb depends heavily on when it can grow and what function is needed from it. A rapidly establishing summer species, an overwintering broadleaf, and a cool-season flowering crop each provide different opportunities across the agricultural calendar.

Phacelia, buckwheat, and camelina represent only a fraction of the forb species available for cover crop use. Other species may offer different rooting characteristics, flowering windows, nutrient-cycling abilities, or adaptation to specific regions and rotations. Planting window, growing conditions, termination timing, and agronomic objective should guide selection.

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

Phacelia tanacetifolia

Phacelia is a quick growing, warm-season flowering plant that is native to the US and can reach heights of up to 4 feet. It is well adapted to soils ranging in pH from 6.5 to 7.8. Phacelia has good cold tolerance and has the ability to establish and grow under colder conditions. Certain studies indicate it may provide some nematode suppression for Sugar Beet Cyst Nematode; more studies are needed to address other nematode control.

Its quick growing fibrous root system is effective at catching excess nitrates and phosphates before they leach into waterways. It's 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 overall ecosystem balance. With its long blooming period and ability to produce nectar even in varying weather conditions, Phacelia is among the top-five highest producing nectar sources.



Phacelia is an excellent insectary for beneficial species and ecological balance.



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

RECOMMENDED VARIETY

Phoenix Phacelia

Phoenix Phacelia was developed through selective breeding to perform reliably under limited moisture conditions. This improved line maintains the fast establishment and abundant flowering that phacelia is known for, while demonstrating greater resilience during dry periods.

Phoenix establishes quickly, producing vigorous early growth and the characteristic purple blooms that attract honeybees, native pollinators, and beneficial insects.

Its drought tolerance comes largely from its efficient, fibrous root system and strong early vigor. Phoenix

Phacelia rapidly develops a dense network of roots that explores the upper soil profile, allowing the plant to capture available moisture before it is lost to evaporation.

Combined with its quick canopy formation and efficient water use, these traits help Phoenix continue growing and flowering even when rainfall is limited, making it a dependable option for pollinator plantings and cover crop systems in drier environments.

Key Benefits



CAMELINA

Camelina sativa

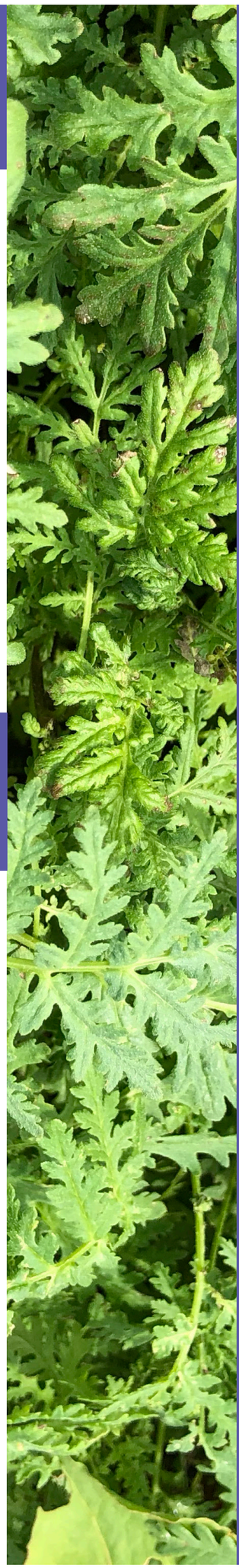
Camelina is a versatile cover crop and a forb within the brassica family, valued for its rapid establishment and flexible growth habits.

Many varieties exhibit facultative winter–spring growth, meaning they can be planted in the fall and overwinter in milder climates or seeded in early spring for quick seasonal growth.

Camelina produces an upright, fine-stemmed canopy typically reaching 1–3 feet tall and establishes quickly to provide early soil cover and weed competition. Its modest nutrient and moisture requirements make it a dependable species for adding diversity and early-season biomass in cover crop systems.



Camelina's narrow, lance-shaped leaves form a dense canopy that helps protect soil and capture sunlight efficiently during early growth.



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 effectively suppress weed growth. 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.

THE BENEFITS AND OPPORTUNITY OF SEED COATING

Many legumes are sold as coated versus raw seed. The reason behind coating has more to do with science than simply charging a marked-up price for lime.



Raw and coated FIXatioN Balansa Clover

There are several reasons as to why the seed industry coats seed. The first and most important is to ensure proper coverage of the seed with needed microbials and micronutrients. Coating allows for a precise quantity of microbial inoculants, like rhizobia which are needed for effective nitrogen fixation, to be placed on the seed and then protected with a filler such as clay, lime, or talc. This sets each seed up for the best possible outcome and allows the seed company to match the seed with the correct rhizobia strain.

Not all rhizobia are the same, and even closely related legumes can require different bacterial partners for effective nitrogen fixation. For example, Balansa and subterranean clover are commonly inoculated with one rhizobia, while white and red clover use another. Although these bacteria belong to the same general group, individual strains differ in their ability to form effective nitrogen-fixing relationships with particular legumes.

Winter peas and vetches require a different rhizobium than clovers, showing the importance of having the right inoculant for the specie. It is imperative that a compatible rhizobia is applied to the seed in order to get reliable nitrogen fixation.

"It is imperative that a compatible rhizobia is applied to the seed in order to get reliable nitrogen fixation."

When compatible rhizobia encounter a legume root, they stimulate the formation of nodules where atmospheric nitrogen is converted into forms the plant can use. Without the appropriate bacteria, nodulation may be limited or ineffective, reducing the amount of nitrogen the plant can fix and decreasing availbility or the followin crop.



Coated and inoculated FIXatioN Balansa Clover and eNhance Persian Clover in a mixture

Some soils naturally contain compatible rhizobia from previous legume crops, but their presence doesn't necessarily guarantee effective nitrogen fixation. By incorporating the appropriate inoculant into the seed coating, seed companies can help ensure the right bacterial partner is available when the seed germinates, particularly when introducing a new legume species to a field.

Coating, too, has a practical reason as it allows for better ballistic properties and can reduce separation from the likely species that it might be mixed with. For example, when GO Seed first created Fixation Balansa Clover they felt that much of it would be mixed with cereal rye. They quickly

discovered that in this instance the smaller Balansa Clover seed would separate and migrate to the bottom of the bag or seed drill. By adjusting the percentage of seed coating, they were able to reduce the separation for a more uniform stand.

At GO Seed they also incorporate different colors of coating for their standard coated products. The reasoning is that it allows the farmer to better visualize the distribution of the seed. There is risk in planting seeds, and they want to allow the farmer the ability to adjust at planting rather than find out that there was an issue after the fact.

Keep in mind that just because a seed is coated it doesn't necessarily mean it needs to be planted at a higher rate. Some legume trials have produced similar established stands from coated and uncoated seed planted at the same pounds per acre, despite fewer seeds in the coated treatment. The goal is an adequate population of established plants, rather than a particular number of seeds planted.

"Just because a seed is coated it doesn't necessarily mean it needs to be planted at a higher rate."

An even distribution of seed is better than a dense application. This is why most row crops are precision planted. If corn seeds are planted at too high of a seeding rate, the plants would compete for resources and productivity would be diminished. Precision planting gives the farmer the ability to plant at the optimum spacing. With small seeds this is more difficult and can result overplanting. Excessive seedling density can intensify competition for light, moisture and nutrients, limiting root development and growth per plant in the fall. The objective is an adequate, evenly distributed stand that establishes quickly and delivers the intended benefit.

Studies have shown that certain seed coatings can reduce feeding by birds, rodents, and insects. In Michael Bredeson's 2019 doctoral dissertation submitted to South Dakota State University, he found nearly 40% less feeding by invertebrates (beetles, and crickets) across seven species of coated seed in a seven-day period when compared to that of raw seed. Additionally, Decker, Avery, and Way (1990) found that clay-coated rice experienced 17% sprout loss compared to 36.5% for uncoated seed in trials involving blackbirds. Similarly, Taylor et al. (2020) found that rats strongly preferred uncoated seed, with even a basic clay-based coating, producing 99% avoidance when uncoated alternatives were available.

There is sound science and practical reasoning behind seed coating, not simply an effort to increase revenue. In fact, coated seed typically costs less per pound than raw seed while offering additional benefits that extend beyond price. The goal of coating is to give the farmer the best possible success for a positive outcome.

Seed coating provides a practical means of introducing beneficial bacteria and fungi alongside the developing root. Properly selected microbial combinations can strengthen biological activity around roots and improve plant performance. The research continues at GO Seed looking at how these associations can support beneficial fungal populations and improve soil function.



GO Seed uses multiple colors of coating to help identify seed in the field to visualize seeding density


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