GREENCOVER SEED

COVER CROPS FORAGES

Soil Health

Education & Resource Guide

5th Edition

Featuring articles by

Gabe Brown, Rolf Derpsch, Dwayne Beck, Jay Fuhrer, Allen Williams, Ray Archuleta, Christine Jones, Wendy Taheri, Jonathan Lundgren, Dale Strickler, and more

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Cover photo by Sandy McDougall. Blooming in all of its glory, this phacelia plant is part of a Green Cover Seed pollinator mix designed for Fraserland Farms in Delta, British Columbia. The bees love our pollinator mixes and so do our customers!

Purpose of this Guide

As farmers and ranchers who make our living from the abundant resources that God has blessed us with, we should be the most adamant and passionate conservationists in the country. Not only do our current and future livelihoods depend on healthy functioning soils and ecosystems, but God has charged us with caring for His creation. Adam, the first farmer, was directed by his Creator to care for and protect the soil. At Green Cover Seed, we believe that we still have this responsibility, and we are called to take the additional step of rebuilding and regenerating our soils.

This Soil Health Resource Guide is dedicated to that end. We acknowledge our own limited knowledge and experience, so we have invited some of the best minds in the Regenerative Agriculture movement to share their valuable expertise and insights for the benefit of all. For some, this Guide may be a reinforcement for what they already know; to others, it may be the first step in the journey towards healthier soils. This is by no means an exhaustive resource in soil health, but rather it is intended to be a concise and simple summary of the big concepts and a gateway to deeper learning and explanations in other formats. Think of this Guide as a number of seeds that can sprout and grow into deeper understanding if you will but plant them.

You will notice that many of the articles in this Guide are summaries. The full article, supporting video, and presentations are easily searchable on our website: **www.greencoverseed.com**

"Then the Lord God took the man and put him into the garden of Eden to tend and keep it (the soil)."

Genesis 2:15

We invite you to do your due diligence and further explore any or all of the topics that we will touch on in this Soil Health Resource Guide.

When Brian and I founded Green Cover Seed in 2009, we made a commitment to educate as many people as possible about soil health and provide as many tools and resources as we could to make it possible for farmers and ranchers to restore and regenerate their soils. This Guide is one of those tools. We would be glad to hear your comments and feedback on this Guide and we will provide additional copies upon request.

Kristi D Berna

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Everyone needs a personal Mission Statement and identified Core Values that will guide and direct their decisions and behaviors. Mission and Values are also critical for any company or organization that wants to grow and not lose their way in the midst of growth, competition, and conflict. We have spent a great deal of time identifying these critical elements for Green Cover Seed, and we want to share them with you and encourage you to consider what your personal Mission and Values are.

Our Mission

To help farmers and ranchers regenerate God's creation for future generations.

Value Statement

Green Cover Seed strives to honor and glorify God through our business ethics and practices and to follow the example of Jesus Christ when interacting with customers and employees.

Our Core Values that guide and direct us are:

- **Do the Right Thing** (Integrity with accountability)
- **Treat People Right** (The Golden Rule in action)
- **Family Matters** (People before profit)
- **Excellence through Teamwork** (Synergy through cooperation)
- **Focused Intensity** (Start strong and finish well)
- **Creation Stewardship** (Tending to our neighbors and our land)
- **Innovation through Education** (Learning and growing together)

History of Green Cover Seed

Green Cover Seed was started in Bladen, NE by brothers Keith and Brian Berns in 2009 after seeing the soil health benefit of cover crops through a SARE grant project they completed in 2008. Utilizing farm ground owned by their father, David Berns, they began to experiment with new ways to utilize and implement cover crops. Their 2,500 acre farm in south central Nebraska has been 100% continuous no-till for nearly 25 years and they have worked hard to research and incorporate cover crops into their farming system where they have researched cover crop water usage, cover crop nutrient content, and cover crop effects on following crops.

Green Cover Seed specializes in designing and delivering custom diverse seed mixes and has grown to be one of the leading cover crop seed providers in the world, with 8,000 customers in all 50 states and Canada. As the industry leader in providing educational events focused on soil health, Green Cover Seed has educated ten of thousands of people through workshops, seminars, conferences, consultations, and on-line videos and interaction. Dedicated employees, heavy investment into modern facilities, cutting edge software systems, and an extensive seed supply network provide a quality, competitively priced product. (See pages 60-63 for more on this)

Ten Years of Soil Health

When Brian and I started Green Cover Seed in 2009, we knew it had real potential, but we never dreamed how fast the Soil Health and Regenerative Agriculture movement would expand and how fast we would grow with it. From our little 2,500 square foot area where we started storing and mixing seed by ourselves, we moved enough cover crop seed in 2009 for about 1,000 acres and a handful of customers. In 2018, the 40 members of the Green Cover Seed team bought, sold, cleaned, moved, mixed, packaged, and shipped enough seed to cover nearly 850,000 acres and worked out of more than 40,000 square feet of facilities and 350,000 bushels of bulk storage with more being planned and built to keep up with the growing demand. More importantly, we count it a great privilege to work alongside our 8,000 customers, who are changing the world with their regenerative soil health practices. We feature the hard work, creativity, and passion of some of these folks in the pages of this Resource Guide, but almost all of our customers are telling their stories both verbally and non-verbally, and it is making a difference on our farms and in our communities.

Above: Humble beginnings - Green Cover Seed operated out of half of this 50x100 building for the first three years.

Below: The Green Cover Seed team numbers more than 35 dedicated men and women.

We are humbled at how God has blessed the timing of Green Cover Seed and how He has brought the right people onto our team and into our lives at critical moments. We are thankful for the support and encouragement that we have received from so many friends and family to not only start, but to grow Green Cover Seed into what it is today. We certainly could not hope to accomplish our mission of helping farmers and ranchers to regenerate God's creation for future generations without all of our dedicated employees and support networks. We are grateful to our hard working team members who make all of the farming, moving, cleaning, mixing, shipping, building, teaching, and leading happen on a daily basis. The future of Green Cover Seed is bright because of you!

We are also very grateful for all of the Soil Health professionals, experts and educators that have had a role in helping us educate producers about Soil Health. Thank you to Gabe Brown, Jill Clapperton, Ray Archuleta, Kristine Nichols, Jimmy Emmons, Wendy Taheri, Jay Fuhrer, Abe Collins, Dwayne Beck, Dan Forgey, Ken Miller, Jonathan Lundgren, Ray Ward, Lance Gunderson, and many others for sharing your time, your influence, and your voice to help us spread the Soil Health message to people all across the world.

One of the best things about Green Cover Seed is all of the great farmers and ranchers we are privileged to meet and work with on a daily basis. Their passion to be better stewards of the soil and to creatively think beyond the norms, encourages us to keep going, challenges us to get better, and confirms that all the work, risks, and investments are worth it! 2019 will be our tenth year in business and we will be planning some special events to celebrate this. We are looking forward to what the next ten years will bring for Green Cover Seed, Soil Health and the Regenerative Farming Movement. Long Live the Soil!

Introduction to Regenerative Agriculture

By Gabe Brown • Bismarck, North Dakota

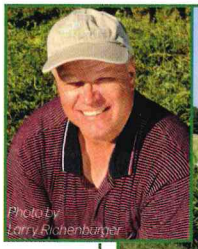


Photo by Larry Richenburger


Photo by Gabe Brown

We often hear producers who use cover crops state that they practice "Regenerative Agriculture." But what is "Regenerative Agriculture?" Regenerative Agriculture is an understanding. It is an understanding that one must work with nature instead of against her. The deep, rich topsoil which once covered a large percentage of North America was the result of a healthy, functioning soil ecosystem. Sunlight, water, minerals, plants, mammals, insects and micro-organisms all working in harmony.

Unfortunately, today much of the current production model is about man trying to impose his will on nature. We have an infiltration problem and we till the field rather than grow a cover crop to build soil aggregates. We see a pest and we spray a pesticide, rather than providing habitat for predator insects which would kill the pest. We have low yields, so we add more synthetic fertilizer rather than feeding soil life with diverse root exudates. We treat symptoms instead of solving the real problem.

The result is a degraded resource. What was once thick, deep topsoil is now but a mere fraction of what it was. I have the good fortune of being on hundreds of farms and ranches all over North America every year and I have never been on an operation, including my own, that is not degraded. As producers, we have come to accept that degraded resource. But if we follow nature's template, using the five principles of a healthy ecosystem, we can regenerate our resources.

Those five principles are:

1. Armor on the soil surface.
2. Least amount of chemical and physical disturbance possible.
3. Diversity of plants and animals, including insects.
4. Living roots in the soil as long as possible throughout the year.
5. Animals integrated into the system.

These five principles are the same anywhere in the world where plants can grow. The "tools" we use to accomplish these principles may differ, such as which cash or cover crops we grow or which species of livestock we raise, but the principles are the same.

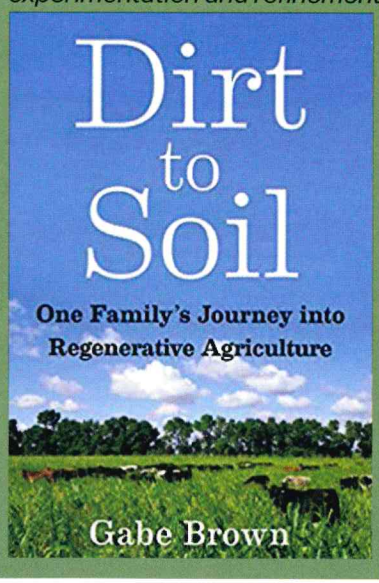
By reducing and eliminating tillage, infiltration rates, water holding capacity and nutrient cycling will improve. Adding cover crops to our rotation will increase biodiversity, protect and grow topsoil, pump more carbon into the soil, feed soil biology and allow the integration of livestock onto cropland. Those who work with nature and follow her principles are seeing an exponential increase in the health and function of their soil, the plants that grow in it and the animals that thrive on them.

Perhaps the greatest testament to "Regenerative Agriculture" is the fact that it significantly improves not only profitability, but quality of life as well. Those who practice it say that it has made farming and ranching fun again!

Charles Kellogg said it best when he stated, "Essentially, all life depends upon the soil…There can be no life without the soil and no soil without life; they have evolved together."

To learn more about Regenerative Agriculture, we recommend reading Gabe's new book, "Dirt to Soil", where he tells the story of his amazing journey and offers a wealth of innovative solutions to our most pressing and complex contemporary agricultural challenge - restoring the soil.

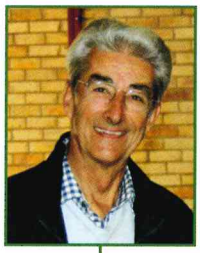
The Brown's Ranch model, developed over twenty years of experimentation and refinement, focuses on regenerating resources by continuously enhancing the living biology in the soil. Using regenerative agricultural principles, Brown's Ranch has grown several inches of new topsoil in only twenty years!



The 5,000-acre ranch profitably produces a wide variety of cash crops and cover crops, as well as grass-finished beef and lamb, pastured laying hens, broilers, and pastured pork, all marketed directly to consumers.

Keep the Soil Covered

By Rolf Derpsch, Ph. D • Asunción, Paraguay



The first step towards soil health is to protect your soil with cover or residue, oftentimes referred to as "soil armor". In addition to preventing wind and water erosion, covered soil has far fewer weeds, much higher infiltration, and much lower evaporation.

Rolf Derpsch, one of the fathers of the South American No-till and Soil Health movement, has this to say about Soil Cover:

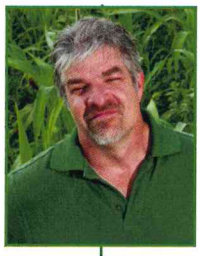
> Not very many farmers understand the true importance of soil cover in the no-till system. Some even wrongly view crop residues as a commodity, waste product, or an impediment to seeding the next crop. A no-till system with low amounts of crop residues, limited crop diversity, and high amounts of soil disturbance will have higher evaporation rates, lower water-use efficiency, and will not attain the full potential of the no-tillage system.
>
> Almost all the benefits and advantages of the no-till system come from the permanent cover of the soil and only a few from not tilling the soil. In other words, it is not so much the absence of tillage, but the presence of crop residues on the soil surface that results in a better performance of no-till in comparison to tilled systems. Failure to pay attention to soil cover has resulted in poor performance of the system (lower yields, increased runoff and erosion, low biological activity, etc.). There is plenty of scientific evidence that no-tillage without soil cover results in poor crop yields.
>
> Contrary to the belief of many US Farmers, there is no need to till the soil every so often after a no-till system has been established. Good examples are South American farmers, who once started, never till the soil again.

The best way to avoid compaction is to produce maximum amounts of soil cover and to use cover crops and crop rotations. This way the roots and biological activity, as well as earthworms and insects, etc. will loosen the soil along with substances like Glomalin that bind the soil particles into stable aggregates and result in a beneficial soil structure.

Cover crops and crop rotation play a very important role in a no-till system in order to achieve the high amounts of soil cover needed. The development of cover cropping along with a permanent no-till system has been a major factor in the unprecedented growth of this technology in South America. In drier climates, farmers are often concerned that cover crops will take moisture out of the soil, making it unavailable for the primary crops. This is and should always be a concern in drier climates. Managing cover crops at the right time, in the right way, and using species that use less moisture are ways of getting around this problem. It must be remembered that while the cover crop removes some soil moisture, the additional mulch from the cover crop will improve water-use efficiency later in the cash crop.

Minimize Soil Disturbance

By Keith Berns • Bladen, Nebraska



Soil disturbance can be the result of chemical, biological, or physical processes, but all forms of disturbance diminish habitat for soil microbes and result in a diminished soil food web. Chemical disturbances occur with the over application of synthetic fertilizers and pesticides and when we substitute chemistry for biological functions, we disrupt the symbiotic relationships between fungi, other microorganisms, and plant roots.

Biological disturbances, such as long fallow periods and overgrazing, limit the potential and the ability for plants to harvest CO2 and sunlight. When plants are not allowed to function properly, the soil and the soil biology suffers because of increased erosion exposure, increased soil temperature, and decreased root growth and root exudates which build both soil structure and biological communities.

In nature, physical soil disturbance is always the result of catastrophic events such as erosion, earthquakes, or glaciers. In a farming system, tillage is also traumatic as it results in broken, bare, and compacted soil that is destructive and disruptive to soil life. Tillage disturbance can lead to the following negative soil impacts:

Erosion

Broken and exposed soil is susceptible to both wind and water erosion. Tillage not only breaks down soil aggregate structure which leads to erosion, but also severely reduces soil residue cover which further exposes soil to erosion.

Compaction

A typical soil is approximately 45% mineral (sand, silt, and clay), 5% soil organic matter, 25% water, and 25% air. The water and air portions exist in the pore spaces between the soil aggregates. Over time, tillage implements reduce and remove the pore spaces from our soils, restricting infiltration and destroying the biological glues which hold our soils together.

Reduced Infiltration

Tillage physically breaks down soil aggregates and destroys root and earthworm channels which makes it difficult for water to infiltrate and leads to ponding water, excessive surface saturation, and soil surface crusting.

Organic Matter Depletion

Tillage physically mixes soil organic matter (carbon) with excess oxygen and the result is a "burning off" of organic matter and the release of excessive carbon dioxide into the atmosphere. Long histories of tillage have led to significant reductions (50-80%) of soil organic matter levels across the majority of the world's arable land.

Limiting soil disturbance is one of the most important things that any producer can do to protect, improve, and regenerate the soil. As stewards of the soil, it is our job to protect our soils from any unnecessary chemical, biological, and physical disturbances.

Cover crops can help minimize all three types of soil disturbance. When weeds are suppressed by covers, chemical disturbance is reduced. Growing cover crops keep the soil biota alive and thriving which eliminates biological disturbance. Cover crops can drastically reduce physical disturbance by reducing erosion, breaking up compaction, increasing infiltration, and adding to the organic matter of the soil.

#soildisturbance

Plant Diversity

By Dwayne Beck, Ph. D • Pierre, South Dakota

Dwayne Beck has had more impact and influence on Plains Agriculture in this generation than anyone else we know. As director of the Dakota Lakes Research Farm in Pierre, SD, Dr. Beck has developed his vision of regenerative agriculture in the field and not in a laboratory or a classroom. His practical approach to systems based agriculture is legendary and his candid style of education is refreshing to anyone who has heard him speak. Dr. Beck writes here about the Power of Plant Diversity:

A diverse crop rotation system consists of growing different kinds of crops in planned sequences to take advantage of the power of diversity and reduce overall risk. One of the most important roles of a crop rotation is to mimic the natural water and nutrient cycle while maximizing the amount of sunlight captured. Historically, rotations have been much more diverse than they are now and most included phases of perennial crops with livestock integration. This loss of diversity was due to a myriad of economic factors including farm program characteristics; mechanization, development of nitrogen fertilizer sources and pesticides, and specialization in livestock production. Interest in diversifying crop production systems has increased recently. Commodity prices that are low relative to the costs of fertilizer, machinery, labor, and pesticide inputs have led producers to examine means of reducing these costs.

In addition, natural selection pressure resulting from longer histories of tight rotations and monocultures have led to species shifts, resistance, and/or changes in pest's traditional habits that have resulted in yield losses. Proper application of rotational planning can increase yields, reduce costs, and improve soil health and fertility. These positive benefits affect whole farm economics by reducing weed, disease, and insect pressure and resistance; spreading workloads to reduce fixed machinery and labor costs; providing more optimum planting and harvesting timing; and diversifying income and spreading weather risks. Failing to match natural systems has caused much of the environmental issues we face in US agriculture.

It is over-simplistic to classify rotations as good or bad, but rather rotations have differing characteristics in terms of their impacts on various aspects of the crop production system used. Designing appropriate rotations is a mix of ar and science. Since all aspects (agronomic, environmental, economic, engineering) must be considered simultaneously, a systems approac is required. For any given situation, there will be a range of rotations that will be appropriat and within this range rotations will have differing characteristics in terms of the risk they pose, which may make some more suitable fo use in a particular location. Management dec sions must be made by individual producers t select the rotation or combination of rotation that is most appropriate for them.

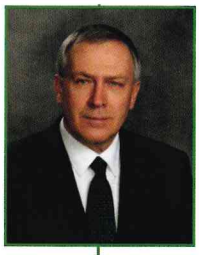
Beck's "Rotation Rules"

- *Reduced and no-till systems favor the inclusion of alternative crops. Tilled systems may not.*
- *A two-season interval between growing a given crop or crop type is preferred. Some broadleaf crops require more time.*
- *Chemical fallow is not as effective at breaking weed, disease, and insect cycles as are black fallow, cover crop, or production of a properly chosen crop.*
- *Rotations should be sequenced to make it easy to prevent volu teer plants of the previous crop from becoming a weed proble*
- *Producers with livestock enterprises find it less difficult to introduce diversity into rotations.*
- *Use of forage or flexible forage/grain crops and cover crops enhance the ability to tailor rotational intensity.*
- *Livestock make using rotations with perennial sequences easy. It is probably not possible to be sustainable over long periods o time without using perennial plants in the system.*
- *Crops destined for direct human food use pose the highest risk and offer the highest potential returns.*
- *The desire to increase diversity and intensity needs to be balanced with profitability.*
- *Soil moisture storage is affected by surface residue amounts, inter-crop period, snow catch ability of stubble, rooting depth characteristics, soil characteristics, precipitation patterns, and other factors.*
- *Seedbed conditions at the desired seeding time can be controlled through use of crops with differing characteristics in regard to residue color, level, distribution, and architecture.*
- *Rotations that are not consistent in either crop sequence or crop interval guard against pest species shifts and minimize the probability of developing resistant, tolerant, or adapted pest species.*

#diversity

Living Roots as Often as Possible

By Jay Fuhrer • Bismarck, North Dakota



Under the direction of District Conservationist Jay Fuhrer, Burleigh County in North Dakota became one of the original epicenters of Soil Health utilization, knowledge, and education in the United States over the last 15 years. Working with innovative farmers and ranchers like Gabe Brown and Ken Miller, Jay led the charge in learning how to improve all aspects of soil health and was an integral part of the acquisition and development of the legendary Menoken Farm. Jay is currently serving as the NRCS Soil Health Specialist for North Dakota and South Dakota and is one of the top Soil Health teachers around. Here is what he has to say about the importance of Living Roots:

> There are many sources of food in the soil that feed the soil food web, but there is no better food than the sugars exuded by living roots. Our perennial grasslands consist of cool season grasses, warm season grasses, and flowering forbs. Consequently, adaptable plants are able to grow during the cool spring and fall weather, as well as the summer heat, allowing for a continual live plant feeding carbon exudates to the soil food web during the entire growing season. Our cropland systems typically grow cool or warm season annual cash crops, which have a dormant period before planting and/or after harvest.
>
> Soil organisms feed on sugar from living plant roots first. Next, they feed on dead plant roots, followed by aboveground crop residues, such as straw, chaff, husks, stalks, flowers, and leaves. Lastly, they feed on the humic organic matter in the soil. Healthy soil is dependent upon how well the soil food web is fed. Providing plenty of easily accessible food to soil microbes helps them cycle nutrients that plants need to grow.

#menokenfarm

When production agriculture began, we converted our grasslands from 50-100 species per acre of perennials into a single annual crop. These diverse species of plants had a lot of root exudates, which provided year-round food to the soil food web. With annual monoculture cropping system came long fallow periods, which were in the spring before planting, and another long period of fallow followed harvest in the fall. I used to think cover crops were important, but now I think they are essential because cover crops are able to fill in the dormant fallow period and provide the missing live root exudate, which is the primary food source for the soil food web. A properly fed soil food web will produce biotic glue compounds like glomalin which is key to building stable soil aggregates. A well aggregated soil has more pore space and thus can both infiltrate and store significantly higher amounts of water.

Photo by Jimmy Emmons

Plant root exudates leaking out to feed soil biology.

Cover crops are game changers as they produce an extra influx of carbon which is also an influx of food for the soil biology. The goal is more root mass with soil aggregates and ultimately more carbon. Cover crops may be incorporated into a cropping system as annuals, biennials, or perennials. Starting on a small acre scale will allow farmers and ranchers to find the best fit for their operation.

#livingroots

Livestock Integration

By Allen Williams, Ph. D • Starkville, Mississippi

A champion of the grass-fed beef industry as well as cutting edge grazing methodology, Dr. Allen Williams is driven to build agriculture systems that provide an attractive, profitable, and sustainable future for many generations to come. He is one of the top grazing consultants in the country and is often on the road teaching farmers and ranchers about regenerative grazing systems and soil health.

Soil health, biological activity, moisture efficiency, and nutrient retention can all be dramatically increased through proper integration of livestock and the grazing of cover crops. There are several ways to accomplish this:

Adaptive Multi-Paddock Grazing (AMP) is a system allowing for flexibility in grazing methodology based on weather and field conditions, rather than locking fields into a rigid system that never changes. Short-term, high intensity grazing on multiple paddocks can carry more animals, have better forage utilization, have superior wildlife habitats, and improve the overall health of the soil over traditional grazing systems. Research has also shown that AMP grazing increases soil aggregate stability, lowers soil temperatures, and sequesters higher amounts of soil carbon than other methods of grazing or non-grazing. AMP grazing can work in any system whether it is perennial grasses or annual cover crop forages. Adaptive grazing also means being adaptive to the people! You don't have to move cattle everyday; it could be every other day, or once a week - it is what works best for you and what works best for the land.

#AMPgrazing

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Winter Stockpile Grazing is when a grower takes advantage of warm growing season to grow forage for winter grazing and can include everything fro perennial forages to warm season and cool season cover crops for winter grazing. It a very simple wa to move cattle through an area in a high- density manner through the winter months, as well as to have the animals self-apply manure and urine in a very even distribution during that time period.

Bale Grazing is a winter practice where hay bales are placed in a field in a checkerboard fashion, about 30 fee apart. Cattle are controlled with a single strand of electrified poly wire and manure and residue is left behind the fields as the animals dismantle and feed on the bale

Poor grazing management practices that result in exces sive plant leaf and tissue removal and excessive trampling create conditions conducive to soil loss. It has bee documented that bare ground experiences a significant decrease in soil microbial activity, a loss in soil organic matter, and subsequent increase in erosion. When poor soil management practices are employed, either throug poor grazing management or conventional farming, soi degradation increases due to increased soil compaction and bulk density, resulting in elevated water penetratio resistance and reduced soil aggregate stability.

Why Cover Crop?

Cover crops are plants or a diverse mixture of plants that are grown in the otherwise fallow periods between harvested crops within a rotation. Cover crops are an important part of any regenerative agricultural system, because they are unique in their ability to deliver so many ecosystem services.

Many people ask, "Why should I spend money on a crop I don't intend to harvest?" That is a legitimate and timely question! Many producers are discovering that cover crops are a wise investment and can provide many benefits and soil services.

This Reference Guide outlines many benefits of cover crops, all of which fall into one of these categories:

1. *Produce above ground biomass that is beneficial for:*
   a. Livestock grazing
   b. Wildlife attraction
   c. Pollinator and beneficial insects

2. *Provide living roots in the soil that are beneficial for:*
   a. Mycorrhizal fungi and other soil biology
   b. Nitrogen fixation
   c. Nutrient (particularly phosphorus) availability
   d. Nutrient scavenging and cycling
   e. Disease and pathogen suppression
   f. Increased water infiltration
   g. Increased soil structure and aggregation
   h. Reduced soil compaction

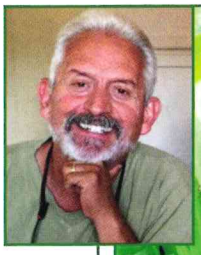
3. *Create soil armor through a residue mulch layer that is beneficial for:*
   a. Reduced or eliminated soil erosion
   b. Decreased soil temperature
   c. Decreased evaporative water loss
   d. Increased water infiltration
   e. Improved drought tolerance
   f. Increased soil organic matter

4. *Provide decayed root channels that promote:*
   a. Air and water movement into soils
   b. Increased soil organic matter
   c. Deeper rooting of subsequent crops through "pilot" holes

All of these benefits help create a more profitable and sustainable system of farming and ranching, but an often under-appreciated benefit is that cover cropping makes farming fun again! Many customers report that their favorite part of farming is inspecting their cover crop stands and seeing the soil improve over time. Regenerative farming and cover cropping has given them a new positive outlook for the future of their farm and a newfound hope of passing the land on to future generations in better condition than when they acquired it.

Photo by Cody Butler

Ecosystem Services from Living Plants



By Ray Archuleta • Greensboro, North Carolina

Ray Archuleta is one of our all-time favorite "soil guys". He is a Certified Professional Soil Scientist with the Soil Science Society of America and has over 30 years experience as a Soil Conservationist, Water Quality Specialist, and Conservation Agronomist with the Natural Resources Conservation Service (NRCS). During his tenure with the NRCS, Ray served in New Mexico, Missouri, Oregon, and North Carolina. After his retirement from the NRCS in 2017, Ray founded Soil Health Consultants, LLC, and Soil Health Academy, LLC, to teach Biomimicry strategies and Agroecology principles for improving soil function on a national scale. Ray also owns a 150-acre farm near Seymour, Missouri that he operates along with his wife and family. To learn more, please visit Ray's website: https://soilhealthconsultants.com

Ecology is the science of interconnected relationships between organisms and their environments. One of the most ecologically influential organisms on our environment is plants. Without plants, life could not exist on Earth as plants impact all four of the critical ecosystem processes that sustain life. In fact, one of the biggest mistakes of soil science is teaching that plants and soil are separate ecosystems, but in reality, they are the same ecosystem. Without plants you cannot call soil… soil — which by definition, denotes life! Soil without plant and microbial life is just geology – dirt and rocks! Soil is the intimate union between biology and geology. Plant-soil life is the most powerful geological force on the planet and without it, these four life sustaining ecosystem processes would not happen and earth would be a lifeless planet.

If farmers, ranchers, and agriculturists are going to make a sustainable living on the land, it is critically important to understand how the four ecosystem processes function and how critical plants are to these systems. These four processes daily provide services that are critical to all of life on the farm, ranch, and other natural ecosystems, and indeed it is not overstatement to say that all life on earth depends on these keystone cycles. These four processes are interconnected and cannot function properly without each other. If one of these processes is missing or compromised, then the other processes will not function properly, which will diminish ecosystem services and reduce our ability to produce feed, fiber, an food for a growing world.

1. Capture Solar Energy

Plants capture the sun's energy through photosynthesis and convert this light energy into chemical energy which is then transformed into carbon-based molecules which nourishes and sustains almost all living organisms on the planet. $6CO_2+6H_2O = C_6H_{12}O_6 +6O_2$ is the most important piece of chemistry in the world! The simple carbon sugar glucose molecule formed in photosynthesis is the basis for our entire food chain… and having breath able oxygen as a byproduct is not bad either! Ancient people used to call plants, "the mouth" of the soil, becaus

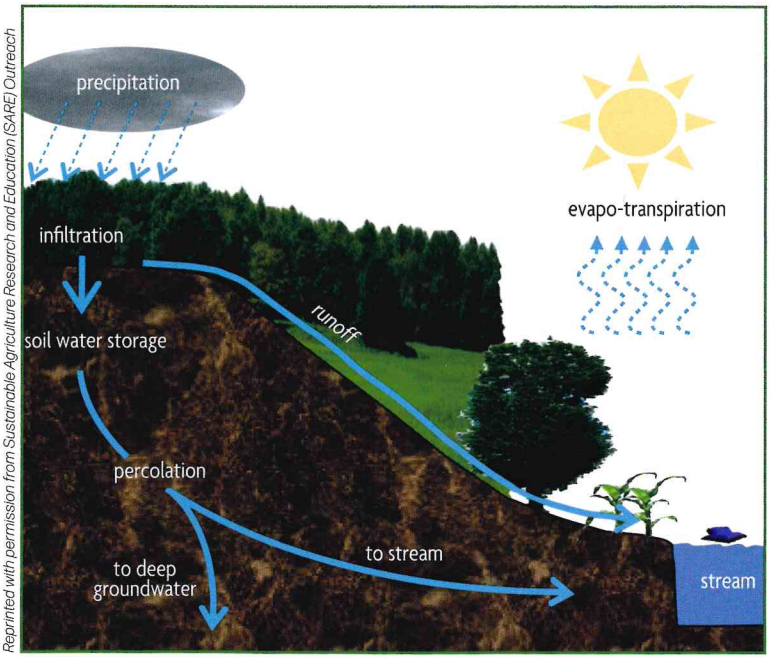
without plants the soil does not eat. Plants are the primary conduits of life sustaining energy which is used to feed the biological life in the soil, which in turn feeds us!

2. Nutrient Cycling

This process occurs when plants exude their myriad of photosynthetically derived carbon-based molecules through their root systems to feed a plethora of soil organisms. In return, this soil biota community mines, extracts, modifies, and delivers nutrients and minerals from the soil matrix and "trades" it back to the plant in exchange for carbon based food. Additionally microbes (rhizobia and others) can convert inert atmospheric nitrogen into plant available nitrogen that allows a plant community to grow and thrive. Plants and microbes are responsible for over 90% of natural nutrient cycling, availability, and production for living organisms.

3. Water Cycle

As plants and microbes collaboratively modify their mineral habitat, they create super biotic glues that aggregate sand, silt and clays to create a porous structure which allows the infiltration of water. Infiltration is the key to the water cycle and its importance cannot be overstated. Plants also increase infiltration through root channels and protection from the kinetic energy of rain drops. The amount of rainfall a farm receives is irrelevant if the rain does not infiltrate into the soil. Many droughts are partially the result of poor infiltration. Additionally, plant evapotranspiration is a key part of the water cycle as 40% of our inland rain comes from plants and soil creating humidity.



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4. Community Dynamics Through Biodiversity

Diversity of plants, insects, microbes, and other organisms are responsible for transporting energy, nutrients, and mass from one organism to another. Biodiversity is the foundational ecosystem services to which our human well-being is intimately linked. No feature of Earth is more complex, dynamic, and diverse than the biosphere, the layer of living organisms that occupy our soil surface and chemically unites the atmosphere, geosphere, and hydrosphere into one environmental ecosystem within which millions of species, including humans, have thrived. Diversity is a conduit or a transport mechanism to all living organisms on the planet. Plants create an architecture of habitat and biodiversity facilitates the self-healing, self-regulating, and self-organizing mechanisms for all natural ecosystems. Diversity creates health and resilience in biological systems and without diversity of plant life, it is impossible to achieve diverse soil life.

Photo by Brendon Rockey

It is important to understand that financial stability can only be accomplished through ecological viability. Simply said, "grow more green plants, if you want to be in the black". Growing more plants will require cover crops. Our farms/ranches must run on new sunlight (capturing solar energy with plants) not on ancient sunlight (petroleum-based inputs). Planting diverse cover crops are not optional as these plant communities facilitate life! The more you feed your soils with diverse plant communities, the more ecosystem services the soil will provide, including nutrient cycling, healthy plants/animals/humans, resilience against drought with increased water holding capacity, less erosion, reduced flooding, stabilized climate, decreased pest pressure, and reduced pesticide usage. These are but a few of the rewards for investing in systems that leverage the power of ecosystem services.

Poly Cropping with Multiple Cash Crops

Axten Farms • Minton, Saskatchewan

The act of poly cropping is the concept of growing two or more crops at one time to harvest. There are multiple benefits to this technique including:

- Reduced fertilizer use (when one crop is a legume).
- Higher combined profit per acre than monoculture crops.
- Reduce or eliminate some herbicide, insecticide, and fungicide passes.
- Plants can synergistically assist one another for improved performance.
- Ability to market two crops from each acre, providing more marketing potential.
- Utilize species to maximize varying soil series within a field.
- Better harvestability of crops (crops prone to lodging are supported by more erect crops).

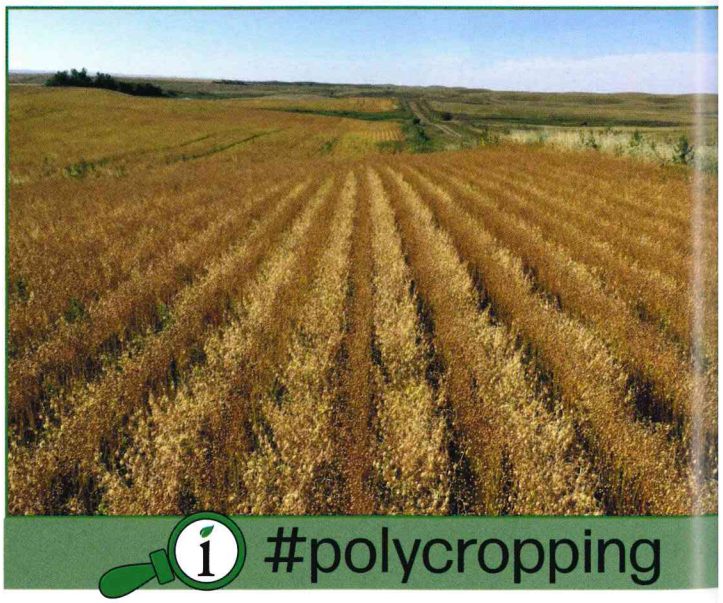
Derek and Tannis Axten from Minton, Saskatchewan, are pioneers in this concept. Their first farm scale poly crop was a pea/canola combination in 2011. Several seasons of success got them to try new combinations including lentils/flax, mustard/maple peas, sunflowers/hairy vetch, chickpeas/flax, canola/chickling vetch, and canola/winter peas. Their cereals (oats and durum) are not seeded as an intercrop but are seeded with clovers as a companion crop. Axten's personal experiences has shown that poly cropping has the potential to yield more profit per acre and gives the farmer two products to market. Green Cover Seed routinely buys both the chickpeas and the flax that the Axtens grow.

Photo by Tannis Axten

The caveat to this system is that harvested crops need to separated prior to marketing. On-farm cleaning systems can be utilized for separation, but it is important to choo species that are different enough in seed size, shape, and density, so they can be easily separated. Chickpeas/flax a great, but mustard /canola (both small, round, and dense would be almost impossible to separate.

Many producers who are poly cropping got their start by making a mistake in termination or planting, but then observed and learned about plant synergism and now try to harness the power of diversity. To get started, we recor mend that you start small and determine what species wi work within your region. If herbicides will be used, start with diverse crop labeled products like Spartan to give maximum flexibility of approved species. Determining th seeding rates of each species may take some experimentation and research, but starting with a 75% rate of each species is a good place to begin.

Learn more about the Axten's farming operation at their website: http://www.axtenfarms.ca/



#polycropping

Cereals Back in the Rotation

Dan DeSutter of Attica, Indiana, is doing something almost sacrilegious in his area: he has quit the corn-soybean only rotation and has added cereal grains back into his rotation, as was done 70 years ago in the Corn Belt.

We caught Dan at a rare moment in his busy schedule when he had time to answer a few questions.

- ***Why do you think putting cereal crops back into the rotation is important?***

Dan: We have identified that a lack of diversity is a major limiting factor to increasing the health and function of our soils. Most of the agronomic problems that we face are due to lack of diversity. Unfortunately, with a limited growing season, there are not meaningful opportunities to introduce diversity into a corn and soybean alternation. Cereal crops not only bring diversity as a cash crop, but more importantly, they give us a window after harvest to inject diversity in the form of cover crop cocktails. On the acres that we have initiated this change, we see significantly less weed pressure as well as a marked increase in plant health.

Photo by Dan DeSutter

- ***What is your current crop rotation?***

We don't have a single rotation as we are constantly trying different combinations to see where the greatest synergies lie. A set rotation implies predictability which is the opposite of what we want. Our goal is to become more unpredictable to keep pests guessing. We are headed in the direction of identifying combinations of companion perennial plants that will provide fertility as well as mycorrhizal and biological support to the cash crop we would like to harvest.

- ***What kind of results and benefits have you seen so far?***

As we try to assimilate the five principles of soil health into all our management decisions, the results are predictable. Organic matter is increasing. Weed pressure is decreasing as is our dependence on all outside inputs. Water infiltration is improving along with the soil's ability to feed our crops without our help.

- ***What problems and challenges have you run into so far?***

Big surprise here, things don't always work out as planned. The first year we employed a complex cover crop mix it was absolutely beautiful in terms of diversity and biomass. The next year we used a very similar mix, but planting was delayed almost 3 weeks after wheat harvest. In an effort to eliminate glyphosate and 24d from our system, we planted as soon as it was fit without a burn down. However, the volunteer wheat had a good head start and this proved detrimental to several species in our mix resulting in less diversity and biomass. Timing becomes even more crucial when you try to operate without band-aids. We have learned that when you try to eliminate chemical disturbance you have to always be planning three steps ahead.

- ***What new practices do you plan to try going forward, and why?***

While it is not necessarily a new practice, we are working diligently to re-introduce livestock into our land-management toolbox. This involves installing fence and water systems on every acre that we wish to have the ability to graze. We believe that we can build soil health much faster with managed ruminant impact than without. Next year, we plan to seed pollinator habitat throughout the farm, especially where we are still employing mono cash crops. The key to avoiding economically damaging insect infestations and/or pressure to resort to insecticide use is enhancing the number and diversity of our predator species by providing them food and habitat. We can solve almost every problem that faces agriculture today if we would employ the Five Principles of Soil Health. Think about it!

Photo by Dan DeSutter

Spring Green Manure

Featuring Burkey Farms • Dorchester, Nebraska

Sometimes full season row crops, adverse fall harvest conditions, or lack of manpower limit opportunities for good fall cover crop establishment. All is not lost as some producers are taking a "Plan B" approach and planting a diverse cover crop mixture in the early spring when soil temps reach the low 40's. This approach still has good growth potential PLUS a spring planting gains extra plant diversity with many spring annuals to choose from. One caution is that if you get caught in a wet early spring weather pattern, spring planting can be a challenge but most years timely establishment is possible.

A good example of this concept in practice is Burkey Farms, an organic farming operation in Southeast Nebraska. They have found that their best irrigated organic corn yields come when living covers are utilized to fix organic N in conjunction with their applied hog manure. To achieve organic N fixation, Burkey Farms will typically fall plant a heavy rate of hairy vetch following bean harvest. However, when fall planting does not get done, diverse spring planted covers heavy in spring annual legumes such as 4010 spring peas and chickling vetch are also utilized.

They report planting these covers about the same time that oats would normally be planted in the region. Burkey Farms told us that they see similar corn yields when using this spring planted system as long as they are patient and allow the covers to grow long enough to do their job. Letting the covers get at least 18-20" tall before termination allows them to make a lush cover averaging 80-150# N on the spring planting and 100-170# N on the overwintered hairy vetch.

Photo by Burkey Farms

Although the primary goal of the Burkey operation is N fixation, spring planted covers offer increased diversity. The Burkey's have observed the benefits of this diversity using plants such as phacelia, mustards, oats, and flax.

Cover Cropping After Hail Damag

It would be great if "Plan A" was the only plan we ever needed, but farming seldom works out that way. For example, when your primary crop is destroyed by hail, it is certainly helpful to have a Plan B.

Rick Kotschwar, who farms near Farnam, Nebraska, had such an event in the summer of 2017 when he lost 700 acres of summer row crops to hail. Rather than just mope, he decided to make the best of a bad situation an plant cover crops for grazing that winter. On the third week of July, he planted a complex cover crop blend that included radishes, turnips, sorghum-sudangrass, lentils, peas, flax, and wheat. Part of this land (500 acres) was irrigated and the other 200 was dryland. On the irrigate land he ran the pivot one circle around to insure good germination and let nature take it from there. The mix grew very well, and by December, Kotschwar was able to rent this land out for winter grazing. He doesn't have firm numbers on how many animals the land carried, but "it was a lot" and he received $1.15 per cow per day, as opposed to the $.55 per head per day he usually receives from corn stalks, and it carried those animals for six weeks. One immediate effect of the cover crop was that soil erosion stopped altogether. A second effect may have come later. Rick notes, "I had my best crops ever th following year and while I am hesitant to attribute all of that to the cover crops, as the weather was favorable and there were several other factors at work, it is evident tha the cover crop certainly didn't hurt anything!"

It is said that when God shuts one door He often opens another. Hail may just be an opportunity to do some soil improvement with a cover crop. Planting covers into hailed crops is a great opportunity to add diversity, suppress weeds, capture and cycle nutrients, and provide supplemental grazing. We can help you design a mixture that works with your residual chemical carryover and will help meet your resource concerns.

Summer Fallow Replacement Cover Crops

The arid High Plains, an area comprised of western parts of Texas, Oklahoma, Kansas, Nebraska, the Dakotas, and the eastern parts of Colorado, Montana, and Wyoming, is one of the most difficult places in the US for farming due to limited and erratic rainfall and high evaporation rates. This is a region where most people assume it is too dry for cover crops; after all, if there isn't enough moisture for one crop in most years, surely it is too dry for two crops, isn't it? However, even in this region, there are some enterprising people who have found ways to make cover crops a benefit in their operations.

Photo by Lance Felkert

Fallow replacement cover crop mix of oats, lentils, rapeseed, flax and safflower.

John Niswonger farms near Sharon Springs, Kansas, just a few miles from the Colorado border. Cover crops are becoming an increasingly larger part of his farming plans. In the traditional wheat-fallow-corn-fallow rotation common in his area, he noticed that by the time he planted wheat, the corn residue had disappeared and the soil was bare and baked hard in the sun. The soil obviously needed more cover and he was having trouble controlling weeds like kochia and Palmer amaranth. They were also short of cattle feed almost every year and had to spend money to buy extra hay.

In response to these conditions, John did something very unusual for his area: he planted cover crops during the long fallow period before wheat in the rotation. Conventional wisdom is that you kill everything during the fallow period to save as much moisture as possible, so what John did was the exact opposite of that! How did it turn out? For the most part, quite well. The fallow periods used to require up to five spray passes to control weeds, now he is down to two passes and occasionally just one. Weeds are also often converted into a resource when cover crops are grazed, as many of them are palatable and nutritious. The tender regrowth of previously grazed weeds seems easier to control with herbicide than tall ungrazed weeds as well. Some of the covers are grazed, adding additional income and allowing much needed rest for their perennial pastures at critical times. Cover crop grazing allows them to expand their cow herd without adding more land.

The covers also seem to have improved moisture management as well. While growing cover crops do use moisture, land covered by cover crop residue has better infiltration of rainfall and less evaporation, thus recapturing what had been used to grow the cover. Niswonger notes that it is essential that rainfall must occur after cover crop termination for good results, but any rain that does fall on cover cropped ground is captured and stored more efficiently than on land without cover crops.

The yields of his crops following cover crops have been mixed, with some yield reductions and some yield enhancements, mostly depending on whether or not he received a replenishing rain following cover crop termination. In spite of the inherent risks, John likes the long-term effects and the trend of his soil condition. His organic matter levels continue to creep up and the availability of phosphorus is improving. The reductions in weed control costs and grazing income are nice bonuses that easily offset the cost of the cover crop seed. When asked about his future plans, Niswonger states: "I plan to incorporate more cover crops as dedicated grazing crops, to boost income from beef and to speed soil improvement. However, it is very important to not remove too much residue from grazing, always leave plenty of residue for soil protection."

Photo by Fletcher Swayze

Fallow replacement cover crop mix ready for termination in early June. Note the excellent weed control with no spring herbicide applied.

While it is a continual learning experience, John is among a handful of High Plains farmers who are figuring out that cover crops can indeed be useful, even where it is "too dry for cover crops".

Aerial Seeding

"Some people swear by seeding cover crops with an airplane. Others swear at it. The difference may boil down to paying attention to details, including picking an aerial applicator who understands how to apply seed."
- Tom Bechman, Western Farmer-Stockman

Aerial seeding of cover crops allows lots of acres to be seeded in a short period of time when it is physically impossible to use ground equipment. Cover crops can get a head start on growing even before the existing crop has been harvested which especially important in areas with a limited growing season. However, aerial seeding is always more risky (for stand establishment) than drilling or incorporation of the seeds, so it's important to do all you can to give the best chance of success.

Photo by Buffalo Air Services, Kearney, NE

Timing is very critical and successful operators like to fly covers into standing corn when the corn is dried up about a third of the way up the stalk, so that the seed has a better chance of getting to the soil surface and more light can reach the emerging cover crop. For soybeans, it's best to fly apply the covers at 25-35% leaf yellow as once the leaves have completely turned, they will fall to the soil surface and help protect the seed and hold moisture for the young cover crop. Of course, flying cover seed right before a nice rain always makes things work better, if you can arrange that with your applicator and the weather man! When picking an aerial applicator, make sure you choose one who is experienced in seeding cover crops. Check some references and talk to farmers experienced in having cover crops aerially applied. Don't be afraid to ask questions about experience, calibration methods, etc.

Photo by Buffalo Air Services, Kearney, NE

High Boy Seeding

A relatively new and growing establishment method for cover crops is seeding with a high boy rig. The advantages of using a high boy type applicator include more exact placement of seed than aerial application, seed does not get caught in leaf whorls, little risk of seed drift into neighboring fields, faster and earlier application than drilling and it is cost effective compared to aerial application and drilling. Disadvantages of using a high boy type applicator include less acres covered in a day (compared to aerial), soil conditions must be right to avoid compaction, and it does not incorporate the seed like a drill.

Because this is a relatively new method, commercial rigs may not be available in your area...yet. As the technology continues to get better and the demand for cover crop seeding increases, high boy rigs will become more commonplace and accessible. Ask your commercial applicator if high boy seeding of cover crops is a service that they offer or are considering. Because high boy seeding is still occurring while the cash crop is still growing, access to sunlight is still the limiting factor for the cover crop survival and growth so timing recommendations similar to aerial seeding should be observed.

Seed Corn Production Fields

Perhaps no sector of agriculture production has adopted cover crops usage quicker than that of the seed corn production industry. Seed corn companies including Pioneer, Monsanto, Bayer, Corteva, Mycogen, Syngenta, Remington Seeds, Ag Reliant Genetics, and Beck's Hybrids see the benefits of cover crops and promote this practice with their seed growers. Many of these companies have over 50% cover crop use in their seed corn production fields, compared to 5% to 10% cover crop usage just a few years ago. This rapid adoption is encouraging, but incomplete, as in our opinion every acre of seed corn production should be covered as it is easy, cheap, and very effective.

Lack of sunlight due to dense crop canopy is often a limiting factor in getting a cover crop to thrive prior to harvest. Seed corn fields are an exception to this rule and growers can take advantage of this extra sunlight by broadcasting cover crops at male row destruction or shortly thereafter. Using low seeding rates of brassicas, clovers, or annual ryegrass, acres can be efficiently covered using a male row destroyer spreader, ATV, or airplane. Studies have shown that cover crops are extremely effective at scavenging and cycling excess soil nitrogen in seed corn fields that may otherwise be lost to leaching. Research by Dean Krull with University of Nebraska-Lincoln and Central Platte NRD shows that cover crops spread into seed corn fields at male row destruction can reduce spring residual soil nitrate levels by up to 75 pounds per acre over no cover crop treatment. That has saved a lot of nitrates from potentially leaching into the aquifer.

The growing and living roots of the cover crops can also greatly increase the carrying capacity and trafficability of the soil which helps limit damage if harvest takes place when the soil is wet. With the combination of sunlight, adequate moisture, and plenty of nitrogen, seed corn field covers grow extremely well and can provide 3-4 tons of highly nutritious forage for livestock.

Photo by Dean Krull

#seedcorn

Doug Cast from Beaver Crossing, Nebraska, has been seeding covers into his seed corn at male row destruction for the past 15 years. "We have an abundance of earthworms where the covers are seeded and the soil seems to be much more mellow in the spring and we have almost no blowing snow or soil", Cast reports.

Photo by Doug Cast

He goes on to say, "Our feeder calves gain 2-3 lbs per day grazing the covers and an acre can carry a calf 3 months, so that is 180# of gain per acre and with calves worth $1.00/lb, that is a pretty big number for the return on investment. The covers will also hold a cow up to 3 months per acre which nets us $30-$45 per acre." Cast is a long time believer and user of cover crops, and he notes that in the last five years the number of fields with covers (mostly turnips) in his area has skyrocketed, mainly for feed but also for the benefits of erosion prevention, nutrient cycling, and compaction breaking.

Photo by Doug Cast

Companion Cropping/Interseeding

Since many farmers struggle to incorporate diversity into their crop rotation, some are looking to push the traditional boundaries by growing cover crops within the commodity crop during the growing season. Before pre-emergence herbicides were standard practice, it was common to seed pumpkins, clovers, or other crops in between rows of corn to gain an additional crop in the season at "layby" time. Modern experimentation with this interseeding concept has been going on for the last several years, but this technique is still very much in its infancy and successful interseeding has a number of challenges to overcome.

1. Stand Establishment: No crop can ever be better than the initial stand that is achieved. For interseeding into growing corn fields, getting the seed in the ground almost always performs better than broadcast seeds, even in high moisture conditions. Companies like Hiniker, Dawn, and Interseeder Technologies have develop equipment just for this purpose.
2. Lack of Sunlight: Interseeded companion crops almost always struggle to get enough sunlight to grow and stay alive. Best results have occurred when covers are interseeded in corn between the V3-V6 stage and a stand gets established before the corn canopies and sunlight is lost. Once a plant is established it can survive better in partial shade. Corn varieties with more upright leaf structure can also help. This practice tends to work better as you move north where the summer days are longer (more hours of sunlight) and the maturity of the corn tends to be shorter.
3. Herbicides and Weed Control: If planting a diverse mix of covers (grasses and broadleaf), most post applied herbicides will not work without hurting the companion crop. Penn State research shows that some pre-plant applied short residual herbicides like Resolve, Prowl, Sharpen, and Verdict may work with companion interseeding. Do not try interseeding in fields where you know you have difficult weed issues that will require post applied herbicides.
4. Crop Insurance: Because intercropping into growing corn is a relatively new practice, there are some gray areas of interpretation when it comes to crop insurance. The guidelines can vary from zone to zone so it is best to always check with your crop insurance agent. The bottom line is that insurance will not cover loss of production resulting from cover crop interference with the agronomic management and harvest of the main crop. With interseeding into corn that is at V4 or late maturity, we are not aware of any studies that show th companion is a threat to the cash crop – and often th companion struggles to survive due to lack of sunligh

Left: Jeremy Wilson seeded this 14 way blend into V6 corn in Jamestown, ND us a modified Yetter dry fertilizer coulter. Great stand establishment, excellent grow and lots of diversity. Picture was taken when corn was fully tasseled. Cost of see mix was around $12 per acre as rates were calculated for intercropping.

Right: Ken Seims and Sons of Chapman, NE planted this blend of ryegrass, red ver, and radish into irrigated corn at V6 with a Hiniker cover crop seeding syste Good stand but growth is being suppressed by lack of sunlight, but wait till harvest and watch it take off!

The methods employed by producers to achieve successfu interseeding is as varied as the producers themselves. If you are interested, we encourage you to experiment on a small scale, but proceed with caution and check with you crop insurance agent to maintain compliance.

Lowell King of Fruita, CO is using his InterSeeder drill to place three rows o companions between each row of corn at approximately V4 stage.

#interseeding

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Cover Crops in a Cotton Rotation

In some areas of the southern plains, cotton is still king, but because cotton is a low-residue crop, both wind and water erosion is a real concern. Cotton rotations present both real opportunities and real challenges for cover cropping and soil health. There are three time frames to look at when establishing cover crops in a cotton rotation: early spring, prior to harvest (early/mid fall), and post-harvest (winter).

In early spring, cover crops can be planted when soil temps reach 45°F. A nice diversity of species can be used, but since residue is critical to maintain in a cotton rotation to prevent erosion, the majority of the mix will be grasses like oats, barley, or spring triticale. Species that have a darker residue when terminated, like flax, phacelia, and faba beans, will allow for more heat absorption for early planting but will still maintain residue. Other springtime species to consider adding include Hubam clover, spring peas, woolly pod vetch, or chickling vetch.

Seeding a cover crop prior to cotton harvest is becoming more common as growers have been having some excellent success with this method.

Photo by Jeremy Brown

Jeremy Brown, owner of Broadview Agriculture in Lamesa, Texas, has been successfully broadcasting a cover crop before defoliation of the cotton and before the September rains. Jeremy has been focusing on his soil health for the past nine years by utilizing cover crops and no-till. In southwest Texas, moisture is a huge factor for farmers, so Jeremy's goal is to properly utilize and manage cover crops and crop rotation to catch every drop of moisture (through better infiltration and no runoff) and to keep that moisture in his soil (by keeping the ground covered to prevent evaporation). Brown typically uses cereal rye, hairy vetch, and radishes in his environment, but he isn't afraid to try new species in order to diversify. Jeremy notes, "One of the more valuable things I have learned is that we have to allow enough time in the spring for the cover crops to grow in order to get the benefits, while at the same time managing for maximum moisture use efficiency. It is a delicate balancing act." Jeremy shares much more information and lots of great videos on their Facebook page: www.facebook.com/BroadviewAgricultureInc

Photo by Tom Cannon

Tom Cannon of Blackwell, Oklahoma, is also a successful practitioner of the pre-harvest seeding method. Tom says, "We flew on a mix of winter lentils, white clover, cereal rye, annual ryegrass, turnips and flax around September 11th but I will try to be a little bit earlier next year as an earlier planting date would have given me more grazing potential. We let the frost desiccate the cotton and apply a boll opener 5 days before the frost, which does not harm the cover crop. We did this on 450 acres and I wish I had done it on 1,000 acres as we will graze these covers in the spring and then plant soybeans in June."

Lastly, planting cover crops after cotton harvest is possible but it is typically limited by lack of growing degree days as cotton is not harvested until November or December. Cereal rye and hairy vetch are the best choices here as they can establish late in the season. If harvest is delayed into late December and January, utilizing clovers along with cereal rye and vetch in a frost seeding scenario can be beneficial, but waiting for a spring plant window may still be the better choice. For more information about seeding cover crops into cotton, please contact one of our sales representatives from the back cover.

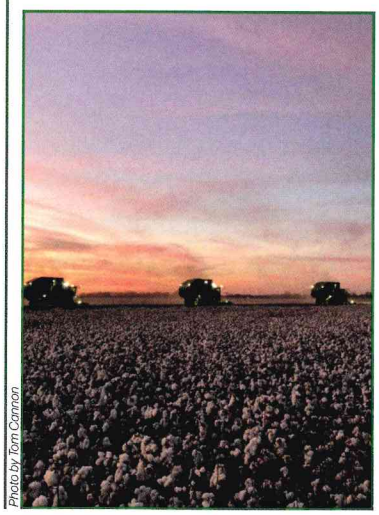


Photo by Tom Cannon

Double Crop Sunflowers

One of the more innovative ways to use cover crops is as companions with a cash crop. One of the early innovators of the practice was the father and son duo of Robin and Kelly Griffeth of Jewell, Kansas, who were perhaps the first people to use companion crops in sunflowers for a cash crop. Like so many innovations, this practice did not start out as an intentional practice. The sunflowers were originally just one component in a multi-species cover crop blend planted after wheat harvest. As fall came, the sunflowers in the blend looked just as good as the hybrid sunflowers they had planted in another field, so they decided to harvest them. To their surprise, they yielded almost as well as the monoculture, but the real surprise came the following year, when the corn planted on this field performed better than any of their other corn. That is when they knew they were really on to something. As Robin says,"Stumbling on to things is how I learn the best things in life. It is God's way of getting my attention when he needs to teach me something. Companion cropping began with one of these 'TEACHING MOMENTS' and I continue to understand and improve this concept to this day."

Photo by Robin Griffeth

Robin sees many benefits to the practice. "Sunflowers themselves improve soil health by adding diversity as well as deep fibrous tap-roots that recycle nutrients, break up compaction and condition the soil. Incorporating other species provide diversity to further enhance soil health. Sunflowers inherently draw an enormous amount of insects, and they are not all good ones. Therefore, I like to add crop species such as cow peas, buckwheat and flax that will provide an environment for the predators and pollinators that are so vital for sunflower's success."

Companions can be selected to provide benefits not only to the sunflowers, but also to the crop that follows. Adding legumes can provide nitrogen for a following crop, and other species can be selected to reduce compaction, create mulch, or suppress weeds. Finally, the companion crops can be pastured after the sunflowers are harvested.

The planting technique is nothing special, just mix the sunflower seed in with the cover crops in a drill box and plant away. While nothing beats this planting method fo convenience, Robin thinks that more precision placemer of the sunflower seed may help it yield even more, but th requires a second pass with a planter.

Robin has tried many species as companions, and the mi evolves over time. When asked about what species he lik Robin said "Cowpeas are a must. I like sunn hemp, buck wheat, mung beans, alfalfa, clovers, rape seed. I tried the squash and watermelon mix this year. It looked good un I sprayed Express. I have not seen any since then. I leave out radish and turnip because sunflower is a deep root a I don't want another deep root competing with it. I am st working on this so nothing is set in stone and remember these are observations, not research."

When asked what advice he would give to people trying companion crops with a cash crop, Robin gave us "Robi Rules for Companion Cropping":

1. First and foremost, TAKE CARE OF THE CASH CROP.
2. Only include companion species that will benefit the CASH CROP.
3. Do not let the companion species over-whelm the CASH CROP.
4. Do not complicate the harvest of the CASH CROP.

We have only begun to explore the concept of companio cropping. Sunflowers are easy to match companion crop with, because only the tops of the plant are harvested so companions tend not to interfere with harvest. They also have a relatively open canopy that lets sufficient sunlight through to allow companion growth. Other cash crops may also have potential for combining with cover crops and who knows what we might learn by providential 'Teaching Moments' in the next few years!

Winter Stockpile Grazing

Winter hay for livestock often can be the most expensive feed bill for the whole year, because feeding hay has many hidden costs (time, depreciation, and maintenance) that will affect your bottom line. These costs can be reduced (or sometimes eliminated) by utilizing cover crops and annual forages as a winter stockpile. Stockpile grazing is a simple concept: Instead of cutting, drying, and storing hay to feed in winter, forage (either perennial or annuals) is grown until it is frost killed and animals harvest their own feed as late into winter as weather conditions allow. Most livestock can graze through quite a bit of snow and can handle colder temperatures than many people imagine. However, like everything in pasture and livestock management, it's more complicated in practice. Successful stockpiling is a result of planning, timing, management, and sometimes a bit of luck.

Photo by Shawn Freeland

Growing stockpiled forages behind a summer harvested crop (cereals or peas) is ideal as the long growing season gives maximum biomass and diversity. This forage growth can add a significant amount of value to the cereal or pea rotation in addition to giving soil health and biology a huge boost.

When choosing forage species for stockpile grazing, ask these questions and the answers will help determine what seed mix to plant and when:

- What animals are you supplementing in the winter?
- Are you maintaining animals' body condition or trying to build body condition?
- When do you supplement the most feed and when will you graze the stockpile?
- What is your estimated planting time frame and growing season before first frost?

Once the forage has been stockpiled, its availability and quality depend on snow cover and temperature conditions throughout the winter. The longer it is out in the field, the more quality and quantity will decline. Stockpiling for spring grazing is a much more questionable proposition than for fall or early winter utilization.

Photo by Brett Peshek

Common summer planted stockpiling species are BMR dwarf sorghum or sterile sorghum, iron & clay cowpeas, guar, Laredo forage soybeans, and sunflowers. If you are grazing through a frost, you may want to consider substitute pearl millet or brown top millet for sorghums to help lower prussic acid risk. Otherwise, millets typically lose forage quality after the first frost and are not preferred by livestock. If stockpile grazing in late winter, utilize forage sorghum (better leaf attachment and retention) and not sorghum sudan (more leaf release and loss). Dwarf varieties can also reduce lodging in late winter. With forage sorghums, grain production (acidosis risk) is a possibility (with long growing season) so consider male sterile types. (See pages 44-47 for more on sorghum types)

When planting a stockpile mix closer to first frost (6-10 weeks before), consider species such as BMR corn, spring oats/barley, peas, brassicas (radish, turnips, collards), sunflowers, and safflower, along with your typical winter species such as rye, winter triticale, or winter wheat. These mixes may not produce as much biomass as the longer growth warm season mixes, but they may be higher quality and hay costs can still be greatly reduced. For more information on this topic, we recommend reading "Kick The Hay Habit: A Practical Guide to Year Round Grazing" by Jim Gerrish.

Grassfed Beef and Soil Health: Profit, Possibilities and Promise

By Tim Goodnight • Pharo Cattle Company

The Program: In early 2018, Tyson Foods approached Cactus Feeders about developing a grassfed beef program due to growing retail demand. Cactus quickly realized that to produce premium grassfed beef they were going to have to select the best genetics available, improve soil health, and utilize cover crops in a rotational grazing system. The genetics questions was solved by exclusively utilizing Pharo Cattle Company genetics, as for the past 30 years, PCC has been producing moderate-framed, easy-fleshing, low/no-input bulls that excel on grass. The soil health questions were solved by partnering with Green Cover Seed to provide customized diverse forage mixes.

Photo by Tim Goodnight

The Process: This system utilizes cover crop forage grazing mixes on pivot irrigation to produce dependable year-round forage. Rotations are done each afternoon when the carbohydrate levels (brix) are the highest in the plants. Providing a diverse mix of forages that include legumes, grasses, brassicas, and forbs allows the cattle to make selection decisions while grazing and enhances animal performance. We have seen these diverse mixes boost plant production, due to the symbiosis that takes place between multiple species that is not achieved in monocultures. We have also added mycorrhizal inoculant that promotes additional symbiosis as fungal hyphae connect the various root systems and translocates nutrients between plant species and make otherwise unavailable soil nutrients plant available. The fungal hyphae also produce glomalin, which is important in building soil health and improving soil organic matter. We are taking the soil health aspect of this project very seriously, as we would not be able to accomplish our goals without the use of proper forage selection fitted for our environment, maximum plant species diversification, added carbon through surface residue/animal impact, and by continually maintaining a growing root system in the soils.

The Challenges: While we will always look for ways to improve genetics, we feel that Pharo Cattle Company ha firm grasp on the genetics required to perform and finis on a 100% forage-based diet. The biggest challenge we faced is degraded soil health in fields that had been corr cotton, with low SOM and almost non-existent soil biol By eliminating tillage and synthetic inputs while adding animal impact, we expect our soil health to grow. As the soil health increases, plant BRIX levels will also increase which will translate into better animal health and perfor mance. Studies also show that higher plant nutrition wil translate to higher nutritional levels in the meat produc which will result in flavor and health benefits to consum

The Future: The program is still growing with 2,000 feeders headed to Cactus Feeders in November 2018. W will also continue to experiment with a variety of forag mixtures that perform best in our environment and res in maximum animal performance. The great working relationship between PCC, Cactus Feeders, and Green Cover Seed has allowed us to accomplish so much in a short time. As we grow, it has been great to work with f ward-thinking groups that are putting a focus on produ ing the best grassfed beef possible. One of our goals wit this project is to displace the large percentage of import grassfed beef that is marketed as a "Product of the USA In 2017, grassfed beef sales totaled over $4 billion, of which only $560 million came from domestic productio Our quality grassfed beef products will help us to reach more consumers and take market share from our foreig counterparts while rebuilding our soils at the same tim

If you have questions or comments about the program you can contact Tim directly.
Office phone: (800) 311-0995 • Email: tim@pharocattle.c

Interseeding into Cool Season Perennials

Cool season perennial grasses such as brome, bluegrass, orchardgrass, and fescue require a great deal of nitrogen fertility for optimum growth and usually grow very little during the heat of summer. These factors have led some people to experiment with drilling or broadcasting other crops into these grasses to increase forage production or fix nitrogen with interseeded legumes. Drilling spring peas, lentils, or chickling vetch in either fall or early spring can provide both additional forage and nitrogen fixation as soon as 60 days after planting, though these species are short-lived. Broadcasting or drilling a blend of red clover, ladino clover, annual lespedeza, chicory, and plantain in either late summer or winter can extend the grazing season further into summer, as well as provide all the nitrogen needs of the stand. This blend takes a while to begin production, but the plants persist for many years. Doing both practices at the same time can provide excellent initial production along with long term benefits. Teff grass or improved varieties of crabgrass can also be broadcast in spring to increase summer production.

Other innovators have discovered that they can graze cool season pastures down in the late spring, then drill a blend of warm season cover crops such as sorghum-sudangrass, BMR grazing corn, pearl millet, cowpeas, and sunn hemp for grazing in late summer for an incredibly high yielding pasture. One eastern Kansas farmer has recorded yields of over eight tons per acre of cover crop dry matter on this system, all produced after a late June grazing of his fescue-clover pasture. He has done this for four years running and his fescue looks better than ever, far better than that of his neighbors.

Cool season grass pasture with no interseeding.

Photo by Shane New

Cool season grass pasture with warm season interseeded cover crops. Eight tons per acre never looked so beautiful.

Interseeding into a perennial stand is always challenging. For the best chance of success, do not try to interseed during peak perennial growth seasons, but interseed into cool season pasture during the warm summer months. Also, weaker perennial stands give a better chance of establishing interseeded annuals, so consider grazing the perennial stand hard before planting the warm season annuals.

A good example of this concept in practice occurred during the summer of 2018 when large parts of Missouri experienced a severe drought. Coupled with poor spring forage production, many livestock producers were facing epic shortages of forages to graze. These scenarios triggered state and federal agencies to aid producers with an array of programs, including an EQIP Emergency Drought Relief Cover Crop Program. This cost share program helped producers plant annual forages into perennial pastures in the most severe drought-stricken regions of Missouri following the principles discussed above. The demand for assistance was high with 1,481 applications but funding could only cover 489 producers on 65,000 acres for a $4,082,000 price tag. From this project the state of Missouri will be able to provide an abundance of information about their experiences with interseeding annuals into cool season pastures over a large geographic region and management systems.

#csinterseed

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Interseeding Into Warm Season Perennials

Warm-season grasses can be tremendously productive, but have a very short growing season, letting a large amount of sunlight go unutilized. Interseeding cool-season species can add to total production, extend the grazing season, improve soil biology, and fix nitrogen if legumes are used

Native Warm Season Pasture

While we are not suggesting this as a practice in pristine native grasslands, many pastures have been broadcast sprayed with herbicides and have had their legume and forb component eliminated. Desirable characteristics of a species to interseed into native grass would include high cool-season productivity, low competitiveness to the perennial grass, forage productivity, and ability to fix nitrogen. Also keep into consideration what type of application you plan to apply seed; either broadcast or drilled, as that may affect what species you want to use. Species that may merit consideration with this practice include: hubam annual sweet clover, yellow and/or white biannual sweet clover, winter lentils, crimson clover, balansa clover, winter or spring peas.

Sod Forming Warm Season Grasses

Bermuda and Bahia Grasses are both sod forming grasses which pose another level of difficulty for interseeding into. Most native grasses are bunch grasses that allow for legumes and other forbs to grow next to them in an ecosystem, while sod grasses are a lot more competitive to other species, especially if fertilized. With sod forming grasses, it will depend on what your goals are, how thick or tall the existing stand of grass is, and how you plan to apply the seed when overseeding. Typically, these sod forming grasses have been planted on soils that have been highly disturbed and degraded from previous farming practices. Desirable characteristics for interseeding into sod grasses are soil building ability (root mass), compaction breaking, high cool-season productivity, nitrogen fixation, ar forage productivity. We would recommend consulting a representative if these practices are applied to hay meac ows as species will change. Species that may merit consideration with this practice include: hubam annual swe clover, yellow and/or white biannual sweet clover, crims clover, red clover, alfalfa, hairy vetch, woolly pod vetch, winter peas/spring peas, annual ryegrass, cereal rye/trit le, oats, chicory, and plantain.

Interseeded spring peas into Bermuda grass in the early fall.

Broadcasting vs. Drilling Into Grasses

With broadcasting into grasses, pay attention to amoun of canopy you are seeding into, the seed size, and seedli vigor you plan to use. If the grass stand is thin or short and you are broadcasting, smaller seed sizes tend to wo better as evaporation increases with short grass stands a smaller seeds take less moisture to germinate. Typically larger seed sizes need much more moisture to germinat so broadcasting these species are not recommended. If stand is thicker, we recommend drilling over broadcast and using species with higher stored energy in the seed Species that have higher energy seed tend to have large seed sizes. When beginning, we encourage experimenta tion with this practice on a limited basis to learn which species are most successful for you.

Hidden Benefit

Extending the growing season by adding cool-season plants is going to add to pasture productivity, but anoth benefit is the added root exudates that feed soil biology below the ground, adding organic matter, improving soil structure, and increasing soil water-holding capacity. Ranchers who have added cool-season annuals into warm-season grasses have noticed dramatic improvem in the depth of their topsoil and darker coloration. Exte ing the period of photosynthesis means more carbon in the soil, and less in the air!

Wildlife

God's creation is extremely diverse and there are no monoculture plant communities in natural settings, so why should wildlife food plots be any different? Whether you are targeting a specific wildlife species for hunting or merely supplying a wildlife sanctuary, it is all about creating a balanced oasis. Wildlife will thrive and be more resilient to droughts, diseases, and heavy predator pressure when the ecosystem is managed as a whole and the principles of soil health are followed. Tillage buries food sources below the surface and shelter is destroyed for smaller wildlife, such as quail. Increasing plant diversity will support a greater variety of wildlife by supplying multiple food sources like seeds, insects, and green plant material and also allows animals to balance their diet better than monocultures. Consistency of food and shelter from year to year is very important for reducing predation on desired wildlife like deer and quail. By starting out with these simple steps, you will begin to improve your ecosystem functions and wildlife health. When planting a diverse mixture try to keep this information in mind:

Deer

The deer food plot industry is "big business", with fancy mixes available for outrageous prices at sporting goods stores. Green Cover Seed has all of the same food plot species that are in fancy mixes for a fraction of the cost.

Deer gravitate towards high protein, nutritionally dense forages, which is why most deer plot mixtures contain brassicas and legumes. Big biomass grasses such as sorghums can provide safe bedding and browsing areas. Let us help you put together a deer food plot mix that meets all of your needs and puts big bucks in your sights as well as putting bucks back in your wallet!

Dove

99% of a dove's diet consists of seeds with a high attractiveness to corn, sunflowers, wheat, sorghum, millets, buckwheat, etc. They prefer open, clean fields in which to feed, so you may want to bush hog the biomass a few weeks before you intend to hunt.

Quail/Pheasant

These game birds consume a variety of food sources including insects, greenery, and seeds. Quail chicks under eight weeks old have a diet consisting almost exclusively of insects. The key to upland bird success is to produce plenty of blossoms, seeds, and insects under a moderately dense canopy with an easily traveled understory.

Turkey

Turkeys have similar tastes as the smaller game birds, but will also browse more like deer on vegetative material. Plant material will make up 90% of an adult turkey's diet while young poults consume protein-rich insects in the first 4-5 months of their life.

Many producers have discovered that when they plant diverse cover crop mixtures for increased soil health, they get the added benefit of drawing an array of wildlife. Do not be fooled by slick marketing promoting high dollar food plot seeds!

Green Cover Seed can provide the same plant species with very similar results at a fraction of the price. If you are currently using a wildlife plot seed mix that you like, give us a chance to mimic or even improve it for more wildlife benefits and boost your soil ecosystem all in one shot.

Rental of Cover Crop Forages

With low commodity cash crop prices, most producers are searching for alternative sources of income. Millions of acres of grass have been converted to farmland over the past 8 years and there are fewer late summer and early fall pastures to be grazed. Many farmers growing cover crops do not have cattle and many cattlemen do not have enough forage. This creates a scenario where many folks are considering how to write an equitable rental agreement for grazing cover crops. Utilizing summer planted cover crop mixes (after a summer harvest), producers and cattlemen can establish mutually beneficial arrangements.

When planting a forage cover crop to lease out, be sure to locate a market and make lease arrangements first. Several type of leases should be considered. The first option is an **Animal Unit Month** basis, in which the landowner assumes more risk of low forage production and the cattle owner assumes more risk of finding alternative forage. The second option would be a **Price Per Acre** basis, but grazing dates and stocking rates should be mutually agreed upon. The third option is an **On The Gain** basis, where both parties agree to a price per pound of gain on market cattle. Taking forage tests for both quality and quantity of the forage may also help the parties agree on a fair and equitable arrangement.

There is no set price on leasing forages, and there are many things to consider when making an arrangement. Be sure to clearly spell out who is in charge of the following responsibilities: fencing, water, daily care, emergency feed, liability insurance, planting and/or termination of cover crops, irrigation, nutrient management, grazing dates, residue management, and stocking rate. Regardless of the lease structure, compensation needs to reflect the expected costs and returns to both parties, respective risk exposures, individual commitment of services, and the cost of other sources of forage.

#ccrent

Milpa Gardens

The milpa system is a traditional multi-species croppin system originally designed by the Mayans and still use throughout Mesoamerica. Traditional milpa gardens u the "three sister" concept with maize (corn), squash, ar beans, but with the addition of many other species for diversity in the system. Even in present day, Mesoamer can farmers will plant milpa gardens behind cleared fo ground for 2 years and then allow the natural vegetatio re-establish for the next 8 years, allowing for soil regen tion to occur.

Green Cover Seed is proud and excited to be a primary sponsor of the Farm to Food bank project in Oklahom Beginning in 2017, milpa garden seed was donated to several regenerative farmers throughout Oklahoma wh partnered with the Regional Food Bank of Oklahoma. Each participant planted several acres of diverse milpa gardens. The simplistic beauty of the system is that all t seeds were mixed together and drilled with a regular gr drill, turning a small field in to a large garden with very low labor inputs. Green Cover Seed provided the mixe which included fresh greens (turnips, collards, mustard root vegetables (radish, turnips), legumes (cowpeas, m beans), and vine crops (squash, melons, cucumbers, pumpkins). The gleaning efforts were a true communit effort with members from various community groups a pitching in to help feed their community.

In 2017, about 6,800 lbs. (about 5,440 meals) of fresh, healthy fruits and vegetables were donated from these gardens to the Regional Food Bank of Oklahoma. The milpa gardens not only provided fresh and healthy foo these local communities, but also helped build commu relationships. These milpa gardens also served as a div cover crop mix to help improve soil health, water quali and habitat for pollinators and wildlife on these farms.

We believe that with healthy soils, we can grow healthy plants, which will produce healthy food, which will bu healthy people, families, and communities. With that i mind, Green Cover Seed will donate up to 2 acres of cu tomized milpa garden seed to anyone who is working v their local food bank or resource center to help feed an build their local community!

Quorum Sensing in the Soil Microbiome

By Christine Jones, Ph. D

In human society, a **quorum** is the number of members of an organization that must be present in order for decisions to be made and business to be transacted. In the microbial world, the term **quorum sensing (QS)** refers to **density dependent coordinated behavior** that regulates gene expression in the microbial population and/or in the host plant or animal.

Quorum sensing was first described in the 1960s in relation to the expression of bioluminescence in the marine bacterium *Vibrio fischeri*. When free-living in the ocean, *V. fischeri* is non-luminescent, but when populations reach a critical population density they 'shine'... but only in the dark. The bacteria know 'how many' of them there are - and they also know that it's dark.

Microbes can't see, think, or hear. But by means of chemical signals, calledauto-inducers, they have the capacity to detect how many others are in their vicinity - both of their own species and of other species. In the last decade, research into quorum sensing has grown exponentially. It is now recognized that quorum sensing is utilized by bacteria, archaea, fungi and viruses in all habitats - in water, on land, in plants, on plants, in the soil and in animals and humans.

Social insects like ants and bees also use signals to communicate. A single bee behaves very differently to a colony of bees. Similarly, a single bacterium behaves very differently to a colony of bacteria. And even a colony of one kind of bacteria behaves very differently when it is the only colony - compared to when there are multiple colonies of many kinds of bacteria.

Quorum sensing in the soil microbiome enables multi-species crops and pastures to function more effectively than monocultures. Once the diversity of plants and hence the diversity of functional groups of soil microbes reaches a certain threshold - or quorum - everything changes. The microbial community begins to function as a coordinated 'super-organism' and can perform tasks that individual microbes cannot achieve alone. The lights come on, not unlike the bioluminescent marine bacteria that suddenly shine brightly in a dark ocean.

Quorum sensing also helps explain how biostimulants improve plant health, even at very low concentrations. The biochemical signals mimic plant and microbial diversity, resulting in the production of growth stimulating and plant protection hormones.

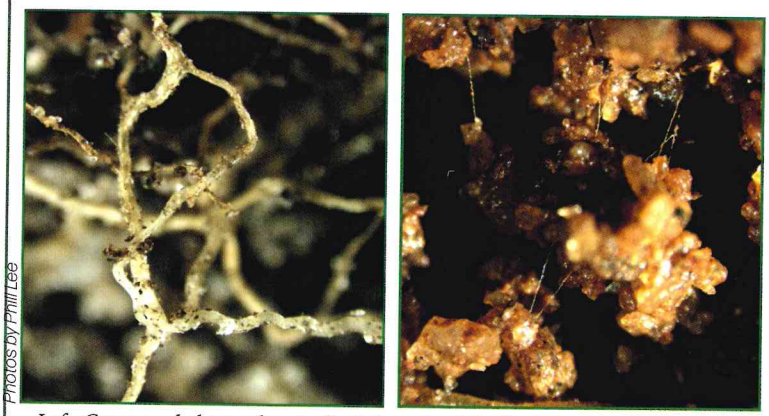
Disease-causing organisms use quorum sensing to express virulence and pathogenicity. The good news is that once the configuration of the signals has been determined, they can be scrambled and rendered ineffective by a process termed 'quorum quenching' (QQ). Quorum quenching is proving to be more effective than antibiotics and fungicides, which kill everything, good or bad.

In soils, both QS and QQ are important for the function and resilience of plant communities, not only in the face of biotic stresses (e.g. pests and diseases) but also in regards to promoting health, abundance and resilience in the face of abiotic stress (such as drought, frost, and nutrient deficiencies).

There is much to be gained by applying our understanding of quorum sensing in the agricultural space. QS is the only process that adequately explains the extraordinary results (such as abundant nutrient availability and enhanced drought tolerance) observed once plant diversity - and hence microbial diversity - reach a critical threshold, or tipping point.

The flip side to quorum sensing is that when there are not enough microbes to form a quorum, nothing happens. No matter whether it is in the human or animal gut - or in the soil - when microbial populations do not attain a quorum some very important genes (that plants, animals, and people require for immunity, for example) get switched off. The lights go out... which is precisely what's happening today in human, animal, plant and soil health.

We need to figure out how to turn the lights back on... and fast.



Photos by Phill Lee

Left: Crops seeded into chemically-fallowed soil in the presence of high rates of N have bare roots. In the absence of a microbial quorum there is no protection from pests and diseases and no soil building.
Right: The roots of crops direct drilled into diverse cover without the use of high-analysis fertilizers support a protective, soil-building microbial quorum.

Nitrogen: The Double-Edged Sword

By Christine Jones, Ph. D

Dr. Christine Jones is an internationally renowned and highly respected groundcover and soils ecologist. She has a wealth of experience working with innovative landholders to implement regenerative land management practices that enhance biodiversity, increase biological activity, sequester carbon, activate soil nutrient cycles, restore water balance, improve productivity, and create new topsoil. A native of Australia, Christine has rapidly become one of the most sought after Soil Health speakers in the world and has been wildly popular on the United States Soil Health speaking circuit. We count it a blessing to call her a mentor and a good friend of Green Cover Seed.

Nitrogen is a component of protein and DNA and as such, is essential to all living things. Prior to the Industrial Revolution, around 97% of the nitrogen supporting life on earth was fixed biologically. Over the last century, intensification of farming, coupled with a lack of understanding of soil microbial communities, has resulted in reduced levels of biological activity on agricultural land and an increased application of industrially produced forms of nitrogen.

Impacts of Inorganic Nitrogen

Much of the nitrogen currently used in agriculture derives from the Haber-Bosch process, in which atmospheric nitrogen is catalytically combined with hydrogen to produce ammonia under conditions of high temperature and pressure. This process uses non-renewable resources and is energy intensive and expensive. Globally, over $100 billion of nitrogen fertilizers are applied to crops and pastures every year. Between 10 and 40% of the applied N is taken up by plants while the other 60-90% is leached into water, volatilized into the air or immobilized in soil. The application of high rates of inorganic nitrogen in agricultural systems has had many unintended negative consequences for soil function and environmental health. Above ground, plant growth often appears 'normal', hence the connection to failing soil function may not be immediately obvious. But underneath, our soils are being destroyed.

Biological Nitrogen Fixation (BNF)

Fortunately - thanks to some 'enzymatic magic' - atmospheric nitrogen can be transformed to plant-available forms by a wide variety of nitrogen-fixing bacteri and archaea - for free. The ability to fix nitrogen is not limited to bacteria associated with legumes. Recent bio-molecular research has revealed a dizzying array of free-living and associative nitrogen-fixing bacteria and archaea across a wide ran of environments. Their abundance is much greater in soils where diverse living groundcover is present throughout the year, compared to soils that have been monocropped or left bare.

N fertilizer placed below the seed inhibits the formation of rhizosheaths on the roots of cereals. Note healthy rhizosheaths above the seed (away from the N).

The Liquid Carbon Pathway

Carbon and nitrogen are essential to plant growth and integral to soil function. A massive 78% of the earth's atmosphere is composed of dinitrogen (N2). Carbon dioxide (CO2), on the other hand, is a trace gas, currently comprising only 0.04% of the atmosphere. The incorporation of both carbon and nitrogen into stable soil organic complexes via photosynthesis and the liqui carbon pathway effectively transports these vital eleme from the atmosphere to the soil. The plant's requiremer for biologically-fixed nitrogen drives this process. Liqu carbon is transferred to complex microbial communities within rhizosheaths and root-supported aggregates where simple carbon molecules are transformed to hig

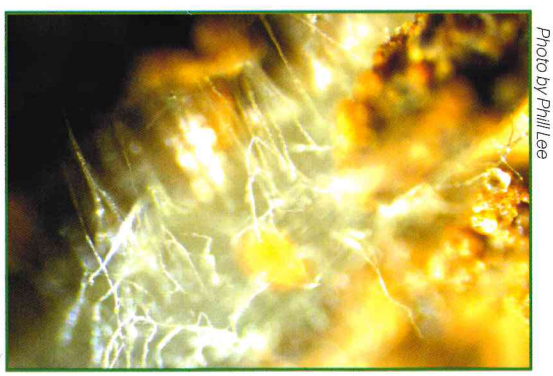


Photo by Phill Lee

Saprotrophic and symbiotic fungi transfer 'liquid carbon' from roots to free-liv N-fixing bacteria and archaea within the rhizosheaths of plants grown withou

stable humic polymers, composed of biologically fixed carbon, nitrogen, bacterially-solubilized phosphorus and soil minerals.

Although mycorrhizal fungi do not fix nitrogen, they play a vital role in the nitrogen nutrition of plants by transferring energy, in the form of liquid carbon (also called photosynthate), to associative and free-living nitrogen-fixing bacteria. The acquisition and transfer of both organic carbon and organic nitrogen via mycorrhizal pathways is highly energy efficient, closing the nitrogen loop, reducing nitrification, denitrification, volatilization and leaching.

Enhancing the Liquid Carbon Pathway

We can utilize our understanding of the liquid carbon pathway to restore natural fertility to agricultural land. Enhanced carbon flow to soil - via plant root exudates - not only supports the biological fixation of atmospheric nitrogen, but also activates the vast network of microbial communities essential to the provision of minerals, trace elements, vitamins and hormones required for plant tolerance to environmental stresses such as frost and drought and resistance to insects and disease. Higher micronutrient densities in plants also translate to improved nutritional value of food. However, if nitrogen is supplied in an inorganic (fertilizer) form, it will short-circuit the liquid carbon pathway. As a result, plant mineral densities fall and immune function is reduced.

Getting the Basics Right

It is now recognized that plant root exudates make a greater contribution to the formation of stable organic complexes within the soil than does the above-ground biomass. But here's the rub. The microbes essential to the stabilization of carbon require living groundcover and are inhibited by high rates of inorganic N. Hence biological nitrogen fixation and humification are rare in agricultural systems where heavily N-fertilized crops are rotated with bare fallows. Further, it has been shown that up to 80lb N/acre can be volatilized and lost from bare fallows due to denitrification in warm summer months. If green plants are present, this N can be taken up and recycled, preventing irretrievable loss. When soil is bare there is no photosynthesis and very little biological activity. Bare soils lose water, carbon and nitrogen, nutrient cycles become dysfunctional, aggregates deteriorate, structure declines and water-holding capacity is reduced. The maintenance of bare fallows - or the use of high rates of inorganic N in crops or pastures - or worse, both - results in the uncoupling of the nitrogen and carbon cycles that have functioned synergistically for thousands of years.

Weaning Off N

The activities of both symbiotic and associative N-fixing bacteria are inhibited by high levels of inorganic N. In other words, the more nitrogen fertilizer we apply, the less N is fixed by natural processes. For this reason it is vitally important to wean your soils off high rates of inorganic N - but please do it S.L.O.W.L.Y. Microbial communities generally require around three years to adjust. Nitrogen inputs can be reduced 20% the first year, 30% the second year and a further 30% the third year. In subsequent years, the application of small amounts of inorganic N will help to prime the natural nitrogen-fixing processes. In addition to weaning off high rates of inorganic N, aim to maintain as much diverse year-round living groundcover in crops and pastures as possible.

There is increasing recognition of the fundamental importance of soil microbial communities to plant productivity. Many biological functions are compromised by commonly used agricultural practices but fortunately redesign of farming practice is not difficult. The five basic principles for regenerative agriculture discussed earlier in this Resource Guide have proven to restore soil health and increase levels of organic carbon and nitrogen. From these, farmers and ranchers can build an integrated land management package that suits their individual property and paddock needs.

More and more farmers around the world are discovering how to restore natural topsoil fertility by moving away from bare fallows to biodiverse year-long green plant cover, coupled with appropriate livestock management and reduced applications of inorganic nitrogen. Improvements to soil function deliver benefits both on-farm and to the wider environment.

For further information, visit
www.amazingcarbon.com

Photo by Christine Jones

Healthy rhizosheaths on 8-week cereal rye seeded early fall without N.

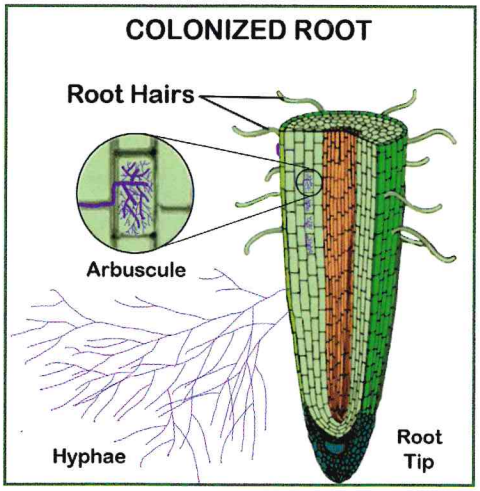
Arbuscular Mycorrhizal Fungi

By Wendy Taheri, Ph. D • Pelham, Georgia

Your crop roots only touch 1-2% of the soil profile but luckily, healthy soils have help from billions of living organisms within the soil. In fact, just one cup of soil has more bacteria and fungi than there are people on the earth. Dr. Wendy Taheri is a microbial ecologist who is transforming the world of agriculture by developing microbe-based, sustainable solutions to replace the plethora of toxic chemicals and environmentally-damaging practices currently used in conventional agriculture. Her research focuses on harnessing the power of arbuscular mycorrhizal fungi (AMF) and other beneficial microbes; and has broad-ranging, practical applications that are good for the environment, regenerate soil quality, and improve profit margins for farmers. Read more about her startup company TerraNimbus on page 19.

Healthy soil is all about the life in the soil. Billions of tiny organisms live in soil; not just bacteria and fungi, but an amazing array of nematodes, worms, arthropods, and other tiny organisms. As these creatures go about their lives they are moving nutrients from one form to another. These organisms are all part of the nutrient cycles that keep plants healthy. How do you manage billions of living things? Well, you really can't. What you can do is focus on the keystone species, which are those species upon which an ecosystem depends. In the case of the agro-ecosystem those species are the plants and their symbionts, the arbuscular mycorrhizal fungi, or AMF for short.

Plants, through photosynthesis, remove carbon dioxide from the atmosphere and convert it to sugars which they use not only as energy for themselves, but because all that life in the soil is where their nutrients come from, plants secrete sugar into the soil. Your plants are farming!



They are growing microbes in what has come be known as the rhizosphere. This is the micr al world that surrounds and associates with p roots. Additional sugars are passed directly tc AMF, without competition, because these fun THAT important to the plant. What makes A special? These fungi are obligate symbionts. T cannot feed themselves and depend on the plant for of their carbon (sugar) needs. Plants are very efficien making sugars. AMF are very efficient at finding pho rus and other minerals that plants need.

AMF Arbuscules inside a plant root

Plants secrete hormones to encourage nearby AMF s to germinate. A fungal filament, called a hyphae, gro towards the root and penetrates into the cells where a organ, called an arbuscule is formed. The plant surro the arbuscule with a membrane, and this becomes th interface for chemical communication and nutrient e change. Plants nurture and feed their AMF, which pr an array of benefits to the plant, including protection disease, improved nutrient efficiency and drought tol ance, just to name a few. The hyphae spread into the s an extension of the plant's roots, increasing the volun soil available to the plant for water and nutrients. AM particularly good at providing phosphorus to plants. limited resource is growing scarce, making the AMF ulations in our soil extremely valuable, since phospho prices will continue rising.

AMF also feed other microbes to help their host. Wh you manage to support AMF, other beneficial organis increase as well, and you need less fertilizer and fewe inputs, as the diversity that comes along with good m agement promotes plant health while creating compe that helps to keep pests under control. Those best pra include: no-till, cover crop mixes, and reduced inputs

Most agricultural chemicals have a negative impact on soil microbes, so save them for the real emergency. Constant use 'just in case' is what leads to pesticide resistance, which means when you REALLY need to get something under control, nothing seems to work very well. Good management results in healthy soil and that is the best crop insurance in the world. "Don't work your soil, let the soil work for you!"

Photo by Wendy Taheri

AMF spores waiting to germinate

#biology

Additional Benefits: AMF can also absorb salt and move it into little capsules where it is sealed off and kept out of soil solution. Research has shown inoculated onions (a very salt sensitive plant) yielded 17 times more than uninoculated onions in salty soil. In addition, many weed species, such as pigweeds, are not colonized by mycorrhizal fungi and do not benefit from them, but AMF makes the roots of colonized crops much more competitive against the weed roots. A North Dakota State study showed a 54% decrease in weed biomass in a crop of sunflowers when inoculated with AMF spores.

AMF Inoculant: It is now easy to more quickly realize the benefits of mycorrhizal fungi, as Green Cover Seed carries AMF inoculant, which contains four species of mycorrhizal fungi. It can be applied to either cover crops or cash crops. Cover crops can also be used to maintain AMF populations between cash crops and further extend the benefits from a single inoculation over several crops.

#AMFinoc

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Regenerative Agriculture's New Paradigm

By Wendy Taheri, Ph. D

Conventional agriculture (defined by management practices that include tillage, toxic pesticides, and heavy fertilization) is receiving increasing scrutiny as public awareness rises in regards to the damage conventional agriculture is causing. Scientists and farmers, working together, are learning more about the complex life in the soil and how that life supports plants, provides nutrients, and suppresses pests. Honestly, it's just in time. Agriculture has grown into the largest ecosystem on the planet, and as such, all those chemicals are taking a toll. Our bees are vanishing and the soil microbes that play major roles in building soil quality are declining. Tillage has created vast landscapes of erosion which transport nutrients into lakes and oceans. This has resulted in over 200 dead zones circulating the oceans and 50% of the lakes and rivers in the USA being impacted as well.

The new paradigm is actually a lot less work, saves money, and is better for farmers, who depend on the very resources conventional agriculture degrades. After all, who wants to see all that expensive fertilizer kill fish rather than feed your crop? The time has come to embrace the change fully and move forward with research that supports the new paradigm. This means getting grazers on the land and increasing the diversity that protects and feeds your crop.

TerraNimbus

TerraNimbus is developing the tools to find the best AMF to support America's cash crops. We will couple that with the best cover crop selections for propagating the microbes that provide the most benefits. Your cover crops will prime the soil and help spread the AMF that provide the most benefit to your cash crop. In order to support this research, we are running a crowd funding campaign. Let's get the most we can out of our soil, while building soil quality. Please give to support what you believe in, and together we can make agriculture wholesome once again. Join the campaign!

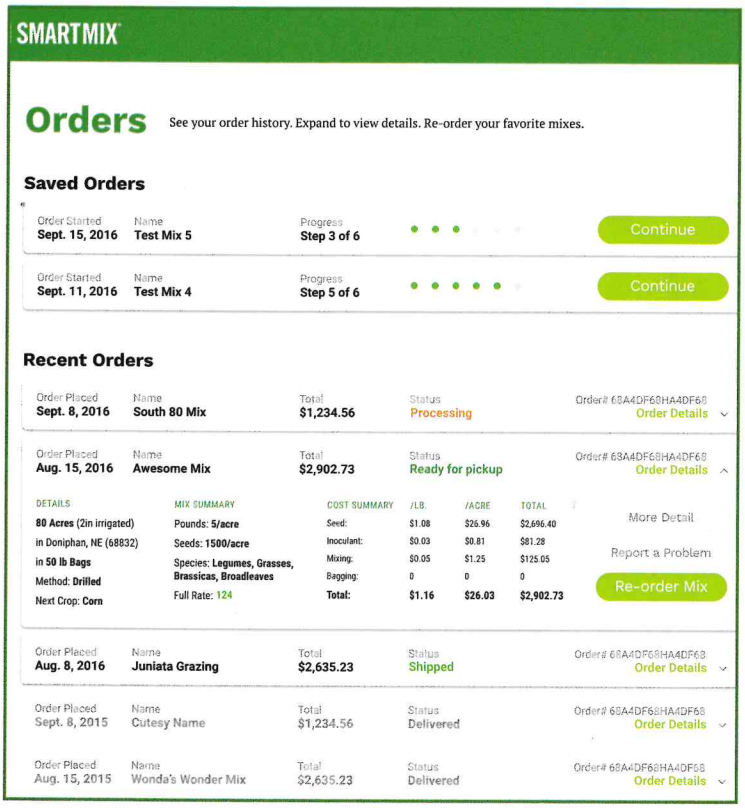
#terranimbus

SMARTMIX®

SmartMix® Calculator

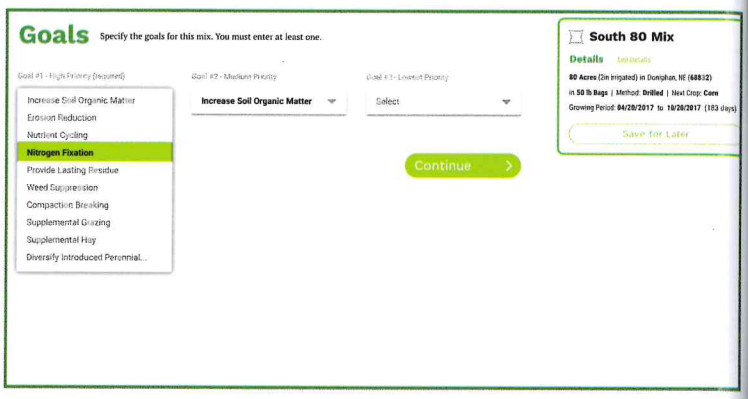
The best cover crop decision making tool in the industry just keeps getting better! The-all new SmartMix® Calculator 5.0 will be completely redesigned and richer in features than ever before. Featuring a new and simplified user interface, clean new graphics, and the ability to edit previous mixes, SmartMix® 5.0 will continue to set the standard for cover crop design tools!

SmartMix® is free for everyone to use, but you will need to create an account (if you do not already have one). This allows each user to have a record of saved and submitted mixtures and allows recall, review, or editing of previously created mixtures. All information contained within your account is kept confidential and will not be shared with anyone outside of Green Cover Seed.



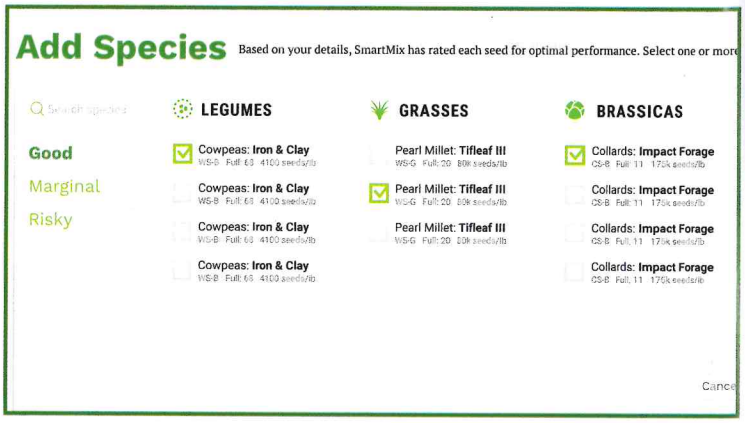
Mix Details

SmartMix® 5.0 is very interactive and allows the user to input details such as zip code, mix name, seeding method, next cash crop, acres, seeding date, termination date, and up to three goals for the mix. SmartMix® will also factor in average annual precipitation, first and last freeze dates, growing degree days, projected irrigation, and plant hardiness zone of any selected zip code.



Species Selection

SmartMix® 5.0 is loaded with more than three million data points including growing degree days, precipitation data, and frost data for all 45,000+ continental state zip codes as well as data on over 100 cover crop species. SmartMix® 5.0 gives ratings for species suitability based on user-inputted goals, planting dates, and geographic location. Mix ratings for C:N ratio, nitrogen fixation, grazing suitability, frost tolerance, winter hardiness, salinity tolerance, and diversity ratings are also calculated. Based on all of the geographical, climatic, and agronomic data gathered during the previous step, SmartMix® will help the user choose the best cover crop species for their unique situation. Species within each family will be ranked by suitability based on goals, location, planting time-frame, and next cash crop. These rankings are based on general plant properties and



must still be carefully considered by the user, but it gives some guidelines and starting points for the user.

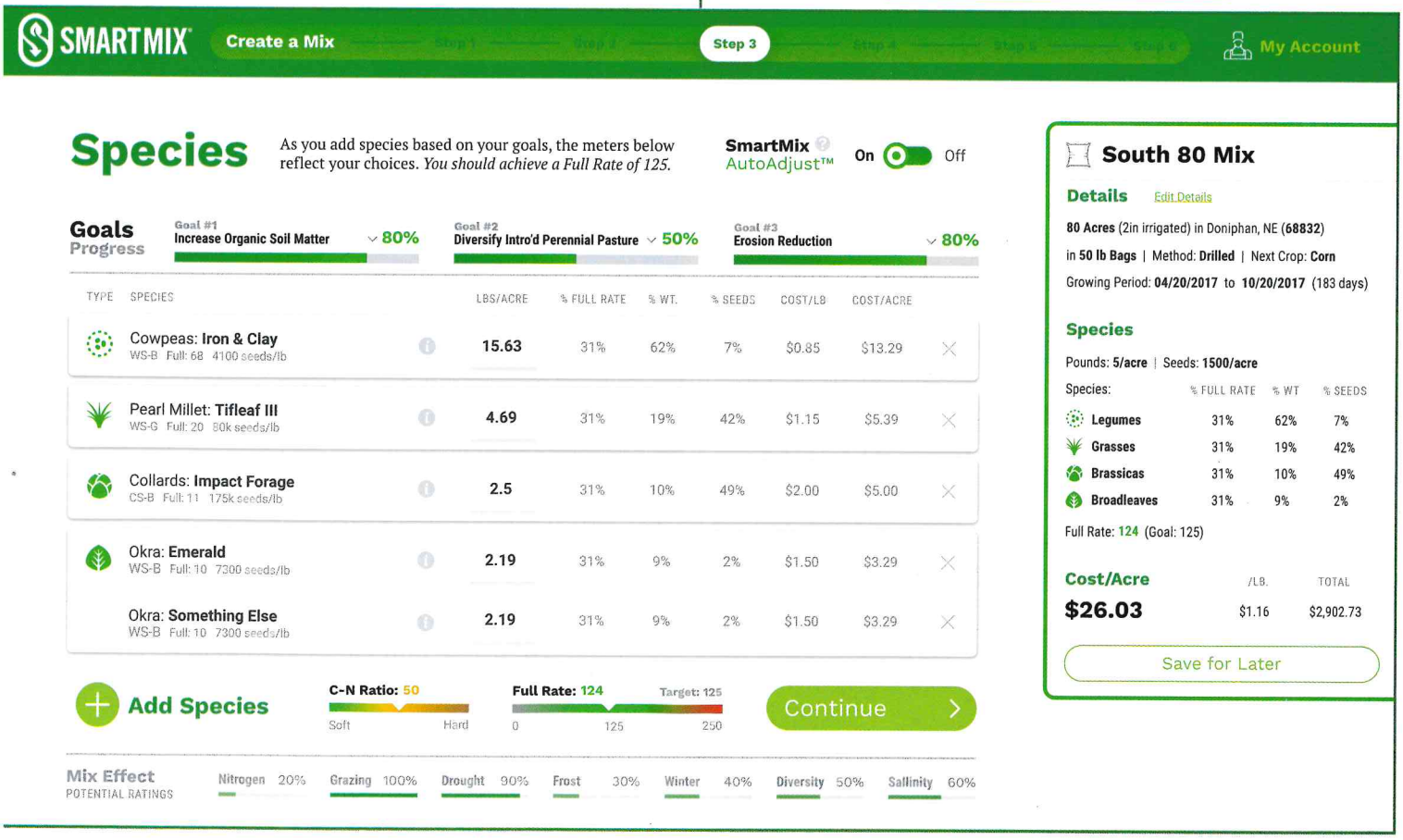
After a species has been selected, a suggested full seeding rate will be given. The user must then decide how much of each species to put in their mix. To keep the mix balanced, we suggest keeping the "Full Rate %" of the overall mix at around 125% for most mixes, with grazing and highly diverse mixes going up to 150-175%.

As a mix is built, ratings for nitrogen fixation, grazing, drought tolerance, frost tolerance, winter hardiness, diversity, and salinity tolerance are given. The Carbon:Nitrogen ratio is also estimated for the mix as it is being designed. A complete accounting of the cost of the mix is calculated and shown in real time. The total is broken down for seed cost, inoculant cost, mixing cost, and bagging cost. Additional information may need to be collected in order to accurately calculate shipping, and we will contact you with a shipping quote after the mix has been submitted.

Feel free to experiment with different species and observe how each selection and seeding rate change affects the calculations, ratings, and cost of the mix. We have found this feature to be highly addictive, and many hours can be spent running through "what if" scenarios and comparing one mix to another!

SmartMix® is designed as an educational tool to help the user make decisions about what cover species to choose. Some of the species suggestions may not be familiar to the user. More information about each cover crop species can be obtained by clicking on the information icon, which will access detailed information pages about cover crop species from the Green Cover Seed website. SmartMix® 5.0 is designed using the latest technology, and best results will occur when using the latest release of the browser of your choice. Older versions of Internet Explorer are not able to run the new code, so please be sure you have the latest version.

We have a three-part tutorial on how to use and utilize SmartMix 5.0. Just go to YouTube and search for the Green Cover Seed channel or search for SmartMix Tutorial. To ensure you will get notified about new videos, please subscribe to our YouTube channel.



Cover Crops for Supplemental Grazing

One of the most widely reaped benefits of cover crops is providing valuable supplemental forage to grazing animals. Well-planned annual cover crop mixes can provide highly nutritious available forage when perennial grass pastures are either unproductive, poor in quality, or in need of rest. The most critical period for perennial pastures is the month prior to fall dormancy and grazing cover mixes and providing rest during this period can greatly improve the long term performance of permanent pastures.

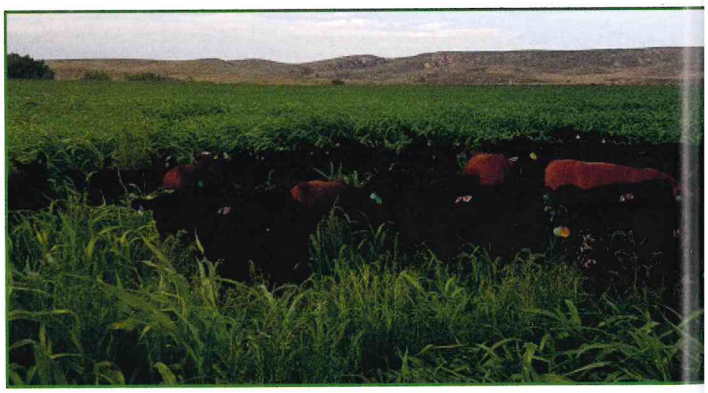
Cover crops can provide quality grazing when grass pastures are of low quality, such as late fall when native grasses are poor quality or early spring before native grass greens up. Most of the production from a perennial grass pasture occurs in the first half of the growing season, while most of the forage demand in a spring calving herd occurs in the last half of the growing season. Incorporating cover crops into a pasture program can provide a sequence of quality forage that can produce excellent animal performance for as much as twelve months a year and eliminate the need for hay or other stored feed. This can be particularly useful for a grass finishing operation which needs a constant supply of high quality forage, for grass based dairy operations, or for any livestock owner that wants to maximize performance and minimize costs. The cost per ton of feed from a grazed cover crop is usually far less than the cost of hay or silage.

For example, a grazing program can utilize native warm season grass in May, June, and July. Using native grass for just this short period is called intensive-early stocking. This allows a doubling of the season-long stocking rate, uses the grass at its peak forage quality, and also allows a rest during the critical period prior to dormancy. Animals can then be moved to a cover crop blend of summer annuals like BMR sorghum-sudangrass and cowpeas for August and September, then transferred to a blend that utilizes cool season covers like turnips, radishes, oats, spring peas, and spring barley. This can be pastured through fal and then the herd can be moved to corn stalks that have been aerially seeded to rye. This can often allow grazing throughout the winter and spring, especially if strip graz to ration out availability of spilled grain throughout the winter. Presto! Twelve months of grazing; no hay needed This is only one set of options among many. There are unlimited cover crop options for providing grazing at different times of the year. See pages 54-56 for examples Spring, Summer, and Fall Mixes.

Photo by Nathan Pearce

Adaptive Multi-Paddock Grazing

When people think of grazing forages, they often think of fencing the whole field with one location for water an mineral and continuously grazing the whole herd until a the forage is eaten. This type of grazing can be destructive to soil health and productivity as it leads to compaction, bare soil, and uneven distribution of manure and urine nutrients. The solution is to introduce an Adaptive Multi-Paddock (AMP) Grazing Principles Management system. Dr. Richard Teague, Texas A&M AgriLife Research, defines in this way: "Adaptive multi-paddock gra ing is a more effective form of rotational grazing in whic one paddock is grazed at a time while other paddocks recover and livestock numbers are adjusted as needed to match available forage as conditions change."



AMP involves managing livestock using multiple small paddocks to provide periods of short duration/high stoc density grazing followed by adequate forage rest and recovery periods. The purpose is to mimic as closely as possible the predator-influenced herd migrations of wil ruminants such as ancestral bison and elks. The tendenc for many graziers is to keep to a planned schedule, but Mother Nature frequently throws curve balls and best la plans do not always work. With adaptive grazing manag

Photo by Gabe Brown

ment, there is no preset schedule. It is based on reading the conditions of the land and forage, assessing the needs of the livestock, and planning the grazing appropriately. When intensively grazing small paddocks for a brief duration, any mistakes are limited to very small areas. Adaptive grazing management is looking at how native ecosystems function and mimicking it with domesticated animals.

Our rich prairie soils were built by large herds of bison grazing in compact groups to avoid predation. These herds would "mob graze" an area and then move on, not returning until the next year. This intense but brief disturbance creates minimal soil compaction and stimulates plant

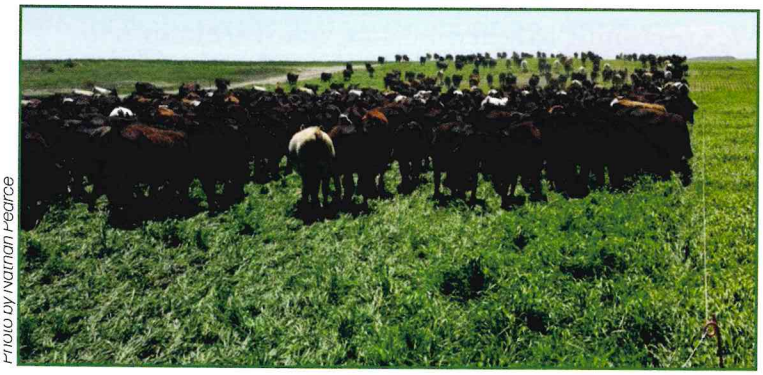


Photo by Nathan Pearce

regrowth during the long period of healing and regrowth. Adaptive grazing can work in any system whether it is perennial grasses or annual cover crop forages. As Allen Williams says, "Adaptive grazing also means being adaptive to the people! You don't have to move cattle everyday; it could be every other day, or once a week - it is what works best for you and what works best for the land."

Prior peer-reviewed research by Dr. Teague shows that north central Texas ranches practicing AMP grazing principles have been able to sequester an additional 12 tons of carbon per acre over a ten year period when compared with more conventional grazing practices. Results from a Mississippi study conducted by Dr. Allen Williams and the Arizona State University School of Sustainability show that with just 5 years of AMP grazing, significant results can be achieved in terms of building soil organic matter, soil carbon, and overall soil health. Immediate observations were that root structure and development, including root depth and mass, were significantly greater with AMP management. In addition, there were noted differences in soil texture, aggregation, and apparent soil life with earthworms present in the soil of the AMP farm. AMP grazing appears to yield results and benefits that far exceed more relaxed grazing rotations. The ability to build such significant differences within a relatively short period of time make AMP grazing an attractive tool for land improvement and remediation.

Dung Beetles

Dung beetles are a crucial part of the ecosystem in that they help distribute and bury manure patties. In doing so, less nitrogen is volatilized into the atmosphere, fly populations are decreased, and water infiltration is improved. Studies have shown that a healthy population of dung beetles can reduce horn flies by 95%, reduce populations of intestinal parasitic nematodes by 75 to 93%, and subsequently reduce fly-transmitted diseases and intestinal parasitic nematode infections. Also, nutrients from the manure become more readily available to plants due to the burial and degradation of manure in the soil. When exposed manure degrades slowly, cattle can avoid the area around the manure for up to 2 years, which reduces the area for grazing.

With healthy populations of dung beetles, studies have shown a total potential benefit of $2 billion annually to US farmers and ranchers, through rapid burial of dung. Dung beetle populations are severely limited or even eliminated with continued use of many popular pour on dewormers and livestock applied insecticides. Replacing insecticides with proper grazing management and utilizing forage plants with natural deworming properties will allow your dung beetles populations to grow, which in turn will start to restore your pasture soils.

Photo by Joshua DuKart

#dungbeetles

Which Cover Crops are Best for Grazing?

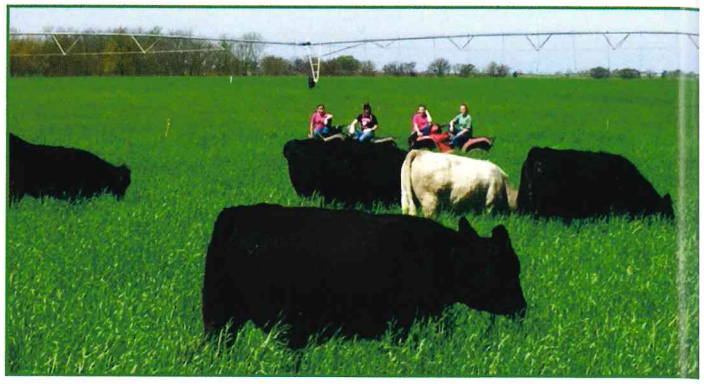
Grasses are king when it comes to growing cover crops for supplemental grazing. In addition to being the highest yielding family of cover crops, they are vital in reaching other cover cropping goals such as reducing erosion, building organic matter, and suppressing weeds. Warm-season C4 plants such as sorghum sudan and pearl millet are popular summer choices and cool-season cereals, such as cereal rye, triticale, oats, barley, and wheat are often used in both spring and fall. Refer to pages 44-47 for more information on grasses.

Legumes do not necessarily produce relatively high amounts of forage, but what they lack in quantity, they make up for in quality. Properly selected legumes can be excellent compliments to their grass cousins in a diverse grazing mix and can really enhance animal gain and performance. See pages 42-43 for more detailed information on legumes.

Brassicas are also excellent team players when it comes to grazing mixes. Both the leaves and the tubers are high in protein and sulfur and their ability to regrow prolifically after grazing makes collards, turnips, kale, radishes, and other brassicas a vital part of a forage mix. See pages 48-49 for brassica information.

Timing Matters: When it comes to producing forage tonnage, it's not only the "What" that is important but also the "When". In a University of Nebraska Lincoln grazing trial, oats planted as a cover crop on August 20th after alfalfa yielded 3,800 pounds of dry matter (DM) per acre. Oats planted two weeks after corn harvested for silage yielded 2,800 pounds of DM per acre. Oats planted an additional two after this would yield barely 1,000 pounds. If grazing in fall is your goal, spring cereals planted 5-6 weeks prior to the first frost date are the best choice for rapid growth and good yields in fall. If spring grazing is your aim, then fall planting winter-hardy species like cereal rye, winter triticale, and winter barley provides early, rapid-growing

Photo by Nathan Pearce



cover crops for spring. UNL Beef specialist Mary Drewnoski says, "Cereal rye is the best choice if you're looking a grass that comes on early as it gets going a week to two weeks earlier than other winter-hardy species, but forage quality of cereal rye declines with maturity. By mid-April in Nebraska, you can expect fall-seeded cereal rye to yield 1,000 to 1,500 pounds per acre and by mid-May, you can expect yields to climb to 4,000 to 5,000 pounds per acre

A Case Study of Soil Improvemer

By Kevin Schilthuis • Lovell, Wyoming

We are farming irrigated entisols, which are known to have high mineral content but little biological activity. We would much rather be farming the more productive mollisol soils, but since you play the hand that you were dealt, we have developed a "mollisolve cocktail" program of minimum tillage, cover crops, irrigation, and grazing to quickly and responsibly mineralize these "poor" soils. First we sold our hay harvesting equipment, and installed fencing. We initially graze sheep as the data shows sheep manure has higher nutrient concentrations and there is good consumer demand for lamb in America. In our poor soils, this program as doubled our cation exchange capacity, OM levels have risen from under 1% to over 4%, animal condition is increasing each year while our veterinary cost has decreased, and erosion of these poor soils have been eliminated. Our banker recently reclassified our soil type from type 4 (poor) to type 2 (good) for lending purposes. This increased our collateral during a poor ag cycle and increased our lending portfolio to allow us to purchase 60 acres of irrigated row crop ground adjoining our operation. Soil Health is bankable! Utilizing Cover Crops to match our precipitation and climate has enabled us to become better stewards of the land, and grow a greater diversity of plants and roots for longer periods each year which allows us to be better caretakers of "all creatures great and small."

Photo by Linda Coffey, NCAT

Multispecies Grazing: A Primer on Diversity

By Lee Rinehart, NCAT Agriculture Specialist

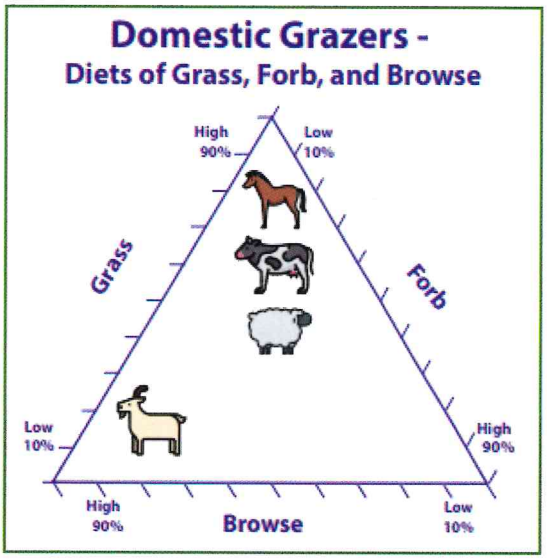
Resilient farms are based on diversity of life, and while much of the focus of agricultural sustainability of late has been on diversity of crops, forages, and soil microbial populations, not much has been said about the diversity of grazing species. Multispecies grazing takes full advantage of biological diversity. Producers who work hard to increase pasture-plant diversity will also see an even greater advantage by adding diversity of livestock to the mix. Multispecies grazing works best when a multitude of forage species make up the pasture composition. As vegetation of pastures becomes more diverse, multispecies grazing tends to improve composition and utilization and will increase the carry capacity. This management practice may be one of the most biologically and economically viable systems available to producers, especially on landscapes that support heterogeneous plant communities.

Studies have shown that when you add sheep to a cattle herd, you get 20 to 25% greater productivity and carrying capacity over cattle alone, and 8 to 9% greater productivity and carrying capacity over sheep alone. This is because different animal species have different grazing habits and dietary overlap and select various forages and combinations of forages. Pastures that are grazed with multiple species have more uniform defoliation and defecation patterns, which affect nutrient cycling and plant–animal nutrition.

Photo by Linda Coffey, NCAT

While cattle prefer not to graze around their dung, sheep have been reported to graze around cattle dung, thus increasing the utilization of pasture. This uniformity of grazing contributes greatly to forage quality and resiliency by keeping forage growth constant and resetting the plants to the same stage of growth with each grazing event and preventing weedy or unpalatable plants from taking over.

Competition has led animals on the same landscape to occupy different dietary niches and develop complementary forage preferences and grazing and dietary habits. Managers can exploit the selective grazing habits of different species to shape the landscape and diversify production.



Livestock producers know that cattle, sheep, and goats will often select different plant species. If you were to observe a herd of diverse grazing animals, you would notice that cattle (grazers) diets generally consist of about 70% grass, 15% forbs (commonly called weeds but including any broadleaf herbaceous plant), and 15% browse (twigs and leaves of shrubs and brushy plants). Thus, rangeland scientists have termed cattle grazers. Sheep (intermediate feeders) eat a diet of roughly 50% grass, 30% forbs, and 20% browse, while goats (browsers) consume around 30% grass, 10% forbs, and 60% browse. So, whereas there are some notable differences in diet choices among species, there is also some overlap, which is an important consideration when determining stocking rates in pastures.

This article was summarized from an excellent 20 page PDF document written by Lee Rinehart, National Center for Appropriate Technology (NCAT) Agriculture Specialist. We encourage you to go to www.greencoverseed.com and search for multispecies to read or download the entire article or visit the NCAT website for this or similar articles. https://attra.ncat.org

Diversity and Pest Management

By Jonathan Lundgren, Ph. D • Estaline, South Dakota

Dr. Jonathan Lundgren is an agroecologist, Director of ECDYSIS Foundation, CEO of Blue Dasher Farm, and every farmer's favorite Bug Guy! Blue Dasher Farm is a living laboratory used to develop and evaluate ecologically based pest and farm management solutions that reduce disturbance and increase biodiversity in crop. Through practical demonstrations they promote regenerative farming practices through teaching and outreach programs focused on educating farmers, the community, and the next generation of scientists. Dr. Lundgren has this to say about Insects and Soil Health:

> Humans have been battling against bugs for millennia and history has shown that insects have killed more humans than bullets or bombs through disease transmission. But not all insects are pests — for every harmful insect there are 1700 beneficial or neutral insects and many of these are incredibly important to the productivity of our agricultural systems.

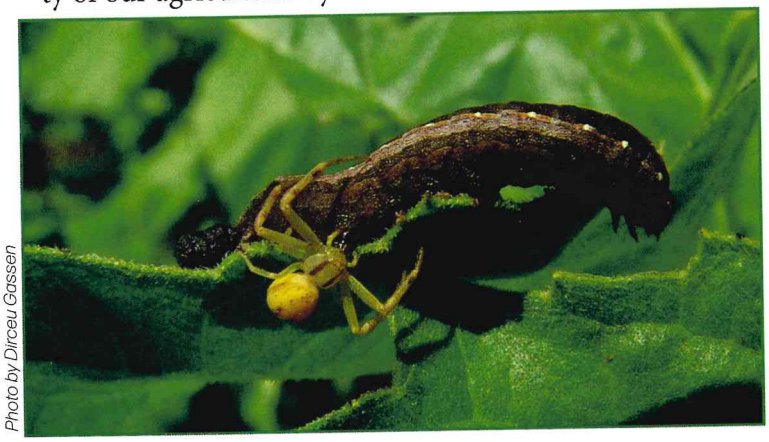


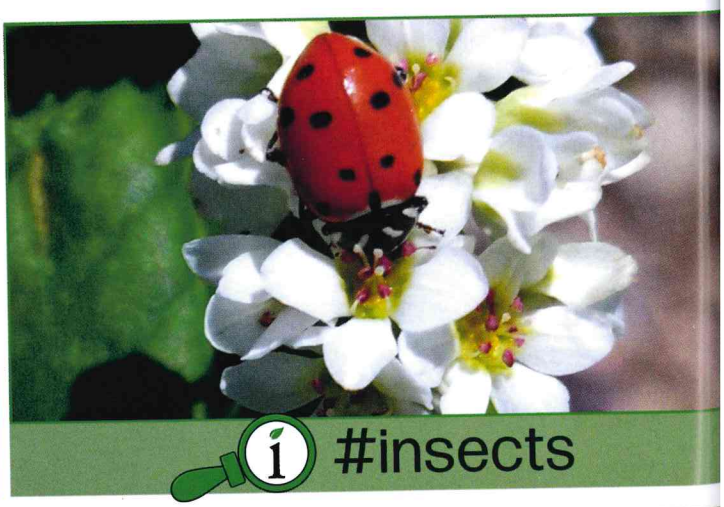
Photo by Dirceu Gassen

Insects contribute hundreds of billions of dollars to the US economy every year through a myriad of services. Insects are incredibly efficient at the conversion of feed to protein, which makes them invaluable as the basis for many food webs. Insects provide pollination services to most fruits and vegetables that we consume, but we are now learning that pollination is also beneficial to major crops such as soybeans. Pollinators and Beneficial Insects pollinate approximately 75% of the crop plants grown worldwide for food, fiber, beverages, condiments, spices, and medicines. If your farm is growing any crops that require insect pollination to produce maximum yield, it is vital to provide food and shelter for these beneficial species.

Beneficial insects are also a major front-line defense against crop harming pests such as aphids. Giving beneficial insects a sanctuary free of pesticides and tillage and providing plant material for nesting fulfills the majority of the needed requirements to develop a healthy population. Many of our beneficial predatory insects also rely on alternative food sources, such as nectar, at some point of their life cycle. If you have been battling a pest species in your crops, it may be that you have created an environment in which that pest can thrive and not be challenged. Attracting beneficial and predatory insects will lead to a more balanced system and pest problems naturally become less of a concern. It is highly desirable to have a healthy population of lady beetles, lacewings, syrphid flies, crab spiders, wolf spiders, mantids, and other predators living in or near crop fields. Building an army of beneficial insects that can be ready to pounce on destructive pests is a great benefit, but for this to happen the proper environment needs to be created. Building populations of beneficial predators can be accomplished with cover crops, insectary strips, and companion crops.

Cover crops can attract predators and build their populations in preparation for protecting the next cash crop. Healthy predator populations can be encouraged and maintained by having a diverse mixture of both cash crops and cover crops. This creates a sequence of pollen and prey insects throughout the year, ensuring a constant and consistent food source through the entire growing season. Many species of predators can also utilize pollen as an alternate food source in the absence of insect prey. Since pollen does not run or fight back, it is an excellent food for newly hatched predators. The larvae of lady beetles, lace wings, and syrphid flies (all good aphid predators) can exist largely on pollen if there is insufficient prey. Cover crops that flower and produce abundant pollen and nectar include buckwheat, mustards, phacelia and many clover species.

Learn more at www.bluedasher.farm



There are thousands of beneficial and pollinator insect species ready to work for farmers, but they are dependent upon a consistent pollen/nectar source through the entire growing season. Green Cover Seed carries more than 35 plant species that are highly attractive and supportive to these species. We can help you design custom mixtures that will flower and attract beneficial insects before your cash crop will need their services. One method to keep the predators in the field is to leave strips of live cover crop every 2 or 3 sprayer boom passes throughout the field during termination. Predators can move and survive longer in these strips and the strips can be terminated and planted later after the emergence of the cash crop on the rest of the field. A twist on this idea is the use of insectary strips which are semi-permanent strips of flowering plants that produce abundant pollen. This is an excellent way to use field access road, field borders, pivot roads, headlands, waterways, and turn rows. An additional innovation is the use of companion crops to attract beneficial insects during the growth of a cash crop. One example is the use of companion crops in double-crop sunflowers after wheat. Interplanting flowering plants like buckwheat, clovers, flax, and mustards can attract pollinators, which cross pollinate sunflowers and help attract beneficials to control pests.

Sugarcane Aphid Case Study

A great example of using companion crops and insectary strips is found in the control of sugarcane aphids in sorghum. In 2017, Jimmy Emmons, an Oklahoma farmer, planted grain sorghum at 4 lbs. per acre mixed with 1lb. flax, 3lbs. buckwheat, and 5lbs. mung beans to attract aphid predators. Emmons also planted a 13-foot wide strip of a flowering cover crop mix around his field, as well as one strip through the middle of his field to help attract predators. He was the only sorghum farmer in his area without problems from aphids. According to Jimmy, the companions may have cost a little yield due to competition, but not nearly as much as the sugarcane aphid would. "I am not saying that if you do what I did, that you won't have aphids," said Emmons. "All I can say is this is what I did and that I did not have aphids and I plan to continue doing it."

Building Defenses Against Armyworms

Armyworms are notorious pests in the south, especially on early cereal pasture or lush Bermuda regrowth. Rather than just spraying pesticides for control, we can also utilize biological methods. Lee Wayne Stepp from Comanche, Oklahoma, has pointed out he had little to no armyworm pressure in the fall of 2017 on his wheat pasture that followed a diverse summer cover crop mix. While we have also heard this from other producers, there are no guarantees against future armyworm pressure, but the successes are encouraging.

Photo by Brett Peshek

Birds are the most effective army worm predator but they often show up too late for effective control. To attract birds and other beneficial insects sooner, other insects must be attracted to the field through plant diversity. In summer cover crops, some species to consider for flowering and attracting insects are: buckwheat, sunflowers, cowpeas, flax, and sunn hemp.

In a perennial scenario, such as Bermuda pasture, there may be more difficulty adding diversity as it reduces your ability to spray "weeds". However some of these "weeds" can be effective at recruiting birds and beneficial insects in late summer just prior to army worm season. By utilizing more of adaptive grazing techniques, weeds can be managed through grazing and trampling. Interseeded species include crimson clover, red clover, hubam sweet clover, yellow sweet clover, hairy vetch, plantain, and chicory.

Photo by Brett Peshek

Legumes are critical components of any cover crop mix. They possess the unique ability to form symbiotic relationships with rhizobia bacteria that fix atmospheric nitrogen inside nodulation colonies that grow on roots. A pure stand of legumes can fix 120-180 pounds of N per acre, and in a mix legumes can fix 30-80 pounds of N per acre. Legumes are high in protein, generally very palatable for livestock, and have a low carbon to nitrogen ratio. Because legumes typically yield less seed than other plants, legume seed is generally more expensive.

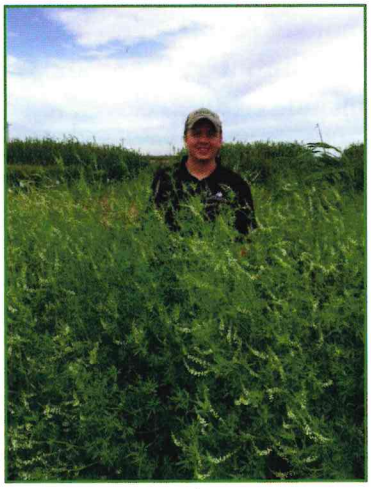
Faba Beans

Faba beans are the only true bean that can grow and thrive in cool wet soils, and are one of the highest nitrogen-fixing grain legumes. Unlike most legumes, faba beans continue producing nitrogen through grain fill and full maturity. Faba beans tiller very well from the axillary buds making regrowth after grazing a benefit. The vigorous taproot of the faba bean can range from 2 to 4 feet in depth and can provide more overall biomass than spring peas. One downfall of faba beans is that the larger seed size does not always work well in seed mixtures.

Sunn Hemp

Sunn hemp is a tropical warm season legume that fixes large amounts of nitrogen. Sunn hemp is typically a very long-season plant that will produce yellow flowers if grown long enough. However, it can't produce much viable seed in the United States. Sunn hemp is very high in protein, but many varieties also contain alkaloids, which can make it less palatable and less desirable to cattle. This trait doesn't tend to bother sheep, goats, or deer. Sunn hemp grows extremely fast in the heat, sometimes reaching heights of 6-7 feet tall in 60 days. Sunn hemp has also been found to greatly reduce soybean cyst nematode populations.

Sunn Hemp



Hubam Sweet Clover

Hubam Sweet Clover

Hubam sweet clover is an annual cool season legume a a phenomenal attractant for pollinators and beneficial i sects. Because it is an annual, it is much faster establish ing and blooming than its well-known biannual cousin yellow blossom sweet clover. The sweet smelling white flower of hubam is very attractive to insects, especially honeybees. Hubam is one of the most heat tolerant of a clovers and grows well through the summer, providing a deep taproot and considerable above ground biomass that is excellent forage.

Cowpeas

Cowpeas are a warm season legume, and are actually a bean, not a pea. There are many varieties of cowpeas, including Iron and Clay (long maturity) and Red Ripper (medium maturity). Cowpeas are very drought tolerant and can provide excellent forage in warm season grazing or haying mixes. Cowpeas have the ability to vine and climb so they are excellent when combined with taller fo ages like sorghum sudan, BMR corn, or sunflowers.

Hairy Vetch

Hairy vetch is the most widely planted winter legume be cause it is the most winter hardy of all legumes. Depend on genetics, properly established hairy vetch can survive

subzero temperatures and with some snow cover it can survive double digit subzero temps. For this reason, hairy vetch is widel used by organic producers who need to fall plant a legume for spring nitrogen production ahe of organic corn production. Nitrogen production from hair vetch can range from 80-200 lbs/A and is highly dependent allowing the vetch to maximize its growth into the sprin Early termination can lead to reduced N fixation rates. Hairy vetch has a great rooting system, with a tap root that will extend up to 3 feet into the soil profile with ma fine branch roots going horizontally through the soil. Th rooting system will allow the vetch to thrive even in dry conditions. There is a weed risk associated with hairy ve because a percentage (0-10% depending in genetics) of seeds will have a hard seed coat which can lay dormant i the soil for several years. This is generally not a problem a corn/bean rotation but is more of a concern for produ ers with cereal grains in their rotation.

Legumes

Warm Season Legumes	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
Cowpeas - "Red Ripper"	4,100	34	High	Excellent	Excellent	Low	Great value legume
Cowpeas - "Iron and Clay"	4,100	34	High	Excellent	Excellent	Low	Long maturity
Cowpeas - "Black"	6,000	34	High	Excellent	Excellent	Low	Very viney
Mung Beans	7,000	33	High	Good	Excellent	Low	Short season maturity
Guar	12,000	32	High+	Good	Excellent	Medium	Exceptionally drought hardy
Sunn Hemp	15,000	32	High	Excellent	Fair	Low	Fast growing
Sunn Hemp - "Tropic Sunn"	15,000	32	High	Excellent	Excellent	Low	Excellent palatability
Soybeans	3,300	32	Medium	Excellent	Excellent	Low	Long maturity

Cool Season Legumes	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
Spring Lentils	21,000	20	High	Excellent	Excellent	Low	Small seeded pulse
Spring Forage Peas	3,200	20	Medium	Excellent	Excellent	Low	More forage than yellow peas
Chickling Vetch	2,500	18	Medium	Good	Excellent*	Low	Great N fixer
Common Vetch	8,000	10	Medium	Excellent	Good*	Low	Cheapest vetch
Woolly Pod Vetch	10,000	0	High	Excellent	Good*	Low	Fastest spring bloomer
Hairy Vetch	12,000	-20	Medium	Excellent	Good*	Low	Best over winter legume
Austrian Winter Peas	4,000	10	Medium	Excellent	Good	Low	Small seeded peas
Faba Beans	2,000	15	High	Excellent	Good	Low	Can tolerate cool soil
Chick Peas	3,000	20	Medium	Excellent	Good	Low	More heat tolerant than other cool seasons
Lupins	4,000	20	High	Excellent	Fair*	Low	Only use sweet varieties for forage
Crimson Clover	120,000	5	Medium	Excellent	Good	Low	Fast growing clover
Berseem Clover	150,000	20	High	Excellent	Excellent	High	Mediterranean type
Berseem Clover - "Frosty"	150,000	10	High	Excellent	Excellent	High	Good cold tolerance for berseem
Balansa Clover - "Fixation"	500,000	0	High	Excellent	Excellent*	Medium	Good winter hardiness
Arrowleaf Clover	270,000	15	High	Good	Good	Medium	Drought tolerant
Persian Clover	150,000	20	Medium	Excellent	Excellent*	Medium	Mediterranean type
Ladino Clover	500,000	-15	Medium	Fair	Excellent*	Low	Long lived perennial
Red Clover	190,000	-10	Medium	Excellent	Excellent*	Low	Short lived perennial
Hubam Annual Sweet Clover	240,000	25	High	Good	Good	High	Best summer clover
Yellow Sweet Clover	180,000	-10	High	Good	Fair*	High	Biannual
Subterranean Clover	150,000	20	Medium	Fair	Excellent	Low	Most shade tolerant
Alsike Clover	450,000	0	Medium	Fair	Good*	Medium	Cross between red and white
Sainfoin	18,500	-10	High	Good	Excellent	Medium	Drought tolerant
Alfalfa	150,000	-10	Medium	Fair	Excellent*	Low	Very productive legume

**Potential toxicity under unfavorable conditions*

Grasses are the workhorse family of the cover crop world, generally producing the highest yields and greatest biomass. Grasses comprise the bulk of many mixes, including most grazing mixes, and are generally very palatable for livestock. Grass plants tend to be higher in carbon to nitrogen ratio and can provide excellent residue if allowed to go to maturity.

Sorghums

There is perhaps no more versatile and widely used family of cover crop species then sorghum and its array of relatives. There are many purposes for which sorghum plants are suited, and different types and traits have been developed to meet these needs.

Sorghum Types

Sudangrass is a fine-stemmed sorghum that regrows rapidly after defoliation. It is earlier maturing and lower yielding than other sorghum types if all are allowed to grow to full maturity. It has a lower sugar content than other sorghums, but is higher in protein and palatability. Sudangrass is lower in prussic acid potential than other sorghum types.

Forage sorghums are coarse-stemmed, long maturity sorghum that are higher in sugar and historically used as a source of syrup. Now used as breeding stock for many modern hybrids to enhance sugar, growth, and palatability, they have poor regrowth but high yield potential if allowed to grow to maturity.

Sorghum-sudans are hybrids between sudangrass and forage sorghum. They are intermediate in most characteristics but also exhibit hybrid vigor, and thus have excellent yield and regrowth potential.

Sorghum Traits

Brown midrib (BMR) is a naturally occurring mutation that makes plants less able to produce indigestible lignin, which give them higher digestibility and far better (usually about 30% better) animal performance than non-brown midrib varieties of similar genetics. If a sorghum is to be used for animal feed, a BMR is preferable.

Brachytic dwarf (BD) is a trait that shortens the inter nodes on a plant, but actually increases the total numb of leaves on a plant. This results in a leafy, short-statur plant with low-set growing points that tends to stand better later in the season.

Dry-stalk (DS) is a trait in which the pith of the plar has less water content than most hybrids, meaning it dry out faster in a swath than other hybrids of simila stem diameter.

Photoperiod sensitivity (PPS) prevents the sorghum plant from heading out until the day length drops belc 12 hours and 20 minutes, which for most areas will be mid-September. Heading is undesirable in a plant use forage, unless the plant is intended for silage. Four thi happen when a plant heads out and they are all bad fo forage production: first, leaf production stops; second growth stops; third, the amount of lignin goes up and plant becomes less digestible; and fourth, water use go up from 30-50%. By delaying heading, a PPS hybrid w very high-yielding, retain forage quality for longer per of time and be very water efficient.

Delayed maturity (DM) is similar to photoperiod sen tivity but does not depend on day length to function, l rather a large amount of heat units.

Male sterile (MS) hybrids have pollen that is not fer and thus cannot self-pollinate, and will not produce unless pollinated by another sorghum. MS hybrids a a great choice to prevent any chance of volunteer see lings the next year but need to be isolated from othe sorghums (including Johnsongrass) for a quarter mil prevent seed production.

Best Sorghum Traits for the Situation

Summer grazing: Rapid regrowth and low-set growir points (for grazing tolerance), as well as a very high le

to-stem ratio, and high digestibility. Look for a BMR, BD sorghum-sudan.

Hay in a humid area: Multiple cuttings, high digestibility, rapid regrowth, and rapid drydown. Look for a BMR, DS sorghum-sudan.

Hay in more arid areas: Single large cutting, delay heading as long as possible. Look for BMR, PPS sorghum-sudan or DM sorghum-sudan for later plantings.

Stockpiled winter pasture: Excellent standability, high digestibility, and palatability even when mature. Look for BMR, PPS forage sorghums or BMR, PPS forage sorghum-sudans, and if planting late (after July 4th, roughly) then a long maturity BMR, BD forage sorghum is the best choice.

Silage: Use a long maturity BD, BMR forage sorghum for early silage plantings. For later plantings, consider a shorter maturity BMR forage sorghum.

Biomass production and cover: Conventional sorghums and sorghum-sudans are the least expensive but often times a PPS, MS, or DM product may be desired to extend the growing season and prevent seed formation.

Wildlife cover and habitat: Use a blend of grain-producing hybrids with different maturities, lodging resistance, and heights. Consider adding a variety of millets as well.

#sorghum

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

Millets

Millets are diverse and broadly adapted group of summer annual grasses that fit a variety of needs. Because millets originate from Asia and Africa, they tend to have excellent heat and drought tolerance and in these countries of origin, they are still widely used as a staple for human consumption. There are a variety of different millets that serve a variety of different purposes so it is important to understand the different types of millets and when and where they should be used so you can select the one that is right for you.

Pearl millet (Genus Pennisetum) has the highest yield potential among millets because of its hybrid heterosis. Because millets have no prussic acid potential, hybrid pearl millet is preferred for grazing under conditions in which prussic acid might be hazardous. Millets, like any plant, can still accumulate nitrates and should be tested if high nitrates are a potential concern. Pearl millet is more tolerant of sandy and calcareous soils than sorghum-sudan, but less tolerant of heavy clay or wet soils. Pearl millet is usually higher in protein than sorghum but loses palatability more rapidly upon maturity and unlike sorghums, pearl millet is safe for horses.

Left: German Millet | Right: Pearl Millet
5 weeks of growth

Foxtail millet (Genus Setaria) is also known as German or White Wonder millet. It is earlier in maturity and has lower forage yield potential than pearl millet; however, it is finer-stemmed and cures more rapidly for hay than pearl millet. When growing as a forage, be aware that once it heads out, it loses forage quality, and the bristly awns on the seedheads can cause sores in animal mouths. Foxtail millet should not be used for horses, as it contains a compound that can cause joint pain and problems with the urinary tract.

Browntop millet (Genus Urochloa) is another rapid-maturing, lower-yielding (as compared to hybrid pearl) millet variety, commonly used in the southern plains as it is more tolerant to higher humidity levels but it can move north also. Browntop holds its palatability after maturity better than other millets so it has a fit in stockpile mixes. Browntop is also safe to feed to horses. It is often used in wildlife food plots as it is a good seed producer with an open panicle for easier foraging.

Japanese millet (Genus Echinochloa) matures rapidly and typically yields less forage than other millets but is more palatable than foxtail millet after maturity and has better regrowth. Japanese millet is exceptionally tolerant of wet soil and will even grow in standing water, finding use in duck food plots.

Proso millet (Genus Panicum) is used strictly as a grain crop and has very little forage value, being both unproductive and unpalatable. However, it is one of the most water-efficient grain crops, and is used to provide animal feed in areas too dry for corn or sorghum. It is also used as a rapid-maturing (as little as 60 days to maturity) grain crop when the growing season is too short for a full-season crop, such as when hail takes out the primary crop or for wildlife food plots.

#millet

Rye vs. Ryegrass

Many people, understandably, are confused by the difference between rye and ryegrass. These two plants, despite the similarity in names, are not closely related and do not behave alike.

Rye (Secale cereal) is a cereal grain, closely related to wheat, with which it can be crossed to form triticale. It is tall and coarse with a long head full of large seeds almost as big as wheat. Rye is the most cold-tolerant grain crop known, and will produce more growth during winter than any other crop. It is the last forage crop to freeze down in fall, and the first to green up in spring but is also the first cereal grain to get stemmy and unpalatable in spring. Rye is very tolerant of drought and sandy or low-fertility soil, but responds well to fertility. It does not like very wet soil. One drawback of rye is that volunteer plants are hard to control in wheat fields if allowed to go to seed.

Ryegrasses (Genus Lolium), on the other hand, are true "grassy" plants, closely related to fescue with which it can be crossed to form the hybrid called festulolium. The seeds are small and fluffy, and are very hard to distinguish from fescue seed. The leaves are erect, dark green, and very shiny due to a waxy layer on the leaf surface.

Ryegrasses perform best in clay soils with good moisture, and tolerate wetter soils than any of the cereal grains. They have fine leaves and do not get very tall compared to cereals. Annual ryegrasses form a dense root system that can hold up animals and vehicles much better than cereals in wet weather. Ryegrass greens up later in spring than rye, but is much more grazing tolerant and grows later into the summer than rye. It also keeps its palatability and nutritional value much later in the season than rye. Annual ryegrass is not closely related to wheat like rye and there are herbicides that can take volunteer ryegrass out of wheat. Ryegrass comes in annual, biannual, and perennial forms, and even hybrids of annual and perennial varieties (intermediate ryegrass).

So which is the better pasture or cover crop choice, rye or ryegrass? Each has enough advantages that the answer is **both**.

#ryevsryegrass

Elbon Cereal Rye

Elbon cereal rye was developed by the Noble Foundation in Oklahoma and has a wonderful combination of winter hardiness and fast growth. Elbon has a shorter dormancy period than northern cereal rye and will give more fall growth as well as earlier spring growth.

It is excellent as a forage in early spring and will provide some of the best weed suppression and erosion control well into the early months of summer as a mulch. Elbon can be planted late in the season into soils as cold as 34°F.

Cosaque Black Oats

Cosaque oats are a black-seeded winter oat with better nutritional value, digestibility, palatability, and tillering ability than traditional oats. Forage yields are very similar to cereal rye. Black oats have good winter hardiness and are commonly a winter annual in the south. Black oats can survive in very poor-quality soil and help build the soil back through its fantastic root system.

813 Triticale

Triticale is a cross between rye and wheat and has some characteristics of each parent. Compared to rye, triticale holds its feed value better into late spring. This makes it well suited for hay, silage, or stretching grazing well into June if you don't mind starting two or three weeks later. The disadvantage to triticale is that it tends to be a bit more susceptible to winter injury than rye but is similar to wheat.

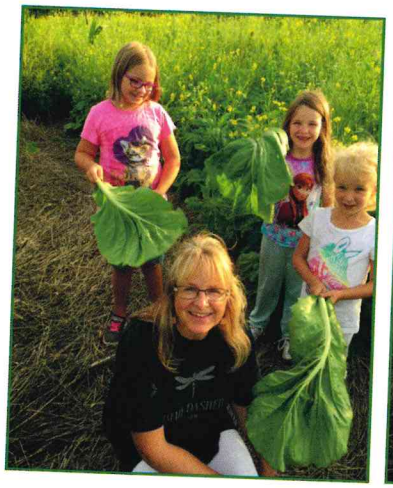
Our top performing triticale is SY813, which is awnletted (very short beards), has excellent fall vigor and growth, and is tolerant of both rust and wheat streak mosaic virus. It is very well adapted to the Southern and Central Great Plains region. This is the go-to winter forage to maximize forage production!

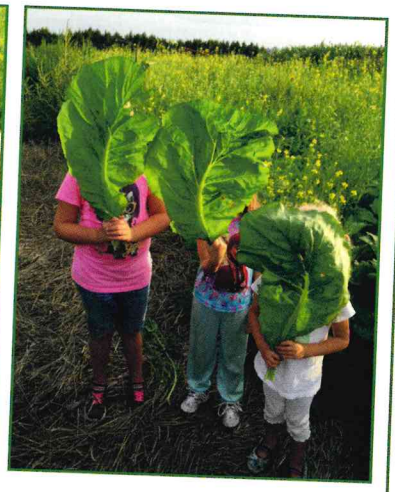
Warm Season Grasses	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
BMR Grazing Corn	2,500	32	Medium	Excellent	Excellent	Low	Great value for forage
Sorghum Sudan	18,000	32	High	Excellent	Good	Medium	High tonnage
BMR Sorghum Sudan	18,000	32	High	Excellent	Excellent	Medium	Low lignin
BMR Sorghum Sudan PPS	18,000	32	High	Excellent	Excellent	Medium	Photoperiod sensitive
Sudangrass	22,000	32	High	Excellent	Excellent	Medium	Fine stemmed
Forage Sorghum	18,000	32	High	Excellent	Good	Medium	Great for silage
Dwarf Sorghum Sudan	18,000	32	High	Excellent	Excellent	Medium	Short internodes
Egyptian Wheat	18,000	32	High	Excellent	Good	Medium	Super tall sorghum
Wildlife Grain Sorghum	17,000	32	High	Fair	Fair	Medium	Attracts birds
Pearl Millet	80,000	32	High	Good	Good	Low	Highest production millet
Browntop Millet	180,000	32	Medium	Good	Good	Low	Great for the south
Japanese Millet	120,000	32	Medium	Good	Good	Low	Grows in wet soils
Proso Millet	120,000	32	Medium	Fair	Poor	Low	Grain millet for birds
German Millet	180,000	32	Medium	Fair	Good	Low	Excellent hay millet
White Wonder Hay Millet	180,000	32	Medium	Fair	Good	Low	Excellent hay millet
Teff Grass	1,300,000	32	High	Fair	Excellent	Low	Super fine stemmed
Cool Season Grasses	**Seeds Per Pound**	**Cold Kill**	**Drought Tolerance**	**Biomass Production**	**Forage Quality**	**Salinity Tolerance**	**Comments**
Spring Oats	15,000	20	Medium	Excellent	Excellent	Medium	Very versatile
Spring Triticale	16,000	5	Medium	Excellent	Excellent	Medium	High spring production
Spring Forage Barley	13,000	20	Medium	Good	Excellent	High	Salt tolerant
Cosaque Black Oats	22,000	10	Medium	Excellent	Excellent	Medium	Great forage
Winter Oats	19,000	10	Medium	Excellent	Excellent	Medium	Overwinters in the South
Cereal Rye	22,000	-30	High	Excellent	Good	Medium	Best weed suppression
Winter Triticale	16,000	-10	High	Excellent	Excellent	Medium	Great spring forage
Winter Barley	15,000	0	Medium	Good	Excellent	High	Decent winter hardy
Hard Red Forage Wheat	13,000	-10	Medium	Excellent	Excellent	Medium	True forage wheat
Soft Red Winter Wheat	13,000	-10	Medium	Good	Excellent	Medium	Good grazer
Italian Ryegrass	190,000	0	Medium	Good	Excellent	Medium	Very deep rooted
Annual Ryegrass	190,000	0	Medium	Good	Excellent	Medium	Very deep rooted

Brassicas are a family of cool season, deep-taprooted plants that have become integral parts of many cover crop mixes. They are especially favored for their compaction-breaking ability and palatability to livestock. Brassicas have very small seeds, are generally low in carbon to nitrogen ratio, and do not provide long lasting residue.

Broadleaf Mustard

Broadleaf mustard is known for its palatability and is often grown as mustard greens. Its quick growth and broad leaf make it an excellent weed suppressor. Broadleaf mustard is the latest maturing variety, reducing the chance of it going to seed. Mustards tend to have a very thick fibrous taproot, which is substantially different than many other brassica species.





African Cabbage

African cabbage is a tall and fast-growing brassica that can be successfully grown with an array of warm season mixtures. Unlike other brassicas, African cabbage will remain erect and retain its leaves after dying from cold weather, making it a very effective snow-catch cover crop. The durable residue and root structure allows moisture from the captured snow to infiltrate and build moisture in the soil profile.

Impact™ Forage Collards

Impact™ Forage Collards are highly nutritious and digestible for livestock. They are slow to bolt and flower when spring planted, making them an ideal choice for late spring and early summer grazing. They have also exhibited excellent ability to regrow after grazing, even under drought conditions.

Impact™ Forage Collards are small seeded and are priced more affordably than many other premium hybrid brassicas, giving them excellent value as a flown on cover crop or as a part of a diverse grazing mix. Impact™ Forage C have a deep-growing taproot and will not form a tu a bulb, instead producing very large and nutritious Impact™ Forage Collards have demonstrated the abi stay green into late December in Nebraska, even aft peratures dropped below 0° F for at least one night.

Smart Radish®

The Smart Radish® is a totally new radish that was bre specifically for the cover crop and soil health market. is not a Daikon, vegetable, or oil seed radish but is a t new plant from top to bottom. Bred by Mr. Adrian Ru with Plant Research New Zealand under contract to N Zealand's Norwest Seed and being marketed in the Un States by Green Cover Seed, this exciting new radish h some great new features that we are excited about.

- Smoother leaf for better forage and grazing.
- Higher plant biomass for forage, soil cover, and green manure.
- Higher plant tillering trait for more leaf area.
- Strong, penetrating "pull down" V-shaped bulb — more in the ground and less above the ground.
- Fibrous lateral rooting mass.

Viva Hybrid Brassica

Viva Hybrid Brassica is a new, fast-growing, leafy brassica with little bulb development. It is best suited for multiple grazing. Viva bolts very late and has vigorous regrowth after grazing, while maintaining high feed quality and digestibility. With proper management, Viva has the potential to yield up to 10,000 lbs. of dry matter per acre over multiple grazing events. Viva can be planted with cereal grains or annual ryegrass in the spring or late summer to provide excellent tonnage and high quality forage.

Bayou Kale

Bayou Kale hybrid is a deep-rooted, medium-maturing forage brassica with good winter hardiness and excellent palatability. Bayou has a smaller stem and more leaf area than other brassicas. Bayou has excellent regrowth when rotationally grazed, and the stems are more palatable than forage rapes for cattle and sheep. Used in food plots for deer as well as upland game birds, animals will eat the Bayou first when planted beside Dwarf Essex rapeseed. When planted in late summer or early fall, it is considerably more winter hardy than radish and helps protect the soil longer from erosion. Initial observations show that when Bayou is grown for cover, it has the potential to reduce Soybean Sudden Death Syndrome and potentially reduces white mold.

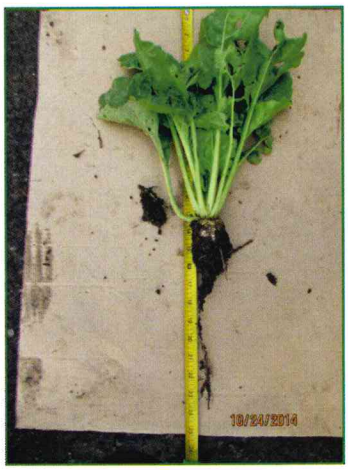
Brassicas	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
Daikon Radish	25,000	20	Medium	Medium	Good	Low	Deep tap root
Forage Radish	22,000	20	Medium	High	Good	Low	Slow bolting
Oilseed Radish	22,000	20	Medium	Medium	Fair	Low	Nematode suppression
Collards	175,000	5	Medium	High	Excellent	Low	Great forage
Purple Top Turnips	175,000	10	Medium	Medium	Excellent	Low	Great value
Hybrid Turnip	175,000	15	Medium	High	Excellent	Low	Excellent regrowth
Forage Rapeseed	175,000	0	Medium	Medium	Good	Medium	Cheapest brassica
Hybrid Rape/Kale	175,000	0	Medium	High	Excellent	Low	Great winter grazer
Hybrid Turnip/Kale	175,000	0	Medium	High	Excellent	Low	Great winter grazer
Kale	175,000	0	Medium	Medium	Good	Low	Very cold tolerant
African Cabbage	180,000	15	Medium	Medium	Fair	Medium	Stands well in winter
Broadleaf Mustard	100,000	25	Medium	High	Fair	Low	Huge leaves - good graze
Yellow Mustard	100,000	25	Medium	Medium	Poor	Low	Nematode suppression
Brown Mustard	100,000	25	Medium	Medium	Poor	Low	Nematode suppression
Oriental Mustard	100,000	25	Medium	Medium	Poor	Low	Nematode suppression
White Mustard	100,000	25	Medium	Medium	Poor	Low	Nematode suppression

Okra

Okra is a warm season broadleaf vegetable in the cotton family that is extremely deep-rooted and has excellent heat and drought tolerance. Okra's massive tap root is an excellent compaction breaker. This fast-growing plant provides a large canopy, long-lasting residue, and winter snow catch. Livestock will graze okra, as the pods are high in Vitamin A, C, and K, along with other minerals and vitamins that help strengthen the immune system and bones. Green Cover Seed is the nation's leader in cover crop okra and we have started growing our own seed supply.

Sugar Beet

Sugar beets are a broadleaf cover crop that can offer your operation another outstanding deep rooting crop with some frost tolerance. Sub-soiling thick taproots can fracture hardpans, and the majority of the root development is below the surface. Beets have a high sugar content and are preferentially grazed by wildlife and cattle. When grazed early enough, beets have shown outstanding regrowth.



Historically, sugar beet seed has been very expensive. We have contracted seed production with an Oregon farmer and are now offering non-GMO sugar beet seed at very competitive prices.

Flax

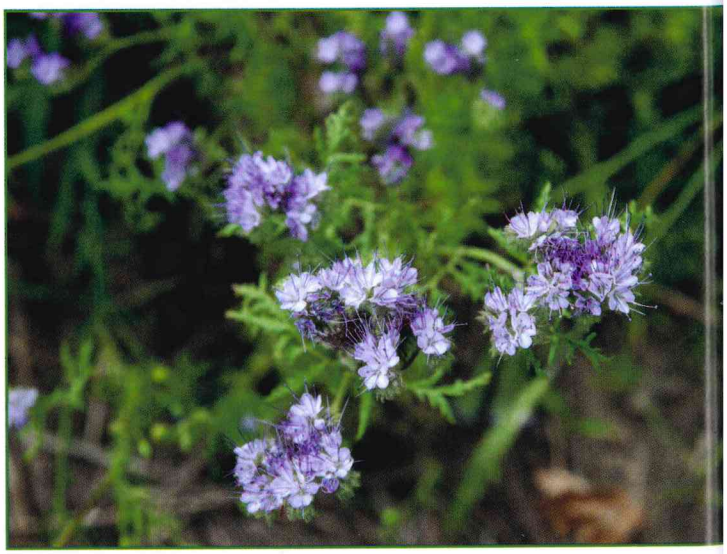
Flax is an annual, cool season broadleaf plant that can be utilized in many small-grain and corn rotations as a potential cover crop. Flax is a shorter plant that does not spread aggressively and has low input needs so it works well as a companion or interseeded crop, especially with sunflowers. Flax is high in lignin and is slow to decompose so it creates long-lasting, high-carbon residue. The pretty blue flowers of flax are a nice addition to any pollinator or insectary strips. Relatively small-seeded and inexpensive, flax is a good bargain and should be included in a great variety of cover crop mixes.

Safflower

Safflower is a drought tolerant, annual, warm season broadleaf that can be seeded in cool soils. Safflower has an exceptionally deep taproot that can reach depths of 8-10 feet, breaking hardpans, encouraging water and air movement into the soil profile, and scavenging nutrients from depths unavailable to most agronomic crops. Safflower provides excellent forage, but most varieties become very prickly with maturity, rendering the plants unpalatable fo livestock. "Baldy" safflower is one of the world's first spine less safflower varieties and has been developed specifically for grazing and cover crops. Baldy can be handled with bare hands even at maturity and is palatable for livestock grazing. Green Cover Seed owns the exclusive marketing rights for Baldy spineless safflower.

Phacelia

Phacelia is a quick-establishing purple-flowering annual that is fantastic bee forage and is considered to be in the top 20 honey-producing flowers. Other beneficial insects and pollinators are also strongly attracted to phacelia. Phacelia is a long-day plant and should be planted in spring or early summer. It can flower for up to 6 weeks as long as there are 12 or more hours of sunlight per day.



Buckwheat

Buckwheat is a fast-establishing warm season crop that can be utilized in a wide array of mixtures to suppress weeds by getting the soil covered quickly. If you need a workhorse to attract beneficial insects and pollinators, buckwheat fills this role exceptionally well. Rapid flowering and seed set provide a valuable source of food for wildlife. Buckwheat is also a very valuable phosphorus source as its root exudates can extract phosphorus from the soil that is not available to many other crops. When cycled, this phosphorus is then available for the next crop.

Sunflowers

Black oilseed sunflowers are renowned for their extensive and prolific root system and their ability to soak up residual nutrients out of reach for other commonly used covers or crops. Because insects are attracted to their extra floral nectaries and the bright colors of sunflower heads, pollinators and beneficials such as bees, damsel bugs, lacewings, hoverflies, minute pirate bugs, and non-stinging parasitoid wasps are often found in fields of sunflower and in following crops. With their upright growth and well anchored root system, sunflowers act as a trellis for surrounding vining/climbing cover crop plants to reach sunlight. Because sunflowers can add significant biomass production in just a short growing season, they can also serve as additional forage for livestock and are preferentially grazed when younger. For less than $1 per acre, sunflowers should be a part of almost any cover crop mix.

Warm Season Broadleaves	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
Sunflower - "Black Oil"	8,000	28	Medium	Medium	Fair	Medium	Inexpensive taproots
Okra - "Spineless"	7,200	32	High	High	Excellent	Medium	Very deep rooted
Sesame	80,000	32	High	Medium	Poor	Low	Durable residue
Squash	4,000	32	High	Medium	Fair	Low	Fast growing
Safflower - "Baldy"	15,000	24	Medium	Medium	Excellent	High	Spineless and grazable
Safflower	15,000	24	Medium	Medium	Poor	High	Deep rooted
Buckwheat	18,000	32	Medium	Medium	Fair	Low	Very fast growing

Cool Season Broadleaves	Seeds Per Pound	Cold Kill	Drought Tolerance	Biomass Production	Forage Quality	Salinity Tolerance	Comments
Flax	80,000	20	Medium	Low	Poor	Medium	Great host for mycorrhizal fungi
Chicory	400,000	0	Medium	Medium	Excellent	Low	Mineral accumulator
Plantain	200,000	-5	Medium	Medium	Excellent	Low	Mineral accumulator
Phacelia	225,000	25	High	Low	Poor	Low	Fantastic pollinator attractor
Sugar Beets - Non GMO	10,000	25	Medium	Medium	Excellent	High	Great for grazing

Perennial Sods in the Crop Rotation: The Fast Track to Soil Improvement

When grain prices went sky high beginning in 2008 and millions of acres of grassland were broken, it was obvious that many of these former grasslands were very productive, despite often being on poorer soil than adjacent cropland. This observation caused many people to reconsider an old, but long abandoned cropping practice: rotation of grain crops with a 3-5 year grazed perennial pasture period.

The reason for the dramatic soil improvement from a perennial sod period lies in the huge root system of perennial grasses. For example, the root system of an annual cover crop like rye might weigh 3,000 lbs/acre while reed canary grass roots weigh in at 10,000 lbs/acre and eastern gamagrass roots a massive 30,000 lbs/acre. This photo (left) from The Land Institute illustrates just how much greater the root system of perennial intermediate wheatgrass is compared to that of annual winter wheat.

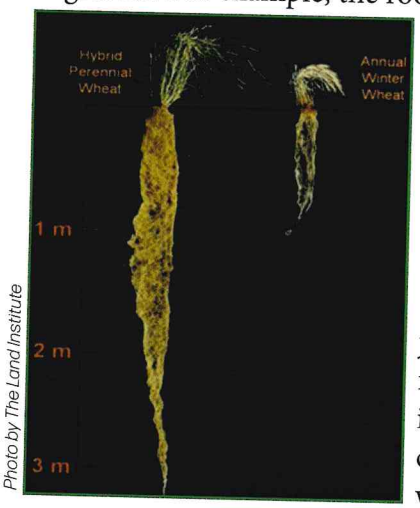


Photo by The Land Institute

Sod-based rotations offer the following advantages:

1. Dramatically improved organic matter and soil structure.
2. Extremely productive pasture during the sod phase.
3. Increase in earthworms, mycorrhizal fungi, and other soil biology.
4. Increased mineral nutrient availability through biological processes.
5. Conservation of fertility through cycling of manure and urine during grazing.
6. Reduction in pest pressure from weeds, insects, diseases, and nematodes.

In the past, establishing a sod has been considered a slow process, often taking three years to achieve a full stand. We have discovered that by inoculating perennial seed with mycorrhizal fungi available from Green Cover Seed, a good sod can be established in one growing season. Some of the most productive grass species, including Eastern gamagrass and switchgrass are shade tolerant enough to be established under a crop of corn, which can help cash flow during the establishment year. The picture below shows first year switchgrass in central Kansas, grown as a c panion crop with cash corn and inoculated with my zal fungi. This shows how a perennial grass can be e lished without sacrificing a year of production.

A good perennial sod should consist of a diverse blen of highly productive grasses, legumes, and deep-root forbs for maximum pasture performance and soil ber Some species to consider include: eastern gamagrass, bluestem, and Indiangrass for warm season grasses; n endophyte tall fescue, and low alkaloid reed canary gr for cool season grasses; alfalfa, red clover, and birdsfo trefoil for legumes; and chicory, plantain, and Maxim sunflower for forbs.

Short Term Sod, Long Term Benefits

If the long-term goal is not livestock production, but rather relatively fast soil improvement at the least cost then a short term sod mix might be the answer. This is mixture of plant species that are both rapid establishin and relatively economical seed cost that will be in pere al sod in place for three or four years. Grasses like orch grass, tall fescue, perennial ryegrass, prairie bromegras festulolium are good fits as well as legumes, such as alf and red clover. For forbs, we would still look to chicor and plantain, as they establish quickly and have relativ ly low seeding rates. The value of this approach is that i makes it much more feasible to get a high percentage o the farm rotated to sod as soon as possible at the lowes cost possible, so that as much of the farm as possible enjoys the soil improving benefits of a perennial sod cr

Forbs: The Forgotten Third Component of Pastures

By Dale Strickler • Courtland, Kansas

In the 1950's, the introduction of the herbicide 2,4-D ushered in a new era of pasture management, in which producers were able to selectively eliminate "weeds" in pastures and create nearly pure stands of grass. We soon found out that a pure grass stand was not as productive as a pasture with mixed, diverse vegetation. We first attempted to improve productivity with nitrogen fertilizer, which helped, but found that animal performance was not as good as on a mixed pasture. Interseeding legumes can improve pasture nutrition, but the more productive legumes like alfalfa also carried a bloat risk. However, for more than a century there has been a small group of pasture enthusiasts who have been advocating the inclusion in pasture seedings of a little used class of pasture plants: forbs, or herbs as others call them.

Ecologists regard weeds as a sign that there is an unfilled niche; in other words, they are an indicator that there is sunlight, moisture, or soil resources that are not being exploited by what we have planted. The only difference between a weed and a forb is that if livestock eat it, we call it a forb, and if they don't we call it a weed. If weeds thrive in a pasture situation it is a good sign that some forb will also be successful, as long as proper grazing management is applied. Selected forbs are much higher in mineral content than either grasses or legumes, and many contain chemical compounds that boost animal performance, including some that help prevent legume bloat. In addition, if forbs are included in a pasture seeding, they fill the niche that would otherwise be occupied by weeds, and therefore suppress weed encroachment.

Some of the more valuable pasture forbs include:

Chicory is a perennial forb that has gained quite a foothold in pasture circles. Compared to other plants, chicory contains relatively high levels of minerals such as potassium, calcium, magnesium, sulfur, zinc and sodium, which are necessary for animal health. Chicory also contains compounds that reduce bloat and reduce intestinal parasitic nematodes. It has very deep taproots and seems impervious to soil compaction. Livestock find it very palatable and the foliage is highly digestible and high in protein (30% or higher), until the plant bolts (forms a flowering stem) when it becomes far less desirable. It is one of the highest yielding pasture species available, comparable to alfalfa in yield if there is sufficient fertility.

Plantain is a perennial low-growing forb that may be even more winter hardy and indifferent to compaction than chicory. It is rapidly gaining popularity, and the people who use it love what it does for both soil and livestock. It is very palatable and nutritious, has a high mineral content, and regrows rapidly after grazing. It contains strong antimicrobial compounds which help animals fight off infectious diseases, and functions in the rumen similar to ionophores like rumensin and bovatec, increasing animal feed efficiency.

Burnet is one of the most drought tolerant forbs, and is unusual among plants in that it retains its nutritive value at all seasons and growth stages, even in winter. This is a valuable characteristic to livestock, but also to wildlife. There are stories of deer pawing through deep snow to eat still-green burnet plants in midwinter.

These plants are some of the absolute best plants available for breaking compaction. Often the best compaction remedy involves the seeding of a forb-rich temporary pasture, inoculating the seed with mycorrhizal fungi, and grazing it for a year or two. The action of the forb roots, the grass roots, the mycorrhizal hyphae, and animals such as dung beetles and earthworms act to penetrate and loosen the tightest, heaviest plowpan.

Including a few forbs in a pasture seeding can make the pasture more productive, more nutritious, and make the animals grazing it healthier. Forbs can also have a great benefit upon the soil itself, deepening the root zone and alleviating compaction.

#forbs

The Secret Behind the Power of Diversity

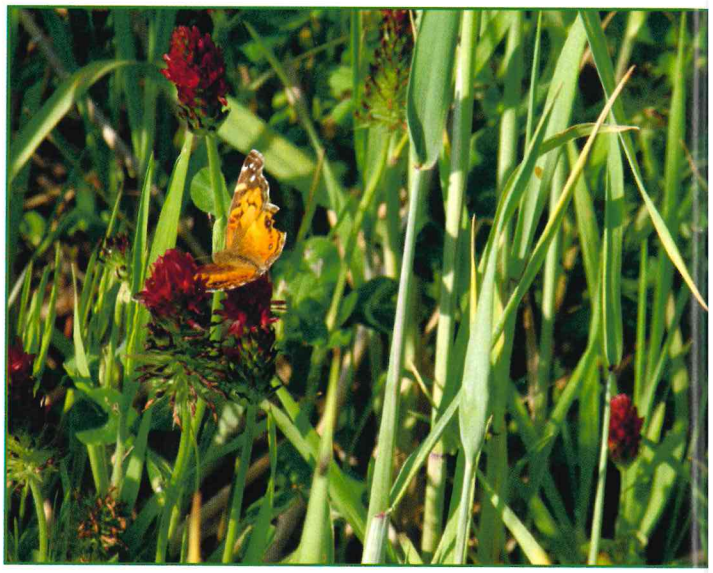
It has been observed that a mixture of plants often performs better than a monoculture of the best performing plant in the mix, an observation that defies "common sense". Dr. Norman Gentsch from the Institute of Soil Science at Leibniz University Hannover says, "In biodiverse mixes, specific species or varieties which are adapted to specific stress conditions such as drought or specific pathogens act as buffers, thereby reducing losses among the less well-adapted plants. This ensures yield stability. The more diverse the mix, the more stress-resistant is the cropping system."

The secret to making this work lies in microbes. Soil microbes thrive under many of the same conditions as rumen microbes, so feed them like a cow: a balanced and diverse diet on a steady basis. We used to think the microbes lived by eating crop residue, but now realize that in a healthy soil, the majority of microbes live by feeding on the nutrient rich exudates from plant roots. Scientists have found that plants leak as much as 40-50% of their energy out of the roots and into the surrounding soil to feed the soil biology.

Each plant species has a unique chemical composition to its exudate. Warm-season grasses have high sugar and high energy exudates. Legumes have exudates very high in protein building amino acids. Buckwheat and lupine produce organic acids that make phosphorus more available in the soil. A diverse mixture of plants (cover crops) growing produces a balanced diet of sugar, energy, proteins, and nutrients and the microbial population increases dramatically.

Dr. Gentsch agrees and points out, "Root biomass increases as the diversity of the cover crops increases. This is because the different species can tap into different root depths, which enables them to make the most of nutrient absorption and storage. As a result of this, mineral levels in the cover crop residues increase, thereby increasing the availability of the essential nutrients nitrogen, phosphorus, potassium and magnesium to the follow-on crops. Diverse cover crop mixes also have a higher leaf area index (LAI), which boosts the rate of photosynthesis. The products of photosynthesis such as sugar are transported more rapidly to the rhizosphere, where they promote microbial biomass growth. This boosts microbial activity and is of great benefit to mycorrhizal fungi. Bacteria in the nitrogen cycle in particular benefit from the energy-rich cover crop residues."

At this point, you may be asking, "Why should I care ab microbes? I am trying to raise crops and I want grain yi not microbes." Have you ever wondered why plants dor such a large percentage of its hard-earned energy to soil microbes - isn't that foolish? Perhaps it is not so foolish after all as science shows us that plants that give off high levels of root exudates tend to be more successful than plants that do not. Just as in human interaction, generos tends to be rewarded. Plants surrounded by healthy, abu dant microbial communities are more drought tolerant, are better supplied with plant nutrients, and more resist to disease; in addition, all this microbial activity increas soil organic matter and improves soil structure.



This is one of the reasons we try to create diverse cover crop mixtures containing several plant families, instead of just picking the highest yielding or the "best one". Pla diversity also provides different root types for better use of soil resources, a layered canopy for better capture of sunlight, better livestock nutrition for grazing, and far lower risk of any one insect or disease taking out the sta While there may be some situations in which a monocu ture cover crop is the best choice, in general you get far more long-term soil benefit by choosing to plant a diver mixture of several plant families for your cover crop.

Green Cover Seed is the leader in designing and deliver ing customized diverse cover crop mixes. We have more than 120 different species to choose from when designin your custom mix. We encourage you to use the Smartmi Calculator (see pages 34-35) to experiment with designi mixes or call or email us and we can help design the best mix for you. Contact information can be found on the back of this guide. Here are some general guidelines for cover crop mixes.

Spring Planted Mixes

Spring plantings are commonly utilized to jump-start soil biology after a long cold winter. These cover mixes are used to "prime" the soil biology ahead of a later spring planted crop. Spring mixes are also used in the western Great Plains as a "fallow replacement", where a living cover provides extra residue and biological diversity for the soil. Moisture used by the cover crop is usually gained back later in the summer through increased infiltration and decreased evaporation. These mixes can be seeded when soil temperatures maintain 40°F, however, greater diversity can be added to these mixtures if planting date is delayed until closer to the frost-free date.

#springmix

Late Spring/Early Summer Mixes

Late spring and early summer plantings are commonly utilized as a forage source for livestock when summer heat begins to reduce cool season grass forage production. These mixes can also be used on prevented planting acres to add biological diversity, suppress weeds, produce nitrogen, and cycle nutrients during the prevented plant year. These mixtures consist of both cool season and warm season species so soil temperatures need to reach and maintain 55-60°F and the last frost risk has passed.

Midsummer Mixes

Planting covers after a summer-harvested cereal or pea crop is the perfect opportunity to implement very diverse cover mixes into a cropping system. Converting the ample hours of summer sunlight into forages and soil nutrients is one of the best ways to improve the biological health of your soil. With so many cover crop options to choose from, these mixes will be driven by your specific goals. These mixes can also work well for early silage fields and seed corn fields. Warm season species will dominate these mixes with a few strategic cool season species added for diversity.

Photo by Darin Williams

#summermix

Late Summer Mixes

Perfect time for both warm and cool season species to be used together. Warm season species will decline after the first killing frost leaving the cool season species to continue to thrive and be productive.

Fall Mixes

Cover crops seeded into or after fall-harvested crops can be beneficial for the soil, but can present challenges for seeding the covers. Fall mixtures vary greatly depending on your goals, planting method, and timing. Here are some basic guidelines to follow:

Planting 4-5 weeks prior to first frost: Use any cool season or fast-growing warm season species for significant amounts of biomass production prior to frost. In many areas, this may require broadcast seeding prior to fall harvest.

Planting 2-3 weeks prior to first frost: Cool season species that winter-kill at temperatures below 25°F or overwintering species are good choices. This is also the ideal time to plant overwintering crops for forage or seed production for the following year.

Planting at or after first frost: With limited heat units remaining in the season, only invest in species with overwintering potential. Fall growth will be limited so use winter hardy cereal grasses and possibly winter hardy legumes can be added if there is adequate time for spring growth prior to the next planted crop. Timing of termination in the spring is an important management decision that will have to be made. Elbon cereal rye is the best option for late planting as it has the most fall growth and the fastest spring growth of any cereal grain we have ever tested.

#fallmix

This icon represents topics that are available in greater detail on our website. Go to www.greencoverseed.com and enter the topic name in the search box.

While we specialize and focus on making diverse custom blends specifically for each customer's needs, there are some specialty situation where we offer some pre-designed mixes that will be more cost efficient for the customer who does not have large areas to seed.

Garden/Small Plot Mixes are diverse blends containing cover crop species from several plant families designed to provide multiple benefits in the garden or small plot, ranging from boosting beneficial soil microbes, cycling soil nutrients, suppressing weeds, attracting beneficial insects, nitrogen production, increasing soil organic matter, feeding earthworms, and suppressing plant diseases. While the species in the mix are selected for their ability to improve soil and perform beneficial ecosystem functions, many of them are both edible and beautiful.

Cool Season Garden Mix: Plant in early spring or late summer/early fall period. Some components will overwinter in USDA hardiness zones 4-7, most will overwinter in zones 8-10.

Warm Season Garden Mix: Plant once spring soil temps exceed 60°F, and up until eight weeks prior to frost in fall. Almost all winterkill below 26°F. Compared to our cool-season mixes, this blend will produce more biomass and soil benefits but has the same growing season as most garden plants so needs to go on rotational areas.

Warm Season Soil Builder/Weed Suppression Mix: Similar to WS Garden mix but has more aggressive species for choking out weeds and fewer legumes for producing nitrogen.

Cool Season Soil Builder/Weed Suppression Mix: Similar to CS Garden mix but has more aggressive species for choking out weeds and fewer legumes for producing nitrogen.

Milpa Mix: Composed of primarily edible garden species but blended together to be planted as a mix. Native Americans called this blending of multiple species together "Milpas", such as the famous Three Sisters blend of corn, beans, and squash. When blended together, the sum yield can exceed the yield of the average yield of the three planted separately.

Wildlife Blends contain many of the same ingredients you will find in glossy bags at the stores for exorbitant prices. We can sell at much lower costs because they are usually the very same species and varieties of seed we use for cover crops and livestock forage.

Bird Mix: Designed to accomplish the following three goals: 1) attract soft-bodied prey insects for young birds in summer, 2) produce a variety of seeds high in energy, protein, and fat that drop to the ground over an extende period, and 3) provide a source of winter cover during inclement weather conditions.

Cool Season Deer Food Plot Mix: Designed to attract deer to a specific location during the fall months, but als contains species that overwinter in much of the US to provide spring nutrition for newly born fawns. It is very diverse and contains legumes, grasses, brassicas, and forl Plant 8-10 weeks prior to first frost.

Warm Season Deer/Food Plot Mix: Designed to provid deer with protein, energy, and minerals necessary for growth of both body mass and antlers during the summ months. It is more attractive to deer than typical summe row crops like corn and soybeans and can be used to attract deer away from those crops. Plant when spring so temperatures exceed 60°F in spring.

Pollinator Mixtures are blends of species that produce copious amounts of nectar and pollen over an extended period of time, with a wide range of flower colors and shapes to attract not only honeybees, but also many nati pollen feeding animals such as butterflies and honeybee These mixtures also are very attractive to many beneficia predatory insects, such as lady beetles, and lacewings. These species also perform other benefits, such as addin organic matter and nitrogen fixation.

Cool Season Pollinator Mix: Produces nectar and polle in late spring and early summer. Plant in early spring as soon as the ground thaws.

Warm Season Pollinator Mix: Produces pollen and nec in late summer through early fall. Plant when spring soil temperatures exceed 60°F.

Perennial Pollinator Mix: Plant once and enjoy for mar years. Multiple flowering legumes and forbs that grow back year after year and are tolerant of occasional mowi Planted either in spring or fall.

Confused and don't know what to plant? When in doub just plant our High Diversity mix, which contains a shot gun blend of more than 20 of our most popular cover cr species, some of which are bound to meet your needs. It has been shown that more diverse blends improve your soil health faster.

Go to our website to learn more about each of the mixes including the exact make-up of each mix.

Cover Crops and Resistant Weeds

With the rapid spread of herbicide-resistant weeds, it has become increasingly difficult to control weeds in no-till systems and many people are considering going back to tillage. Before taking this drastic step, consider enlisting cover crops as an ally against weeds.

Cover crops can provide weed control benefits through three main mechanisms:

1. The first mechanism is **simple competition**. Rapid-growing, large-leafed cover crops such as buckwheat, okra, sorghum-sudan, and Florida broadleaf mustard can simply outgrow and shade most weeds. Crops like cereal rye that grow before winter annual weeds get started also give excellent weed suppression. Plant diversity is important so that the mix has multiple levels of canopy to intercept all of the sunlight before it can get to emerging weeds. It is amazing how effectively a diverse cover crop blend can prevent weed growth. Many customers report that planting a cover crop in wheat stubble eliminates the need for several weed control passes.
2. The second mechanism is **nitrogen sequestration**, a particularly useful concept if the desired subsequent cash crop is a legume, such as soybeans or peas. A well fertilized corn crop often leaves as much as 25% of applied nitrogen in the soil after harvest. If this nitrogen is still present in the soil when a legume crop is planted the following year, the nitrogen will stimulate weed growth and delay nodulation. A winter cover crop, such as cereal rye or winter barley, can take up and sequester nitrogen and hold it in the residue, becoming available later in the year when the residue decays. Many weeds, pigweeds in particular, require free nitrate in order to germinate and do not grow well in low nitrogen conditions.

The picture below shows the weed control from cover crop cereal rye (left half) versus no cover crop (right half) prior to planting soybeans. The rye out-competed the weeds as well as sequestered all available nitrogen, thus suppressing weed growth.

3. The third weed control mechanism is **allelopathy**, or the secretion of chemicals by plants that suppress the germination or growth of other plants. Rye produces an allelopathic compound that is highly effective against marestail and pigweeds, while oats are highly allelopathic to kochia. Other allelopathic plants include sorghum-sudan and many brassicas, particularly mustards.

Herbicide Carryover

Herbicide carryover is often a topic of concern when it comes to cover cropping. The best producers are able to successfully use herbicides and covers together. Following these basic rules will help you succeed in this area:

- Read your label. Every chemical has recommended withdrawal period for various crops. From the labeled species, observe the recommendations most similar to your desired cover crop. If a cover crop is not listed, a soil bioassay can be conducted by taking some treated soil, planting the desired cover crop into it, and observing for 2-3 weeks to watch for plant injury.
- Utilize chemicals that have a short residual period in the soil profile.
- If grazing a cover crop after a chemical that has carryover potential, always read the label for grazing withdraw periods. The producer has the legal responsibility to be aware of the effect that these chemicals may have on their livestock.

Herbicide Planning Strategy

When planning a weed management strategy that will allow cover crop implementation, consider these concepts:

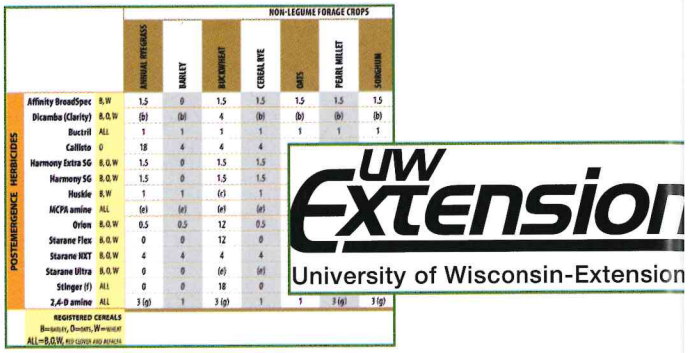
1. **Grass Weeds or Volunteer Cereal Control:** When the grassy undesirables begin to present themselves, utilize grass-specific herbicides (Select or Clethodim) and follow the cash crop with a primarily broadleaf/legume/brassica based cover crop mixture.
2. **Broadspectrum Weed Issues:** Look for herbicide options that offer control of your targeted weeds but are also labeled for an array of desirable cover crop species. This will allow you to plant a diverse cover crop mixture with species that tolerate the applied herbicide. A good example of a herbicide of this type is Spartan, which uses Sulfentrazone as its active ingredient, but is labeled for over 16 domesticated crops.
3. **Companion Mixtures:** When utilizing companion crops with your cash crop (check your crop insurance regulations first!), you must look for herbicide options that are labeled for both the cash crop and the companion crop, or at least will have minimal effect on your companion crop. A great example is utilizing Spartan herbicide with a cash crop of sunflowers, with labeled companion crops of soybeans, chickpeas, peas, cowpeas, flax, some brassicas, and more. Another example would be using a product like Verdict which is labeled for corn, popcorn, milo, and soybeans, so interseeded cowpeas or soybeans into the corn would work.

#herbicide

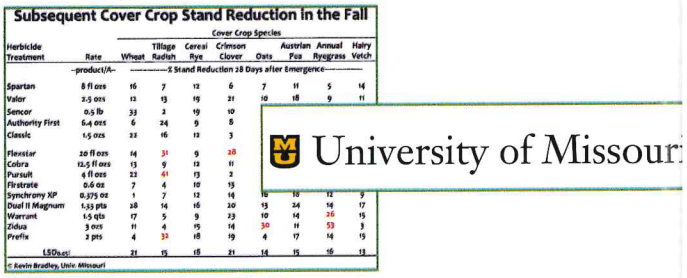
Herbicide and Cover Crop Interaction Resources

There are a number of excellent resources on the interne that deal with cover crops and herbicides. Three of the b that we know of are highlighted and previewed here:

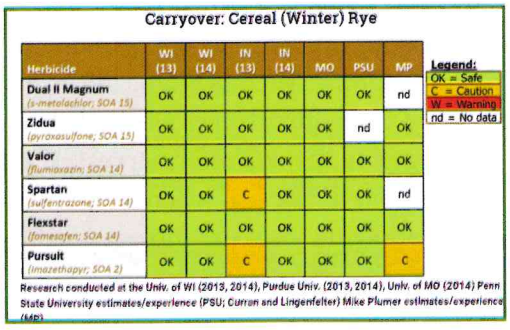
- Herbicide Rotation Restrictions in Forage and Cover Cropping Systems from the University of Wisconsin E tension provides an extensive table on plant back inte vals for cover crops with most popular herbicides.



- A second excellent resource is A Weed Scientist's Perspective on Cover Crops by Kevin Bradley of the Univ sity of Missouri. It summarizes a number of herbicide cover crop interaction studies.



- To get a sense of which herbicides can be used before specific cover crop species and which can't, Purdue U versity weed scientist Bryan Young compiled research that looked at Dual II Magnum, Zidua, Valor, Spartan Flexstar, and Pursuit herbicides' impact on cereal rye, annual ryegrass, radish and crimson clover. https://www.no-tillfarmer.com/articles/6809-evaluating-herbicide-carryover-on-cover-crops



Moisture Math

Concern about reduced moisture availability probably keeps people from trying cover crops more than any other reason. While it seems counterintuitive, using cover crops can actually increase the moisture availability to the following crop. Let's do a little moisture math. Assume an average of 22" of annual precipitation with 7" of that in May and June. If you harvest wheat on July 1st, and you plant corn the following May, there will be (on historical average) about 15" of moisture on that field from July through April. Most soils hold about 2" of moisture per foot, so a three foot root zone can hold 6" of our predicted 15". What happens to that extra 9" of moisture that the soil cannot hold? Nothing good! It either runs off (causing erosion), percolates through the soil (taking nitrogen with it), or evaporates away (and is wasted). Why not use some of the extra moisture to grow a cover crop for soil protection and improvement?

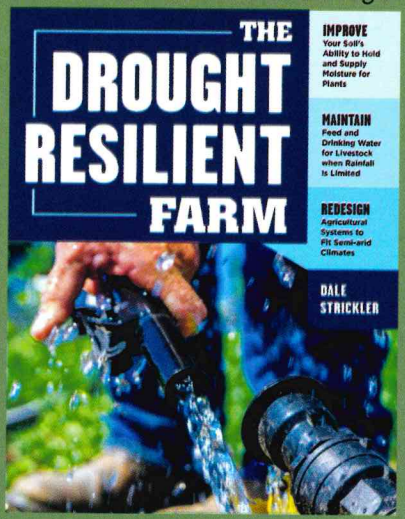
While a canopy of growing plants does in fact use more moisture than bare ground, the difference is not as great as is commonly assumed. Recent research at Kansas State indicates that land planted to cover crops had approximately 1.5" less moisture in November than chemical fallowed wheat stubble. However, by the following spring and summer (when it counts) there was more moisture in the cover cropped fields than the no-till wheat stubble without cover crops. Cover crops can help increase soil moisture in five main ways:

- Cover crops greatly increase water infiltration rates through a protective mulch layer, slowing raindrop impact and allowing the water to follow root channels down into the soil.
- Cover crops greatly reduce evaporation through the protective mulch layer. Research indicates that a soil with 75% coverage of residue mulch can reduce the evaporation during the growing season of a corn crop by 3".
- Cover crops increase rooting depth of subsequent crops. Deep-rooted cover crops like Nitro radish, sunflowers, okra, sorghum, or cereal rye can penetrate plow pans and clay layers. If these root channels are not destroyed with tillage, the roots of the next cash crop will follow these old root channels and go much deeper than usual. In a USDA study in purposely compacted soil, corn roots following radishes went 16" deeper than corn roots on fallow ground.
- Cover crops increase the organic matter levels of the soil and each additional percentage point of organic matter can add an extra inch of water holding capacity per foot of soil.
- Cover crops boost the population of mycorrhizal fungi that colonize plant roots and extend hyphae up to two feet past the root zone to bring additional water and nutrients back to the plant for improved drought tolerance.

Left: Turnips | Right: Multi-species cover crop mix
Both plots planted May 30, 2006 and pictures taken July 31, 2006.
Less than 1" of rain from planting to picture. Less than 3" rain year to date.

In a country with a history of being devastated by the Dust Bowl and other droughts, there is a curious lack of books targeted to helping commercial farmers and ranchers survive drought. That has now changed.

Beginning in June of 2018, The Drought Resilient Farm (published by Storey Publishing and written by our own Dale Strickler) is now available. The book begins by explaining how to manage soil to improve drought tolerance, with techniques to improve rainfall infiltration, water-holding capacity, and the ability of plants to develop a deeper and more efficient root system. The second section deals with low-cost or no-cost methods for providing water and feed for livestock in a drought. Finally, the book covers how the cropping practices in the semi-arid areas on the High Plains are so poorly suited to the area and how to create a system of farming that is not only much more moisture efficient, but also far more profitable.



After reading this book, you will have far less reason to complain about lack of rain, but we are just fine with you praying for it–it might help your neighbors who haven't read this book!

Green Cover Seed: Built to Serve You

We have grown significantly during our first ten years, but the people that make up the Green Cover Seed team have been and will always be the most important.

Almost everyone here works in more than one area, but here is where we spend the majority of our time!
**Years of service in ( )*

Sales Team: These are the faces you see and the voices you hear when you are developing your plan or placing your order. We also have outside sales representatives - see the back cover for contact information.

L to R: Colten Catterton (6), Dale Strickler (3), Noah Young (6), Jakin Berns (8), Keith Berns (10), Brett Peshek (4)

Support Team: These are the guys who receive, unload, clean, transfer, haul, store, organize, and monitor all the seed prior to it getting mixed.

L to R: Victor Alvarez (1), Sam Portner (4), , Rick Pendleton (5), Jon Holl (7,
Not pictured: Caleb Berns (7), Doug Hyler (4)

Mix Team: These are the folks who mix, inoculate, and bag your seed and prepare it for shipment.

L to R: Glen Brumbaugh (1), Joseph Kirchner (1), David Nelsen (3), Syn Dee Wulf (1), Joshua Berns (6), Dan Weber (2), Trevor Cleveland (2), Tyler Licking (1)

Service Team: These are the folks behind the friendly voices in the office and the great customer service you receive with Green Cover Seed.

L to R: Carli Shuck (1), Teri Anderson (2), Stephanie Holl (7), Doris Zuellner (1), Adrienne Jacobus (5), Adam Jacobus (5)

Production Team: These are the guys who run the farm, grow the seed, keep the cattle, and make the compost.

L to R: Brian Berns (10), Troy Steiner (4), Jonathan Ellis (8)

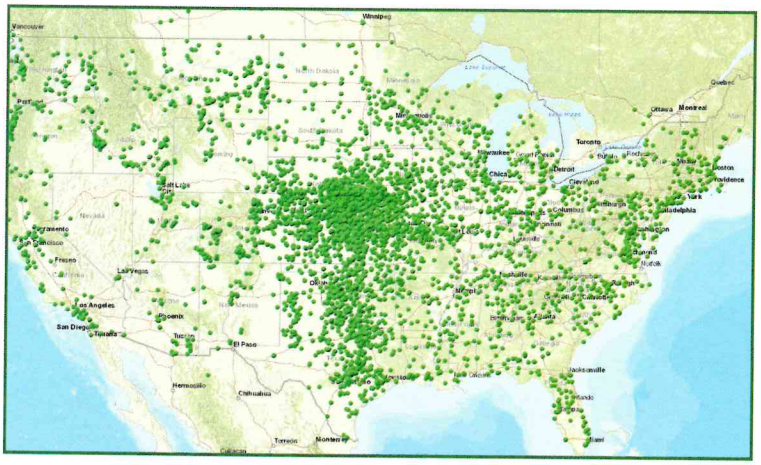
Maintenance/Construction Team: These are the guys who plan, build, construct, maintain, and fix the equipment and facilities and keep us going.

L to R: Jeremie Trew (3), Tim Hinrichs (1), Travis Berns (7), Joe Stayner (2), Victor Alvarez (1)

Shipping

Green Cover Seed is a leading national source for cover crops and forages, having shipped seed to more than 7,500 customers in all 50 states and most of the Canadian provinces. While the majority of seed is shipped to Nebraska, Kansas, Iowa, Missouri, Colorado, Oklahoma, Texas, South Dakota, North Dakota, and Montana, we have sold significant quantities of seed to many other areas.

Because we carry so many different cover species and specialize in custom mixes, we are able to meet the specific needs of customers across the entire country. We have even shipped multiple pallets of seed to Hawaii and across the border into Canada.



Whether we are shipping a pound, a pallet, or a bulk semi load, we strive to provide each customer with the best shipping method for their situation. Being well-connected with freight companies, and having our own trucks, we are able to move seed throughout the country at a fair price.

We run seasonal routes with our own trucks in Nebraska, Kansas, Iowa, Missouri, Colorado, Oklahoma, Texas, South Dakota, North Dakota and Montana. We have excellent flat-rate pallet shipping rates in Nebraska, Kansas, Oklahoma, Texas, Wisconsin, Iowa, Missouri, Indiana, and Illinois. We also have competitive national rates through FedEx Freight and other major carriers.

There are many variables in calculating shipping costs. Please call or email us for the most accurate shipping quote for your seed order. Contact information can be found on the back cover of this guide.

Infrastructure

High-quality seed standards are achieved by growing, storing, and conditioning much of our seed supply through our own operation and facilities. With our expanding network of contract growers, Green Cover Seed is able to provide customers with quality seed at an affordable price. We are contracting seed production with growers in Nebraska, Kansas, Colorado, Missouri, Oklahoma, Texas, Florida, Alabama, South Dakota, Montana, Idaho, Oregon, and Canada.

We have built more than 20,000 square feet of warehouse and production facilities as well as bulk storage for more than 320,000 bushels over the past 7 years, and more storage and automation is being planned for future expansion.

Q-Sage Seed Cleaner

Our Q-Sage seed cleaner utilizes state-of-the-art technology and can condition 500 bushels of seed per hour through its 5 ½ screen shoes. Coupled with a debearder and a high-capacity gravity table, quality will not be sacrificed for the sake of productivity. This cleaning facility will allow us to have quick processing times for summer-harvested cereal crops for late summer or early fall plantings.

Custom-built Mixing System

At Green Cover Seed, we take pride in our commitment to design custom cover crop mixtures for each customer to meet their individual goals and needs. While this is good for the customer, it is the least efficient and most labor-intensive method to manufacture a product. To offset this, we have invested heavily in a custom-built mixing system that has the ability to blend up to 12,000 pounds per batch and allows us to work on three batches at a time. We can simultaneously bag one batch, mix a second batch, and weigh out a third batch. Bulk automation from twelve Meridian bins allows for higher efficiencies in the mixing process. A high-capacity toting and bagging system, as well as a bulk holding tank for mixes, increases productivity and reduces the amount of time needed to mix and process large orders.

Bulk Seed Handling

The key to efficiently handling and mixing 30,000,000 pounds of seed per year is our pod of twelve Meridian cone-bottom bins and KSI conveyors. This 60,000 bushel system is computer-controlled through a custom-built and programmed PLC system that is self-correcting and self-adjusting to ensure accuracy.

This system allows us to handle bulky cereals and large-seeded legumes with precision and efficiency. We hope to be able to add another 40,000 bushels of capacity to this system to handle future volume increases!

IntelliFarms BinManager

Green Cover Seed has invested in the IntelliFarms BinManager system that dries, cools, and even re-hydrates seed to optimum-quality levels for maximum germination. Each type of seed is analyzed and the BinManager system is custom programmed to keep the seed in the best condition possible.

BINMANAGER®

Fishbowl Inventory

The Fishbowl inventory system has been a tremendous asset to our systems and processing operations, by enabling us to automate information and avoid manually entering data.

The SmartMix® calculator interfaces directly with Fishbowl. Online order submissions can be sent directly to Fishbowl, allowing orders to be processed and mixed accurately and efficiently. Fishbowl also works with QuickBooks Accounting software, making invoicing more efficient.

Using barcodes and scanners, Fishbowl keeps detailed records of seed inventory with lot number and seed test information, as well as specific storage locations. Green Cover Seed sales representatives have the ability to know exactly how much inventory is on hand at any given moment when a customer calls to inquire about seed.

Fishbowl®

GREENCOVER SEED

COVER CROPS FORAGES

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