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Building Healthy Soils and Profits with Cover Crops

In the wake of a wide range of forces, including extreme weather, nosediving commodity prices and even the recent coronavirus pandemic, farmers have been waking up to the powerful reality that monoculture farming is facing some challenges.

From an overreliance on inputs to degraded soils and herbicide resistance, many modern agricultural problems can be tied back to the practice of growing crops in monocultures.

For many no-tillers, cover crops are a big part of the solution. Soil biologist Kris Nichols, founder of KRIS (Knowledge for Regeneration and Innovation in Soil Systems) says the key to building a resilient and profitable farm operation is for more farmers to follow the "soil regeneration pyramid," the foundation of which is keeping living roots in the soil for as long as possible (see story on p. 4).

Nichols explains that plants provide carbon to the fungi and bacteria in the soil, which in turn use that energy to capture nitrogen, solubilize phosphorus and improve soil structure and porosity among other functions. "In a diverse agricultural system," she says, "plants and animals become the tools to manage weeds, pests and disease."

Adopting cover crops, especially diverse multi-species mixes, adds a lot of complexity to a farm operation. Choosing species that will work together, understanding the different seeding rates, growing requirements, termination timing, and more can seem truly daunting.

Yet no-tillers have embraced the practice. They've seen first-hand the many benefits, including reduced erosion, improved weed suppression, reduced reliance on inputs and much more. They know that cover crops contribute to healthy soils, which in turn lead to healthier plants and healthier profits.

In this special report, you'll read about some of the farmers and researchers who are pushing the boundaries of cover crop management, discovering new ways they can extend the growing season, supplement grazing, capture more sunlight, feed the biology underground and even improve the bottom line.

Whether you're brand new to cover crops or have several years' experience, I hope the innovative approaches covered within these pages spark new ideas for implementing cover crops in your no-till operation.

Julia Gerlach, Managing Editor

In This Special Report:

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Lessons from the Field:
Profiting from Regenerative Soils

Increasing plant diversity and following a simple soil-testing program can significantly add to the bottom line, growers say.

By Angela Lovell

In the not-so-distant future, the key to building a resilient and profitable farm operation may require farmers to see their system as a pyramid that uses biological tools to build and manage healthy, productive soils and produce nutrient dense food.

Soil microbiologist Kristine Nichols — founder of KRIS (Knowledge for Regeneration and Innovation in Soil Systems) — calls this the "soil regeneration pyramid," and at the foundation of it is living roots that are growing for as long as possible. It's a worthy goal, she says, even for farmers facing challenges with growing-degree days or growing season length.

"I can guarantee you can have something green and growing out there for probably 250-280 days, but you also have to choose the right plants," Nichols said at the Regenerative Agriculture Conference in Brandon, Manitoba in 2019. "This is about poly cropping, relay cropping and intensifying your systems.

"Having something growing during the vegetative growth phase is when carbon will be going below ground to maximize your system's success."

The total weight of organisms in the top 6 inches of soil, on a per-acre basis, can vary. But in a healthy soil it should be 20,000 pounds, Nichols says, adding it's about the equivalent of feeding 15-23 cows per acre every day all year round. "That's the amount of photosynthesis we need to have for a healthy soil," she says.

TWO YEARS OF COVERS IN ONE PASS. Garry Richards says grazing livestock on biannual cover crops brings about $50 in grazing value for only $4 in seed costs.

Embrace the Jungle

After living roots, plant diversity is the next level of Nichols' pyramid, which provides a diverse community of microorganisms in the soil. Without this diversity, the system will not be resilient.

"How we build resilience is by how we manage the system," Nichols says. "If you see a problem out there, figure out how to utilize the best, cheapest and most efficient tools to manage that."

In a diverse agricultural system, plants and animals become the tools to manage weeds, pests and disease, with the last resort being mechanical or chemical control, she says.

Reducing or eliminating synthetic nutrients is the next goal, Nichols says, pointing out there is plenty of phosphorus (P) and nitrogen (N) in the soil. Most of it is unavailable to plants, with nutrient-use efficiency of N at 50% and 30% for P.

"We've known this since we first applied these chemicals and although our yields have increased over time, our efficiencies have declined," Nichols says. "In 1960, more than half of the N came from the soil from microbial processes. Those microbe populations declined over time because they didn't get fed, so they weren't available to do the job and efficiency has declined. We need to regenerate our soils to solve this issue."

Nichols explains that plants provide carbon to fungi and bacteria in the soil, which use that energy to fix N, solubilize P and improve soil structure and porosity among other functions.

N-fixing and P-solubilizing bacteria grow on the hyphae of mycorrhizal fungi which connect the roots of legume and non-legume plants and transfer N and P back and forth between the plants to meet their needs, while also feeding carbon to the bacteria to keep the process going.

"We've known about this process since the 1980s. We can have these things occurring in our system but we need to look at how we can manage our system better," she says.

Keeping the soil covered is also important, Nichols says, because crop residues protect the soil from erosion or extreme temperatures and provide food for the microbial community.

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At the top of the soil regeneration pyramid is reduced or no-till practices.

"No-till is going to improve the structural habitat of the soil environment and help provide food for the microorganisms in the soil," Nichols says. "We want to create an environment that is favorable for the microbial community and create a system in which we're utilizing biogeochemistry."

Tips for Managing the System

All of the benefits of regenerative agriculture can only be realized if the system is managed to do so. Garry Richards, a farmer speaking at the Regenerative Agriculture Conference, explains how he's changed his management practices to build soil health and make his farm more profitable.

Richards had been away from farming for 15 years, pursuing a career as a pharmacist, when he decided to return to the family farm near Bangor, Saskatchewan in 2000.

The farm had been growing monocultures of wheat and canola with a no-till system for decades. But after taking a holistic management course 16 years ago, Garry and his wife, Lynn, knew they needed to become "grass farmers" and add cattle to the mix to help improve soil health and increase profitability.

In 2003 they seeded their first perennial stand, a mix of 10 grasses and legumes, but it wasn't until they heard Gabe Brown of Bismarck, N.D., speak about using polycrops to increase soil organic matter and eliminate fertilizer and chemical inputs that they started to look at multiple species cover crops.

"Polyculture is the biggest thing, whether it's perennials or annuals in the cover crop," Richards says. "Gabe calls it a biological primer to kick start the soil. You can do that much more quickly with annuals in a cover crop cocktail than you could with perennials, and then you just continue to make gains in soil health."

Since then, the Richards use cover crop mixes to ensure they have living roots in the ground for as long as possible and also find the system provides them more options than they ever had as strictly grain farmers.

"On the fields where we do this, from the middle of April when the snow melts until the middle of November, we're photosynthesizing," Richards says. "We've had 220 days where we've had green growth on our land and are building soil instead of 70 days that we had with monocrops."

He's also experimented with planting biannual species cover crops that give him 2 years of covers in one seeding pass.

"The first time we did that, we put in winter triticale, hairy vetch, sweet clover and rye grasses that persist into the second year," Richards says. "We silage- or graze that off the next July."

It occurred to Richards that if he added a couple of perennial species to the mix like alfalfa and red clover, they would re-grow after he silaged or grazed the cover crop in the second year and provide grazing in September and October. The seed cost him only about $4 per acre and he estimates making $50 per acre value from grazing it. This also leaves the option open to seed a winter cereal into this land in September. Often, he seeds winter triticale and hairy vetch.

"Soil organic matter is the most important thing. If you see an increase in soil organic matter you basically know soil aggregation, microbiology, the availability of nutrients and all those factors that go into soil health are just going to follow along," says Richards, who's increased organic matter by 1% over 5 years from 4.3% to 5.3%.

Soil tests have shown that no additional N fertilizer is needed for wheat and only 10 pounds of N for canola in the fields with cover crops and livestock compared to about 100 pounds per acre that most farmers in his region use, translating to at least $50 per acre savings, less risk and less damage to soil biology.

Richards also estimates that he has $680 per acre value in more-available nutrients because of his 1% increase in SOM (based on a study by Ohio State University that demonstrated that value). That extra SOM also holds 27,000 gallons per acre more water, which is about 1 inch of rain stored, he says.

"I've got available nutrients, and a thatch layer on my soil to protect it against the July heat, which typically shuts down the microbiology if it's bare ground," Richards says.

These biological soil tests are useful but can be expensive, Richards says, so he uses them every 3 to 5 years or so to ensure sure he's still moving forward in building soil health. But he maintains the best tests are still done with a shovel.

"Go out and dig and look at the soil, the amount of aggregation there is," he says. "You can do simple things like a slake test to see how well that soil holds together. You can count earthworms. You can use an insect deadfall trap.

"Water infiltration, bulk density, all these tests can be done on the back of a half-ton and they're very important."

> "If you see an increase in soil organic matter you basically know soil aggregation, microbiology, **the availability of nutrients and all those factors that go into soil health are just going to follow along...**"
> *– Garry Richards*

Basic Testing Works

Richards emphasizes it's important to test soil not just for the macro- and micronutrients but for the biological activity of soil microbes. He uses the Solvita field test to measure CO2 that soil microbes give off and correlates it to give an estimate of the density of the microbial population.

He's also used the Phospholipid Fatty Acid Analysis (PLFA) that measures phospholipid fatty acids (which every living cell has) to determine the volume of microbes in the soil. The volume can be quantified using a range where less than 500 is very poor and more than 4,000 is excellent. Richards' score was 5,000-6,5000, but he hopes to increase that to 10,000 over time.

Interseeding Tools
Get Cover Crops Off to Faster Start

No-tillers can avoid the mad rush to get cover crops seeded after harvest by planting them into standing cash crops.

By Laura Barerra

One of the most common challenges no-tillers encounter with cover crops is at the very start — getting them seeded.

In some areas of the U.S., particularly in northern states, there may not be enough time to get cover crops seeded after harvest — especially if a no-tiller is hoping to achieve decent cover crop growth before winter.

Aerial seeding via an airplane or helicopter is an option, but establishment can be spotty.

Depending on a no-tiller's goals, climate, row widths, cover crop species and even herbicide programs, interseeding covers — the practice of seeding them with a drill, spinner spreader, toolbar or sprayer into an established and growing cash crop — may provide a solution.

Interseeding Advantages

Predictability is what led Loran Steinlage to interseeding covers on his no-till farm in West Union, Iowa.

"Airplanes are too unpredictable," he says, "and the drill after harvest is too late."

So several years ago he took a spinner box and seeded his covers, by hand, down six corn rows while the corn was still small and growing. Since then he's modified a variety of different toolbars for interseeding. Now he's using Dawn Equipment's DuoSeed cover crop interseeder row units on a rig he built to interseed annual ryegrass and clovers into corn at the V4-V6 stage, which he says is the ideal time for his area.

Despite the changes in equipment and associated costs, Steinlage says the cover crops are paying their way. He reports an average 15-bushel increase in corn yield and soil organic matter levels average 3-5%, with some field areas climbing up to 6% and 7%.

No-tiller Allen Dean of Bryan, Ohio, had a similar experience to Steinlage. He tried interseeding cover crops with both a helicopter and an airplane but he wasn't happy with the results.

"In our area there's a lot of homes, odd-shaped fields and trees," he says. "And we just knew that if we had a ground rig, we'd do a better job of distributing and getting the seed exactly where we wanted it."

Today, Dean and his family run a custom interseeding business with the Miller Nitro cab and chassis with a front-mounted boom modified into an inter-row air seeder, and he says the seeding rates and establishment from it are near perfect.

In Indiana, Ag Conservation Solutions no-till consultant Dan Towery is doing interseeding cover-crop trials with several growers at the V4-V7 stage in corn. In addition, he says a group in Quebec has been doing similar research for several years and is reporting a 5-bushel bump in the following soybean crop's yields, as well as a 4- to 8-bushel increase for corn.

In Decatur, Ind., Mike Werling has a neighbor custom

HELPING OUT. The Sussex Conservation District in Georgetown, Del., purchased this Miller Nitro air seeder to help growers in the area afford interseeding their cover crops. They began interseeding into corn on July 30, 2015, and continued into soybeans until Oct. 15, 2015, seeding a variety of mixes that included radishes, triticale, clover, oats, hairy vetch, wheat and rye.

interseed cover crops into corn using drop tubes on a Hagie sprayer and says he's never had a bad crop. Werling hasn't calculated a yield increase from interseeding, but that doesn't mean it's not paying off.

"My return on investment may just be soil health," he says. "It doesn't have to be dollars for me. The value of erosion control is No. 1."

Mildmay, Ontario, no-tiller Gerard Grubb has interseeded cover crops for several years and has noticed an increase in soil tilth and improved soil structure. For his northern location, interseeding is the only way he can get a cover crop established. He tried seeding annual ryegrass after soybean harvest one year, but says it was too late.

Not for Everyone

While interseeding cover crops has its advantages, it may not be the best practice for everyone.

Corn silage is one situation Towery thinks may not work well due to the amount of wheel traffic that usually goes over the field during harvest.

"A lot of them use semis to transport the corn silage," he says. "You've got that little seedling out there and will it tolerate that kind of wheel traffic? You may end up with some, but it may not be what you want."

Dean adds that corn silage is generally harvested earlier anyway, so growers have a better chance of getting cover crops, especially mixes, seeded afterward.

Another situation that may not work are no-tillers using narrow rows. Towery says without special equipment, he doesn't think a no-tiller could drive into anything less than 30 inches.

Dean agrees, saying growers with narrow rows will probably be dependent on an airplane if they want to get covers seeded into standing crops.

Early vs. Late

If a no-tiller wants to interseed his cover crops, one of the first decisions he has to make is when.

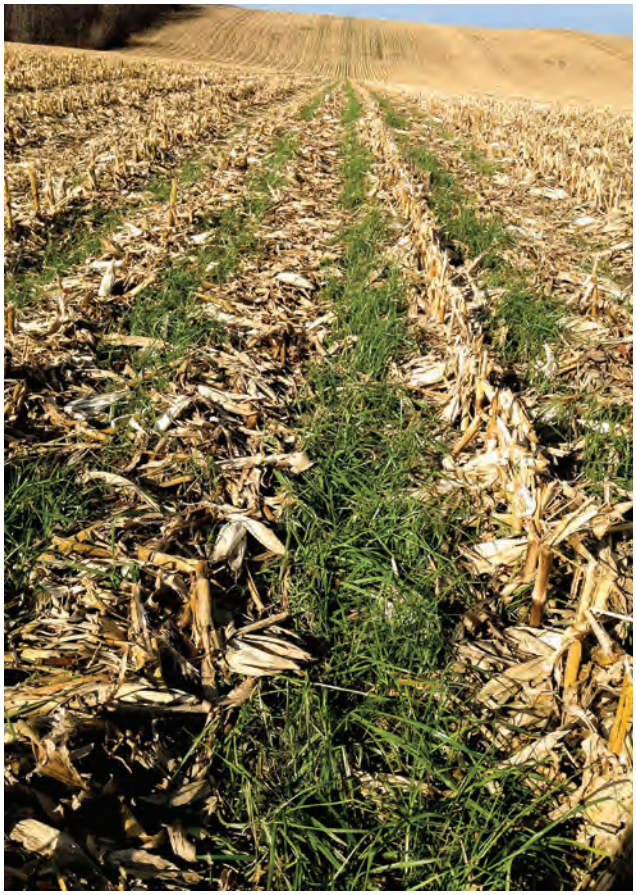
Some no-tillers, like Steinlage and Grubb, prefer to do it early in the growing season before their corn crop gets too big, usually between the V4-V7 stage. The key to this method is to use cool-season cover crops that will establish and grow several inches tall while the corn is still small, then go dormant under the corn canopy, Towery says, adding that he considers annual ryegrass the No. 1 cover crop for this.

A common concern about seeding a cover crop that early is it could steal water or nutrients away from the growing corn crop. But Towery says if it's seeded at the right time, it shouldn't be a problem.

"The whole point of putting it in corn when it's V4 is getting enough sunlight to get the cover crop established, but then the corn shades it and it's what I call semi-dormant," he explains. "It's just sitting there. It's not using a lot of water. Not using much nitrogen."

Towery has measured the roots of annual ryegrass seeded at that time and found they only grew to 4-5 inches before corn harvest. Competition shouldn't be a problem unless no-tillers seed covers at V2 or earlier.

"We've been inundated over the years with the message that you can't have anything competing with the crop," he says. "If it's weeds that can grow taller than corn, yes, that's bad. But in this case, with cover crops, it's very compatible."



STRONG START. Ontario no-tiller Gerard Grubb has noticed an increase in soil tilth and improved soil structure from the annual ryegrass he's interseeding into his corn. For his location, interseeding is the only way he can get covers established on time.

On the other hand, if a no-tiller seeds covers too late and it doesn't get them established before the canopy closes, he probably won't have a cover crop stand after harvest.

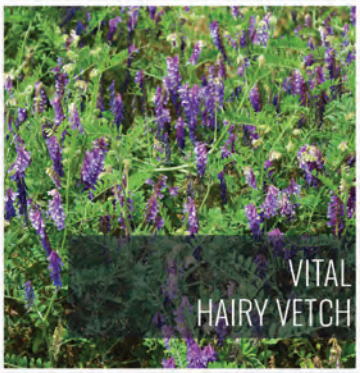
But if a no-tiller wants to use a cover crop that may not survive that type of shading, such as cereal rye, then interseeding later in the season may be the better option.

That's the case for Werling, who prefers using cereal rye. He says it's a great cover for planting his soybeans into and creates a lot of biomass to suppress weeds. He also interseeds rapeseed with the cereal rye because it's inexpensive and germinates quickly.

Werling prefers to seed covers at corn's black layer because that's when the corn starts to drop its leaves, which provides sunlight to the covers.

Gary Fennig, whose company developed the FE4R system for fertilizer application and cover-crop seeding on the Hagie highboy sprayers, says Fennig Equipment has tried seeding cover crops both around sidedress time and toward the end of the growing season, and both methods get the job done.

"That's the whole background of the interseeding process — getting the cover crop established before harvest so you have something there over the winter," he says.



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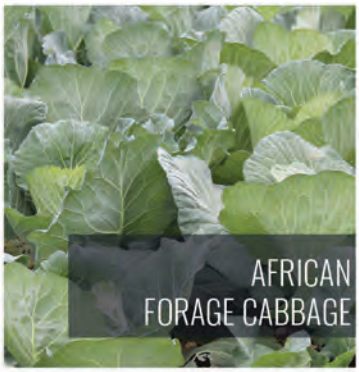

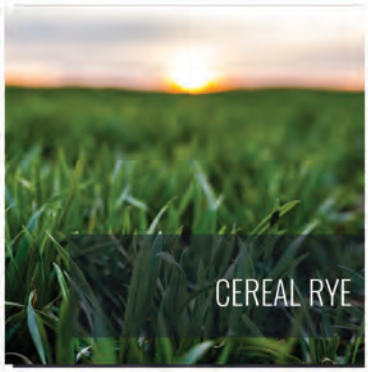

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Moisture is Key

Whether a no-tiller is interseeding covers at sidedressing time or when the cash crops are reaching maturity, weather conditions are still an important factor to consider.

While Werling has never lost a cover crop from interseeding, if the weather is dry, the cover crop stand may be thinner or emerge slower than usual, he says.

Weather may have a greater impact on the no-tillers interseeding earlier. Towery says no-tillers might lose a cool-season cover crop if it's seeded in dry soils and it doesn't rain for 2 weeks. He adds that a prolonged hot and dry period in August to early September may results in the loss of a cover crop stand, since the cover crop roots aren't very deep.

This is why Grubb tries to interseed right before a rain.

"As soon as I finish sidedressing my corn, I want to get in there at about the sixth leaf stage," he says. "And I will do my best to get it on before a rain."

Towery adds that interseeding at the V4-V7 stage may not be suitable for growers in the southern Corn Belt. He speculates that south of Indianapolis typically may be too warm and dry for this practice with cool-season cover crops. Also, sandy soil types may not be a good fit for interseeding, unless they are irrigated.

EVEN ESTABLISHMENT. Ontario no-tiller Gerard Grubb is using an AGCO Spra-Coupe 4455 sprayer with a Valmar 3255 air seeder to interseed his cover crops. Originally he was using a Flexi-Coil air cart, but he didn't have any control on the seeding rate. He says the Valmar seeder lets him seed more rows accurately and evenly.

Start with Herbicides

While there's a decent track record of success with no-tillers making interseeding work, one major potential stumbling block is residual herbicide, if seeding cover crops between V4 and V7, vs. seeding them approximately 6 weeks later.

Unfortunately there's no clear-cut solution for avoiding herbicide carryover, as soil characteristics and weather both play a role in herbicide degradation.

"When you apply an herbicide to the soil, the No. 1 factor that determines how much is going to be there later is how strongly it's absorbed by the soil," says Bryan Young. "If it's absorbed by the soil it can't degrade. That's why Roundup sticks to your soil for up to 3 weeks for a half-life, because it's tightly bound to the clay minerals. It eventually gets released, and when it does, it degrades."

The Purdue University weed scientist adds that weather also impacts herbicide degradation, because microbes need certain conditions in order to break it down.

"It needs the right water and air temperature," Young explains. "With the right conditions, you're going to favor the breakdown of the herbicide. If you don't have those conditions — you have drought, cold conditions or the pH is off — well, you're not going to have faster breakdown."

No-tillers and weed scientists have found some herbicides shouldn't be a problem, while others should be avoided.

Towery says Verdict and Sharpen both provide burndown capabilities and have a short residual effect. He encourages no-tillers to use them as a pre-plant application and then come back with glyphosate or Liberty, depending on the herbicide-tolerant corn trait, right before seeding.

As for herbicides to avoid, Towery says Lumax and Callisto can't be used with legumes, while Dual and Zidua should be avoided on grasses. He adds that atrazine can work if it's applied at less than 1 pound per acre.

Steinlage originally moved away from residual herbicides because of the carryover issues he witnessed in his cover crops. While he wasn't having weed issues, he says he could see them coming.

So to bring residual herbicides back into his weed-control program he built brackets for his planter so he could band herbicides in the corn row and still interseed covers.

Success with Interseeding into Soybeans

Most no-tillers interseeding cover crops are seeding them into corn. But Allen Dean, who only grows soybeans and wheat, has had great success interseeding covers into his soybean crop.

He struggled at first to get the cover-crop stands he wanted in soybeans, but found that by interseeding them in the middle of August – a little earlier than he was before – there's enough moisture left for the crop to get established. He says soybeans are putting on pods at that time, and a couple weeks later will turn yellow and start dropping leaves.

"I know some guys get a little concerned and ask, 'How big is this stuff going to be when we get ready to harvest?'" he says. "But we found as we cut the soybeans off the field, the covers hold back a little bit until we get full sunlight."

He adds that while the covers may be green during harvest, they haven't impacted harvest operations, noting that they seem to go through the combine with all the dry soybean straw.

"I went back to a simple, cheap acetochlor product with some atrazine in a 10-inch-row band," he explains. "Our weed issues haven't been in between the rows, they're right on the row where you cleared the strip. We usually have enough residue piled in between the rows that weeds are a non-issue."

Equipment Matters

If the option is available, hiring someone with an interseeder to custom seed cover crops may be an option. Werling says his custom applicator uses a Hagie sprayer with a Valmar air seeder and drop-down tubes to seed the covers in between the corn rows, and notes the stand is much better than when the Hagie was running a Gandy air seeder.

"Now he can do better rates," he says. "Before he was limited with the Gandy. He would drive so slow and if it had any chaff in it, he would have trouble. The Valmar will seed anything."

Grubb is also using a Valmar 3255 air seeder, which he mounts to his AGCO Spra-Coupe 4455 sprayer. He says he's modified the unit so he can take the tank off and mount the Valmar on in a few hours.

Originally he was using a Flexi-Coil air cart on the back of his sprayer to experiment with interseeding, but he didn't have any control on the seeding rate, prompting him to invest in the Valmar seeder.

"The other thing is I was driving a big tractor and air cart through the field and we have to be primarily concerned with the crop in the field," Grubb says. "If you hit cornstalks and run some plants over, it's going to hurt your yield.

"With the Valmar unit on my three-wheel sprayer, I'm seeding a lot more rows more accurately and more evenly."

Dean and his family modified the Miller sprayer so it could variable-rate seed their cover crops, allowing them to bump up their seeding rate on slopes and areas more susceptible to erosion.

The seeder also has a scale, Dean says, which allows them to double check that the Miller Nitro is seeding the cover crops at an accurate rate.

Steinlage has been modifying and experimenting with different seeding equipment every year since he started interseeding, including a Hiniker drill that he adapted for twin-rows and using drop tubes on his toolbar.

A few years ago, Steinlage attached Dawn Equipment's DuoSeed cover crop interseeder to a Dalton toolbar that he ran with a Hiniker box to drill soybeans, then switched out the Hiniker for a Montag to interseed covers and sidedress nitrogen.

"It's working phenomenal," he says. "We drilled soybeans with it, and did all of our sidedressing with it. We then switched right over to interseeding cover crops."

SEARCHING FOR PERFECTION. Iowa no-tiller Loran Steinlage says his Dawn Equipment DuoSeed cover crop interseeder (above) works "phenomenally," noting he used it to drill soybeans (right), sidedress nitrogen and then interseed covers. He typically sees a 15-bushel increase in that year's corn yields where he interseeded annual ryegrass with clovers into them at the V4-V7 stage. The yield increase alone makes the cover crops pay for themselves, Steinlage says.

Steinlage had planned to add a nutrient metering system on the machine that would allow him to seed cover crops and apply N at the same time but has since decided that the timing of interseeding is so critical he didn't want to risk getting it wrong just to avoid another pass. With the implementation of controlled traffic, he says the extra pass is not a big deal.

Fennig says the FE4R system was designed to allow no-tillers to interseed their cover crops and make dry fertilizer applications with one machine, allowing growers to utilize their sprayer for more than just spraying.

Fennig says the FE4R system is currently designed for Hagie sprayers, as well as Deere, Miller, New Holland, Walker and Apache systems.

"There are a lot of companies trying to come up with the best way to do interseeding," he says. "This is just one way a farmer can utilize what he has already."

3 Planter Setups for No-Tilling Green

Growers in central Pennsylvania share how they tweaked their planting units to optimize corn stands while getting cover crops into their rotations.

By John Dobberstein

Soil conditions in Pennsylvania can vary as much as the terrain, from sandy or clay loam to rocks and knobs of shale — presenting a potential nightmare for no-tillers trying to achieve consistent stands and protect yield potential.

The Lancaster County no-tillers work in the largest livestock-producing county in Pennsylvania that also happens to have the most impaired streams, making it a major contributor of pollution to the Chesapeake Bay. Farmers are under the gun for reducing nitrogen (N) inputs to limit nutrient runoff. Adding to this challenge, the county got 75 inches of rain in 2018, when a normal year sees just 42 inches.

At 2019's Pennsylvania No-Till Alliance Field Day no-tillers Kevin Balmer, David Breneman and Jim Hershey shared how they set up their planters to no-till into living covers.

Jim Hershey

Crops: Corn, wheat, soybeans
Livestock: 1.7 million broiler chickens, 6,500 wean-to-finish hogs
Soils: Sandy loam
Planter: Case IH 1240 Early Riser
Rows: 12
Tractor: Case IH Magnum 190
Label: Dawn ZRX rollers

Elizabethtown, Pa., no-tiller Jim Hershey uses a highly accessorized 12-row Case IH 1240 Early Riser planter outfitted with Dawn Equipment's ZRX rollers to roll down tall cover crops and plant corn in one pass.

"This roller-crimper system is adaptable to many kinds of soil conditions and engineered for rolling extreme cover crops," Hershey says, noting it's not unusual for him to plant through 8,000-10,000 pounds per acre of biomass in spring.

The planter has offset disc openers with a leading edge that cuts through the residue and penetrates soil better than some of the competition, Hershey says.

Hershey's planter is equipped to apply a popup fertilizer in furrow of 6-24-6 with zinc and dribble on 28-0-0-2 at 30-50 pounds per acre on top of the row. "We continue to put more N on at planting time and less at sidedress time. And we haven't used coulters at all on that planter."

Hershey also no-tills soybeans into living covers but uses a Case IH 500T air drill with an airbag system adjusted depending on soil conditions.

Dawn ZRX rollers

Succeeding with Custom Interseeding

Another equipment innovation on display at the 2019 Pennsylvania No-Till Alliance Field Day was a custom-built cover crop interseeding toolbar designed and made by BZ Mfg., a division of Hershey Farms, the field day's host.

The interseeder units can be made with rigid, folding and end-transport configurations and accommodate 6, 8 and 12 rows. Jim Hershey and Brian Zimmerman designed the frame.

Hershey says the smaller models have been popular with organizations such as conservation districts, while farm clients like the 12-row toolbar.

David Breneman

David Breneman is renting a 6-row John Deere MaxEmerge 2 planter and front-mounted roller-crimper to plant 30-inch corn into different combinations of cover crops that includes oats, cereal rye, clover, rapeseed, wheat, triticale and annual ryegrass.

He fastened the roller-crimper to his John Deere 750 drill to plant soybeans in 15-inch rows on his 85-acre farm. The Totally Tubular system applies a 6-24-6 in the furrow, and beside the row he uses a Deere disc system to apply a half-and-half mix of 28-0-0-2 and 9-0-0-13.

He uses Martin row cleaners on a modified framework to make room for the fertilizer discs without interfering with the frame-mounted row cleaners. In the tractor he uses a Raven precision monitor for field mapping and guidance. The monitor came in handy when he was planting into rolled cover crops and needed to hold his place, but having the roller-crimper on the tractor's front improved accuracy.

Crops: Corn, soybeans, hay
Soils: Sandy loam, some silt loam
Planter: John Deere MaxEmerge 2
Rows: 6
Tractor: Case IH Magnum 5250
Labels: Dawn Curvetine closing wheels; Keeton seed firmers; Martin row cleaners, shop-made framework; Front-mounted roller-crimper

Kevin Balmer

Crops: Corn, soybeans, alfalfa, rye
Soils: Sandy loam, some clay
Livestock: 125 dairy cows
Planter: Case IH 1225
Rows: 6
Labels: Fertilizer application system; Yetter floating row cleaners

Kevin Balmer no-tills 30-inch corn into cover crops and alfalfa to maximize feed per acre, but isn't planting into big cover crops as he takes most of that for forage. But he still wants to move enough residue with his 6-row Case IH 1225 planter to get solid stands in the rye and alfalfa.

The row units are standard save for the Yetter floating row cleaners. "They clean really well in front and move the trash out of the way without digging into the soil," Balmer says. "That's what the dealer recommended."

Balmer applies 15 gallons per acre of 28-0-0 with sulfur beside the row with the planter, which is only used for corn.

Decoding C:N Ratios to Unlock Fertilizer Savings

The use of the right cover crops over an extended period can provide optimum soil C:N ratios for a thriving biological population and can significantly lower nutrient inputs over time.

By Dan Crummett

Long-time cover-crop consultant Steve Groff says many growers are missing management opportunities in their lack of understanding the relationship of carbon (C) and nitrogen (N) in the soil and in field residue.

"If you'd asked me to explain the 'C:N ratio' 10 or 15 years ago, I couldn't have given you a meaningful answer, but over time I've learned that knowledge of carbon and nitrogen content in soils, cover crops and residue is an important factor in making covers work, and in better management of fertilizer inputs."

Groff operates a research-based no-till farm near Lancaster, Pa. He explained the C:N ratio recently for cover crop growers.

CARBON PENALTY. A high C:N ratio cover crop such as this cereal rye residue will likely mean supplemental nitrogen is necessary to meet the needs of the emerging corn crop. Soil microbes quickly scavenge available sources of nitrogen before it can be made available to the cash crop.

Driving Decomposition

"Simply put, the C:N Ratio is the comparison of the mass of C to the mass of N in a substance," Groff explains. "If you have 10 units of C for each unit of N, the C:N ratio would be 10 to 1."

Groff says knowledge of the ratio is important because it directly affects how quickly residue of both cover crops and cash crops decompose, and has a direct bearing on N management.

"Basically, the lower the C:N ratio, the quicker materials decompose," he explains. "As an example, rye straw has a C:N ratio of about 82:1, compared with a cover crop of hairy vetch at 11:1."

Microbes Eat First

To make sense of C:N ratios in crop and fertilizer management, Groff says it's important to know that the microbial component of the soil has a C:N ratio of 8:1 and requires a diet with a C:N ratio of 24:1 for optimum health.

"These microbes use about two-thirds of the C they eat for energy and the remainder for maintenance," he explains. "But, it's important to realize in the case of N, microbes eat first, taking what they need, and then whatever's left over goes to the adjacent plants."

While common wisdom tells growers that corn planted into standing rye straw needs extra N to thrive, it's actually the microbes the extra N is satisfying, and they, in turn, mineralize C in the soil to provide the emerging corn crop its nutrients.

"Because of this, it's important that growers provide the microbes an environment as close to a 24:1 C:N ratio as possible to maximize the health and numbers of microbes which process and release nutrients for cash and cover crops," he says. "It's that processing that affects our long-term overall bottom line through reduced inputs."

Groff says providing the ideal 24:1 C:N ratio for microbes is much like going to an all-you-can eat buffet.

"Faced with a smorgasbord, you're likely to pick out your favorite foods, and when you consume them, you're happy," he says. "It's the same with microbes, when they eat what they want they perform better, and that correlates directly to better crop performance for growers."

Management Tactics

Groff says managing the microbial component of farm fields is not an exact science but it involves managing an array of residues to provide at least a portion of the ideal C:N ratio at any given time.

"If the ratio is high, microbes will consume any available source of N to supplement their needs, and that means an N-loving cash crop like corn will need applied N to make up the difference. This is known as the 'Carbon Penalty'" he explains. "Eventually, the microbes will return nutrients to the soil when they die and decompose, but in early stages of this type of management, supplemental N usually is needed to feed the microbes."

Groff says there are valid reasons for planting into a high-C residue such

as rye straw, namely that cereal rye and other small grains are the only covers that will grow dependably in fall and winter conditions. To manage around this situation, however, he says planting cover crop mixes can help provide supplemental N and ultimately a more ideal menu for microbes.

"One trend to manage the C:N ratio is to plant a cover crop mix. As an example, planting hairy vetch (11:1) along with cereal rye, which has a C:N ratio of about 37:1 when its actively growing just before reproduction, can provide supplemental N to the environment before a cash crop is planted. This is a good duo," he say. "This effect also drives the performance we see in multiple-species cover crop mixes that include a dozen or more species."

Groff says it's not all about the cover crops and their various C:N ratios, however.

"After 5-10 years of managing your C:N ratio…**nutrient inputs will be lower and your organic matter levels will increase…**"
– Steve Groff

"The soil biology itself has a lot to do with how various residues are processed," he explains. "Also, temperature and moisture are important to how quickly residues break down, along with the intensity of biological activity."

He says in fields just entering no-till or cover crop management, soil microbes and earthworm activity may not be at optimum levels, and residues may take much longer to decompose.

"On the other hand, I had a long-time no-till field which had been planted to a cover crop mix of sunflowers, crimson clover, hairy vetch and other species that actually had too low a C:N ratio, and by the time I planted the following year there was essentially no residue on the surface. The earthworms and the microbes had eaten it."

Over the next two years, Groff says he planted covers that would provide higher C:N ratios to enable him to maintain his goal of 100% cover on his fields throughout the year. He says it's that kind of management that's possible with various cover crop mixtures.

"That's why, when managing cover crops between cash crops, it's essential that growers do on-farm testing to determine what works best in their individual climates and field conditions. There are so many variables it's impossible to make accurate blanket recommendations," he says. "What I've learned on my farm in southern Pennsylvania is probably far removed from what might work in the Great Plains."

One example of how to manage what covers to grow in various cropping situations might include the use of low C:N ratio species on fields covered with heavy corn stalk residues. Planting a high C:N ratio cover such as cereal rye in a field like that likely would cause a carbon penalty in the following crop, he says.

"Another example might be the use of higher C:N ratio covers ahead of soybeans, which tend to benefit from lower nitrogen-content soils for proper nodulation. This phenomenon is seen across a wide geography as soybeans almost universally thrive behind a cereal rye cover," he added.

Groff emphasizes that managing for optimum C:N ratios involves maintaining a healthy microbe component, which means using the least tillage possible.

"Yes, some tillage can improve residue breakdown by putting residue in contact with moisture and reducing its size, but any tillage kills or at least beats up on the biological populations of earthworms, arthropods, bacteria and fungi," he says.

Nutrient Availability

Material	C:N Ratio
Rye straw	82:1
Wheat straw	80:1
Oat straw	70:1
Corn stover	57:1
Rye cover crop (anthesis)	37:1
Pea straw	29:1
Rye cover crop (vegetative)	26:1
Mature alfalfa hay	25:1
Ideal Microbial Diet	24:1
Rotted barnyard manure	20:1
Legume hay	17:1
Beef manure	17:1
Young alfalfa hay	13:1
Hairy vetch cover crop	11:1
Soil microbes (average)	8:1

C:N RATIOS. Carbon-to-nitrogen ratios of various crop residues and other organic materials show the wide range of nutrient availability of different cover crops and the corresponding relative decomposition rates.

"While I've been a 100% no-tiller for more than 20 years, I don't like to tell growers how to do their farming. I recommend using the least amount of tillage possible to try to maintain that 24:1 C:N ratio that is so important to maintaining the organisms that are working for us."

Also, Groff says his experience shows managing for diversity in cover crops as well as a rotation of diverse cash crops is beneficial to maintaining a healthy biological component.

Economic Results

Groff says the short-term benefits of managing for an ideal C:N ratio include what he calls "optimal N use."

"I'm not saying you'll immediately use less N, because just starting into this management will likely involve planting corn or other crops into high C:N ratio residue and probably will require supplemental N to produce a profitable crop.

"After 5 to 10 years of this management, however, I can promise your N and other purchased nutrient inputs will be lower and your organic matter levels will increase," he says.

Tips for Managing Cover Crop Mixes for More No-Till Benefits

Choosing a cover crop cocktail is only a start, says Adam Daugherty, as managing carbon-to-nitrogen ratios and adapting planting strategies play a big role in success.

By Angela Lovell

There are many variables for growers to consider when they're implementing cover-crop mixes into their no-till rotation — including mix design, carbon-to-nitrogen (C:N) ratios, cash crop goals, termination strategies and biomass management.

"The goals will be different for everyone and will change from field to field, with changing conditions and with time," says NRCS district conservationist Adam Daugherty.

Staying in Balance

It's vitally important for no-tillers to understand the C:N ratio of crop residue and how they play a role in the soil. C:N ratios are especially important when ascertaining how long it will take for soil microbes to break down residue (see p. 14).

"The soil is a jungle ecosystem," says Daugherty. "It has big and little critters. They all have to eat and they all play a role in cycling residue."

The ideal C:N ratio to feed microbiology in the soil, so it can efficiently consume biomass and cycle nutrients, is 24:1. Higher C:N ratios will slow down the decomposition of biomass and lower C:N ratios will speed it up, Daugherty says.

Most annual cropping systems have a high C:N ratio: wheat straw is 80:1 and corn stover is 57:1, which means residue decomposes slowly and leaves more protective biomass on the soil surface. Plants with a lower C:N ratio (legume hay is 17:1) decompose residue faster and result in less cover being left on the soil surface.

Daugherty generally advises no-tillers to stay on the high end of the C:N ratio because one of the first things that destroys soil function is leaving it naked.

"I want to keep the soil covered the best I can so I shift a little to the high side on the C:N ratio, especially in fields that have had cover crops for a couple of years and I'm getting a good idea of what they've got going on," he says.

Keep it Simple

Don't over-complicate cover-crop mixes, advises Daugherty, but aim for one that has at least some diversity with grasses, legumes and brassicas.

> "In general, as the soil biology functions increase, **more carbon needs to be managed in the mix...**"
> – *Adam Daugherty*

What generally works for Daugherty's growers is 20 pounds an acre of legumes, 40 pounds an acre of grasses and 2 pounds of brassicas.

To achieve this ratio, a fairly common mix would be 10 pounds per acre each of Austrian winter peas and oats, 5 pounds of crimson clover, 5 pounds of hairy vetch, 15 pounds each of cereal rye and triticale, 1½ pounds of Daikon radish and ½-pound of another broadleaf.

"That's a common mix for us and we can manage that mix to achieve a lower or higher ratio," says Daugherty. "That's another thing that diversity will let you do — get more flexibility in managing your C:N ratios."

He recommends growers try out online cover-crop calculators to see how different species, maturities and percentages can alter the C:N ratio.

Management Comes First

Daugherty says it's better to manage a less-ambitious mix properly than choose a "silver-bullet mix" and manage it poorly.

"I design in the fall and manage in the spring for my desired results. This is going to hold true no matter where you're at," he says. "You can do the same thing with summer mixes. It all boils down to what my goals are for the field and the logistics that I'm going to manage to reach those goals in the spring."

No-tillers should always be ready for something unexpected to happen and have a Plan B to deal with it. He explains that two fields planted side by side with the same cover crop mix on the same day and managed the same way can have very different results, with one field an explosion of diversity and the other almost entirely heavy vetch, for example.

"I think that the soil gets the ability to dominate what species it needs growing," he says, explaining that the two fields would need to be managed differently for planting. "Sometimes crazy stuff happens, but it's not the end of the world. We can manage anything."

Art, Not Science

Growing cover crops is an art, not an exact science, says Daugherty.

"You cannot write one recipe and just stick to it," he says. "You've got to be very dynamic in your thought process. You have got to be able to switch on the go and do something different on Wednesday than you did Monday. It's that variable."

Specifically, it's important to do regular soil evaluations and analyze not just the nitrogen (N), phosphorus and potassium values but things such as microbial biomass, diversity index, organic matter, fungi and CO2 content. That will help to determine the cover-crop mix and management that fits best.

"We can use this data up front to start making predictions, so we don't plant something with too low a C:N ratio that we know is going to disintegrate," Daugherty says.

Look and Listen

The final grade card is learning to read your field, Daugherty says. He cautions that there's no soil test available that is more effective than growers who develop an ability to read the symptoms of what's happening in their fields.

Once a grower gets soil biology activated and working properly, they must keep feeding it to ensure there's enough of what the system requires — especially carbon — to meet both soil and crop needs.

"Carbon is our limiting nutrient, but liquid carbon is a different feed from other forms, like organic matter," says Daugherty. "Primarily we'll be growing a monoculture cash crop and for at least half the year we're going to be very non-diverse in a system that wants to be diverse.

"In general, as soil biology functions increase, more carbon needs to be managed in the mix."

Growers must monitor stand establishment of their cash crops, assess the amount of residue left on the ground throughout the crop's growth cycle and, in the end, determine if they have achieved their goals for the crop and the soil.

"I don't really worry about this when I'm starting with a degraded system," Daugherty says. "I want to start priming it with a lower C:N ratio. But three or four years on, as the system begins to work, you've got to start watching this."

Seed Depth Rules

What never changes with a cover crop is the planting depth for the following cash crop.

"If you don't want a yield drag, whether it's clean dirt, no-till dirt or biomass dirt, you have to plant at the right depth," Daugherty says. "Covers are forgiving of a lot of things but that doesn't mean you can go out there and broadcast corn."

START SIMPLE. For beginning cover-crop users, using a mix with low biomass potential — 6,000 pounds of biomass per acre or less — might be best to start with because it's easier to plant into and won't need to be rolled down or crimped, says NRCS district conservationist Adam Daugherty. But getting to medium- or high-biomass covers eventually will lead to more resilient soils and potentially lower inputs, he notes.

What typically works for planting in Daugherty's area of southeastern Tennessee is working in good-to-dry conditions using a smooth, solid closing wheel, which can be changed to a spiked closing wheel in wetter conditions. Wrapping isn't usually a problem when planting into green crops that are crimped or rolled as long as growers plant in the same direction as the crops are lying, he says.

Growers in Coffee County generally have a fair amount of moisture during the spring and fall, which in their heavy clay loam soils means they have to be careful to avoid compaction of the seed trench.

Cover crops are a definite plus in these conditions, especially when growers plant into green crops preharvest, but Daugherty notes the firmness of the ground underneath the cover crops or post-harvest residue is still an important consideration. He advises no-tillers evaluate the seed trench by reading the sidewalls.

"When you start seeing air pockets there, let it dry up a day," he says. "Just because you're planting into covers doesn't mean you can mud corn in."

Low and High

Planting cash crops into low or medium biomass situations requires different techniques, Daugherty explains.

With low-biomass cover crops — which he defines as 6,000 pounds of biomass per acre or less — the cash crop is easier to plant, even when it's into a cover crop. There's generally no need to roll or crimp it to the ground first.

"With low-biomass planting, I highly recommend no-tillers leave it green because your planting window is going to be a lot wider," he says. "Once you spray it, you're at the mercy of the sunshine and the rainfall. There is nothing else out there to manage with. There won't be any wrapping when you're planting into this stuff."

What growers need to watch in a low-biomass cover crop is that the following cash crop — especially a heavy feeder like corn — can begin to run out of carbon as the residue begins to disappear by June or July.

"You can still grow good corn. Infiltration and a lot of things are better, but it's not bio mimicry," he says. "You're not rejuvenating the resources to the degree that you can, so you won't have the results you could potentially get."

In a medium situation with 6,000-10,000 pounds of biomass per acre, Daugherty says growers can make tremendous strides and achieve extreme resource rejuvenation. "You can gain resiliency with this and start lowering inputs."

Maximizing Solar Efficiency for Higher Profits, Better Soil Health

Increasing plant diversity and following a simple soil-testing program can significantly add to the bottom line, growers say.

By Julia Gerlach

On Twitter one day, Jason Mauck revealed that his wife asked him if he thinks in complete sentences or not. "No," he told her, "it's more like spectrums — abstract and non-verbal." Talking with him, he often seems tangential but then manages to knit concepts together, creating a wholistic picture from seemingly disparate parts.

The Constant Canopy system Mauck has implemented on his a 400-acre portion of his farm seems like a natural extension of his thought process. As he looked at the constraints, bottlenecks and hurdles his operation faced, his ideas coalesced. Mauck saw how he could make better use of available water and sunlight to grow crops in somewhat surprising ways.

Like any disruptor worth his salt, he's heard many times that his ideas won't work. But year by year he continues to tweak his approach and has zeroed in on a system of polycropping that captures sunlight and carbon while suppressing weeds and managing water and nutrients.

Water, Water Everywhere

After several years of working in landscaping, Mauck came back to his family's 3,100-acre farm near Gaston in northeastern Indiana and quickly found himself questioning the traditional farming methods that were in practice.

"I was frustrated growing monocrops," he says. "I came from being a landscape contractor and growing just one crop didn't make sense. Plus, we were having wet springs and I thought we could combat some of that water by just managing consumption."

Mauck could see that finding a way to deal with the stresses of increasing variability in precipitation was going to be necessary.

"You hear people say that they'd get the perfect crop if only they'd get two-tenths of an inch of rain every day and some sunshine in the afternoon. Well it never plays out that way, so I'm trying to figure out how to add some resilience to the cropping system so we don't have to worry about that so much," he says.

So 5 years ago he set out to grow wheat and soybeans together in the same field, with the idea that the wheat would take up extra water and also serve to suppress weeds. While a few specifics change every year, Mauck says that the general concept has shown great promise.

CONSTANT CANOPY IN ACTION. (Left to right) On Jason Mauck's farm, 20-inch wide strips of wheat on 60-inch centers that's been planted in 4 rows grows throughout the winter. Two rows of soybeans planted 10 inches from the wheat take advantage of the water-holding and infiltrating capacity of the neighboring cereal. Soybeans begin to fill in the gap between the rows of wheat. Nearing harvest, the soybeans have completely filled in the spaces between the wheat rows. After pruning the wheat, the soybeans will continue to fill in any remaining spaces.

The basis of the system is 20-inch-wide strips of wheat grown on 60-inch centers that is seeded into a cover crop of radishes and oats. Following corn harvest, the wheat is seeded around mid-October in four rows.

The wheat is seeded with a Dawn Pluribus strip-till rig, with the two outside rows being seeded with Dawn DuoSeed row units and the inner two rows being dropped in between them along with fertilizer. The wheat will be several inches tall by mid-April when twin-row soybeans are planted in the 40-inch spaces between the wheat strips. The purpose for this setup is two-fold, says Mauck.

> “When we terminate our cover crops and then come back to plant, **I don’t think we’re getting the same benefit.** It’s a beautiful thing when you can grow two crops at once...”
> – *Jason Mauck*

“We’re making room for traffic lanes and making room for light to penetrate the intercrop. When you go to wide rows and then the rows themselves are wider, you can empower the solar angles.”

As far as water management is concerned, his Constant Canopy system goes beyond just dealing with springtime moisture.

“Wheat consumes about an acre-inch of water for every 3 bushels of wheat you produce. In our area, we get about 40 inches of rain and the moisture in the spring is usually a liability because the young root hairs (of the soybean crop) have a tough time growing under those saturated conditions,” he says.

“So in the 20- and 40-inch row schematics, the soybean is placed 10 inches away from the wheat roots, and the wheat really helps infiltrate the water and the soybean can follow the wheat roots that are already established, 2-3 feet deep. It makes a favorable environment for the soybeans in which they can take the stress of extreme temperature variations or too much rainfall but still have plenty of light to flourish.”

He adds, “We have this scarcity mentality, but a lot of our gains come by keeping things more in equilibrium. Sometimes you need multiple plants to get more efficient production. You might think you’re taking water out of the system with an intercrop, for instance, but you might actually be increasing water because you can stop it on a hill or infiltrate it in place and blow your evaporation later. It’s these ancillary benefits that don’t show up on FieldView or on your stat sheet that are most valuable, in my opinion.”

Mauck has a Hagie self-propelled sprayer which they’ve used in the past to spray dicamba on wheat, but Mauck say she doesn’t see the point in spraying the cereal.

“Grandpa raised wheat without herbicides his whole life,” he says. “So we’re developing a hooded sprayer that will only spray the space where the summer annual is. We’ll leave the cereal to control the weed pressure and 50-55% of the surface area. And we’ll be integrating that with our Dawn strip seeder. Our goal is to plant, plant, harvest, harvest and take all the trips out.”

Cohabitation Spikes Yields

A few years ago, Mauck seeded monocrop wheat after doing a dragline manure application. When the wheat came up, he noticed it grew 2-3 times taller in the strips with the manure.

The following year, he attached a Gandy gravity box and deflection plates to his Balzer 6350 manure spreader so he could drop the wheat seeds right above the manure injection sites. He took off half of the shanks and installed them in 60-inch rows. He was impressed with the results.

“The wheat roots would go down into the manure and change their physiological makeup — they would produce a lot of tillers in that space,” he says. “If a wheat seed had 3-4 inches of space from another wheat seed, it would put on 15, 20 or even 30 tillers. And as spring would come around, the wheat would grow more horizontally like crabgrass and we’d get multiple wheat heads per plant.”

Because his soil nutrient levels are relatively high as a result of having livestock for several years, Mauck realized he could apply less manure. So he eliminated the shanks from the manure spreader and drove it as fast as he could to feed the wheat seeds without overapplying.

Mauck tested 17 varieties of soybeans that year, seeding some as monocrops and others as relay crops. In every single test but one the relay crop yielded better. They even broke a state record with one soybean plot that yielded 108 bushels per acre.

"Comparing the two systems, relay delivers a tremendous increase in yields. It's not so much top end as it is just a more even stand and a more even yield across the field," he says. "I think this cohabitation thing is really interesting. When we terminate our cover crops and then come back to plant, I don't think we're getting the same benefit. It's a beautiful thing when you can grow two crops at once."

FEWER PLANTS, MORE EARS. By drastically reducing corn populations, Jason Mauck says he can boost ear count, in some cases seeing 3-5 ears per plant.

Solar Corridor for Corn

Mauck has expanded his trials with 2 years of experiments intercropping corn and soybeans. In 2018, he planted 60-inch, single-row corn with 20- and 40-inch soybeans planted in the gaps, but he found that this arrangement didn't allow enough light to get to the soybeans and they grew tall and leggy.

Farmers around the country are experimenting with wide rows, but Mauck has put his own spin on it. Instead of pushing corn populations ever higher, he's experimenting with low populations, intercropping a second cash crop and focusing on higher yields per plant instead of per acre.

As luck would have it, he met plant breeder James Bates who was experimenting with ultra-low corn populations to get more light into the stand.

"Instead of trying to get anywhere near normal corn yields, he started putting a gap between the corn plants themselves and really driving corn plant populations down to 5,000-6,000 plants per acre," Mauck says. "He would plant two plants and then have a 3-4-foot gap, and then plant two plants to make these very large solar corridors."

Mauck explains that as the sun changes positions through the day, it changes the shadows that are cast on the intercrop — in this case soybeans — and they still get plenty of light. That means they're not driven vegetatively to compete for light so they stay relatively short. With this system, he's seen that he can maintain "normal" soybean yields, but corn yields are another matter.

"Corn has usually 28-30 leaves and 14-15 nodes," he says, "and in a monocrop situation, they're driving all their energy off the top 2 or 4 leaves. But with these low populations, all 28 or 30 leaves are empowered with sunlight, photosynthesizing and increasing the energy in each plant. So you'll trigger 3-5 ears per plant. The ears will grow big, and fill out to the top with plenty of moisture."

Re-emphasizing that he's not shooting for top yield, he explains that with a normal corn population he would average 200 bushels per acre.

"But if you plant only one-fifth of that, you're not going to get only 40 bushels — you may get 80 or 100, so you're increasing plant yield 2-4 times, depending upon your schematic but drastically reducing seed input costs."

As an added benefit of the system, Mauck says as the season progresses, the corn can live off the nitrogen (N) from the legume, allowing him to lower his nitrogen needs.

In one 15-by-375-foot field in 2019, Mauck planted 60-inch corn at a population of 11,200 (seeds per acre) and interseeded 20- and 40-inch soybeans in June. Because he likes multiple variables in his test fields, he changed up the corn seeding by making gaps: He started with six consecutive plants followed by a gap, and then five consecutive plants followed by gap, then four, then three and then two so he could study the relationship of the corn and the soybeans together.

"The soybeans changed their genetic expression dramatically. As we put bigger gaps in, the soybean nodes increased from 12-13 up to 17-18 and the plants became shorter," he says.

"I'm pretty excited to put some technology behind this and start putting skips in the vDrives of our planter and scale this up. And if we can start integrating controlled starter where we only squirt starter where the corn seeds are or use seed-coated energy, I think we can drive our nitrogen use very low per bushel."

COMPACT PLANTS, MORE NODES. When relay cropping corn and soybeans, Jason Mauck found that leaving big gaps between the corn plants encouraged the June-planted soybeans to develop more nodes and stay relatively short and close to the ground.

In fall 2019, Mauck harvested the corn and soybeans together for 196 bushels (on a per acre basis), 50-52 of which were soybeans. For low-population corn, he says that's not a bad result. He notes that it can get complicated figuring out how best to proceed because soybeans are valued at a ratio of 2.2-2.6 per bushel of corn, so if he introduces additional variables that hurt the beans but improve corn yield, he may not gain anything.

Variety Stated: Advancing Cover Crop Genetics and Performance

Advances in cover crop species and variety evaluation, development and breeding will hopefully soon make seed bag tags with "Variety Not Stated" (VNS) the odd rarity, not the norm.

By Martha Mintz

The steady rise of cover crop use and interest in recent years has plant breeders, geneticists, agronomists, researchers, government agencies, universities and seed companies turning their attention to making the practice a success. Each treads one of the following paths to improving cover crop species and their use in a cropping system:

1. Cover crop field trials assessing best practices and geographies for currently available varieties.
2. Introducing varieties from other countries or from heritage lines.
3. Breeding new germplasm lines and introducing new varieties.
4. Using gene sequencing to advance positive traits.

Each method delivers more functional and successful options for farmers looking to work cover crops into their farming systems. No matter their success or lack of it in the past, the advances made in understanding and developing cover crop varieties should have farmers looking into regionally adapted varieties each year to take advantage of the most current genetic advancements.

"It's an exciting time. We've made a lot of headway with cover crop improvement in the last 10 years and in the next 10 years I wouldn't be surprised to see double, to triple the improvements," says Jerry Hall, president of GO Seed (formerly Grassland Oregon), one of few private companies with an active cover crop breeding program.

DEFINITE DIFFERENCE. A variety trial at the University of Illinois Ewing Demonstration Center shows clear differences in variety performance. Kentucky Pride crimson clover, on the left, was developed by the University of Kentucky for improved cold tolerance. On the right is Dixie crimson clover, a variety from the 1950s used for re-seeding pastures that hasn't been improved since its introduction.

Breeding: The Near Future

For the first time in decades, there is a concerted effort to advance cover crop genetics.

Steven Mirsky, USDA research ecologist, helped spearhead a nationwide effort that has become known as the Cover Crop Breeding Project (CCBP). Coordinated teams are testing regionally adapted cover crop germplasms, aiming to develop 5 new varieties for each species under development.

Cooperators are spread throughout the United States from Oregon to New York and North Dakota to Texas. They include USDA-ARS plant material centers, universities and the Noble Research Institute — entities that usually work independently, Mirsky says. Together they manage multiple cover crop projects including research station and on-farm breeding, advanced line trials and growing seed supplies for new varieties.

The initial focus for CCBP has been on breeding legumes, such as hairy vetch, winter pea and clovers. The scope has since expanded to include brassicas and grasses. Small grains and forage crops are also being evaluated to determine best varieties for cover crop use.

"The legumes coming out of our program are outperforming what's commercially available. We're looking forward to releasing varieties soon," Mirsky says.

Advances have been made in winter hardiness of hairy vetch, crimson clover and winter peas. They've also selected for higher nitrogen (N) fixation, early growth and high biomass production. Varieties from these efforts should become available in the next 2-5 years.

"We take any advances and distribute them to a number of sites across the nation. We compare improved material by regions to see where they will be the most successful," Mirsky says.

In the next 2 years, they expect to release multiple varieties of hairy vetch targeting specific regions, including the Mid-Atlantic and North Central United States. The varieties have improved winter hardiness, growth rate and N production over the VNS seed that dominates the market for many cover crop species.

"Most hairy vetch seed is VNS and produced in Australia or Argentina. It has no winter hardiness," says research geneticist Heathcliffe Riday, who is breeding new hairy vetch and crimson clover cover crop varieties for the Agriculture Research Service's (ARS) U.S. Dairy Forage Research Center. "For our breeding program, we sought out material produced in the upper Midwest and other cold climates to build a named variety that performs better."

Riday also pulled from the U.S. Nicotiana Germplasm Collection for winter hardy hairy vetch germplasm from the Ukraine and Russia.

Disease resistant winter peas will be targeted to more southern states in the next 2 years. To follow will be crimson clover with earlier growth rates and in roughly 5 years soft seeded/shatter resistant hairy vetch. CCBP cooperators are beginning to look into higher allelopathic rye as well.

Private breeders are also making advances. GO Seed bred and released FIXatioN Balansa clover and Frosty Berseem clover and look forward to releasing a new Persian clover variety in 2021. FIXatioN Balansa clover is touted to produce 200 pounds per acre of N, be cold tolerant to -15F and quickly produce a substantial amount of root and forage. Frosty Berseem boasts of improved cold tolerance and productivity.

These improved varieties can make a huge difference in a range of climates. In a Mississippi State cover crop variety trial, FIXatioN Balansa clover made 186 pounds per acre of N available to crops when terminated April 1 vs. the 124 and 53 pounds per acre of N produced by the other two varieties in the trial.

In an Idaho USDA cover crop study, FIXatioN had a 47% better winter survival rate than the other variety in the study along with a 22-inch height advantage at 50% bloom. It bloomed a full month later than the competing variety.

Winter pea breeding has the advantage of decades of ongoing robust genetic advancement for human consumption and for forage. Rebecca McGee, USDA-ARS research geneticist, is branching out from those programs to breed winter peas more suited for cover crops, though it's no easy task.

"Winter peas used for cover crops are conceivably in the field for 10-11 months depending on the system and are hit with every environmental extreme you can imagine and vulnerable to every pest you can think of as well as all the diseases," McGee says.

As a result, her breeding programs focus on cold tolerance and resistance to diseases, insects and soil-borne and foliar pathogens. Additionally, she's working to advance biomass production, N fixation and nutritive quality.

McGee notes through field trials they've learned a lot about how different varieties perform in different regions which has helped guide the cross block decisions they make for adapted varieties.

"We have a tremendous pipeline full of material we can hope to release over the next 10 or so years. We're in a state of constant improvement," she says.

In the past 10 years, McGee and her collaborators have released one cultivar and one germplasm line suitable for cover cropping. In the coming year or two, though, she expects quite a few germplasm and cultivar releases.

Curated Collection

Cover crop seed companies play an important role in the improvement of cover crop success. They're invested in finding the best solutions for their customers. That includes identifying, sourcing and proving up various cover crop varieties and species.

Breeding cover crops isn't in the business model for Green Cover Seeds, for example, but they work to identify and bring to market cover crop varieties and species that provide growers with effective options.

"We have 130 different varieties of cover crop seeds. We've had many more over the years, but we no longer carry them because we've found something better. We're always on the lookout for better genetics," says Keith Berns, Green Cover Seeds co-owner. He notes they keep a diverse lineup as they serve producers throughout the country.

One quarry of his is a better sunnhemp variety. Most VNS sunnhemp is produced in India or South Africa and doesn't adapt well to many U.S. regions. However, the USDA developed a variety known as Tropic Sun in Hawaii in the 1970s. It features lower alkaloids, making it safer for grazing and shows improved performance compared to what's currently on the market, he says. While they can get the germplasm, they've run into difficulties trying to produce the seed. But it's a problem they're working to overcome.

The company ventured to a breeder in New Zealand to bring the Smart Radish variety to their customers. It features a 'pull-down' tap root with many branching roots that keeps more biomass in the ground instead of pushing up and out of the soil surface. It also brings more biomass for better ground cover and grazing possibilities, Berns says. Closer to home

COLD EDGE. Frosty Berseem clover was bred for cold tolerance. This stand of Frosty Berseem plants were hit with a heavy frost that would have killed other Berseem clover varieties. It fully recovered.

they licensed Baldy Spineless Safflower — useful for grazing and compaction relief — from Montana State University.

Building Data

A challenge to the improvements made in cover crop varieties are the blanket statements made about cover crop performance due to limited field trial data that includes variety comparisons. This is problematic as varietal performance can vary wildly within a species.

People cite research saying, 'See, this species won't work here,' when in reality, the study only looked at one variety. "It's my biggest pet peeve. If you're not evaluating the majority of varieties available you can't condemn a species for a region. You're not doing justice to the plant breeders working to develop improved varieties," Hall says. Or to those looking to use them.

Those breeding new cover crop varieties and conducting research are working to generate more complete data sets for specific, proven recommendations in hopes of replacing the generalizations.

NRCS and university research on differences between different cover crop varieties is increasing.

"I'm very excited about the national NRCS cover crop variety trial that began several years back. Some of the locations have begun to release their data and there are tremendous differences between varieties," Hall says. Reports are available from NRCS Plant Materials Centers in Aberdeen, Idaho, and Corvallis, Ore.

Hall notes the initial reports revealed some winter pea varieties easily winter killed despite their name while other varieties showed tremendous cold tolerance, for example. In addition, there were significant variations in seed size between different cereal rye varieties, allowing for lower seeding rates that would help curb costs.

"Varietal performance issues can be huge. Going forward, hopefully research will help identify varieties that can fill potential niches," Hall says.

The CCBP also tests diverse cover crop genetics at more than a dozen sites nationwide. Combined with NRCS cover crop variety trials, the data provides an unprecedented analysis of regional variety trial performance. Data generated is being worked into cover crop selection tools, which is part of the CCBP mission.

"We're actively involved in cover crop councils and other organizations, helping to produce supporting materials, information and tools for implementing cover crops. This includes actively developing regionally adapted information on the performance of different varieties," Mirsky says.

Challenges to Advancement

There are certainly hurdles to overcome in breeding, sourcing and selling improved cover crop varieties. Seed production is one.

McGee says traits that make a good cover crop don't always line up with easy seed production. A late-maturing clover may produce more biomass, but may not have enough time to produce viable seed. Successful cover crop varieties must meet both needs.

Private investment in breeding cover crop varieties can be risky business, Berns says. The programs are costly and little to no protection exists to keep farmers from selling seed to each other instead of going back to the source.

The advantages of going through a seed company such as Green Cover Seeds, Berns says, is that they ensure seed quality, screening for weeds and ensuring good germination rates. Seed companies such as GO Seed will also likely take some profits and reinvest in their breeding programs for even more advanced genetics down the line.

Mixes present a complicated knot to unwind. Additional scrutiny must be placed on how traits are impacted when varieties are grown together in a mix. For instance, some brassica varieties are touted for control of various nematodes, causing the nematodes to become active when their target crop isn't growing. However, if those brassicas are grown in a mix and there's a host plant also in the mix, this could serve to increase nematode populations instead of controlling them. All are factors that must be studied.

Genome Sequence Breeding

A positive for cover crop development is the use of genome sequencing. The pea genome has already been sequenced and McGee hopes to resequence several additional breeding lines and cultivars with a focus on cover crop traits.

CCBP researchers are currently sequencing the hairy vetch genome, which will guide breeding against hard seeds that cause hairy vetch to come back in subsequent crops. Sequencing is also being used in work to reduce hairy vetch seed shatter, which will help increase seed availability for cover crop usage.

While exciting advancements are being made, more are on the way. Creating a new variety can take up to 10 years and most of these projects are just at the 5-year mark.

There's been little advancement in cover crop genetics since they fell out of use in the '70s, so there's plenty of ground to cover. Thankfully breeding projects are moving forward quickly.

Those working to add cover crops in their cropping systems would be well-served to pay close attention to the work being conducted on cover crop varieties in their regions. Just like a corn hybrid or wheat variety, making the right choice can make all the difference in the world.

For more information on the Cover Crop Breeding Project, visit *CoverCropBreeding.com*.

Learn The Terms

Technical talk in plant breeding can get a bit confusing. What is the difference between germplasm and a cultivar? These terms are just different classifications that reflect levels of improvement. Let's start at the broadest level:

Species: A group of like organisms that can interbreed.

Germplasm: The base genetics of a species from which new plant lines are developed. This would be the parent material to potentially many varieties, cultivars and hybrids.

Variety: A naturally occurring isolated group within a species bearing unique traits. Varieties will breed true, producing seed with generally the same characteristics as the parent plant.

Cultivar: A combination of "cultivate" and "variety," a cultivar is a variety that has been carefully selected and bred for by plant breeders. Cultivars often will not breed true, creating offspring that do not resemble the parent plant.

Hybrid: The result of crossing two varieties. Like cultivars, hybrids will not breed true.

Opening Up Opportunities: No-Tilling 60-Inch Corn

While yield benefits are a work in progress, growers say interseeding cover crops into wide-row corn offers other perks, like grazing opportunities and high amounts of biomass and nitrogen.

By Julia Gerlach

Good ideas have a way of resurfacing, even if "progress" seems to have left the ideas far in the past.

In the U.S., corn-row spacing has generally been getting narrower over the decades. Rows that used to be spaced 40 inches apart to make room for horses to pass through have shrunk to 30 inches in general, but sometimes as low as 15 or even 12 inches, packing plants tightly together in pursuit of ever-higher yields.

But recent experiments fly in the face of this trajectory, as a number of farmers are now exploring the possibilities beyond yield by no-tilling corn in 60-inch rows. The system creates the potential for harvesting more sunlight for seeding cover crops or companion crops, grazing livestock, building soil health and growing nitrogen to benefit the next year's rotation.

Chart 1: 2018 Practical Farmers of Iowa 60-Inch Corn Trials

	Fred Abels, Holland, Iowa	Jack Boyer, Reinbeck, Iowa	Kessel/Johnson, Lamoni, Iowa	Chris Teachout, Shenandoah, Iowa
Pre-plant N fertilizer date; rate	May 8; 80 lb. N/ac,	May 1; 30 lb. N/ac.	October 2017; 11 lb. N/ac.	n/a
Corn planting date; population	May 12; 36,000 seeds/ac.	May 8; 35,000 seeds/ac.	May 10; 31,000 seeds/ac.	Apr. 25; 33,000 seeds/ac.
At-plant N fertilizer; rate	30 lb. N/ac.	120 lb. N/ac.	70 lb. N/ac.	45 lb. N/ac
Cover crop interseeding date	June 15	June 8	June 7	V4 corn stage
Cover crop interseeding rates	Cowpeas, 24 lb./ac. Annual ryegrass, 9 lb./ac. Buckwheat, 15 lb./ac.	Cowpeas, 10 lb./ac. Guar, 10 lb./ac. Cereal rye, 5 lb./ac. Annual ryegrass, 5 lb./ac. Rapeseed, 2 lb./ac Buckwheat, 5 lb./ac.	Cowpeas, 25 lb./ac. Annual ryegrass, 10 lb./ac. Buckwheat, 15 lb./ac.	Cowpeas, 8 lb./ac. Mung beans, 1 lb./ac. Sunn hemp, 1 lb./ac.
Side-dress N fertilizer date; rate	June 24; 60 lb. N/ac.	n/a	July 1; 33 lb. N/ac.	V2 corn stage; 25 lb. N/ac.
Total N rate	170 lb. N/acre	150 lb. N/acre	114 lb. N/acre	70 lb. N/acre
Corn harvest date	Nov. 8	Oct. 13	Oct. 17	Oct. 12
Corn harvest average yield 30-inch rows	228 bushels/ac.	200 bushels/ac.	121 bushels/ac.	193 bushels/ac.
Corn harvest average yield 60-inch rows	159 bushels/ac.	205 bushels/ac.	111 bushels/ac.	182 bushels/ac.
Cover crop biomass, 30-inch rows	3,681 lb./ac.	339 lb./ac.	964 lb./ac.	n/a
Cover crop biomass, 60-inch rows	4,225 lb./ac.	3,870 lb./ac.	3,766 lb./ac.	n/a
Cover crop N, 30-inch rows	n/a	7 lb. N/ac.	20 lb. N/ac.	n/a
Cover crop N, 60-inch rows	n/a	100 lb. N/ac.	60 lb. N/ac.	n/a

YEAR 1 STUDIES. In the 2018 Practical Farmers of Iowa studies, corn yields were lower in the 60-inch rows than in the 30-inch rows for all growers except Jack Boyer. On the other hand, cover crop biomass and nitrogen (N) content was higher in the 60-inch plots vs. the 30-inch plots on all fields where it was measured.

Settling on 60s

Retired John Deere engineer Bob Recker of Waterloo, Iowa, says that farmers need to focus on developing advanced practices that can enhance what he calls the "triple bottom line" — sustainable income, improved soil and, of course, high crop yields that can feed and fuel the world.

In 2004, Recker was working with a grower on strip-intercropping and noticed that the outside row or two of corn in the strip had consistently higher yields than the inner rows.

A few years later after retiring from John Deere and starting up the consulting firm Cedar Valley Innovation, he worked with another farmer on a trial of 12 rows of 20-inch corn. The overall yield of the strip was 275 bushels but the outside rows yielded 437 bushels.

This stopped Recker in his tracks, he says, and got him to wondering "why waste all that space in the center — why not just have more edges? If we can just do edges and they do really well, the edges will pay for themselves."

His experiments over the next few years — on his own farm as well as collaborations with others —led him from strips of 4 30-inch rows separated by 6 empty rows to 4 30-inch rows with a single skipped row in between. "I had realized that anything more than a single row in between was wasting sunlight."

With this spacing, Recker was seeing yields of 348-360 bushels per row on the outside rows. In order to maintain field seeding populations, he pushed populations to 55,000 on the two outside rows and 45,000 on the two inner rows. The overall yield on the 4-row strip was 298.

COWPEA COMPANIONS. Though the cover crop mix Chris Teachout planted in 2018 included cow peas, mung beans and sunn hemp, the species that thrived best was the cow peas. Teachout says cow peas love the understory and despite their viney nature, they caused no problems for the combine at harvest.

Recker thought that was pretty good, until he realized that because the skipped rows yielded nothing the actual total yield was more like 238 bushels, which was about the same as the normal yield for that field.

His experiments — and a dare from fellow grower Reno Rodeghiero, who was working with Recker on his wide-row trials — led him in 2017 to attempt single 60-inch rows in order to "harvest as much sunlight as possible."

By studying images from a time-lapse camera, Recker had realized that edge rows were bathed in light for much more time than inner rows. While conventional wisdom suggested a quick canopy was a good thing because it would shade out weeds, it also led the lower leaves of the corn plants to get shaded out also, which restricted their ability to utilize the sunlight.

The 60-inch rows were formed by simply disengaging every other row unit on a 30-inch planter, so no special equipment was required for the basic experiment.

Recker thought his experiment was going to be a disaster but in fact his 60-inch rows had a field average of 218 bushels, which was just 5% less than the 230-bushel field yields seen in the 30-inch rows. Again, he had doubled the seeding population to 68,000 in the 60-inch rows to equal the same 34,000 population as the field planted to 30-inch rows.

"The rows that get the extra sunlight can tolerate a much higher population than anyone in their right mind would normally plant corn in," says Recker.

As a point of clarity, Recker explains that when harvesting the 60-inch rows, he divides the yield in half in order to obtain the field yield, which reflects the fact that he's skipping every other row. Therefore, the 60-inch row with a field yield of 218 actually had a row yield of 436.

Though the overall field yields for the 60-inch rows came in slightly below 30-inch row averages, Recker says the system has promise, especially if the grower is interested in grazing livestock because the gaps present the opportunity to interseed cover crops.

In fact, weed management becomes much more of an issue in 60-inch rows because the extra sunlight not only allows the corn to thrive, it also provides an extra boost for weeds.

Therefore, he only recommends planting 60-inch rows if a grower wants to grow cover crops for grazing, soil building or planting a second crop like hay.

Extended Trials

In 2018, Recker worked with 30 growers from 9 states to evaluate the results of 30-inch vs. 60-inch corn, each grown with and without interseeded cover crops.

Data from 2018 is consistent with what Recker had seen in his own trials, showing about a 5% decrease in field yields in the 60-inch rows compared to the 30-inch rows (186 bushels vs. 196 bushels). Where cover crops were interseeded, yields went down to 187 in the 30-inch rows and 172 in the 60-inch rows.

For the producer who's not interested in the benefits of growing cover crops, like soil building, grazing and weed suppression, he acknowledges there's no up-side to growing 60-inch corn.

"It's not worth doing if you're not going to plant cover crops, because you don't get any more corn. But with this system, you can dedicate half of your corn growing space to improving your 'triple bottom line' by giving up 5% of your corn yield," he says, as the interseeded cover crops offer income potential/feed cost savings by grazing livestock as well as building soil health, which can further enhance profits down the line.

Interseeding Studies

Practical Farmers of Iowa (PFI) learned of Recker's experiments and rolled out trials of its own in 2018 and 2019.

In 2018, three participants — Fred Abels of Holland, Iowa; Jack Boyer of Reinbeck, Iowa; and Brian and Heather Kessel and Jim Johnson in Lamoni, Iowa — planted both 30-inch and 60-inch corn plots and then interseeded all strips with cover crops in early summer.

EYE OPENING RESULTS. Farm consultant Bob Recker first started thinking about wide-row spacing after laying out this representational array of corn after harvest. The outer two rows on each edge produced a much higher yield than the remaining rows, suggesting that getting sunlight all the way down to the bottom of the plant could lead to higher yields

Boyer's 60-inch corn was seeded in twin rows. Chris Teachout in Shenandoah, Iowa, also planted 30- and 60-inch strips, and in early summer he seeded half of each row to cover crops and left the other half without cover crops. Details of the interseeding systems are shown in ***Chart 1*** (see p. 22).

In early- to mid-June (or approximately V4), each producer seeded a cover crop mix of their choice between the rows.

When the corn was harvested, three of the farms saw lower yields in the 60-inch strips compared to the 30-inch strips. Abels logged a 30% decrease (159 bushels for the 60-inch rows vs. 228 for the 30-inch rows); Teachout's 60-inch rows yielded 182 bushels compared to 193 bushels in his 30-inch rows; and Kessel/Johnson yielded 111 bushels in the 60-inch rows vs. 121 bushels in the 30-inch rows.

Boyer saw a slight bump of 5 bushels per acre in the 60-inch rows (205 bushels) compared to the 30-inch rows (200 bushels).

Besides testing corn yield, the PFI trials also measured the cover crop biomass and nitrogen (N) content near the time of corn harvest in order to quantify the potential opportunities for grazing.

While biomass was higher in the 60-inch rows than in the 30-inch rows in all cases where it was tested, it was more than 10 times higher on the Boyer farm (3,870 pounds per acre vs. 339 pounds per acre) and 4 times higher on the Kessel/Johnson farm (3,766 pounds per acre vs. 964 pounds per acre). It was noted that the predominant species visible in the cover crop biomass was cowpeas.

Cover crop biomass N was also tested and was found to be considerably higher in the 60-inch rows compared to the 30-inch rows on the two farms where it was measured. On the Boyer farm, cover crop N was 100 pounds of N per acre vs. 7 pounds of N per acre; the Kessel/Johnson 60-inch rows measured 60 pounds of N per acre compared to 20 pounds of N per acre in the 30-inch rows.

PFI trials in 2019 had similar results, with slightly lower corn yields in 4 out of 6 farms but higher cover crop biomass and cover crop N in all locations where it was measured (2 farms were unable to interseed a cover crop).

Two of the participants in 2019 (Abels and Boyer) had also participated in the 2018 trials. Unfortunately, Abels was unable to interseed a cover crop. Boyer seeded a different cover crop mix than he had in 2018 and at corn harvest the biomass of the cover crop in the 60-inch rows was about 5 times higher than that in the 30-inch rows, compared to 10 times higher in 2018 — perhaps a result of seeding a much lower rate of cowpeas than he had the year before (only 3 pounds per acre in 2019 vs. 10 pounds per acre in 2018).

GRAZING POTENTIAL. After harvesting his interseeded rows of 60-inch corn, Chris Teachout of Shenandoah, Iowa, found that cowpeas were the predominant cover crop that had thrived during the growing season. Testing revealed 70-90 pounds of nitrogen in the biomass of the cover crop, nutrients Teachout says can help boost yields in the following year's crop.

Interseeding After-Effects

Teachout, one of the producers who participated in the 2018 PFI trials, specifically decided not to do the PFI 60-inch row trials in 2019 because he wanted to study the after-effects of the interseeding and wide row spacing from 2018.

While his cover crop N rates hadn't been reported in the PFI study, he says he measured 20 pounds of N per acre in the 30-inch rows and 70-90 pounds of N per acre in the 60-inch rows, about a fourfold increase.

Creating 'Skip Zones' with a Hooded Sprayer

Matt Griggs no-tills cotton, corn, soybeans, hay, wheat, rye and cover crops in Humboldt, Tenn. He started planting his cash crops "green" a few years ago, no-tilling them directly into living cover crops, which he would then spray and roll down.

But he was struggling to get a good stand of cotton through the dense biomass, so he developed a unique method of creating skip-rows with a hooded sprayer.

In fall, he seeds cover crops right after harvest. When the covers are about ankle-high, usually in mid-March, he uses the hooded sprayer to terminate 8-inch-wide strips between the hoods, on 30-inch spacings. The cover crops in the 8-inch strips die back, creating a skip-zone where he can plant his cotton.

About 2 months later, Griggs terminates the covers in the entire field. Within 2 hours, he does a pass with a roller-crimper to flatten the plants into a thick mat. Shortly after he plants cotton with his 12-row Kinze 3600 to plant the cotton. The sub-inch accuracy of his RTK guidance makes it easy to target the 8-inch strips where the seeds will go.

"This has worked really well, as I'm able to get a good, consistent stand of cotton and also get all the benefits of the high biomass, including cooler soils, better water infiltration, and weed suppression," says Griggs. "We have herbicide-resistant pigweed and this technique works really well to combat that."

Griggs has also started using this technique with his corn and says he saw a yield bump of about 5 bushels per acre in 2019. "I can't say that it was because of this technique – it could have been any number of factors. But I did think the corn came up faster because it had less biomass to grow through."

SPRAY-DOWN SKIP ZONES. Matt Griggs creates skip rows by using a hooded sprayer to terminate the cover crop in the row where the cash crop is going to be planted about two months later. Then at planting he sprays the entire field, flattens it with a roller-crimper and then plants directly into the terminated cover crop.

"So many people asked me if the next year's crop would be able to take advantage of the nitrogen and other soil benefits produced by the cover crop, I thought I'd see if I could discern that," he says.

So in 2019, he planted 30-inch soybeans that were indexed to the 60-inch rows from 2018. While most of the 40-acre field all yielded statistically about the same at an average of 73 bushels per acre, soybeans grown where the 30-inch rows with cover crops yielded 4 bushels more per acre.

"It's only a 5% increase. But if someone raising corn on corn can get 90 pounds of N per acre with cover crops, and is doing 60-inch corn, maybe they can offset back and forth with that 60-inch row pattern where it lines up with that legume, essentially doing an in-field rotation every year," he says.

Having done some other interseeding tests over the years, Teachout also concluded that warm-season mixes — like the cowpeas, sunnhemp and mung beans he planted in 2018 — work best in this type of scenario where one of the desired outcomes is a robust biomass for grazing or N production for the following crop.

While Teachout used to raise livestock, he doesn't anymore but says the interseeded 60-inch rows would be a great system to use if he were going to re-integrate animals into his operation. In the absence of livestock or a corn-on-corn rotation, Teachout says wide rows also offer the opportunity to "rebuild and re-aggregate soil, create more infiltration, and feed biology."

Teachout says these tests have brought up more questions for him as well. For instance, he says that in 30-inch rows there are usually 700-750 corn kernels per ear and he wonders if growing corn in 60-inch rows would increase that count.

He also wonders, "are 60-inch rows a little too wide? Maybe it would make sense to go back to 40-inch rows, like when the width of a horse dictated row spacing."

Practice is Spreading

Iowa growers aren't the only ones pursuing 60-inch corn. While Bob Recker's tests took place there, he's worked with farms in Illinois, Wisconsin, Minnesota and Colorado.

A small group in France has formed to test the concept as well. A report in Le Bulletin des Agricultureurs indicates that in 2019, their first year of testing, only 1 in 6 producers had yields from 60-inch corn that equaled their 30-inch corn, and the remaining producers saw an average yield hit of about 20%.

"It will take several years to get a good idea of the yield potential," says Pierre Rémillard, research and innovation project manager at Agrinova, one of the organizations associated with the group. "Several elements must be examined. For example, we want to check which hybrids best respond to the method. We have indications that they do not all react the same way.

"Weeds are a big challenge — especially annuals, because they benefit from the extra light," says Rémillard. "The current idea is to sow the cover crop at the same time as the corn and to choose species that will take full advantage of the light."

Profiting from Grazing Covers in Dryland Acres

High Plains research shows positive profit potential and improved soils with grazing of spring-seeded cover crops in semi-arid areas.

By Dan Crummett

Recent research in the High Plains is showing cover crop and forage mixtures offer soil-building and profit potential even to growers in areas of low rainfall.

A 2 year on-farm study by researchers from Colorado State University (CSU), Kansas State University, and the NRCS shows spring-planted cover crops afford growers 30-40 days of grazing before a fall-seeded winter wheat crop, as well as improvements in soil quality.

DIVERSITY RULES. A cover crop mix containing 5 pounds of spring peas, 15 pounds of oats, 15 pounds of forage barley, 5 pounds of hay millet, 2 pounds of rapeseed, and 1 pound each of flax, safflower and sunflowers not only fed the cattle in the study, it also built soil nutrients for the producers.

Results show cover crops provide cropping system flexibility, even to growers in semi-arid conditions in some years, according to Meagan Schipanski, an assistant professor of cropping systems at CSU, and a principal researcher on the 2016-17 project.

"Many growers are concerned that a cover crop will use valuable moisture needed for subsequent small grain crops in the fall when compared with just fallowing the fields," she explains. "The results of this study show fallow management does provide more moisture at the 3-6 foot level than in treatments of a spring-planted and grazed cover mixture, but moisture levels nearer the surface were usually not significantly different."

> **"We're diversifying the income stream and reducing inputs** to offset potential yield drag in the following wheat crop..."
> – *Meagan Schipanski*

Schipanski says the deeper moisture found in fallowed ground would make a difference to small grain production, particularly if no rain fell through the growing season after establishment.

"There's good reason to believe wheat roots get that deep and that you would notice a difference if you didn't get any more rain," she explains. "If it doesn't rain, it's going to affect your wheat crop. But we do have indications the covers are improving the soil."

On-Farm Results

In the first year of the study, one field had a significant reduction in wheat yield following the grazed cover crops, and in the other four there was no difference. In the second year, one of three fields showed a reduced wheat yield.

"While the averages showed fallow treatment wheat yields at 50.6 bushels per acre, compared with 42 bushels for grazed treatments, and 40.9 for ungrazed treatments, the fallow yields were not statistically significant from grazed cover crop yields," Schipanski notes.

The study, located on fields in northwestern Kansas, northeastern Colorado and southwestern Nebraska involved a March-planted cover crop mix of 5 pounds of spring peas, 15 pounds of oats, 15 pounds of forage barley, 5 pounds of hay millet, 2 pounds of rapeseed, and a pound each of flax, safflower and sunflowers. The seeding rate of the mix was 45 pounds per acre at a cost of $18 per acre.

Four grazing blocks were established at each site, each with a 60-by-400-foot exclusion area (3 combines wide), along with a smaller fallow area as a control. Grazing began May 15-June 15 and ended from June 15-July 15.

"On five sites in 2016 and '17, the spring covers supported an average of 28 days of grazing with gains of 2 pounds per

The Benefits of Keeping the Soil Covered

Mike Neff, one of the cooperators in the project, farms in Dresden and Sheridan Counties in Kansas, and says the study reinforced his own beliefs in cover crops and keeping something growing on the land throughout the year.

Neff took advantage of the study's second year option for producers to use the spring grazing treatment, or wait to plant their covers until after wheat harvest for a fall grazing opportunity.

"That fall-planted cover gave me about 33 days of grazing from mid-December until mid-January, and left me with ample standing cover to catch snow through the rest of the winter," he explains. "I followed that with a corn crop."

RELIEVING WATER WOES. Neff, a 20-year veteran of cover crop management on both dryland and irrigated cropland, says the system provides significant flexibility over conventional farming methods, particularly handy in an area that receives 21 inches or less precipitation per year.

"In this part of the country, using conventional farming methods we can only use about 1 inch of every 4 inches of rain that falls. It just makes sense to plant something to help save much of that other 3 inches," he explains. "It's nice to get rain, but it's more important to use every drop that your fields receive. It also adds flexibility to my operation.

"If I seed after wheat harvest and get a decent cover stand, whether I graze in September or December or not, I'm slowly building soil aggregates and water holding capacity," he says. "If we get an extremely dry spring and can't foresee a successful corn or grain sorghum planting, that's where the system allows you to come back in and plant something else and graze in the summer."

Neff says the animal factor is important to the flexibility of the system as well as being vital to nutrient recycling on grazed acres – which reduces the need for applied fertilizer.

"You don't have to be in the cattle business yourself," he explains. "We custom graze and get the same benefits. In fact the grazing we did during the second year of the study paid for the cost of the cover crop seed plus some, so it was a win-win for me and guy who needed the forage.

"I figure cattle are little combines that don't require diesel fuel," he says. "If you don't have animals involved, you're relying solely on cash crops."

During the study, Neff used the same cover crop mixture prescribed for all participants. On his own, he uses a mix with much more diversity.

"I usually plant 11-16 species for the additional diversity. It's like an insurance policy against whatever the season throws us," he explains. "This kind of farming does hinder you a bit if you're following government program regulations, but I find the reduction in input costs is worth it to me."

REDUCING INPUTS. Neff says over the past 4-5 years he's realized a 15-20% reduction in fertilizer use because of the soil-building qualities of cover crops he has planted over the years. That average includes fields in the system for 20 years, and newer fields just being treated to covers.

"A good example is a field I've had in the system for nearly 20 years. I estimated a 150 bushel dryland corn yield and, using the Haney test for soil carbon and potential nitrogen (N) in the planting zone, the recommendation was for 40 pounds of N," he explains. "I was hesitant to use that little N, but decided to follow the test.

"In the end, I flew on an additional 12 pounds of N along with a fungicide 'just for insurance sake' but the field ended up making 144 bushels on a nominal amount of fertilizer," he says. "Three weeks of drought during grain-fill kept me off my yield goal, but the longer my fields are in the system, the less fertilizer they need."

day," she explains. Stocking rates averaged 534 pounds per acre across the 2-year multi-site project, for an average daily gain of 2.17 pounds. Dry matter yields averaged 2,917 pounds per acre.

In 2016, the plots yielded roughly 2 tons per acre of forage with little reduction in cover due to regrowth in a year of timely moisture. In 2017, the forage production dropped below a ton per acre because of cooler conditions.

Schipanski says in both years of the study, the grazed acres showed an improvement in soil aggregate size when compared with the fallow areas.

"Just having roots in there vs. not, we are seeing positive effects on soil properties," she explains.

Economic Results

While economic results varied widely over the 2 year study period ***(see Table 1)***, the practice of planting and grazing a spring cover crop shows positive returns ranging from $16.77-79.02 per acre.

"The $79 was pretty high, but overall the practice showed a net positive profit," Schipanski explains.

"Overall, we found there is an improvement where they grazed, but to some extent there is a reduction in moisture at depth," she says. "That can have an impact on your wheat yield.

"But again, we're diversifying the income stream and reducing inputs to offset potential yield drag. How and whether that works, and whether there's a spring grazing window or a post-wheat grazing window depends upon the individual operation and the availability of cattle and grazing management."

Table 1. Economics of Grazing Cover Crops

	Per AUM*	Per Acre
Increased Returns	**$31.87-81.17**	**$44.26-73.56**
Reduced Returns		**$8.00-40.00**
Additional Costs		
Fence (materials)	$2.77-6.85	$1.18-7.20
Labor (fence)	$1.70-5.10	$0.72-2.02
Labor (livestock)	$3.74-3.76	$1.59-1.72
Seed ($18/acre)	$11.15-24.53	$10.44-18.00
Fertilizer	$6.75-16.25	$6.91-9.10
Herbicides	$4.75-12.00	$5.11-9.421
Machinery Costs	$12.19-12.94	$5.19-22.88
Other (e.g., water)	$0.93-18.52	$1.31-7.88
Total Costs	**$52.23-91.70**	**$39.02-71.65**
Reduced Costs		
Herbicides		$14.50
Feed		$11.25
Pasture leases		$20.00
Total Reduced Costs		**$14.50-49.25**
NET CHANGE IN INCOME:		**$16.77-79.02**

**AUM = animal unit: Calves = .5; Steers = .75; Cows, heifers, and bulls = 1.0*

Online Tools for Making Better Cover Crop Decisions

New selection tools and 'recipes' help growers simplify the decision-making process and build a cover crop mix that is tailored for their location, crop rotation and goals.

By Julia Gerlach

After deciding to adopt cover crops on a farm, the next important decision is what to plant. Some online resources have become available that can help make the decision-making process a little easier. These tools give users customized advice based on location, cropping rotation, cover crop attributes and more. but each tool features different parameters.

SmartMix Tool

The SmartMix tool offered by Green Cover Seed allows growers to customize a mix to achieve specific goals. It's free to use and doesn't commit the user to buying seed from the company, although an online account is required.

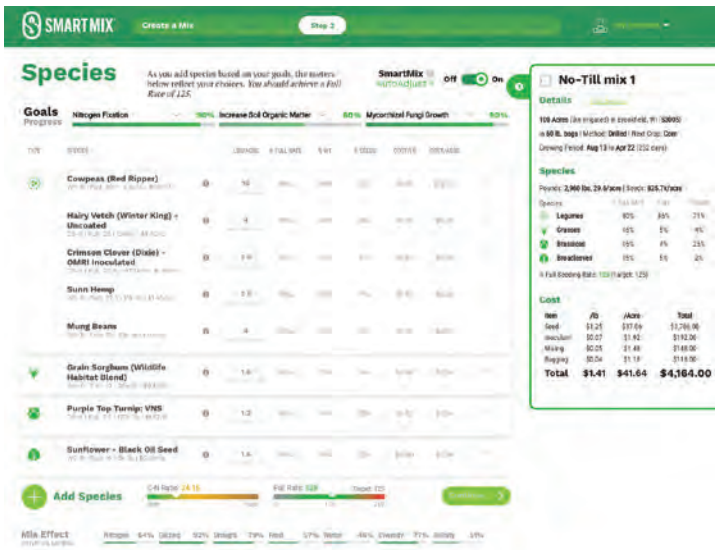
After entering basic cropping information, the user chooses from a wide range of cultivars that are ranked by how well they will help the grower achieve their cover copping goals.

The tool automatically calculates how much of each species should go into the mix, the carbon-to-nitrogen ratio of the mix, the extent to which the mix will achieve the stated goals as well as other effects, and the associated cost based on Green Cover Seed pricing.

The results panel is interactive and users can add or remove species, change goals, and click though to get in-depth information about each cultivar.

The SmartMix tool is integrated with the Green Cover Seed catalog and online ordering system. Mixes are saved in the user's account to facilitate re-ordering.

Three videos on the website guide users through all of the how's and why's of using the SmartMix program. Find it at *GreenCoverSeed.com*.



INTERACTIVITY IN THE MIX. The SmartMix tool from Green Cover Seed lets users select species and goals on the fly and shows pricing, seeding rates and more as the mix is changed.

Cover Crop Decision Tool

The Midwest Cover Crops Council's Cover Crop Decision Tool is not tied to a subscription or an account and users don't need to be logged in to use it. The tool covers 10 Midwestern states — Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio and Wisconsin — plus Ontario, and users can drill down to the county level to indicate location.

The tool gives farmers a snapshot of what cover crop species will work within the given parameters, and show cover crop planting dates, when there is a freeze risk to establishment, and even if and when they can be frost-seeded. In addition, the cover crops are rated in terms of how well they meet the desired attributes.

Click-through links for each species provides information on seeding rates, termination guidelines, cultural traits, potential advantages and disadvantages and more. Try it at *mccc.msu.edu*.

Covers in the Northeast

Still in development, the Northeast Cover Crops Council is creating a tool modeled after the one used by the Midwest Cover Crops Council. It will cover all the northeastern states from Maine in the north to Maryland in the south and West Virginia to the west and promises to be "three interconnected tools: a species selectors that helps you decide which cover crop(s) to plant; a seeding rate calculator, especially useful for planning cover crop mixtures; and an economics calculator." Keep an eye on the progress of the tool at *NortheastCoverCrops.com*.

NRCS Selection Tools

Growers in the Southeast and Pacific Northwest can use the NRCS's Cover Crop Selection Tools, which are specifically designed for those regions.

The Southeast tool is a downloadable Microsoft Excel spreadsheet, and cover crop recommendations are based on cropping rotation, management practices and resource concerns. Find it at *SouthernCoverCrops.org*.

The Pacific Northwest tool is based on a Microsoft Access database and requires both access and Microsoft Word to run. To find it, visit *nrcs.usda.gov*, and drill down to Plant Tools & Data through the Technical Resources topic.

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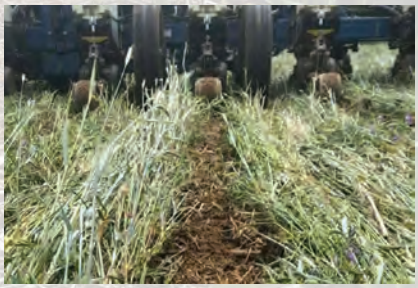

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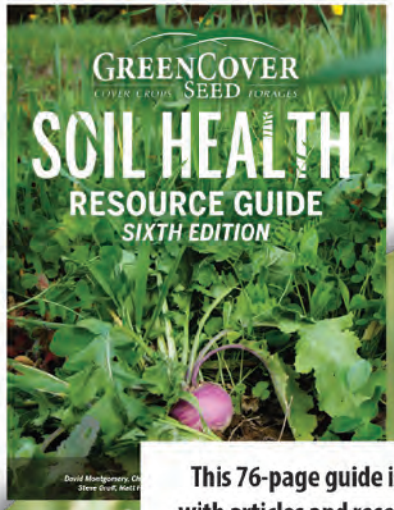

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This 76-page guide is packed with articles and research from farmers, ranchers, and scientists. Visit www.greencoverseed.com to request a free copy.

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