An Overview of Organic Farming Systems

Designing a farming system to tie together principles of sustainability and productivity is complex. Organic farmers must consider how the various components of their system - rotations, pest and weed management, and soil health - will maintain both productivity and profitability. This section outlines the major principles incorporated into organic farming systems.

University of California- Davis researchers comparing long-term farming systems found that organic safflower yields equaled conventional safflower over 10 years.
–Photo courtesy of University of California-Davis

Rotations

Although practices vary from farm to farm and region to region, at the core of any successful annual organic farming system is the crop rotation. According to "Cereal-Legume Cropping Systems: Nine Farm Case Studies in the Dryland Northern Plains, Canadian Prairies, and Intermountain Northwest," productive rotations:

Enhance soil conservation and build soil organic matter;
Provide weed, disease and insect control;
Enhance water quality and conservation, biological diversity and wildlife habitat; and
Ensure economic profitability for the farming system.

As the main management tool for all aspects of the farming system - including weeds, pests, insects, soils, and crop production - a well-planned rotation is more than the sum of its parts, addressing the connections between all of those factors. For example, successful rotations, according to "Switching to a Sustainable System" by Fred Kirschenmann:

Include the use of cover crops to provide fertility, control weeds and provide habitat for beneficial insects;
Have a diversity of plant species to encourage natural predators, discourage pest and disease build-up, and minimize economic and environmental risk;
Provide a balance between soil conservation and crop production by adding organic matter to the soil to both supply nutrients and improve soil quality properties such as water infiltration and water holding capacity; and
Provide weed control by alternating between warm and cool weather plants and including weed inhibiting plants (such as rye and sorghum).

Newark, N.Y., organic vegetable farmer Elizabeth Henderson, who farms 15 acres, considers rotations featuring summer and winter cover crops a key component of her successful system and relies on them to minimize erosion, maintain and build soil quality, and control pests.

For agronomic crops, a standard organic corn belt rotation of alfalfa, corn, soybeans and small grain accomplishes multiple functions because:

The legumes fix nitrogen, providing for the subsequent non-legumes in the rotation;
Several pest cycles are interrupted, especially that of the northern and western rootworm species, which can be devastating to corn;
Several plant diseases are suppressed, including soybean cyst nematode; and
Weed control is enhanced when perennial weeds are destroyed through cultivation of annual grains; most annual weeds are smothered or eliminated by mowing when alfalfa is in production.
(From ATTRA's Overview of Organic Crop Production, available at: http://attra.ncat.org/attra-pub/summaries/organiccrop.html or call (800) 346-9140.)

For some farmers, switching to an organic rotation may not be more difficult than expanding upon or changing the timing in an existing rotation. When Lydia and Dennis Poulsen of Snowville, Utah, decided to convert their 800-acre beef, hay and small grain operation to organic, making the switch was much easier than expected.

"An organic dairy was coming and they needed feed," recalled Poulsen. "We had alfalfa in our original rotation and we were already trying alternatives to make the ground healthier." Because their alfalfa-wheat-oat hay rotation fit right into an organic system plan, the only substantial change they made on their ranch was to plow in alfalfa as green manure for their subsequent wheat crop, rather than letting the cows mow down the alfalfa in its final year.

Soils

Along with developing a successful rotation, ensuring healthy soil is imperative to a profitable and successful organic system.

Jack Lazor of Butterworks Farm in Westfield, Vt., shows the end product of composted dairy manure, which he uses to build soil organic matter, during one of his popular pasture walks. – Photo by Lisa McCrory

"A lot of people don't think of the soil as an ecosystem but, in fact, it's probably the most complex ecosystem on earth," said Ray Weil, a University of Maryland soil science professor. "A healthy soil should be breathing out carbon dioxide, breathing in oxygen. It should hold and absorb water so the plants can survive between rains. It should resist erosion."

By contrast, a less healthy soil can wash away and pollute surface waters. From a production standpoint, poor quality soil can limit plant growth and vigor.

In organic farming systems, the majority of nutrients are supplied from organic matter additions such as compost, manures and cover crops. These amendments not only feed the plants, but the soil organisms as well. As soil organic matter accumulates, soil structure improves, and populations of other important soil organisms, such as earthworms - which tunnel through the soil, improving aeration and infiltration - increase. Those organisms break down organic material to release nutrients at a steady pace so they are available for plant uptake. Soil microorganisms also hold nutrients in a more stable form so they are less susceptible to being lost - through leaching, soil erosion or runoff.

The soil is a virtual microscopic zoo of organisms. Soil biologists are just beginning to tease apart how those organisms function in organic farming systems. Numerous studies show that organic systems have higher microbial populations and activity. The long-term SAFS trial in California's Central Valley comparing organic and conventional farming systems in a tomato, bean, corn and safflower rotation found significantly higher microbial populations and activity in organic systems than the conventional ones. New research from North Carolina State University shows that increases in microbial populations and microbial activity may occur by the first or second year of the transition to an organic system.

Researchers also are discovering that they can improve fertility in organic systems by micro-managing the soil fauna. In the SAFS experiment, researchers studied the role of bacteria-feeding "good" nematodes, small soil organisms that help make nitrogen available to plants. The researchers found that by irrigating plots in the fall to improve

cover crop germination, the nematode population increased. This higher beneficial nematode population led to more nitrogen release from the cover crop in the spring. The nematodes also stored nitrogen over the winter that might otherwise have been lost.

Cover crops, an essential part of organic systems for soil building and soil fertility, also benefit the soil by improving soil structure, which in turn improves water infiltration and water-holding capacity. The long-term systems trial at UC-Davis proved some of those benefits dramatically, such as 50 percent higher water infiltration and 35 percent lower runoff in the organic plots.

"Nobody could have possibly predicted such a dramatic difference in the water runoff and infiltration between the organic and conventional systems," said SAFS project leader Steve Temple. "It's given us a new appreciation of the importance of cover cropping and residue management."

Cover crops planted after a crop is harvested - also known as catch crops - recover nutrients that would otherwise leach into the subsoil and groundwater.

Cover crops prove invaluable to organic growers who don't have access to affordable sources of compost and manure. A study of potato production in Idaho found that legumes such as alfalfa, pea and pea-oat hay could provide 80 to 100 percent of nitrogen needed for a potato crop, and if harvested for feed or seed, 40 to 60 percent of the required nitrogen for the subsequent crop. Similarly, a northern California research project showed a nitrogen replacement value of 150 pounds per acre with cover crops.

Carmen Fernholz, who grows organic barley, oats, wheat, flax, corn, soybeans and alfalfa on his 410-acre west central Minnesota farm, manages a three-year, four-year or even longer rotation heavily reliant upon cover crops. Without exception, he underseeds all of his small grains with a legume crop, such as red clover or annual or perennial alfalfa. After harvesting the small grain, he allows the underseeded legume cover crop to serve as a green manure - or, with perennial alfalfa, as a cash crop. The number of seasons for the perennial alfalfa will depend on the weed and nutrient histories of the particular field.

"Cover crops, coupled with my managed applications of animal manures, have become the mainstay of my soil nutrient-building management plan," Fernholz said. "They are the foundation of my rotation because they supply a significant portion of the nitrogen needed for crops such as corn and wheat. They are a reliable, nature-friendly, easily managed fix between my cash crops."

Organic farmers also use manures and composts regularly, especially when they are accessible and affordable. Many organic farmers make their own compost, either by using livestock manure from their own operations or from a nearby source and combining it with straw or wood shavings. Manures and composts provide many of the same soil-building benefits as cover crops. (Federal regulations dictate that raw manure may not be applied 90 days prior to harvest if the edible portion of the crop does not

contact the soil, or 120 days prior to harvest if the edible portion of the crop does contact the soil).

Vollmer, the North Carolina tobacco farmer who converted to organic strawberry production, ripped into "The Secret Life of Compost" by Malcolm Beck to learn how to make his own compost. He uses horse manure, wood shavings, oat straw and any other suitable materials he can find.

Compost provides many other benefits, too. Since transitioning to organic, said Vollmer, "I'm able to see improvements in the soil - the pH has risen from 5.2 to 6.7, I don't need to add lime, the water holding capacity has increased, and there's less soil crusting."

Weeds

Although they joke about it now, it probably didn't seem too funny when Joe Rude and Wende Elliott thought they'd lost their first year alfalfa crop to an invasion of weeds (see profile). Yet weed management for organic and transitional farmers is a formidable problem and ranked number one among research priorities in a national survey of organic farmers.

Standard organic weed management strategies include:

Smothering weeds with cover and forage crops. A dense mat of cover crops will prevent weed germination or crowd out weeds struggling to gain a toehold. Residue from a grass cover crop decomposes slowly, while legume residues break down faster. Grass-legume mixtures also can control weeds while providing more nitrogen to the cash crop. Forages serve a similar process; in his five-year alfalfa, corn and oat rotation, "the three year alfalfa goes a long way to getting the weed seed bank out of the field," said Joe Rude.

Managing weeds selectively. Identify weeds and manage them according to their lifecycle and reproductive strategies. For example, tilling weeds like quack grass and Canada thistle is ineffective in the short run, since tillage may propagate their rhizomes. Repeated cultivation, however, forces them to draw upon their storage, and can eventually weaken the population. Biennials, on the other hand, must not be allowed to seed and

Researchers at USDA 's Agricultural Research Service find that dense mulches of cover crops, particularly grasses such as rye, provide excellent early-season weed control. No herbicides were applied to this soybean field – the rye was killed with a modified Buffalo stalk chopper. – Photo by Dr. Aref Abdul-Baki

persistent mowing can eventually exhaust root reserves.

Conservation tillage. Mark Davis, an agronomist working on a long-term organic farming systems research trial run by the USDA Agricultural Research Services Sustainable Agricultural Systems Lab in Beltsville, Md., uses a regular no-till planter to sow corn directly into a living stand of vetch, and then rolls and crimps the vetch with a Buffalo Stalk chopper. "This system has great potential for no-till organic cropping systems because it provides weed control and nitrogen fertility at the same time," Davis said. By allowing the vetch to grow longer in the spring, the researchers are increasing the amount of nitrogen added to the system. At the same time, the mat of vetch smothers the weeds long enough for good early season weed control.

"It gives you the best of both worlds," Davis said. "Your no-till practices help reduce soil erosion, improve soil structure and increase organic matter, and you can still manage the system organically." The one caveat, he cautions, is that in years with a dry spring, the late growth of the vetch can deplete soil moisture for the following crop.

Using living mulches. Inter-seeding one crop into another can be done on a large scale by sowing rye from aircraft over corn acreage, or from tractors or by hand. The second crop, which should germinate after the first, will compete for nutrients and moisture so this technique should only be used when crops are well established or have ample soil fertility and moisture. Dutch white clover, for example, is effective in corn or late season brassicas. Its high density keeps out weeds, it fixes its own nitrogen, and it is low growing so it doesn't compete with the crop for sunlight.

Many organic farmers also use some sort of mechanical weed control in combination with the above strategies. (For more information on mechanical weed control see *Steel in the Field* in "Resources")

Some organic farmers believe that weeds do not need to be eradicated, just managed. Knowing when a weed is a threat and when it can be ignored, something often gained by experience, remains a common strategy.

"Our farm becomes so much simpler all the time," said Dan Nagengast, who farms five acres of cut flowers and mixed vegetables in Lawrence, Kan., and has been growing organically for 15 years. "We've learned from our mistakes - it used to be if we were eight to 10 days away from harvesting lettuce, we would hoe the weeds. Now we know when the crop will make it, and we don't have to do all the extra things we thought we needed to."

In a bit of a radical departure from the conventional approach of "the only good weed is a dead weed," some organic farmers choose to integrate weeds into their cropping systems for the benefit of the whole farm. Steve Gilman, who farms 15 acres in Stillwater, N.Y., and grows fresh market vegetables such as lettuce, tomatoes and peppers in 4-foot-wide raised beds, decided there was no need to spend the "time and energy needed to keep the two-foot wide, permanent strips between the beds clean-cultivated."

As explained in his book "*Organic Weed Management*," Gilman was concerned about the susceptibility of the bare soil to erosion. So he began planting "bio-strips." First, he eliminated perennial weeds such as quack grass and thistle with repeated cultivations before forming the beds. Then he sowed Dutch white clover between them, allowing a mix of perennial grasses, wild herbs and wildflowers to flourish.

Gilman sees numerous advantages of these bio-strips, including:

A diverse, protective habitat and food supply for beneficial insects and microorganisms in the field alongside the crops;
A source of organic matter or mulch from the clippings of the plants (making sure to mow before any wildflowers go to seed); and
Confinement of potential compaction to bio-strips, where the soil is supported by root system of this mix. The planted inter-spaces also provide muck-free footing when Gilman needs to walk or drive a tractor between the beds.

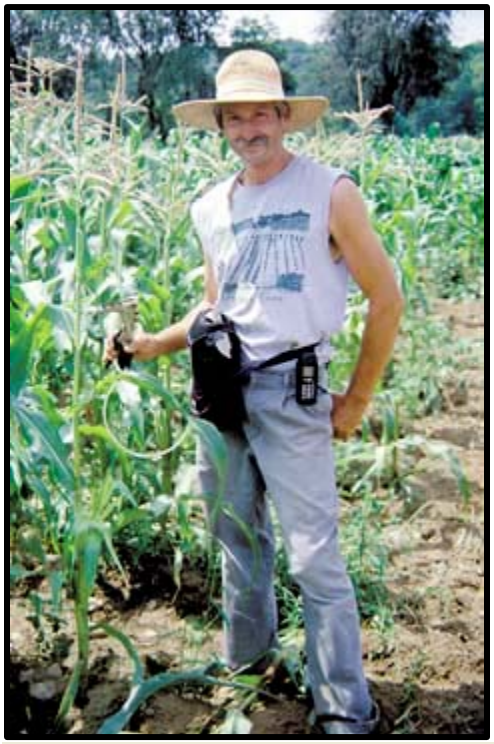
(To learn more about *Organic Weed Management*, a book produced with support from a SARE grant, see "Resources")

The bio-strips enable Gilman to retain one-third of his farm acreage in permanent no-till, preventing erosion and preserving soil organic matter. In the beds themselves, Gilman quickly sows catch crops after each harvest to keep the soil covered and to prevent weeds from taking hold. The increased growing capacity of the raised beds, which can support much higher plant densities, offsets the land lost to interspaces, while the high density planting helps prevent weeds.

Insects and Diseases

"Organic farming requires more intensive management than conventional methods," said Joe Rude, the poultry farmer from Colo, Iowa, "because without access to a broad spectrum of pesticides and antibiotics, you have to understand the life cycle of the pests that are attacking your crops and animals. You have to understand the biological and chemical processes and work with the environment."

For organic farmers, this means employing strategies such as crop rotations, enhancing biodiversity, determining threshold levels of pest populations, introducing natural enemies and using good sanitation practices. Although certain sprays such as *Bacillus thuringiensis* (Bt) and rotenone are permitted, many organic farmers do not rely upon them exclusively. Rather, the key focus of organic pest control is prevention.



Vegetable growers like Steve Mong of Stow, Mass., have controlled corn earworms, a significant pest for organic farmers, by using a new device designed by SARE- funded researchers that dispenses corn oil and Bacillus thuringiensis (Bt). – Photo by Ruth Hazzard

In California, where dry summers make it less challenging to grow organic fruit, a SARE-funded on-farm study comparing organic and conventional apples found that synthetic pheromones, biological control agents and sanitation successfully controlled codling moth mating in most locations. Disease control with sulfur and copper, when timed right, was as effective in scab control as the synthetic fungicides used in conventional systems.

In New York, where the wet humid summers pose enormous challenges for organic fruit production, Robert Pool, a Cornell University viticulture professor, found that organic grapes could be managed to be as pest-and disease-free as conventional ones. During a three-year, SARE-funded experiment, which compared organic and conventional grape production on three varieties, pheromone disruption and insect scouting allowed researchers to eliminate regular insecticide use.

"Going in, we thought the main problem would be diseases," said Pool. But instead, researchers applied, on average, less than one spray per year and found that the powdery mildew commonly observed on Concord grapes was far less destructive than predicted. The researchers also learned that pheromones successfully controlled grape berry moth and that scouting allowed them to control insects that emerged when the

regular spraying was eliminated. They avoided an expected huge spike in grape leafhopper by releasing predatory wasps.

Other SARE-funded research has shown similar control:

In a study of potatoes in Idaho, researchers were able to control Colorado potato beetle with mineral and biological compounds.

In the Northeast, where sweet corn can be devastated by caterpillar pests, Bt and corn oil were used effectively to control corn earworm. Eight farmers from Vermont to Connecticut found that the oil controlled ear damage in 83 percent of their trial plots in 2000.

Many organic farmers have observed that, over time, pest populations seem to decrease. Results from a California on-farm organic tomato experiment showed the presence of 46 percent more predators and parasitoids and 43 percent more natural enemies on the organic farms, which could provide one possible explanation for reductions in pest populations. A SARE-funded study in Washington testing mowing frequency in pear orchards found that mowing only once a month rather than more frequently as done on conventional farms, creates alluring habitats, attracting beneficial insects that control pests.

"By reducing the frequency to once a month, we see a dramatic increase in natural enemies moving into the ground cover without a big increase in pests that feed on fruit," said David Horton, the ARS researcher testing mowing regimens.

Stone fruit grower Marilynn Lynn of Bridgeport, Wash., relies on living mulches to attract beneficial insects that prey on potential pests before they can harm her peaches, apricots and nectarines. "We mulch extensively," Lynn said during a satellite broadcast about organic production aired by Washington State University in spring 2003.

Calling their orchard grass, yarrow and clover covers a "bed and breakfast" for beneficial insects, she added: "They give a nice diversity to the floor of our orchard, providing food and water in the spring when they wake up."

For soil borne-disease control in organic systems, many growers use composts, long known as effective plant pathogen suppressants. Rotations also are important for decreasing pathogen populations, as most pathogens are plant specific. In general, rotating the crop, planting resistant varieties, and adding organic matter have all been shown to reduce the incidence of soil-borne diseases: In the SAFS project in California, a four-year organic rotation had lower incidence of corky root and red root rot than a two-year conventional rotation; an on-farm tomato study in the Central Valley of California showed that organically managed soils may be suppressive to the organism that causes corky root; and in North Carolina, another SARE-funded study showed disease was significantly reduced by organic soil fertility amendments and on organic versus conventional farms.

Livestock Systems

Traditionally, livestock have played an important role in integrated operations and fit well in organic farming systems. Livestock feed on forages and grasses, essential elements of organic rotations, and provide manure, an important organic fertilizer. Although semi-confined livestock systems are allowed under the federal organic rules, the animals must be given access to fresh air, sunlight and the outdoors. Most organically raised animals do have access to the outdoors and pasture, and spend limited time in confinement. Organic confinement systems are typically less crowded than conventional confinement operations. (For more information, see NCAT's *Organic Livestock Workbook*, available for free. Call (800) 346-9140 or go to http://attra.ncat.org/attra-pub/summaries/livestockworkbook.html).

Jersey cows at Butterworks Farm in Westfield, Vt., lounge on a deep-bedded pack of straw, their cold- weather alternative to pasture during New England 's severe winters.
– Photo by Lisa McCrory

At the core of many organic livestock systems is the grazing system. Animals forage on pastures for their own feed while spreading manure, yielding energy and labor savings, and reduced equipment costs. Composed of legumes, grasses and other broadleaf species, pastures provide multiple benefits for the soil and ecosystem as well.

"The fibrous roots of the grasses in perennial pastures hold soils in place and help reduce soil erosion," said Heather Karsten, assistant professor of crop and soil science at Penn State University, who has researched pasture management and rotational grazing systems in both New Zealand and the U.S. "When the roots and stubble of the grazed grass die back, they contribute organic matter to the soil. These improvements in organic matter from the grasses, as well as the legumes, help improve water infiltration, soil structure and nutrient accumulation and storage."

Nick Maravell, who has been farming organically since 1979, branched into beef not long after he increased his Buckeystown, Md., operation to 165 acres in 1997. "When I expanded, it just made sense to become more diversified," said Maravell, who was already growing organic forages, hay and grains. "When you have animals, you complete the cycle of feeding the vegetative matter through the rumen, and it comes out the other end to fertilize the soil."

Maravell, who pastures a small herd of Black Angus on 16 acres, also likes the additional flexibility. "The cattle can be used in different ways," he said, "by sending in the cows to cull the crops - rye, barley, alfalfa, or even soybeans, when green - if you decide you don't want to harvest them."

Although pastured animals are not necessarily organic, and some organic producers do not extensively pasture their livestock, organic growers can capitalize on the benefits of grass-raised animals by marketing their product as "grass-fed" as well as organic.

Maravell feeds no grain to his cattle and grows all his own grass and hay on his farm. The lack of grain means that his animals do not have high intra-muscular fat - which fetches a higher USDA rating than the lower fat meat - "but," he said, "my customers want this beef because it is grass-fed and organic. They've seen articles documenting the benefits, and they don't want antibiotics, hormones or pesticides, all of which you eliminate when you raise animals organically." Maravell, who sells direct to his customers, added that another benefit of pasture-raised beef are the higher levels of conjugated linoleic acid (CLA) and omega-3 fatty acids.

"There is good evidence that conjugated linoleic acid can prevent cancer in animals and may protect against heart disease and diabetes and obesity in humans, while omega-3 fatty acids have the potential to decrease the risks of cancer and cardiovascular disease," said Donald Beitz, a Professor of Animal Science and Biochemistry at Iowa State University.

Beitz, who collaborated on a SARE-funded study in Iowa on the effects of pasturing animals, added that CLA levels can be 4 to 6 times higher in the milk of cattle who feed on fresh pasture versus cattle who eat stored feed such as silage hay and grain. Karsten, the Penn State researcher, also found that the eggs of pastured poultry had three times the amount of omega-3 fatty acids and higher levels of vitamins A and E than did the eggs of conventionally fed poultry.

Managing good health for organic livestock presents challenges since no antibiotics or hormones may be used. (See "National Organic Standards"). In general, the focus on animal health is preventive, and the incidences of diseases typical to animals in confinement can be reduced or mitigated by pasturing the animals, focusing on good nutrition and providing preventative care.

According to Karsten, there is evidence that the health of pastured animals is better. "Since the animals are not standing on cement, they have fewer foot and leg problems, the fresh air reduces respiratory problems and the incidence of mastitis is decreased since the animals are not lying in their own manure in the barn."

Dairy farmers also successfully manage their herds without the use of the standard conventional treatments. "Some people believe that you must use penicillin or manage dry cow treatment with antibiotics, but organic farmers don't add anything for dry cow treatment," said Lisa McCrory, the dairy technical assistance coordinator for the Northeast Organic Farming Association of Vermont (NOFA-VT). "If a cow does get mastitis, homeopathic methods and colostrum products work well."

Focusing on animal nutrition through high quality feed and good soils also goes a long way toward reducing stress, illness and the need to treat animals for medical problems, added McCrory.

Hubert Karreman, a veterinarian in Lancaster County, Pa., who has been treating organic dairy cows for almost 10 years, agreed that the incidence of many diseases is lower in organic and grazed herds. "But," he added, "just because you're using organic management does not mean you won't have health problems." He sees more pasture bloat and hoof punctures and abscesses in grazed animals, but also believes that preventive strategies such as probiotics (immune system builders), and homeopathy and botanical medicines can be used very successfully to manage and treat organic herds.

Integrating Organic Crops and Livestock

Many organic hog systems rely on deep straw, which, mixed with manure, provides heat in barns or hoop structures and reduces environmental concerns about waste storage and disposal. – Photo by Jerry DeWitt

Even if Darrell Parks didn't like working with pigs, he would still raise hogs on his 400-acre farm in the Flint Hills of Kansas, if only for the manure. Parks' 50 sows provide manure that makes up a key part of his soil fertility program.

Parks, who raises organic corn, milo, wheat, soybeans and alfalfa, relies on nitrogen-fixing legume cover crops such as yellow clover, red clover and Austrian winter peas to amend the soil. But for areas in need of extra fertility, Parks spot-treats with hog manure, illustrating one of the benefits of his integrated crop/livestock farm.

"I've worked to better utilize farm-produced manure and cover crops, as well as a crop rotation and management system that allowed me to eliminate purchased fertilizer, herbicides and insecticides," said Parks, who received a SARE grant to hone his use of manure on cropland.

Parks especially likes how manure corrects micronutrient deficiencies in his soil. He regularly tests his soils, and then targets problem areas with a heavier application of manure.

Cover crops supply most of his nitrogen. Parks grows a legume cover crop in the winter, followed by a cash crop of milo or soybeans. Before planting, he'll treat the field with manure to ensure the cash crop will not lack nutrients.

At the root of Parks' system is increasing organic matter in the soil, which will improve water infiltration and soil structure. The cover crops help compensate for what Parks describes as "heavy" soils. He chooses cover crops such as sweet clover that break

through compacted soil with their deep taproot and anticipates continued improvements in his soil structure as he continues to perfect his rotation.

"Back in the '20 and '30s, they did some of these things and had good systems in place, then fertilizer became cheap and everyone forgot about cover crops as a possible solution," he said. "I have some fairly tight, heavy soils, and this system provides a way to make those soils better over time."