Compound Interest: Building on the Benefits of Organic Production

With soils that are rich in microbial life as a result of growing cover crops in a diverse crop rotation, no-tillers have the opportunity to boost their bottom lines with organic production.

By Julia Gerlach, Managing Editor

MANY FARMERS WHO switch to organic production start out motivated by increasing profits, says Dani Kusner.

At the 2020 National No-Tillage Conference, the agronomist for The Andersons said continued consumer demand for organic products often translates into a stronger bottom line for the farmer who's willing to do the work.

But the many benefits of organic production can compound over time, creating a healthy, dynamic ecosystem that builds soil while optimizing no-till efficiencies.

Weed Seedling Emergence Sequence

Emergence Date	Early				
Group 0 Emergence occurs in fall or early spring	EMERGENCE DATE	horseweed (marestail)	white cockle	field pennycress	shepherd's purse
Group 1 Emergence begins several weeks prior to corn planting GDD < 150		giant ragweed	common lambsquarters	Pennsylvania smartweed	common sunflower
Group 2 Emergence begins just before or at corn planting GDD = 150-300		redroot pigweed	common ragweed	velvetleaf	giant foxtail
Group 3 Emergence begins at end of corn planting GDD = 250 – 400		yellow foxtail	eastern black nightshade	common cocklebur	wild proso millet
Group 4 Emergence begins after corn emergence GDD > 350	Late	large crabgrass	fall panicum	waterhemp	morning glory species

WEED AWARENESS. Emergence groups arranged according to GDD (base temp 48 F) at 10% seedling emergence. For groups 0-4, the colors refer to different durations of weed seedling emergence: white = 2-3 weeks, light brown = 3-7 weeks, orange = 8-10 weeks. *— Iowa State University*

Carbon is King. The keystone to no-till organic production is maximizing increased biomass and soil organic matter so soils are functioning at peak performance. And carbon is at the heart of the system, says Kusner, as it's the foundation for all soil physical, chemical and biological processes and can be a limiting nutrient — just like nitrogen (N), phosphorus (P) and potassium (K).

"In addition, there's a direct correlation between soil organic matter and soil carbon. A 1% increase in soil organic matter adds 10,000 pounds of carbon to the soil and removes 15-20 tons of atmospheric carbon," she says.

According to Kusner, soils on organic farms support larger amounts of soil organic matter and carbon for longer periods of time than with conventionally farmed soils. A 9-year study that analyzed more than 659 organic soil samples from 39 states and 728 conventional soil samples from the 48 contiguous states showed that soil from organic farms is better at sequestering carbon than soil from conventional farms.

The scientists who conducted the study — Geoffrey Davies and Elham Ghabbour at Northeastern University — say organic soils contain more carbon because they have 44% higher levels of humic acids than conventional soils.

Humic acids bind to soil, making it more fertile, allowing it to retain water, and assisting plants in absorbing nutrients, according to Davies and Ghabbour. Humic acid also captures carbon from the air and stores it long term.

Optimizing Microbes. These improvements in soil structure result in increased water infiltration rates, reduced run-off and soil erosion and improved water quality, Kusner says, and can reduce fertilizer need through optimized nutrient cycling.

"Soil microbes control residue decomposition and nutrient cycling. Think of them as tiny soluble bags of fertilizer," she says, explaining that microbes need four things: a food source, oxygen, moisture and adequate temperature.

"A farm manager can provide crop residues, organic matter and/or manures and fertilizer to make sure microbes have the carbon and nitrogen they need to thrive," she says. "Oxygen and

No-Till Takeaways

- ✔ Start small with a 20- or 40-acre field, maximum.
- ✔ Be willing to change your approach to pest control (weeds/insects/disease) from chemical to promoting soil biology for nutrient management, pest management and weed control.
- ✔ Just as you look at no-till as a complete system, you need to look at organics as a complete system, with a long-view lens of 5-10 years out.

moisture are impacted by soil composition, compaction, tillage and crop rotation. Temperature, of course, is most influenced by weather, which we can't control."

As microbes consume organic matter, nutrients become immobilized and unavailable to the crop, she explains. "But when the microbe dies, the nutrient is released. That's mineralization, that's what becomes available to the plant. As residue is used up or eaten, organisms die, and soil nutrient levels increase in the stable form of humus."

To illustrate, Kusner does some "microbe math" to show how soil microbes use the carbon and nitrogen in crop residues to complete their life cycles.

Bacteria have the lowest carbon-to-nitrogen (C:N) ratio, she says, and nematodes have the highest. All microbes have a particular C:N ratio and the "higher" microbe species (nematodes) have more carbon and eat the "lower" species, she says.

Microbial species	C:N ratio
Bacteria	5:1
Fungi	20:1
Protozoa	30:1
Nematodes	100:1

For example, a protozoa (30:1) needs to eat 6 bacteria (5:1) to fulfill its carbon needs.

Bacteria — 5:1 x 6 = 30:6

The protozoa needs only 1 unit of N, not 6 units, so the protozoa releases the extra N to the soil as 5 NH4.

"This example shows how we can have N in the soil if the microbes are functioning at maximum levels," Kusner says. "This doesn't mean you can get all your nitrogen needs from the soil biology," she cautions.

Kusner says an easy — if not entirely scientific — way to evaluate how well your soils are cycling is to do earthworm counts.

"In the soil microbiome, earthworms are the only things that are visible to the eye. Unless you want to send your soil off for lab analysis or DNA identification, or look at your soils under the microscope and count microbes, count your earthworms. If you have high earthworm counts — 20 earthworms per shovelful of soil is the 'gold standard' — you'll have high levels of everything underneath because earthworms need to eat those higher-level nematodes and fungi."

Earthworms have another benefit, says Kusner. "Because earthworms eat nematodes — both the good nematodes and the predatory bad nematodes — they can be considered a natural nematicide, which can take the place of having to spray a chemical."

In the Weeds. For no-tillers, probably the biggest stumbling block to adopting organic practices is weed management, as the traditional herbicides used for management aren't allowed under the National Organic Program (NOP).

So organic growers generally rely heavily upon cultivation, cover crops, crop rotations and no-till weed management practices, such as the roller-crimper and the flame weeder. To successfully implement these practices, organic growers can benefit from becoming very intimate with the timing of weed flushes, which are based on growing degree days (GDDs). ***(See Figure)***

"Back in the day, before we had all these fancy chemicals, agronomists used weed seedling emergence charts that showed the windows of time when certain weeds emerge," she says. Knowing what's emerging and when will help a grower determine what practices to use for different weeds. "This is some old school stuff and it works really well. But the level of intensity it takes to dig down into this definitely requires some time and effort."

Cover crops have a huge potential for suppressing or controlling weeds, Kusner says. Interseeding cover crops between growing cash crops is gaining in popularity for organic growers because having living roots in the soil while the cash crops are also growing provides in-season weed suppression that can cut the need to spray herbicides.

Kusner cites experiments done by researcher Joel Gruver of Western Illinois University that compared interseeding cowpeas between 60-inch row corn vs. 30-inch corn.

"In 2019, in the 60-inch row, there was 20% less yield overall than in the 30-inch row, but he had five times more cover crop biomass in the 60-inch system," she says. "But if that allows you to cut out a weed control pass or allows for livestock grazing, it might be a cut you're willing to take."

In addition to providing biomass that can smother weeds, some cover crops also have allelopathic properties that can prevent weeds from germinating. "A recent study from New Zealand showed that certain cover crops could inhibit weed seed germination by up to 40%," she said. "Cereal rye is number one, and clover is a close second."

A Note on Nitrogen. For no-tillers, working the ground is generally the least desirable practice for weed management due to the issues with breaking down soil structure and potentially introducing compaction, erosion and other problems.

But Kusner says it may be necessary to do a certain amount to tillage in an organic system and she notes that in contrast to other conservation management practices, tillage has the least effect on potentially mineralizable nitrogen (PMN) — the N that could be available to a growing crop.

No-till increased PMN 23% over chisel and moldboard plow tillage, which seems great. But other conservation practices had stronger positive differences:

1. More diverse crop rotations
- 3 or more crops resulted in 44% higher PMN than monoculture
- Two-crop rotations vs. monocultures – no difference in PMN

2. Cover crops vs. no covers
- Legume cover crops resulted in 211% more PMN
- Mixtures of legumes and non-legumes produced 77% more PMN

3. Adequate nitrogen fertilization vs. no fertilization
- Inorganic N fertilizers increased PMN by 22%
- Manure for N upped PMN by 34%

Thus, Kusner says, tillage done at the right time and for the right reason won't necessarily destroy the whole soil profile.

"For example, when performed at only a shallow ½-1-inch depth to kill white thread stage weeds, deeper layers of soil structure remain intact, while the early stage weed flush is controllled," she says.