Tough weather is tough on soil: Rebuilding soil aggregates at Woodside Vu Farm

Dr. Franklin Egan

Ben Hushon's father, Joe Hushon, on the combine at Woodside Vu Farm.

This case study is part of a series on soil health challenges and innovations revealed through our Soil Health Benchmark Study, a participatory research project we began in collaboration with farmers in 2016. Each case study examines a soil health challenge a farmer participating in our study is experiencing, and considers possible solutions offered by other farmers who attended a workshop we hosted in March 2019. Find other soil health case studies at pasafarming.org.

Soil stewardship has long been a priority for Ben Hushon and his family at Woodside Vu Farm. Along with his father Joe and brother Bill, Ben raises corn and soybeans using entirely no-till methods on their 100-acre farm in southern York County, Pennsylvania. They have not used a chisel or disk harrow on the farm since 1995, and the moldboard plow was phased out even earlier.

As a certified crop advisor and professional agronomist, Ben also pays close attention to his nutrient inputs. He applies nitrogen with stabilizers like Nutrisphere N to prevent nitrogen losses to the atmosphere and runoff water, and

METHODS

Farmers participating in our Soil Health Benchmark Study choose three fields that span their typical crop rotation. We collect soil samples from these fields in October, which we then submit to the Cornell Soil Health Lab. The lab assesses the samples according to a set of indicators covering physical, chemical, and biological aspects of soil health—such as available water capacity, aggregate stability, and extractable phosphorus.

Cornell rates the soil samples on a 100-point scale (see chart to right) relative to thousands of other samples from similar soil types—in other words, a sandy loam will be rated according to a different set of standards than a soil high in clay.

OPTIMAL (80-100)
EXCELLENT (60-80)
AVERAGE (40-60)
LOW-LEVEL (20-40)
CONSTRAINED (0-20)

We also collect farmers' detailed management records for each field, and generate our own indicators for days of living cover, tillage intensity, and organic matter and fertilizer inputs.

We compile both the soil health data generated by Cornell and our own measurements into a custom benchmark report for each participating farm. Our benchmark reports collate the soil health data of all of the study participants, so that farmers can see how their soil health outcomes compare to peer farms. With their benchmark data in hand, farmers can collaboratively explore ways to improve their soil health management systems.

uses detailed soil maps to tailor fertilizer amounts to soil variations across a field.

Given this attention to eliminating tillage and choosing inputs carefully, it's not surprising that Woodside Vu's soil health tests revealed optimal scores in most areas, including organic matter and nutrient levels. Yet Ben and his family were surprised to see low scores for aggregate stability—an important indicator of soil physical health that shows how effectively a soil can withstand water, wind, machinery, and other stressors.

Woodside Vu's low aggregate stability score, but otherwise stellar soil health test results, was not an uncommon phenomenon among farms growing annual crops, according to the results of our 2018 Soil Health Benchmark Study (see "Methods"). We found that most fields planted in annual crops during the 2018 season, which saw near-record rainfall, showed low aggregate stability scores—a testament to the substantial impact weather can have on even healthy and resilient soil ecosystems.

WHY IS AGGREGATE STABILITY IMPORTANT?

Soil composed of stable aggregates is structurally intact, which is critical for mitigating damage caused by severe weather. Soils with low aggregate stability can become compacted and develop surface crusts. This hinders seed germination, makes plants more susceptible to disease, and reduces water percolation. Additionally, compacted and crusted soils can cause downstream flooding, and structurally unstable soils are prone to erosion.

Beyond avoiding these pitfalls, soil with stable aggregates is easier for farmers to manage—it will better drain excess water and enable farmers to more quickly work their fields after rain.[1]

[1] Moebius-Clune, B.N., Moebius-Clune, D.J., Gugino, B.K., Idowu, O.J., Schindelbeck, R.R., Ristow, A.J., van Es, H.M., Thies, J.E., Shayler, H.A., McBride, M.B., Kurtz, K.S.M., Wolfe, D.W., & Abawi, G.S. Comprehensive Assessment of Soil Health, Cornell University (2017), 45.

While it's not surprising to see low aggregate stability on farms that are tilled intensively, aggregate stability also suffers when soils are pummeled with rain all season long—in 2018, rainfall totals in many parts of Pennsylvania were 50 percent above average. When farmers drive heavy planting and harvest equipment over saturated soil, aggregates will break down. Out of the 11 no-till row crop farms currently enrolled in our study, we found a median aggregate stability score of just 35 on Cornell University's Soil Health Lab's 100-point scale, with a minimum value as low as seven. And while 2018 was Woodside Vu's first year contributing to our study, we observed a 54 percent drop in aggregate stability between 2017 and 2018 among farms planted in annual crops.

At a meeting we hosted in March 2019, which was focused on collaboratively troubleshooting common soil health challenges, Ben posed his issue to other row crop farmers in attendance: How could he and his family work to repair Woodside Vu's soil aggregates after a season of relentless rain?

Rebuilding aggregates with cover crops

The group discussion focused on utilizing cover crops for rebuilding stable aggregates. Aggregate stability is a dynamic soil property, and previous research suggests that soil aggregates can be repaired through cover cropping.[2] While no-till has been part of the Hushon family's management philosophy for decades, cover crops are a more recent addition to the farm.

Ben began experimenting with cover crops in 2010, and has had some success with broadcasting winter rye, barley, and tillage radish after corn and soybean harvest. But eight years in, he's finding that getting satisfactory emergence and ground cover can be hit or miss. He's also interested in exploring the benefits of other kinds of cover crops.

Ben's peer row crop farmers offered several promising ideas for helping Woodside Vu improve its cover cropping methods in order to rebuild soil aggregates.

Seed drilling

After corn harvest, Ben typically broadcasts a cover crop, but—especially with the wet and erratic weather the previous fall—he wasn't able to get all of his fields seeded, and emergence was spotty in the fields he was able to seed.

Several farmers in the group shared that, instead of broadcasting, using a grain drill to seed cover crops into corn residue can be both more efficient and more effective. During 2018's wet season, Charles Dotterer of Dotterer Farms near Lamar, Pennsylvania, observed that even where the grain drill didn't plant seeds to the right depth,

[2] Liu, A., Ma, B. L., & Bomke, A. A. (2005). Effects of cover crops on soil aggregate stability, total organic carbon, and polysaccharides. *Soil Science Society of America Journal*, 69(6), 2041-2048.

heavy rains promoted better seed-to-soil contact, and even stimulated some seeds to germinate within chunks of corn stalk residue and extend roots down into the soil.

Dave Wilson, a Penn State Extension educator in Berks County, Pennsylvania, also recommended drilling cover crops, and provided this additional tip: It can be a good investment to hire a grain drill operator to follow the combine and ensure that a cover crop gets planted the very same day as corn harvest. That way, the farmer avoids any chance that a change in weather will delay or prevent cover crop planting, and that cover crops get the maximum growing window before winter sets in.

Growing fibrous roots

Although not technically a cover crop in the sense that it's harvested for sale, several farmers suggested that growing winter wheat could be an appealing option for Woodside Vu—it would cover the fields over winter, and add more diversity to its crop rotation. Often planted after soybean harvest in a corn-soy-wheat rotation, winter wheat has a dense, fibrous root system that can have significant benefits for holding soil in place over the winter and rebuilding soil aggregates after in-season stresses like heavy machinery traffic.

In southern York County, Pennsylvania winter wheat can be harvested in early July, presenting Ben with an interesting set of options about what comes next: He could either choose to "double crop" soybeans (planted in early to mid-July and harvested in November), or he could forego the extra income and plant a cover crop with an extra-long window to grow and mature.

In the latter situation, Dave McLaughlin, a row crop and dairy farmer in Perry County, Pennsylvania, suggested "going all out" by planting a diverse cover crop mix that can provide a range of biomass-generating, nitrogen-fixing, nutrient-scavenging, and pest-suppressing benefits. Dave suggested a mix of annual ryegrass, oats, sorghum, sunflower, buckwheat, winter rye, *Phacelia,* and even leftover corn and soybeans. Dave has experimented with different cover crops for years, and noted that cover cropping doesn't need to be an "either-or" situation—at Woodside Vu, Ben could choose to plant some of his fields in soybeans and others in cover crops, splitting the difference between achieving short-term cash flow and mid-term soil building.

Fixing nitrogen

While cover crops with fibrous roots are a powerful tool for rebuilding aggregate stability, legume cover crops can also help build soil structure and bring the additional benefit of adding nitrogen to the soil. Charles Dotterer, a no-till row crop farmer in Centre County, Pennsylvania, pointed out that because corn usually follows winter wheat in the region, Ben could incorporate a legume cover crop for fixing nitrogen. Charles' go-to cover crop in this situation is red clover, which can produce 50–70 pounds of nitrogen per acre by the following spring.

Drew Smith, chief scientist at Rodale Institute, recommended hairy vetch, which can produce as much as 150 pounds of nitrogen per acre and is particularly valuable in organic rotations where fewer options for nitrogen fertilizers are available. One of the challenges with hairy vetch, and other legumes, is that most of the crop-available nitrogen is generated during the flowering stage. Legumes terminated in-bloom will leave behind biomass that both decomposes quickly and can provide plant-available nitrogen just as the corn crop is emerging and growing rapidly. Legumes terminated during vegetative growth stages may still provide ample nitrogen, but the organic matter will decompose more slowly and will mineralize more gradually over the course of the growing season.

Allowing legume cover crops to mature to the bloom stage, which would typically happen in mid-May in southern York County, Pennsylvania, could be a challenge for Woodside Vu. Ben's father, Joe Hushon, prefers to plant corn in late April. ("At his age, he doesn't want to wait a week to do anything," says Ben.) One approach to sticking with an early planting date, while also generating more legume growth, might be to "plant green." In this scenario, corn would be planted in April in a standing cover crop. The legume cover crop would be terminated a few weeks later using a mower or roller crimper combined with an application of an herbicide compatible with corn. Dave McLaughlin mentioned that a key part of planting green successfully is to dial back the seeding rate in the cover crop the previous fall, so that the stand isn't too thick for precise corn planting. Charles Dotterer has also had success with planting green, and the approach is growing in popularity with row crop farmers across the mid-Atlantic region.

USING COVER CROPS TO CONTROL SLUGS

Grey garden slugs and other slug species that feed on corn seedlings can be a major problem in no-till production systems, where thicker crop residue provides a moist, sheltered habitat that slugs love. Increasing rainfall makes this even more problematic.

Fortunately, cover crops provide habitat for ground beetles, which are voracious predators of slugs. Several studies have found higher numbers of ground beetles in fields planted in cover crops versus bare fallows.[3,4]

Additionally, Dave McLaughlin, a farmer in Perry County, Pennsylvania and contributor to our study, has observed rising numbers of ground beetles on his farm after he decided to stop using insecticides and insecticide-coated seeds, which can indirectly harm ground beetle populations. This has augmented the positive effects cover crops have had in reducing slug damage on his farm.

By rebuilding aggregate stability through improving its cover cropping methods, Woodside Vu could simultaneously create habitat for ground beetles and other beneficial insects to help biologically control slugs and other pests.

---

[3] Carmona, D. M., & Landis, D. A. (1999). Influence of refuge habitats and cover crops on seasonal activity-density of ground beetles (Coleoptera: Carabidae) in field crops. *Environmental Entomology,* 28(6), 1145-1153.

[4] Douglas, M. R., & Tooker, J. F. (2012). Slug (Mollusca: Agriolimacidae, Arionidae) ecology and management in no-till field crops, with an emphasis on the mid-Atlantic region. *Journal of Integrated Pest Management,* 3(1), C1-C9.

Moving along the cover crops learning curve

Variable weather and a limited growing season will always make it challenging for row crop farmers in the mid-Atlantic to fit cover crops into their rotations. Unfortunately, the record rainfalls in 2018 are not likely to be a one-off occurrence: Climate change models for the region predict rising rates of annual precipitation, which would increasingly occur in strong doses of heavy downpours. As wetter weather becomes the new normal, maintaining aggregate stability will likely become a major soil health challenge. And while cover crops will be a critical tool for building and reviving stable aggregates, more frequent wet weather will make it even more difficult to fit cover crops into rotations.

Farmers, researchers, and private industry are experimenting with new and different approaches to cover cropping. This includes inter-seeding winter rye or clover into corn in July; encapsulating cover crop seeds in coatings that would allow farmers to broadcast them when they plant their crops in the spring, but delay germination until later in the summer; and introducing new cover crop varieties and genetics that would allow overwintering cover crops to grow more biomass in the late fall and early spring. Researchers with the Northeast Cover Crop Council are also developing "decision support" tools that can help farmers make smarter choices regarding varieties, seeding rates, and planting dates.

Cover crops are a key tool for addressing a wide array of soil health challenges. In areas poised to increasingly experience severe weather it's important for farmers to remain current on advances in cover crop research and resources, and to draw from the experiences of their peers, to develop cover cropping strategies uniquely suited to their systems and their land.

LEARN MORE

Find more information about our Soil Health Benchmark study—including how to participate—on our website at pasafarming.org.

ACKNOWLEDGMENTS

Thanks so much to Ben Hushon and Woodside Vu Farm for openly and generously sharing their soil health data with farmers everywhere in the name of growing the soil health movement. Also thanks to Bob Schindlebeck and Joe Amsili at the Cornell Soil Health Lab for their support and guidance of this project.

Our Soil Health Benchmark Study is funded by an NRCS Conservation Innovation Grant. Additional support has been provided by Lady Moon Farms, Kimberton Whole Foods, MidAtlantic Farm Credit, the Heinz Endowments, the Henry L. Hillman Foundation, the family and friends of Jerry Brunetti and Shon Seeley, and more than 100 other private donors.