THE ORGANIC CENTER™

Maximizing Carbon Sequestration in Organic Systems

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New study pinpoints practices that boost carbon sequestration by double digits!

Organic agriculture's proven ability to lock carbon away in the soil is a critical tool for combatting climate change. Now a new study directed by the University of Maryland in collaboration with The Organic Center, digs down into the specific ways that organic farmers can take their climate change fighting power to the next level.

The study looks at three best management practices: the use of organic soil amendments, conservation tillage and cover crops. While all three farming practices boost carbon sequestration, the study found that using best practices for organic soil amendments like compost and manure has the biggest impact in the shortest period of time.

Read on to learn more about what this means and why this matters

Organic: Maximizing carbon sequestration

Carbon sequestration is a critical tool for combatting climate change. Locking carbon away in soil reserves reduces greenhouse gases in the atmosphere, helping to mitigate global climate change.

Organic farms sequester more carbon in the soil than their conventional counterparts, and a new study out of the University of Maryland takes a deep dive into ways that organic farmers can maximize those carbon sequestration benefits.

This report looks at the importance of agriculture in contributing to – and fighting – climate change, and the critical role organic plays in climate change mitigation and adaptation. We also highlight the latest research on carbon sequestration in organic systems, detailing the organic techniques that have the biggest impact on carbon sequestration.

SPOILER ALERT

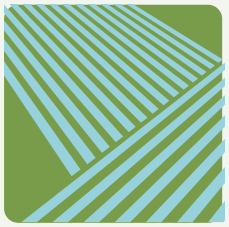
Using best practices in soil amendments like compost gives soil carbon the biggest (and fastest) boost – more so than both conservation tillage and cover cropping (which are also important!)

Carbon Sequestration: organic's powerful advantage against climate change

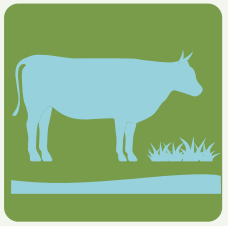
Organic farming provides a model for how agriculture can help mitigate climate change and help farmers adapt to the climate changes we are experiencing. Eighty percent of the Earth's terrestrial carbon is stored in soils, and while agriculture is one of the main causes of carbon depletion in the soil and increased carbon dioxide gas in our atmosphere, a number of studies suggest that organic practices actually increase the carbon pool in our soils while reducing greenhouse gas emissions – making organic part of the climate change solution.

Past work from the Organic Center shows that using organic practices increases overall carbon sequestration, and keeps that carbon in the soil for longer periods of time. New work that builds off this research helps pinpoint the specific practices that are most effective at carbon sequestration, which will guide organic farmers to be even more a part of the climate change solution.

Organic farming utilizes techniques that change the soil structure in important ways and help lock carbon into the soil. These practices include:



extended crop rotations



rotational grazing

fallowing and the use of manure

compost and legume cover crops

Agriculture and climate change: why it matters

1 Agriculture contributes to climate change through GHG emissions and soil carbon depletion

We need to think about agriculture when we talk about climate change, because about 40% of the world's ice-free land is used for agriculture and up to 23% of human-caused greenhouse gas (GHG) emissions comes from conventional agricultural production. At the same time, conventional agriculture has been depleting carbon at an alarming rate: over the last 1,200 years 133 billion metric tons of carbon have been lost worldwide in the top 2 meters of soil alone, and that rate keeps increasing every year. Increasing GHG emissions and the release of carbon from the soil into the atmosphere directly contributes to climate change and extreme weather events occurring across the globe.

2 Agriculture is affected by extreme weather associated with climate change

Climate change is causing both gradual and extreme changes in weather conditions like temperature, rainfall, and devastating storms. These changes influence the success of crops by causing stress to the crops during drought, flood, or extreme temperatures. Populations of beneficial biodiversity like pollinators and natural enemies of pests are also impacted, while all kinds of pests and pathogens also change with the weather, typically increasing with more heat and humidity. Farmers are faced with fluctuating extremes in nearly every growing condition which makes it challenging to produce reliable yields each year.

All of these benefits result in overall healthier soil which helps farmers adapt to climate change and increases crop yields.

3 Farming practices can mitigate climate change by increasing soil carbon storage

While the situation may sound dire, this also means that we have a great opportunity to reduce the food system's contribution to climate change by using farming practices that reduce GHG emissions and draw carbon back into the soil. These practices include reducing tillage, pesticide use, and reliance on synthetic fertilizer (ammonium nitrate). When carbon is stored in the ground for both the short and long term, it not only helps mitigate climate change, it also improves the soil structure which:

- Reduces erosion
- Reduces compaction
- Improves aeration, filtration and water holding capacity
- Provides a reserve of essential nutrients for plants
- Supports soil organisms by providing a food source which in turn helps fight soil borne diseases and supports more above ground diversity

Remember: Organic stores more long-term soil carbon

The Organic Center partnered with the National Soil Project at Northeastern University to explore how organic farming impacts carbon sequestration in the soil and found that not only do organic farms store more soil carbon in general, but they also store more of the type of carbon that stays in the ground for longer periods of time.

By analyzing over a thousand soil samples from organically and conventionally managed from across 48 U.S. states, this ground-breaking work found that organic soils had 13% higher soil organic matter and 44% higher long-term carbon storage than conventionally managed soils.

These results highlight the potential of organic agriculture to increase the amount of carbon sequestration in the soil, contributing to climate change mitigation.

Digging Deeper: New research quantifies specific practices that increase carbon sequestration

A new study published in *Agriculture, Ecosystems & Environment* digs deeper into organic management and quantifies how specific organic soil management techniques can optimize carbon sequestration so that organic farming can be used as a tool to move the needle even further in mitigating climate change.

UNIVERSITY OF MARYLAND

Researchers at the University of Maryland sorted through over 4,000 scientific articles to find data that puts numbers behind the soil carbon-building techniques that organic farmers use, and to identify the best strategies for carbon sequestration on organic farms. This is important because implementing practices that maximize impact requires a strong understanding of how well different practices can increase soil carbon storage.

Organic: The results are impressive

The results of this meta-analysis show that by adopting best management practices organic growers can boost their soil organic carbon by an average of **18%**, and increase microbial biomass carbon by an average of **30%**. This means that by understanding and implementing the latest information on organic techniques organic farms could continue to increase their impact on sequestering carbon in the soil, above the baseline benefits previously found by past studies.

The second major finding of this study is that organic soil amendments are key players in carbon sequestration. Organic production uses natural sources of soil amendments like compost and this gives organic the biggest boost in carbon sequestration with quick results—according to this study, using best practices when it comes to biological soil amendments boosts soil organic carbon by an average of **24%**. And because much of that carbon was found in the top 50 cm (20 in) of soil, using organic amendments is one of the most impactful strategies to quickly replenish carbon back into the soil, which improves soil health and builds resilience to climate changes.

Organic: And the benefits keep giving

The importance of soil amendments is no surprise given past research that has looked into conventional management of soil inputs. Some studies, for example, have estimated that fertilizer contributes 75% of total agricultural greenhouse gas emissions.

Studies looking at recently transitioned organic farms and studies looking at farms that have been managed organically for over a decade all show increased carbon stores in the soil from organic soil amendments.

The carbon benefits of conservation tillage are not as strong as best practices in soil amendments, which is notable because tillage is an important weed management tool for some organic farmers. Even with tillage, organic farmers still see a benefit to carbon sequestration from the amendments they're using, and this study shows that conservation tillage can add an additional level of carbon sequestration if it is feasible for the farm.

Using conservation tillage on top of organic management has a beneficial impact on carbon sequestration, with an average increase of 14% in soil organic carbon concentrations.

This study also quantified not just how well each organic soil management practice sequestered carbon, but also how long each practice takes to see positive impacts on soil health.

Interest in the impacts of long-term organic management practices has increased lately, especially as results from long-term systems trials suggest that soil health and yield can increase over time the longer a farm is managed organically. However, understanding exactly how many years are needed to see the impact of specific farming practices is less understood. This study found that some practices had immediate effects, such as the use of organic amendments, which improved soil carbon after just months of their use. Other practices took longer to have a significant effect: cover cropping, for example, showed a significant increase in carbon sequestration after five years that rivaled that of conservation tillage.

Diversifying practices matters

The study authors also stress the need for the adoption of multiple best management practices simultaneously. While each individual practice has benefits to carbon sequestration, challenges associated with organic farming can be better mitigated by a holistic suite of conversation tools when they are implemented in tandem.

Finally, this study identified important research gaps that need to be filled in order to better understand how organic farming can continue to lead the way in increasing carbon sequestration. One practice that needs more scientific exploration is the length and diversity of crop rotations, as there is a dearth of research on how crop rotations impact carbon sequestration within organic systems. There is also little information about the impact of climate engineering tools such as biochar. While the use of biochar has been suggested as a tool for increasing carbon sequestration, few studies have examined these impacts within organic systems.

Organic: Mitigating and adapting to climate change

Intensive agriculture can have devastating effects on soil health as it degrades soil aggregation and water holding capacity, prevents carbon sequestration, and leads to runoff and erosion. In contrast, the improvement and maintenance of soil health is considered a cornerstone of organic and the National Organic Program mandates that farmers use practices that ultimately reduce greenhouse gas emissions, lock carbon into the soil, and increase resilience to extreme weather conditions associated with climate change. For example, certified organic farmers are prohibited from using synthetic pesticides or chemical fertilizers that release a lot of greenhouse gas into the atmosphere. Instead, they rely on crop rotation, fertilizers derived from compost or manure, and the planting of winter cover crops.

These practices build robust communities of pollinators and natural enemies that manage pests and squeeze out weeds so that farmers don't need to rely on pesticide sprays, and restore important minerals in the soil that provide nutrients to crops and microbes that help fight diseases. Together, organic practices not only reduce greenhouse gas emissions, but they also put carbon back into the soil to help slow down climate change. And the healthy soils that result from organic farming help farmers adapt to drought, flooding, and severe storms that are already increasing due to climate change.

The Organic Center has been building an extensive portfolio looking at ways to fight climate change and build soil health. In addition to showing the benefits of organic in sequestering carbon and reducing global nitrogen pollution, we have also worked on projects that will help farmers build soil health within their farms. Check out this project that examined over 150 published studies to take an inventory of current knowledge on best practices within organic for enhancing soil health, providing a roadmap for current management opportunities and future research directions.
Here are some of the key practices to improve soil health from the project:

Crop rotations

Crop rotations are a fundamental farming practice that is defined simply as a sequence of different crops grown on the same land over time. They break pest and weed cycles to more efficiently cycle nutrients and to reduce economic risk. Longer rotations with perennial crops like alfalfa have been shown to be the most impactful.

Cover crops

Cover crops are usually non-cash crops that are incorporated into crop rotations in place of leaving the ground bare while resting. Cover crops can reduce erosion and runoff, improve nutrient cycling, and accumulate large quantities of above and belowground biomass that leads to more carob sequestration.

Organic soil amendments

Instead of using synthetic nitrogen fertilizers to manage soil fertility, organic farmers use soil amendments such as compost, aged or raw manures, and green manure (nitrogen-rich cover crops that are turned back into the soil). When organic amendments are combined (e.g. manure + vermicompost) they show higher nitrogen availability, soil pore connectivity, crop yield and more carbon sequestration than when applied alone.

Conservation tillage

Tilling soil is used to help manage weeds and to turn the soil before planting the next crop. But too much tillage can destroy soil structure and can lead to soil organic carbon loss, which negatively impacts soil infiltration, water holding capacity, nutrient cycling, and microbial dynamics. Reduced-tillage strategies maximize soil ecosystem services while providing weed control.

About The Organic Center

The Organic Center is your trusted source on the science of organic food and farming. We serve up unbiased research so you can make choices based on scientific findings.

The Organic Center is a 501(c)(3) non-profit research and education organization.

This project with the **University of Maryland** builds on the extensive work The Organic Center has completed to support soil health and climate change mitigation. After our ground-breaking large-scale study with **Northeastern University** showing that organic soil management sequesters significantly more carbon in the soil, we have built a network of studies that fit together to provide critical information for battling climate change. Our scientific publications and research reports look at everything from boosting soil health to reducing nutrient pollution.

We have several ongoing projects that will leverage the findings from this project. Research in collaboration with the **University of California Berkeley** connects organic farm practices for managing carbon sequestration and soil health to farmer yields. Another project, in collaboration with **Harvard University**, takes a look at the climactic impacts of organic agriculture from cradle to grave, identifying the positive aspects that organic has to offer mitigation.

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