Tackling Soil Health from Every Angle

Dr Christine Sprunger

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Soil health is fundamental to feeding the growing human population and mitigating the most damaging effects of global climate change. Despite its importance, the complex and dynamic nature of soil means that best practices for protecting and restoring Earth's soil are not always available. By bringing together different fields and employing innovative new techniques, **Dr Christine Sprunger** and her team at The Ohio State University are gaining insights on how to improve soil health and tackle some of our planet's biggest threats.

Save Our Soils

The soil under our feet is much more important than many of us believe. Soil is not the static substance it can appear to be at first glance. Instead, soils are diverse environments for a wide variety of lifeforms, and host some of the planet's most important chemical and biological cycles. Soil also sits at the centre of many of humanity's greatest challenges, including climate change and food insecurity.

As the global human population grows, we face multiple seemingly contradictory goals. With an estimated 26.4% of Earth's population experiencing food insecurity, we need to greatly increase our global food production. At the same time, we also need to reduce the negative impact of agriculture on Earth's soils – a critical resource that is quickly becoming degraded around the world.

Over the past few decades, the major focus of conventional agriculture has been to increase crop yields. Most cropping systems involve adding synthetic fertilisers and churning up the soil between harvests, in a process known as tilling. Tilling is a common practice often used to mechanically destroy weeds and prepare the soil for planting. In the short term, tilling and adding synthetic chemicals lead to huge increases in yields; however, these practices degrade soils, causing them to lose nutrients over the long term.

As soil becomes degraded by chemical fertilisers, pesticides, tilling and other management techniques, it can lose its structure and become washed away. In fact, billions of tonnes of fertile topsoil are lost every year, and with it the crucial ecosystem services it provides, including its amazing ability to simultaneously produce food, purify water and store carbon.

Furthermore, agriculture is a major source of greenhouse gas emissions, contributing to global climate change. By increasing the severity and frequency of extreme weather events such as droughts and storms, climate change further threatens our ability to grow food. Not only do fertilisers indirectly release greenhouse gases during their manufacture, but they also directly release nitrous oxide within the soil. Nitrous oxide is a potent greenhouse gas with a warming effect 300 times that of carbon dioxide.

Healthy soil is a vital piece of the puzzle in our fight against global climate change. Not only are healthy soils more resilient to climate events, but they can actually act as a carbon sink, capturing carbon dioxide from the atmosphere and storing it in the ground as organic matter. Globally, soils store as much carbon as all plants above ground. Thus, if restored and protected, soils offer a real option for mitigating global climate change.

As soil is a complex dynamic system, it can be difficult to obtain a clear picture of what constitutes as 'healthy'. Fortunately, emerging techniques have given us new tools that allow scientists to measure soil's vital signs.

Perennial Plants and Crop Diversity

Dr Christine Sprunger and her colleagues at The Ohio State University are using new soil indicators to investigate how different management practices can lead to real improvements in soil health. In a recent study, Dr Sprunger's team examined the effects of different types and mixtures of crops on soil health.

'We have a primary goal of examining how global change biology, biodiversity, and management impact soil health and rhizosphere processes for enhanced ecological function in annual and perennial dominated landscapes,' explains Dr Sprunger.

Perennial plants are plants that live and grow year after year, as opposed to annual plants, which grow, produce seeds and die all within one growing season. Perennial plants have some advantages: they are in the soil year-round, exhibit deep root systems and biological activity, ultimately reducing erosion as the soil is never left bare.

Dr Sprunger and her colleagues used new soil health indicators that are more sensitive to changes in soil management than previous approaches. They hoped to gain a deeper understanding of soil carbon dynamics. Greater knowledge of these mechanisms would help researchers to understand exactly how soils store and release carbon dioxide, in order to find ways of maximising the amount of carbon stored. The team examined soil health indicators at the Biofuel Cropping System Experiment, a long-term experimental trial located at the W.K. Kellogg Biological Station in southwest Michigan. The experiment was established in 2009 and consists of annual row-crops, perennial grasses of just one species, and multiple species of perennial plants mixed together.

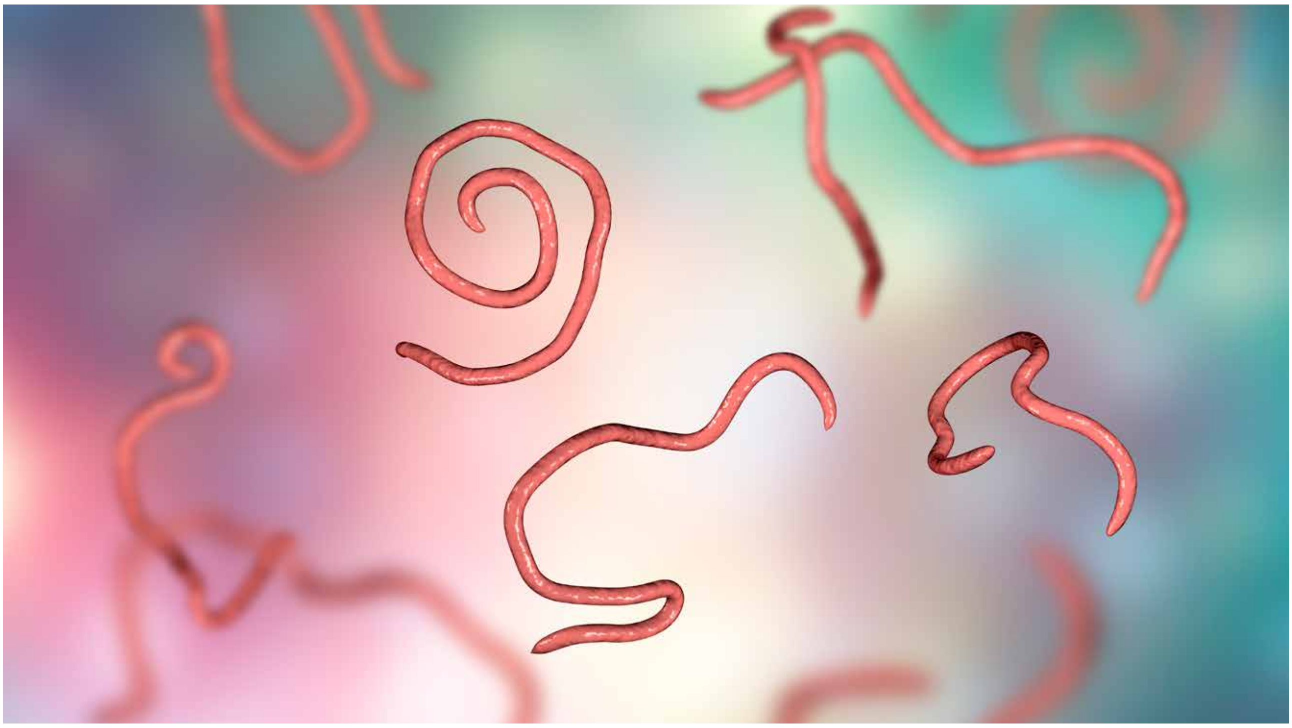
Their findings demonstrated that having a diverse mixture of different crops planted together enhanced soil health in both annual and perennial systems. They saw the largest gains in soil health in plots containing a mixture of perennial species, showing that this could be an effective strategy for stabilising carbon into the soil – allowing the soil to act as a carbon sink.

'The realisation that both perenniality and diversity are needed for accelerated accumulation of carbon is a novel finding that has important implications for land managers working to sequester carbon,' says Dr Sprunger.

Her team's study gives more evidence to core soil health practices – namely increased crop diversity, year-round cover, living roots, and reduced soil disturbance from tilling.

Science via Mail

Agricultural scientists will usually have test strips of land at their research centres to study different agricultural practices. This allows them to control various research parameters, so that they can isolate the benefits and disadvantages of each different factor. However, such studies can often fail to capture all of the different, complex and complementary approaches that farmers use to manage their land. Therefore, on-farm studies can offer a much more realistic picture when assessing the effects of farming practices.



Therefore, Dr Sprunger and her colleagues sought to find evidence for how different organic farming practices affect soil health in the context of real farms. 'I work on interdisciplinary teams to assess how management impacts soil health on local and regional scales,' says Dr Sprunger. 'Linking management practices to soil health outcomes at regional scales has rarely been done, making this work extremely innovative.'

The team wished to determine which organic farming practices are best suited to which soil types using data collected from real working farms. However, practical constraints usually mean that a study like this can only be conducted on a very small number of farms. The team had an ingenious solution to this issue: mail-in soil. The team asked farmers to collect samples of their soil and mail them to the university for analysis.

Using this novel method, her team collected 195 samples from organic cornfields across Michigan, Indiana, Ohio, and Pennsylvania. This alone would provide useful data, but by combining it with surveys on the farmers' management practices, the team could tease apart the complex interactions between soil type, management practices and soil health.

Dr Sprunger showed that in a farm setting, increasing the diversity of crops was not enough. In fact, the farmers that had the best soil health indicators not only grew diverse mixtures of perennial species, but they also practised low tillage to minimise soil disturbance.

Planet of the Worms

Dr Sprunger and her lab noticed that most soil health research focuses only on bacteria and fungi, opening up new opportunities for investigating different organisms. 'Our lab has recognised an important need in developing nematodes as a potential indicator of soil health,' says Dr Sprunger.

Nematodes are microscopic worms found in soils across the world. These tiny worms are so ubiquitous, that it has been estimated that about four out of every five animals on Earth are nematodes. Nematodes live short lives, so their numbers respond quickly to changing environmental conditions. In addition, they feed on fungi and bacteria, and play numerous roles in soil cycling.

Dr Sprunger's work is also gaining attention: she has been awarded a total of six grants to further explore nematodes as a potential indicator to assess ecosystem health. Findings from her team reveal that nematodes reflect how the nutrients in the soil are changing, offering important insights into the nitrogen and carbon cycles.

The Future of Soil

Climate change and conventional agricultural practices pose serious threats to one of our planet's greatest assets: its soil. As extreme weather events increase in frequency, we need a deep understanding of how our soil will be affected. Dr Sprunger and collaborators have also received a large grant from the National Institute of Food and Agriculture to explore flooding impacts on soil dynamics in corn fields.

The health of Earth's soils is fundamental to our ability to produce food in the face of climate change and other threats. However, with a deeper understanding of soil dynamics, we could transform humanity's future on this planet, by enabling the soil to work as a carbon sink, and recovering damaged soil ecosystems – all while increasing global crop yields.

Meet the researcher

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Dr Christine Sprunger gained her PhD in Crop and Soil Sciences and Ecology, Evolutionary Biology, and Behavior at Michigan State University in 2015. Upon graduating, she became an NSF Postdoctoral Fellow in Biology at the Agriculture and Food Security Center at Columbia University.
Dr Sprunger then moved to The Ohio State University to work as a Postdoctoral Research Scientist in the School of Environment and Natural Resources. She now works in her current position as Assistant Professor of Soil Science and Rhizosphere Processes in the same department. In her research, Dr Sprunger focuses on interactions between soil, plants, water, animals and humans, and how we can build resilience in our agricultural systems in the face of a changing climate. Starting from August 2022, Dr Sprunger will be joining the Department of Plant, Soil, and Microbial Sciences and the Kellogg Biological Station at Michigan State University as an Assistant Professor of Soil Health.

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FURTHER READING

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