

Effective soil organic carbon monitoring in perennial agriculture systems *Sampling protocol development and evaluation*

Perennial agriculture is gaining traction as a more sustainable option compared to traditional annual farming methods. One reason for this shift is its potential to boost soil health by increasing soil organic carbon (SOC) content. Carbon farming, which focuses on sequestering carbon in soils as a way to mitigate climate change, is also becoming increasingly popular due to the economic incentives it offers to farmers.

This MSc study aimed to develop and execute a sampling protocol for establishing a baseline for SOC levels, as part of a larger research project comparing the SOC balance of fields planted with perennial grain Kernza™ versus fields growing conventional annual crops over a five-year period. It also looked at the efficiency of different sampling protocols for accurately detecting changes in SOC over a short timeframe, by comparing the sampling protocol developed for this study to the sampling protocol proposed by the Swedish carbon farming initiative Svensk Kolinlagring (*Swedish Carbon Sequestration*).

This study, conducted in Alnarp, south Sweden, found that the SOC stock of the Kernza™ field was measured at 136.76 Mg SOC per hectare, while the control fields with conventional crops had 150.06 Mg SOC per hectare. This data was gathered through extensive field sampling and laboratory analysis. The difference between the two research fields was mostly due to the presence of a single outlier in the control field with unusually high SOC levels, especially at depth. Upon further investigation, it was found that the high levels at this location could possibly be explained by hydrology and land management.

When comparing the different sampling protocols, it was discovered that a large number of samples were necessary to be able to accurately detect relevant levels of SOC sequestration over a short time frame. It was also found that stratification—dividing the soil into subareas with similar characteristics—did not significantly reduce the required sample size. While the sampling protocol developed for this study would likely be able to detect the expected rate of SOC sequestration during the study period, the Svensk Kolinlagring protocol would not. It also would not be able to detect their own standard value of SOC sequestration of 300 kg ha⁻¹ yr⁻¹ during the five-year time frame.

Overall, the study underscores the importance of robust SOC sampling designs for both research purposes and the carbon farming market. It highlights the need for careful consideration of sampling protocols to accurately assess changes in SOC levels, which is crucial for advancing sustainable agriculture practices and maximizing the potential benefits of carbon farming initiatives. By better understanding how different agricultural methods impact soil health and carbon sequestration, we can work towards building more resilient and environmentally friendly food systems for the future.

Keywords: Physical geography, ecosystem science, soil organic carbon, soil sampling, perennial crops, carbon sequestration, carbon farming, Kernza™, SOC stock

Advisor: Jonas Ardö

Master's degree project 30 credits in Physical Geography and Ecosystem Science, 2024
Department of Physical Geography and Ecosystem Science, Lund University. Student thesis series INES nr 636