

4 per 1000 Soil Carbon Sequestration

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Abstract

The 4 per 1000 initiative aims to demonstrate that agricultural soils can play a crucial role in tackling food security and climate change. It intends to increase global soil organic matter stocks by 4 per 1000 per year as a compensation for the global emissions of greenhouse gases by anthropogenic sources. This paper surveyed the soil organic carbon (SOC) stock estimates and sequestration potentials from 20 regions in the world. This global snapshot showed that most countries demonstrated efforts and scopes for soil carbon sequestration. The potential to increase SOC is mostly on managed agricultural lands. Under best management practices, 4 per 1000 or even higher sequestration rates can be accomplished. High SOC sequestration rates can be achieved for soils with low initial C stock, and at the initial five years of the implementation of best management practices. Areas that have reached SOC equilibrium will not be able to increase their sequestration rate. The challenge for cropping farmers is to find disruptive technologies that will further improve soil condition and deliver enhanced soil carbon. As a strategy for climate change mitigation, soil carbon sequestration buys time over the next ten to twenty years whilst other effective sequestration and low carbon technologies become viable.

Introduction

The COP21 or 21st Conference of the Parties to the United Nations Framework Convention on Climate Change in Paris (November 30 to December 11, 2015) produced the Paris Climate Agreement on the reduction of climate change, limiting global warming to less than 2 Celsius degrees (C°) compared to pre-industrial levels and to pursue efforts to limit the increase to 1.5 C°. At the same time, the French Minister of Agriculture Stéphane Le Foll also initiated the ‘4 per mille Soils for Food Security and Climate’ programme. The 4 per 1000 initiative aspires to increase global soil organic matter stocks by 4 per 1000 per year as a compensation for the global emissions of greenhouse gases by anthropogenic sources. It was supported by almost 150 signatories (countries, regions, international agencies, private sectors and NGOs). The 4 per 1000 rate is not a fixed target but is meant to demonstrate that a small increase in the soil carbon stock of agricultural soils can offset greenhouse gas emission and contribute to improving soils condition and agricultural production. Stakeholders commit in a voluntary action plan to implement good farming practices that maintain or enhance soil carbon stock on agricultural soils and to preserve carbon-rich soils.

This paper brings together SOC experiences from 20 regions of the world (New Zealand, Chile, South Africa, Australia, Tanzania, Indonesia, Kenya, Nigeria, India, China Taiwan, South Korea, China Mainland, United States of America, France, Canada, Belgium, England & Wales, Ireland, Scotland, and Russia). We surveyed the soil carbon stock estimates of each region and asked whether the 4 per 1000 initiative can be adopted.

Results and Discussion

Soil carbon demonstrated a high spatial variation with increasing variation from field to regional, continental, and global extent. SOC stock varies with latitude and longitude with greater stocks at higher latitudes, decreases in the mid-latitudes, and increases in the humid tropics. Fig. 1 shows an estimate of global topsoil C stock based on legacy soil information and digital soil mapping techniques.

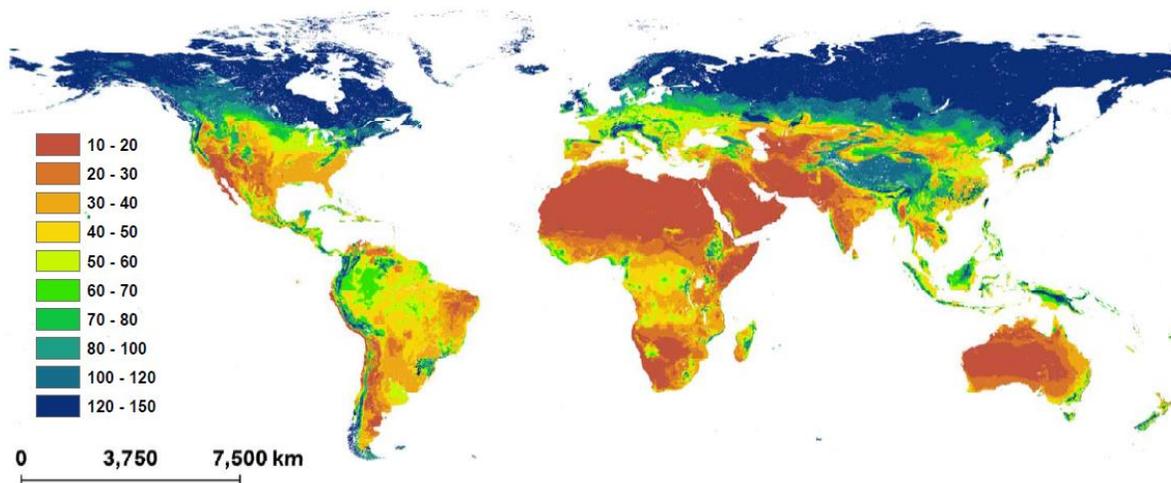


Fig 1: Global soil C stock (0-30 cm) in tonne C per ha.

We surveyed SOC sequestration potential from 20 countries and regions as a global snapshot of soil carbon conditions. Most countries are optimistic on the 4 per 1000 initiative and demonstrated efforts for soil carbon sequestration. Some countries (e.g. Australia & USA) have large agricultural areas with great potential to increase SOC stock, while in other countries, the total area available for cropping is limited (e.g. Belgium, S. Korea). In regions with high inherent SOC content, it may prove difficult to further increase their SOC levels. Conversely, in regions with low (inherent) SOC (e.g. India), it can also be difficult to increase the C content, as high temperature enhances decomposition, and the removal or burning of crop residues are still frequently practiced. Organic soils and peatlands present a massive problem in many countries (e.g. Chile, Scotland, Ireland, New Zealand, and Indonesia), here the aim is to ensure that these areas are carbon neutral.

Reported SOC sequestration rates generally show that under best management practices, 4 per 1000 or even higher sequestration rates can be accomplished. Global data indicated that there is a tendency of a higher C sequestration potential (10-30 per 1000) on croplands with low initial SOC stock (topsoil ≤ 30 t C ha⁻¹). Sequestration rates on grasslands which already have a high initial SOC stock (topsoil > 60 t C ha⁻¹) are limited to 4 per 1000. It also depends on the number of years after management practices have been employed. Data showed that within the first 5 years sequestration rate can be up to 20 per 1000, after 20 years up to 10 per 1000, and after 40 years limited to 4 per 1000 (Fig. 2).

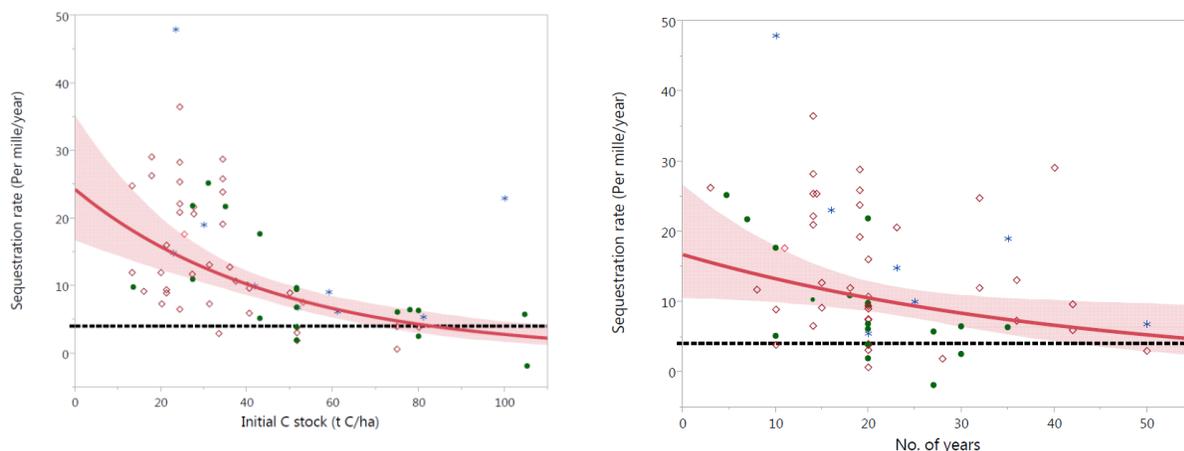


Fig 2: SOC sequestration rates in per 1000 based on studies in 20 regions of the world as a function of initial SOC stock and number of years since management practices been applied. The red curve is a regression model fitted to the data, the dotted line is the required 4 per 1000.

Conclusions

The 4 per 1000 initiative, for the first time, sets a global goal to promote good soil management that can help mitigate climate change. The top 1 m global agricultural soils hold about 480-790 Gt of C, and increasing SOC stocks for all of these areas by 4 per 1000 (between 2-3 Gt C per year) can offset about 20-35% of global greenhouse gases emission. Global studies showed that there is some scope to increase SOC. In addition, the initiative is an opportunity to implement a sound and credible soil carbon auditing protocol for monitoring, reporting, and verifying SOC sequestration which can be fit into national GHG inventory procedures.

As a strategy for climate change mitigation, SOC sequestration should be implemented immediately. It buys time over the next ten years whilst other effective sequestration and low carbon technologies will become viable.

Advancement in 4 per 1000 requires collaboration and communication between scientists, farmers, policy makers, and marketeers. Farmers and land managers primarily apply management practices to improve their soil's condition and, in doing so, contribute to the sequestering of SOC and mitigating climate change. Scientists provide innovation that can result in greater SOC sequestration, and SOC functioning. Scientists also develop new technologies in measurement, mapping, and auditing to verify SOC sequestration, which is expected by the market to provide confidence in investment. Farmers' SOC sequestration effort provides compliance to the policy makers. This has to be integrated with institutional regulations and policies that facilitate market-based approaches, such as C trading.

References

Minasny et al., 2017. Soil carbon 4 per mille, *Geoderma*, Volume 292, 15 April 2017, Pages 59-86, ISSN 0016-7061, <http://dx.doi.org/10.1016/j.geoderma.2017.01.002>.