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The 4 for 1000 Initiative - Increasing soil organic carbon to mitigate climate change

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Introduction, scope and main objectives

On December 1, 2015, the French Government launched the*"4 per 1000 Initiative: soils for food-security and climate"*, that will use a range of agricultural systems to sequester CO_2 and store in in the ground as soil organic carbon (SOC). Thirty-one countries signed onto this initiative along with key international organizations such as United Nations Food and Agriculture Organization, the Global Environment Facility, the International Fund for Agriculture Development, the World Bank and the Asian Development Bank. Twenty-six research institutes and universities have signed on along with over one hundred NGOs and private sector organizations. This initiative is intended to complement the necessary efforts needed to comprehensively reduce global greenhouse gas emissions.

The *4 per 1000 Initiative* is part of the framework of the Lima-Paris Action Agenda (LPAA). The title comes from research that determined: "A "4‰" annual growth rate of the soil carbon stock would make it possible to stop the present increase in atmospheric CO_2." (http://4p1000.org)

"This growth rate is not a normative target for every country but is intended to show that even a small increase in the soil carbon stock (agricultural soils, notably grasslands and pastures, and forest soils) is crucial to improve soils fertility and agricultural production and to contribute to achieving the long-term objective of limiting the temperature increase to +1,5/2°C, threshold beyond which the IPCC indicates that the effects of climate change are significant." (http://4p1000.org)

Atmospheric CO_2 level are increasing at 2 ppm per year. The level of CO_2 reached a new record of 400 parts per million (ppm) in May 2016. This is the highest level of CO_2 in the atmosphere for 800,000 years. (NOAS 2017)

In order for the *4 per 1000 Initiative* to achieve its objective to stop the present increase in atmospheric CO_2, agricultural systems would have to sequester 2 ppm of CO_2 per year. Using the accepted formula that 1 ppm CO_2 = 7.76 Gt CO_2 means that 15.52 Gt of CO_2 per year needs to be sequestered from the atmosphere and stored in the soil as SOC.

Stopping the increase in GHGs and then reducing them must be the first priority and this should be non-negotiable. Just moving to renewable energy and energy efficiency will not be enough to stop the planet from warming over the next hundred years and going into damaging climate change. 400 ppm is past the level needed to meet the Paris objective of limiting the temperature increase to +1.5/2°C. The levels need to be below 350 ppm. The excess CO_2 must be sequestered from the atmosphere to stop damaging climate change.

Soils are the greatest carbon sink after the oceans. There is a wide variability in the estimates of the amount of carbon stored in the soils globally (Scharlemann et al. 2014). According to Lal, 2008, there are over 2,700 gigatons (Gt) of carbon stored in soils. The soil holds more carbon than the atmosphere (848 Gt) and biomass (575 Gt) combined. There is already an excess of carbon in the oceans that is starting cause a range of problems. We cannot put any more CO_2 in the atmosphere or the oceans. Soils are the logical sink for carbon.

The scope of this paper is to use examples of agricultural systems that have published studies documenting their increases in SOC and to extrapolate the data to see how much CO_2 could be sequestered per year, globally to meet the aspirational goals of the *4 per 1000 Initiative* to stop the present increase in atmospheric CO_2. It is not the intention of this paper to use these types of generic exercises of globally extrapolating data as scientific proof of what can be achieved by scaling-up these systems. These types of very simple analyses are useful for providing a conceptual idea of the considerable potential of agriculture to sequester CO_2 on a landscape scale.

Methodology and Results

Most agricultural systems lose soil carbon with estimates that agricultural soils have lost 50 to 70% of their original SOC pool, and the depletion is exacerbated by further soil degradation and desertification. Agricultural systems that recycle organic matter and use crop rotations can increase the levels of SOC. (Lal 2014) This is achieved through techniques such as longer rotations, catch-crops, cover crops, green manures, legumes, compost, organic mulches, perennials, agro forestry, agroecological biodiversity and livestock on pasture using sustainable grazing systems. These systems are starting to come under the heading of regenerative agriculture because they regenerate SOC.

The Rodale Institute in Pennsylvania, USA, has been conducting long-running comparisons of organic and conventional cropping systems for over 30 years. The Farming Systems Trial manured organic plots showed that CO_2 was sequestered into the soil at the rate of 3,596.6 kg of CO_2 per hectare per year and when extrapolated globally across agricultural lands, would sequester 17.5 Gt of CO_2 per year. (La Salle and Hepperly 2008)

Total Agricultural Land: 4,883,697,000 ha *Source:* (FAO, 2010)
Organic @ 3,596.6 kg CO_2/ha/yr x 4,883,697,000 = 17.5 Gt of CO_2 /yr.

A meta-analysis by Aguilera et al. 2013 of 24 comparison trials in Mediterranean climates between organic systems and non-organic systems found that the organic systems sequestered 3559.9 kilograms of CO_2 per hectare per year. When the data is extrapolated globally across agricultural lands, these systems would sequester 17.4 Gt of CO_2 per year.

The Louis Bolk Institute made a study to calculate soil carbon sequestration at Sekem, the oldest organic farm in Egypt. Their results show that on average Sekem's management practices sequestered 3,303 kgs of CO_2 per hectare per year for 30 years. Based on these figures, the widespread adoption of these practices globally has the potential to sequester 16 Gt of CO_2 into soils per year. (Koopmans et al, 2011)

The Rodale Compost Utilization Trial showed that CO_2 was sequestered into the soil at the rate of 8,220.8 kg of CO_2 per hectare per year and if extrapolated globally would sequester 40 Gt of CO_2/yr. (La Salle and Hepperly 2008)

68.7% of the world's agricultural lands (3,356,940,000 ha) are used for grazing (FAO, 2010). There is an emerging body of published evidence showing that pastures can build up SOC faster than many other agricultural systems and this is stored deeper in the soil. (Fliessbach et al 1999,Tong et al 2015)

Research by Machmuller et al. 2015: "In a region of extensive soil degradation in the southeastern United States, we evaluated soil C accumulation for 3 years across a 7-year chronosequence of three farms converted to management-intensive grazing. Here we show that these farms accumulated C at 8.0 Mg ha−1 yr−1, increasing cation exchange and water holding capacity by 95% and 34%, respectively."

To explain the significance of these figures: 8.0 Mg ha−1 yr−1 = 8,000 kgs of carbon being stored in the soil per hectare per year. Soil Organic Carbon x 3.67 = CO_2, means that these grazing systems have sequestered 29,360 kgs (29.36 metric tons) of CO_2/ ha/yr.

If these regenerative grazing practices were implemented on the world's grazing lands they would sequester 98.5 gt CO_2/yr. (Grasslands: 3,356,940,000 ha (FAO, 2010) x 29.36 = 98.5 gt CO_2/yr)

At the time of writing there are a range other regenerative agricultural systems that are getting high levels of carbon sequestration. These systems are currently in the process of being published in peer reviewed scientific journals.

Discussion

The above examples show that there are agricultural systems that could sequester enough CO_2 and store it as SOC to meet the aspirational goals of the *4 per 1000 Initiative*.The key issues here are:

1. Urgent research should be commenced to understand how and why these systems sequester significant levels of CO_2 and then look at how to apply the findings for scaling-up on a global level in order to achieve a significant level of GHG mitigation.
2. The signatories the *4 per 1000 Initiative*, including governments and international organizations, should start programs training farmers in the regenerative agriculture systems that increase SOC.
3. Further research can improve the rates of sequestration.

The immediate goal must be to stabilize the CO_2 in the atmosphere at 400 ppm to prevent any further increases in the extreme weather events caused by climate change. Ideally, this should be done by capping the current emissions and adopting a combination of renewable energy and energy efficiency. However under the Paris agreement this will not happen until 2030 at the earliest. The widespread introduction of regenerative farming systems can make a considerable contribution to stabilizing atmospheric CO_2.

Conclusion

The *4 per 1000 Initiative* has enormous potential to assist in sequestering CO_2 and mitigating climate change. The fact that many countries, international organizations, research institutions, universities, NGOs and private sector organizations are signatories means that there is a significant level of support for the implementation of this initiative. The potential of the regenerative agriculture systems are enormous, considering that these data are based on current practices.

These examples are ‘shovel ready’ solutions – while research is needed to improve the rates of sequestration, the examples given are based existing practices. There no need to invest in expensive, potentially dangerous and unproven technologies such as carbon capture and storage or geo-engineering. All that is needed is to scale up the existing good regenerative agriculture practices. Their rates of sequestration can be further improved through research.

Regenerative agriculture can change agriculture from being a major contributor to climate change to becoming a major solution. The widespread adoption of these systems should be made the highest priority by governments, international organizations, industry and climate change organizations.

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