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COMMENTARY

Challenges to increasing the soil carbon pool of agro-ecosystems in China

LIN Er-da, GUO Li-ping, JU Hui

Institute of Environment and Sustainable Development of Agriculture, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China

Abstract

Climate change will place agro-ecological systems and food security at serious risk. At the 21st Conference of the Parties (COP21) in Paris in December of 2015, parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a historic agreement (Paris Agreement) to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. An initiative named the "4‰ initiative: Soils for food security and climate" was proposed by the French Minister of Agriculture, and this initiative was launched officially at the COP21 and adopted by many global organizations. The aim of this initiative was to increase carbon sequestration in soil to mitigate fossil fuel combustion emissions of greenhouse gasses. The present study found that China has high CO_2 emissions but a low soil carbon pool, and indicates that 4‰ increments of the soil carbon pool will not be sufficient to offset national CO_2 emissions. The current soil carbon sequestration rate would also not reach the mean level requested by the initiative. Therefore, China faces big challenges to achieve this initiative. An integrated use of straw technology may be used more widely to improve carbon sequestration, and other opportunities include improved fertilizer use efficiency and greenhouse gas mitigation through the waste management project under construction in China. This paper suggests that China may put forward the biomass treatment centered high yield and fertilizer-carbon sequestration project to enhance resilience of agro-ecosystems to climate change.

Keywords: soil organic carbon sequestration, climate change, greenhouse gas mitigation, agriculture resilience

1. China is party to the Paris Agreement that aims to mitigate climate change global warming to under 2 degrees

On December 12, 2015, at the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of the Parties (COP21) in Paris, France, 195 parties around the world have adopted the Paris Agreement, to ensure that the global average temperature rise does not exceed 2 degrees. Before the climate conference in Paris, more than 180 countries, including China, submitted mitigation related documents (Xinhua 2015), such as actions and

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Correspondence LIN Er-da, E-mail: linerda@caas.cn

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policy measures including agricultural adaptation measures to achieve climate change goals. If the average temperature rise is near or above 2 degrees, climate change will greatly increase the uncertainty of agricultural production, and threaten food security.

2. Control of agricultural greenhouse gas (GHG) emissions should be incorporated into China's climate change strategy

Agricultural ecosystems are not only the victims of climate change and extreme events (Smith *et al.* 2014), but are also emitters of GHG such as N_2O and CO_2. The National Inventory of greenhouse gases did not give estimates of direct emissions from soils due to some uncertainties (Yu *et al.* 2007; NDRC 2014). In 2007, non-CO_2 greenhouse gases accounted for 13% of Chinese total GHG emissions (NDRC 2014). As they form a large part of total emissions, the control of agricultural greenhouse gas emissions should be incorporated into the national climate change strategy as soon as possible (Xinhua 2015).

3. The 4‰ initiative for increasing the soil carbon pool to offset national greenhouse gas emissions from fossil fuel combustion

At the end of the 2015 UN Climate Conference in Paris, the French Minister of Agriculture put forward an international initiative called the "4‰ initiative: Soils for food security and climate" which aimed to show that achieving food security and combating climate change are complementary, and to ensure that agriculture provide solutions to climate change. This initiative consists of a voluntary action plan under the Lima Paris Agenda for Action (LPAA), and is backed up by a strong and ambitious research program (Minasny 2015; UNFCCC 2015).

The "4 per 1 000" Plan is based on the global amount of organic carbon stored in 2-m deep soil of 2.4 trillion tons, and the current global fossil fuel emissions from combustion of about 8.9 billion tons of carbon equivalent, which is equivalent to 4‰ of global reserves of soil organic carbon. This means that global fossil fuel emissions can be offset by increasing world soil organic carbon reserves by 4‰ each year. The "4 per 1 000" Plan is beneficial for global food security by improving the soil organic matter content and is a key support to mitigate climate change (Sun *et al.* 2010; Milne *et al.* 2015). Therefore, the project can be thought of as an ambitious plan for the sustainable development of the world.

The plan calls for an average increase in soil carbon of 0.6 tons per ha per year for the 149 million square kilometers of global land used by the global population of 7.5 billion for producing enough food, to offset the global fossil fuel combustion emissions of greenhouse gases (Minasny 2015).

A recent study suggested that from 1985 to 2006 in China, the surface soil organic carbon (0–20 cm) increased by an average of 25.5 Tg yr^{-1}, about 0.2 tons per ha, only one third of the 0.6 t ha^{-1} yr^{-1} was needed to offset greenhouse gas emissions from fossil fuel combustion (Pan *et al.* 2010; Cheng *et al.* 2013). Further, on non-cultivated land, there is likely to be little or no increase in soil carbon.

China therefor faces big challenges to achieve this initiative. An integrated use of straw technology may be used more widely to improve soil carbon sequestration, and other opportunities include improved fertilizer use efficiency and greenhouse gas mitigation through the waste management project under construction in China.

4. Enhancing resilience of agricultural ecosystems

This paper suggests that China may put forward the biomass treatment centered high yield and fertilizer-carbon sequestration project to enhance resilience of agro-ecosystems to climate change. Enhancing the capacity of irrigation to increase production and improvement of soil fertility are two important measures to ensure agricultural resilience. Since 2005, the Ministry of Agriculture of China has implemented a soil testing and fertilizer project (MOA 2009) called the "Soil Organic Matter Increase Subsidy Project" across the country (Lu *et al.* 2009; MOF 2016), that supports farmers returning straw to the soil, planting green manure crops, and increasing organic fertilizer application. It is expected to run for 20 years, and increase soil carbon sequestration of farmland over the whole country to 0.6 to 1 Pg, namely an increase of 30–50 Tg per year on average, equivalent to 0.25–0.4 t ha^{-1} annual carbon sequestration (Pan *et al.* 2010). If implementation of the project increases the amount of straw returned to soil, and at the same time, incorporates the use of organic fertilizer containing more beneficial microorganisms, and other manure and technologies such as soil conditioner, the soil carbon sequestration rate may reach 80 Tg yr^{-1}, or 0.6 t ha^{-1}.

In the long run, improved farmland management and restoring degraded land are key measures to promote agricultural ecosystem productivity and resilience. If more crop straw can be returned into soil and become soil organic carbon, the system resilience will be enhanced.

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