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Conservation Tillage on the Loess Plateau, China: Food security, Yes; Carbon sequestration, No?

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Climate change is expected to affect food security globally and increase the variability in food supply. At the same time, agricultural practices offer a great potential for mitigating and adapting to climate change. In China, food security has increased in the last decades with the number of undernourished people declining from 21% in 1990 to 12% today. However, the limited relative amount of arable land and scarce water supplies will remain a challenge. The Loess Plateau of China, located in the mid-upper reaches of the Yellow River and has an area of some 630000 km2 with a high agricultural potential. However, due to heavy summer rainstorms, steep slopes, low vegetation cover, and highly erodible soils, the Loess Plateau has become one of the most severely eroded areas in the world. Up to 70% of arable land is affected by an annual soil loss of 20-25 ton ha-1, far exceeding the threshold for sustainable use (10 ton ha-1). Rainfed farming systems are dominant on the Loess Plateau, and the farmers in this area have been exposed to a steadily increasing temperature as well as an erratic, but slightly decreasing rainfall since 1970. Therefore, adaptation of the regional agriculture is required to adapt to climate change and may be even engaged in mitigation.

This study analyzed the potential contribution of conservation tillage to adaptation and mitigation of climate change on the Loess Plateau. In total, 15 papers published in English were reviewed, comparing two tillage practices, conventional tillage (CT) and conservation tillage typically represented by no-tillage (NT). Soil organic carbon (SOC) stock across soil depths as well yields and the inter-annual variations with regards to and their annual rainfall precipitation were compared for NT and CT.

Our results show that:

1) The benefit of NT compared to CT in terms of increasing total SOC stocks diminishes with soil depth, questioning the use of average SOC stocks observed in topsoil to estimate the potential of NT in increasing SOC stocks to reduce net CO_2 emissions.

2) In each soil layer, the total SOC stocks also declined over time. Such a decreasing trend suggests that the SOC sink was approaching its maximum capacity. This implies that the overall potential of NT in improving SOC stocks is apt to be over-estimated, if annual increases derived from short-term observation are linearly extrapolated to a long-term estimation.

3) Yields of NT increased evidently by 11.07% compared to CT. In particular, during years with precipitation <500 mm, NT yields are 18% higher than for conventional tillage. Such greater yields reduce the probability of food production falling below minimum thresholds to meet subsistence requirements, thereby increasing resilience to famine.

Overall, conservation tillage (no-till) has great potential in stabilizing crop yield and thus ensuring local subsistence requirements on the China Loess Plateau. However, the potential of NT to sequestrate SOC is limited than often reported and has maximum capacity, and thus cannot be linearly extrapolated to estimate its effects on mitigating climate change.