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Losses in Carbon and Nitrogen Stocks in Soil Particle-Size Fractions along Cultivation Chronosequences in Inner Mongolian Grasslands

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Cultivation in semiarid grasslands induces large changes in soil organic matter (SOM) stock. To better predict the effects of cultivation on SOM pools, there is a need to identify the soil fractions that are affected and the extent to which they are affected. Using four cultivation chronosequences in Inner Mongolian grasslands of northern China, we investigated the changes in soil organic carbon (SOC) and total nitrogen (N) stocks in soil particle-size fractions to identify the effect of cultivation on SOM dynamics. The results showed that conversion of native grasslands into croplands significantly decreased the SOC stocks (4.34–31.65 Mg C ha^{-1}) and N (0.19–2.54 Mg N ha^{-1}) in the 0- to 100-cm layer after cultivation. Prominent changes were observed in the SOC and N stocks in the 0- to 10-cm layer and were, on average, 6.56 Mg C ha^{-1} (24.85%) and 0.63 Mg N ha^{-1} (23.48%), respectively. The effect of cultivation on the SOC and N stocks in soil fractions was in the order sand > silt > clay. The C and N stocks in the 0- to 10-cm soil layer in the sand fraction in croplands decreased, on average, by 4.74 Mg C ha^{-1} (35.86%) and 0.48 Mg N ha^{-1} (41.30%), respectively, compared with those in native grasslands. The declines in the silt and clay fractions were small. Thus, sand fraction was a more important contributor to C and N losses in soil after cultivation than silt or clay fraction. Our findings indicate that the preliminary responses of SOC and N to cultivation in a semiarid grassland area and have significant implications for assessing the loss or gain of C and N during grassland conversion.

Grasslands cover approximately 40% of the world's land area and store approximately one-third of the total terrestrial carbon (C), of which more than 70% is stored in the top 100-cm soil layer (White et al., 2000). Changes in land use can induce substantial changes in soil organic carbon (SOC), which represents an important source or sink of atmospheric CO_2, although the processes and mechanisms involved in C cycles in soil are not completely understood (Guo and Gifford, 2002; IPCC, 2007). In the past few decades, grasslands around the world have received more attention for their potential to act as C sinks in view of their substantial area and immense SOC stock (Conant et al., 2001; Soussana et al., 2004; Lal, 2009).

Temperate grasslands in northern China constitute an area of approximately 110×10^6 ha, and a large number of native grasslands have been converted into croplands; this occurred especially in the 1960s and 1990s. Some studies have shown that conversion from native grasslands to croplands can result in a 20 to 70% net loss of SOC in surface soil, and the decrease depends on grassland type, soil properties, and duration of cultivation (White et al., 2000; Guo and Gifford, 2002; Wang et al., 2008). When native grasslands are converted into croplands, cultivation practices destroy native vegetation and soil structure, decrease surface cover, and modify the biogeochemical cycles in soil. This enhances the microbial decomposition of soil organic matter (SOM) and wind and water erosion, which leads to substantial SOM losses (Guo and Gifford, 2002; Liu et al., 2004; Lal, 2009). On the other hand, whenever a change in land use decreases SOC, the reverse change usually increases SOC by C sequestration, and vice versa (Conant et al., 2001; Guo and Gifford, 2002). Therefore, data from cultivation chronosequences in northern China should be a good indicator of not only the SOC as a source of atmospheric CO_2 but also of the potential of C sequestration in the region through the conversion from croplands to grasslands.

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Abbreviations: AC0, Site A native grassland; AC19, Site A 19-yr cultivation; AC49, Site A 49-yr cultivation; BC0, Site B native grassland; BC19, Site B 19-yr cultivation; BC39, Site B 39-yr cultivation; BD, bulk density; CC0, Site C native grassland; CC39, Site C 39-yr cultivation; CC51, Site C 51-yr cultivation; SOC, soil organic carbon; SOM, soil organic matter.