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Land-use change reduces soil nitrogen retention of both particulate and mineral-associated organic matter in a temperate grassland

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ABSTRACT

Soil organic matter (SOM) fractions vary in formation and microbial activities, thus playing different roles in exogenous nitrogen (N) retention in terrestrial ecosystems. However, it remains unclear how land-use and environmental changes affect the behavior of SOM fractions in retaining exogenous N. Here, we investigated N distribution among four SOM fractions and how soil N retention capacity responds to tillage and increased snowfall. We monitored N retention in SOM fractions by adding $^{15}NH_4^{15}NO_3$ isotope in the field in a temperate grassland in Inner Mongolia. Our results showed that the fine mineral-associated organic matter (MOM < 20 μm) had the largest N pool with a lower mass. The free particulate organic matter (fPOM) accounted for only 0.8% of total SOM mass, representing the second-largest N pool. The coarse mineral-associated organic matter (MOM > 20 μm) represented the fewer N pool with the largest mass. MOM < 20 μm and fPOM retained >90% of the ^{15}N tracer in soil. Deepened snow did not affect ^{15}N retention in SOM fractions, while tillage decreased ^{15}N retention in MOM < 20 μm, fPOM, and occluded particulate organic matter within aggregates (oPOM). We suggested that the reduction in soil total N retention under tillage conditions was mainly due to the reduced N retention in fPOM and MOM < 20 μm. Structural equation modeling analysis revealed that tillage-induced decrease in ^{15}N retention of MOM < 20 μm was regulated by both decreased microbial ^{15}N retention and reduced clay and silt contents. The decrease in ^{15}N retention of fPOM was probably due to the decreased microbial ^{15}N retention along with the increased plant ^{15}N uptake. This research reveals divergent pathways of ^{15}N retention among different SOM fractions in response to land-use change and provides novel insights into the estimation of soil N retention capacity with SOM fractions taken into consideration.

1. Introduction

During recent decades, fossil fuel combustion and fertilizer use have resulted in increasing atmospheric nitrogen (N) deposition, potentially impacting the N cycle in terrestrial ecosystems (LeBauer and Treseder, 2008). Soils that consist of various soil organic matter (SOM) fractions are the main long-term sinks for deposited N (Nadelhoffer et al., 2004; Templer et al., 2012). An increasing number of studies suggest that N is distributed in different SOM fractions (Giannetta et al., 2018; Liao et al., 2006). Different SOM fractions exhibit different abilities to retain exogenous N (Compton and Boone, 2002; Ma et al., 2020). Hence, further investigation of the mechanisms by which SOM fractions regulate soil N retention is needed to understand N retention in response to land-use and environmental changes.

The storage form of exogenous inorganic N in the soil is usually closely related to SOM fractions. Specifically, the newly formed nitrogenous residues and by-products after being absorbed by microorganisms mainly exist in the SOM interacting with soil fine minerals (MOM < 20 μm), representing the largest N pool in SOM fractions (Giannetta et al., 2018; Liang et al., 2020). Some N-containing compounds in the form of plant litter and microbial residues are stored in free particulate organic matter (fPOM), while others are retained in occluded particulate organic matter within aggregates (oPOM). Tillage, as one of the most common land-use changes in grasslands, can affect SOM fractions and subsequent soil N retention through direct and indirect processes (Alvarez et al., 1998; Beare et al., 1994). According to

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