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Distribution of soil organic carbon fractions as related to land use and management in the Loess Plateau, northern China

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Introduction

Organic C in the soil is not a uniform material but rather a complex mixture of plant, animal and microbial residues at different stages of decomposition (Post and Kwon 2000). So the dynamics of soil organic carbon (SOC) is usually described by dividing total SOC into different fractions (Six *et al.* 2002). Of all the different fractions, density defined fractions (light- and heavy fractions) may relate better to specific functions or processes (O'Hara *et al.* 2006), and the changes in SOC due to land use and management may be partly explained by the way C is allocated in these different SOC fractions (Tan *et al.* 2007). Previous research in the Loess Plateau of northern China indicate that, compared with the grassland restored from cropping, continuous tillage and proper management in cropland increased SOC storage in the lower soil horizons (Li *et al.* 2008). This study was conducted to investigate the distribution of light- and heavy fractions of SOC under cropland and grassland, aiming to better understand how the density fractions of SOC were affected by the land use conversion.

Methods

A grassland (GL) and an adjacent cropland (CL), each 2 ha, were selected as the experimental sites in the Semi-Arid Climate and Environment Observatory of Lanzhou University (SACOL) located Gansu, China (35°57'N, 104°09'E, 1966 m elevation). The region has a continental semi-arid climate with a mean annual air temperature of 6.7°C and a mean annual precipitation of about 382 mm. The soil is classified as a Sierozem. The grassland had been restored from cropping for 25 years and the dominant perennial grass species is *Stipa bungeana*. The cropland had been under arable use for at least 55 years and was planted with *Setaria italica* (L.) Beauv. in 2010. Three replicated plots (50 × 50 m) for each site, and two parallel 50 m transects 17 m apart within each plot were established. In May 2010 (after tillage but before sowing), composite soil samples for SOC and organic C fractions determinations were collected. Five samples at five soil intervals (0-10, 10-20, 20-30, 30-40, 40-60 cm) from the same transect were collected using a soil probe (6 cm diameter and 20 cm long) and then pooled by depth. Soil samples were separated into light- and heavy fractions following the

modified procedure of Gregorich and Ellert (1993). The collected light fraction was oven-dried (65°C for 72 h), weighed, and finely ground to pass a 60-mesh (250 µm) sieve for organic C determination. Total soil organic carbon (SOC) and light fraction organic carbon (LFOC) were analyzed by the oil bath-K₂CrO₇ titration method (oxidization with dichromate in presence of H₂SO₄, heated at 175°C for 5 min). Heavy fraction organic C (HFOC) was determined by the difference between SOC and LFOC. Soil bulk density was measured using metal rings of known volume.

Results

The results showed that SOC storage in the surface soil layer (0-10 cm) in GL was 31.4% higher than CL, while SOC storage in 0-60 cm soil layer and in each of 20- to 60-cm soil layers in CL was significantly higher than that in GL (Table 1). Both LFOC and HFOC in 0-10 cm soil layer were significantly higher in GL than that in CL, HFOC contributed more to the increment in SOC storage

Table 1. Characteristic summary of SOC storage associated with density fractions

Depth (cm)	Treat.	Carbon storage (g/m ²)			Storage contribution (%)	
		SOC	LFOC	HFOC	LFOC	HFOC
0-10	CL	731.9b	115.0b	616.9b	15.7b	84.3a
	GL	961.5a	199.3a	762.2a	20.7a	79.3b
10-20	CL	733.8a	92.0a	641.8a	12.5a	87.5a
	GL	682.9a	78.7a	604.2a	11.6a	88.4a
20-30	CL	771.9a	28.0a	743.9a	3.6b	96.4a
	GL	521.0b	33.5a	487.5b	6.5a	93.5b
30-40	CL	928.3a	22.2a	906.1a	2.7b	97.6a
	GL	437.5b	18.9a	418.5b	4.3a	95.7b
40-60	CL	1571.1a	28.0b	1543.1a	1.8b	98.2a
	GL	560.6b	41.9a	518.7b	7.5a	92.5b
0-60	CL	3951.6a	271.3b	3680.3a	6.9b	93.1a
	GL	3163.4b	372.4a	2791.1b	12.2a	87.7b

Note: Means within a column and depth followed by the same letter are not significantly different at $P < 0.05$. The storage contribution of the LFOC and HFOC to SOC.

in this soil layer (63.0%). The increase in the LFOC and HFOC with the conversion of cropland to grassland is probably due to increased aboveground biomass deposited on the surface and root litter incorporated into the soil (Li *et al.* 2008) and suboptimal decomposition environment in undisturbed soils (Guimarães *et al.* 2013). But in 20-30, 30-40 and 40-60 cm soil layers, HFOC storages in CL were 52.6%, 116.5% and 197.5% higher than that in GL, which might explain the higher SOC storage in CL. The higher HFOC storage in the lower soil horizons in CL were probably due to topsoil, rich in manure originated C (Römkens *et al.* 1999), being mixed with deeper horizons (Don *et al.* 2011) and being placed deeper caused by plowing and enhanced organic matter vertical transport (even to 80cm layer) (Römkens *et al.* 1999).

Conclusion

Restoration from cropland to grassland increased both LFOC and HFOC in surface soil, while long-term conventional cultivation with application of organic manure led to the increase in HFOC in lower soil layers, thus increased total SOC storage in cropland.

Acknowledgements

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