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Chemical composition of organic matter in a deep soil changed with a positive priming effect due to glucose addition as investigated by ^{13}C NMR spectroscopy

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ABSTRACT

Fresh organic carbon becomes more accessible to deep soil following losses of surface soil and deep intentional incorporation of crop residues, which can cause the priming effect and influence the quality and quantity of SOC in deep soil. This study determined the priming effect due to addition of water-dissolved ^{13}C-labeled glucose (0.4 g C kg^{-1} soil) to a soil taken from 1.00 to 1.20 m depth. The changes in chemical compositions of SOC in soils without (G_0) and with ($G_{0.4}$) glucose addition during a 31-d incubation were investigated with solid-state ^{13}C cross polarization/total sideband suppression (^{13}C-CP/TOSS) and CP/TOSS with dipolar dephasing nuclear magnetic resonance (NMR) techniques. No glucose remained in the soil after 21 days of incubation, with 48% being completely mineralized into CO_2 emission and 52% being incorporated into SOC. The native SOC was decomposed by 0.23% more in $G_{0.4}$ than in G_0. The NMR spectra demonstrated that both labile and recalcitrant organic compounds in SOC changed during the incubation, but in different manners in G_0 and $G_{0.4}$. During the incubation, the -$(CH_2)_n$-abundance in G_0 did not change over time, but in $G_{0.4}$ it decreased from Day 0 to Day 21 and then increased from Day 21 to Day 31, suggesting shifts of soil microbial communities only in $G_{0.4}$. After the incubation, in G_0 the abundances of ketones/aldehydes and nonpolar alkyl C increased, but those of aromatic C–C and protonated O-alkyl C (OCH) decreased; In $G_{0.4}$, the abundances of NCH and protonated O-alkyl C (OCH) increased, but those of nonpolar alkyl C and nonprotonated aromatic C–O and ketones/aldehydes decreased. Such inconsistent changes in recalcitrant compounds between G_0 and $G_{0.4}$ indicated that glucose addition likely primed the decomposition of aromatic C–O and suppressed the formation of ketones/aldehydes. We have demonstrated for the first time that the priming effect of SOC decomposition in the deep soil was involved with larger notable changes in both labile and recalcitrant structures of native SOC due to glucose addition compared with that without glucose addition.

1. Introduction

Soil is the largest pool of terrestrial organic carbon (Jobbágy and Jackson, 2000). Deep soils below the A horizon contribute 50%–81% of total soil organic carbon (SOC) storage in 1-m soil profiles (Jobbágy and Jackson, 2000), and provide more than one third of the plant nutrition of N, P and K, especially when the topsoils are dry or nutrient-depleted (Kautz et al., 2013). Deep soils become more accessible to fresh organic C inputs following

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