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Weaker priming and mineralisation of low molecular weight organic substances in paddy than in upland soil

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ABSTRACT

Although soil organic matter (SOM) and microbial biomass pools in flooded paddy soils are generally larger than they are in upland soils, the processes (i.e., slower mineralisation, other types of C stabilization, and a negative priming effect) underlying higher SOM stocks in paddy soil are unclear. To elucidate these processes, three ^{13}C labelled low molecular weight organic substances (^{13}C-LMWOS) (i.e., glucose, acetic acid, and oxalic acid) were incubated in upland and paddy soils under simulated field conditions. Within 30 days of incubation, acetic acid exhibited the highest mineralisation in both soils. The amount of mineralisation of glucose in upland soil was higher than that of oxalic acid ($p < 0.05$), whereas the opposite was observed for paddy soil. Mineralisation of all three LMWOS was lower in paddy soil than that in upland soil ($p < 0.05$), illustrating that the molecular structure of the LMWOS as well as soil management determined the mineralisation rate. The priming effect evoked by oxalic acid and glucose was lower in paddy than in upland soil ($p < 0.05$). Therefore, the generally weaker mineralisation and priming effect of LMWOS observed in paddy soil contributed to higher carbon accumulation than they did in upland soil. Priming effect was positively correlated with fungal abundance, which was lower in paddy soil than in upland soil. Thus, slow organic C turnover in paddy soil is partly attributed to the suppression of fungal activity by flooding.

1. Introduction

Terrestrial ecosystems play an important role in the global carbon (C) cycle. Low molecular weight organic substances (LMWOS), e.g., sugars, carboxylic acids, and amino acids, are derived from root exudates [1,2], leached litter products [3,4], microbial residues, and metabolic products [5]. The rapid mineralisation and turnover of LMWOS appears to dominate the total CO_2 emission of soil, despite their low concentration of these substances [4,6]. The mineralisation rates of LMWOS are generally very fast, ranging from minutes to days [7–9]. For example, in one study [10], 50% of glucose-C was observed to have been released as CO_2 within 20 days (d) in grassland soil, and more than 50% of applied ^{13}C amino acids (alanine and glutamate) were observed to have been mineralised after 10 d in an arable soil in another study [11]. Mineralisation is LMWOS-specific, e.g., a higher proportion of amino acids (19.4% of the total ^{14}C added) than of glucose (14%) are mineralised to CO_2 within 2 d in arctic tundra soil [12]. Moreover, C in a −COOH group oxidizes to CO_2 faster than C in a $-CH_3$ group [7]. Thus, the $-CH_3$ group contributes more to the formation of soil organic matter (SOM) than does the −COOH group. In short, the chemical nature of LMWOS largely

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