Soil Biology and Biochemistry 126 (2018) 179–190

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Interactive priming effect of labile carbon and crop residues on SOM depends on residue decomposition stage: Three-source partitioning to evaluate mechanisms

Muhammad Shahbaz[a,b,*], Amit Kumar[b,c], Yakov Kuzyakov[b,e,f], Gunnar Börjesson[a], Evgenia Blagodatskaya[b,d]

[a] Department of Soil and Environment, Swedish University of Agricultural Sciences, PO Box 7014, SE-75007, Uppsala, Sweden
[b] Department of Soil Sciences of Temperate Ecosystems, Department of Agricultural Soil Sciences, Georg August University Göttingen, Büsgenweg 2, 37077, Göttingen, Germany
[c] Chair of Ecosystem Functioning and Services, Institute of Ecology, Leuphana University of Lüneburg, Universitätsallee 1, 21335, Lueneburg, Germany
[d] Institute of Physicochemical and Biological Problems in Soil Science, Russian Academy of Sciences, 142290, Pushchino, Russia
[e] Agro-Technology Institute, RUDN University, Moscow, Institute of Environmental Sciences, Kazan Federal University, 420049, Kazan, Russia
[f] Soil Science Consulting, 37077, Göttingen, Germany

ARTICLE INFO

Keywords:
^{13}C & ^{14}C isotopic labelling
Glucose
Microbial activation
Residue quality and decomposition stages
SOM priming

ABSTRACT

Inputs of crop residues and labile C (*e.g.* root exudates) can affect the decomposition rate of soil organic matter (SOM) through the priming effect (PE). Most previous priming studies describe the addition of single labile or residue C, ignoring the interactions of labile C and fresh or decaying crop residues commonly present in field conditions. Using a dual $^{13}C/^{14}C$ labelling approach in a 62-day incubation, we investigated the effects of adding labile C (40 µg glucose-C g^{-1} soil) together with wheat shoot or root residues (3.1 mg C g^{-1} soil) on SOM priming at three residue decomposition stages: intensive (day-1), reduced (day-9) and stabilised (day-24). To estimate the PE, total soil CO_2 efflux and microbial biomass were partitioned for three sources: labile C (^{14}C-glucose), plant residues (^{13}C-labelled) and SOM (unlabelled). Without glucose, roots were decomposed less than shoots but induced 1.4-fold stronger cumulative SOM priming (365 µg C g^{-1} soil) than shoots. Addition of glucose increased SOM priming, with a stronger effect in the presence of shoot than root residues. Glucose addition at the intensive stage of shoots decomposition slightly increased SOM priming. However, compared with residues alone PE, the addition of glucose during reduced residue decomposition stage, increased SOM priming by 60% (roots) to 104% (shoots). Remarkably, this SOM priming after glucose addition was followed by a decline in residue decomposition and by an increase (up to 50%) in SOM-derived C in microbial biomass. Hence, following glucose addition, microorganisms utilised more SOM rather than feeding on decaying residues during reduced decomposition stage. During stabilised residue decomposition stage, the impact of glucose on SOM priming declined again, while the residue decomposition rate remained unaffected. Furthermore, a large proportion of added glucose (up to 10%) was retained in microbial biomass and its mineralisation rate declined strongly (compared with intensive and reduced decomposition stage). Therefore, the glucose amount was not sufficient to influence microbial activities determining SOM or stabilised residue decomposition rates. Overall, SOM decomposition increased by 1- to 4-fold more than the amount of added glucose C, which resulted in a negative net soil C balance compared with residues alone. Thus, we demonstrated for the first time that 1) the interactive effects of glucose (trace amount) and residues on SOM priming depend on plant residue type (higher under shoots than roots) and 2) stage of residues decomposition (higher SOM priming when labile C was added after the end of intensive decomposition stage of plant residues).

1. Introduction

Soil organic carbon (C) accrual is controlled by the balance between C input via plants and C output via microbial decomposition of soil organic matter (SOM) (Jastrow et al., 2007). The main sources of C inputs to soil are crop residues (freshly incorporated or partly

* Corresponding author. Department of Soil and Environment, Swedish University of Agricultural Sciences, PO Box 7014, SE-75007, Uppsala, Sweden.
E-mail addresses: muhammad.shahbaz@slu.se, shahbazmu@yahoo.com (M. Shahbaz).

https://doi.org/10.1016/j.soilbio.2018.08.023
Received 13 March 2018; Received in revised form 18 August 2018; Accepted 22 August 2018
Available online 05 September 2018