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Role of Soil Microorganisms in Soil Organic Carbon Dynamics in Different Cropping System

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SUMMARY

Soil micro-flora and fauna are major reservoir of biodiversity in soil ecosystem. Soil microorganisms play the important role in carbon dynamics in soil through different processes such as rhizodeposition, decomposition, translocation, anabolisms, sequestration, photosynthesis and respiration. Soil microorganisms are key driver of soil ecosystem because they directly involve in organic matter decomposition nutrient cycling. Therefore, it is important to maintain soil health and sustainability by agricultural practices. Soil microbial carbon and soil carbon storage both are key component for improving soil fertility and sustainability. Biostimulation and bioaugmentation of microbes both are crucial in soils for increasing long term soil carbon storage.

INTRODUCTION

Crop rotation promote growth and activities of rhizospheric microorganisms and influencing carbon use efficiency (Bedini et al., 2013). King and Blesh (2018) reported that crop rotation may lead to greater deposition of microbial driven C into the soil organic carbon reservoir. Diversified cropping system enhances diversity and activities of Arbuscular mycorhiza fungi in soil (Murrell et al., 2020). AMF mycelium improves the formation of stabilization of soil aggregates in the long term (Wu et al., 2014). Bakhshandeh et al. (2017) reported that diversified cropping system also increase the glomalin production in soil which contributes approximately 5% of soil carbon. Glomalin enhance the soil aggregates stability and carbon sequestration in soil sequestration (Singh et al., 2017).

Kallenbach et al. (2018) reported that soil microbial activities are more dominant over the physical transformation of dead organic matter in the formation of soil organic carbon under different cropping system. Because crop rotation encourage the growth and activity of soil microbes and enhanced soil microbial biomass. Reintroduction of dead microbial biomass also takes place in stabilization of soil organic carbon (King and Blesh, 2018). Liang et al. (2019) investigated that microbial biomass contributed more than half of soil organic carbon.

Role of plant growth promoting microorganisms in carbon dynamics in different cropping system

Plant growth promoting microorganisms enhance root exudate secretion which directly involve in soil organic carbon formation (Zhu et al., 2020). The response of plant growth promoting microorganisms, particularly AMF causes change in plant biochemical and metabolic processes as well as increase the quality and quantity of exudates. AMF form mutualistic relationship with host plant in order to provide nutrients (P) for growth of host plant and uptake photosynthetic product from host plant. This mutualistic relationship act as a channel for C transfers between root and rhizosphere.

Wang et al. (2021) found that soil organic carbon was highly correlated with microbial biomass carbon. Soil microorganisms are the primary agents of C mineralization (a process through which carbon is loss from soil) and immobilization (gain of organic carbon via their residue). Similarly, Wieder et al. (2013) investigated that size of microbial biomass may affect the soil organic carbon negatively due to mineralization process. However, microbes also contribute to nonliving organic carbon through deposition of microbial derived carbon (immobilized carbon). Therefore, a positive correlation is present between microbial biomass carbon and soil organic carbon (Crowther et al., 2019). There are various reports in literature which indicated that contribution of microbial necromass carbon (persistent organic carbon) to soil organic carbon could be from 10% to 80% (Fan et al., 2021; Liang et al., 2019; Simpson et al., 2007; Zhang et al., 2013; Trivedi et al., 2016)).

Hassan and Bano (2015) investigated that inoculation of *Pseudomonas moraviensis* and *Bacillus cereus* significantly increased soil organic matter in rhizosphere of pots grown wheat plants by 35% over the uninoculated control. Ju et al (2019) investigated that co-inoculation of *Paenibacillus mucilaginosus* and *Sinorhizobium meliloti* with alfalfa significantly increased soil microbial biomass, enzymatic activities, total nitrogen, available phosphorus, and soil organic matter contents in alfalfa-soil system compared with the uninoculated control. Microbial biomass carbon (MBC) content was increased by 10.1%, 36.2%, and 65.7%, due to inoculation of *P. mucilaginosus*, *S. meliloti*, *P. mucilaginosus* + *S. meliloti* *respectively* compared to uninoculated control. Similarly, Egamberdieva et al. (2019) also found that Soil organic carbon was two to three fold higher over the control due to application of *Mesorhizobium ciceri* in chickpea-soil system. Enhancement of soil organic carbon in soil might be correlated with increased mineralization process due to soil soil enzymatic activities (Ouyang et al., 2014).

Table- Role of microbes in soil carbon dynamics under different cropping system.

Sr. No	Cropping system	Initial O.C.	Inoculation of microbes	Changed due to microbial inoculation	References
1.	Pearlmillet -Wheat	0.35%	Cyanobacteria	Cyanobacterial applications increased TOC of soil by 50% during 90–180 d when millet was grown. Subsequently, the differences in TOC between BF treated and untreated soils narrowed down and at 240 d it was just 10% higher as compared to control in pearl millet-wheat (Pm–Wh) cropping sequence.	Nisha et al., 2007
2.	Maize-Fallow-Maize	0.45%	Cyanobacteria (Nostoc)	Application of *Nostoc* significantly increased soil C contents in the surface soils. The percentage increases when averaged was 14%.	Maqubela et al (2009)
3	Rice-wheat	0.4-0.5%	Three bacterial strains (*Providencia* sp. PR3, *Brevundimonas dimunuta* PR7and *Ochrobactrum anthropi* PR10) and three cyanobacteria strains (*Anabaena laxa* CR1 , *Anabaena* sp. CR2 and *Anabaena oscillarioides* CR3)	Organic carbon showed a two-fold enhancement in inoculated treatments as against fertilizer controls (0.4–0.5 to 1.0–1.75%	Prasanna et al., 2012
4	Wheat	In Non-PGPR soil, soil organic matter content was 3.57%.	*Bacillus subtilis* and *Paenibacillus azotofixans*	After application of PGPR, soil organic matter content was 3.80%.	Çığ et al. 2021
5	Wheat-Barley	At the beginning of the experiment SOC ranged from 0.91 to 0.93%.	Trichoderma reesei, and Bacillus megaterium	Trichoderma and Bacillus increased soil organic carbon by 9.1 and 7.0% respectively over the uninoculated control.	Jurys and Feizienė 2021

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