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Biofilm Biofertilizer Increases Soil Carbon Sequestration in Tea and Paddy Cultivations

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Abstract

Several recommended practices are currently being applied for soil carbon sequestration (SCS) and conservation *viz.* adding crop residues, planting cover crops, and growing cereals, legumes and other crops. However, increasing carbon (C) without manipulating microbes in Nitrogen (N) rich soils may naturally boost soil microbes that consume N and emit the more potent greenhouse gas nitrous oxide, potentially offsetting SCS's climate benefits. Moreover, simply adding C sources to the soil does not necessarily mean that the C is going to retain in the soil, because C deposited in the soil release back to the atmosphere by the priming effect. Therefore, microbial interventions may be required in order to stabilize sequestered C in agricultural soils. In the present study, the effect of Biofilm biofertilizers (BFBFs) on SCS was investigated in lowland paddy as well as upland tea cultivations. Two systematic extensive field experiments were carried out in 17 locations in total; Ampara (n = 3), Kurunegala (n = 3), Kegalle (n = 3) and Polonnaruwa (n = 5) for rice, and Nuwara Eliya (n = 1) and Badulla (n = 2) for tea. The BFBF practice of 50% of chemical fertilizer (CF, for rice, 225 kg CF ha^{-1}; for tea, 188 kg CF ha^{-1}) with 2.5 L ha^{-1} BFBF was compared with 100% CF (for rice, 425 kg CF ha^{-1}; for tea, 375 kg CF ha^{-1}) practice. Three random soil samples were collected from 0 - 25 cm depth in each experimental field, and the experimental locations acted as replicates for each practice. The samples were analyzed for soil moisture, total N, total C, labile C, and stable C (difference between total and labile C). In addition, crop yield, rooting depth, tea leaf total polyphenols, and endophytic diazotrophs were also measured as plant and microbial parameters. The results showed that in addition to crop yield benefits (i.e. ca. 25% yield increases in rice) the BFBF practice sequestered 15 t stable C ha^{-1} $season^{-1}$ over the 100% CF practice in paddy cultivation ($p<0.05$). This was due to increased rooting depth (11.2 cm and 7.8 cm in BFBF and 100% CF practices, respectively) and C assimilation in the root-zone soil. Also in tea cultivation, SCS was higher significantly by *ca.* 100% (0.3 t stable C ha^{-1} $season^{-1}$) with the application of BFBF ($p<0.05$). The increased SCS with BFBF application in paddy and tea cultivations was generally associated with increasing trends of endophytic diazotrophs, soil moisture and total N, and tea leaf total polyphenols. In conclusion, the BFBF practice can increase SCS while replacing bulky quantities of organic matter inputs in paddy and tea cultivations. As such, the BFBF practice would lead to economic benefits through C trading, also contributing to the "4 per 1000" initiative to increase soil C stocks by 0.4% per year. Therefore, this enormous potential of BFBF practice in SCS particularly in rice cultivation should be extended globally.

Keywords: Biofilm biofertilizer; Paddy rice; Soil carbon sequestration; Tea