Non-puddling practice for rice-based cropping system increases carbon sequestration in soil

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Introduction

In Indo-Gangetic Plains, intensive rice-based cropping systems with conventional crop establishment practices has been followed for many years. Contradictory results are reported about the effect of rice monoculture or rice-upland crop rotations on soil properties. While CA practices may sequester C into the soil organic C pool and improve soil health, in most cases, the practice of CA in rice-upland rotations is only partial; conservation tillage and residues retention are followed for upland crops only but not for rice. So, whatever benefits may accrue from CA practices followed for upland crops are lost by several wet tillage operations followed by puddling. In the EGP, rice-upland crop growers are now adopting CA increasingly, namely non-puddling of rice, in the intensive triple cropping systems (Alam et al. 2016; Haque et al. 2016). The incorporation of minimum tillage and retention of more residues in these systems of the EGP will change the dynamics of C in soil but nature of these changes has not been explored yet. The study was, therefore, conducted to determine the C cycling in soils of rice-upland triple cropping systems under CA practices.

Materials and Methods

The implications of C cycling under novel and conventional rice production technologies on a long-term field experiment were studied at Alipur, Durgapur of north-west Bangladesh (Alam et al. 2016). The treatments comprise three crop establishment practices (conventional puddling-CT, non-puddling with strip planting-SP and non-puddling with bed planting-BP) in combination with low residue retention (LR- the current practice) or increased residue retention (HR). The soil of the experimental field was Calcareous Brown Flood plain with silt loam texture. Undisturbed surface soil samples (0-15 cm) from three locations per experimental plot were collected from field experiments in November-June 2014-15 by means of a push type auger (2.5cm dia). The complete procedures for collection of gas and measurement of heterotropic microbial respiration can be found in Alam et al. (2016). A simple model was used to predict the rate of C change in soil (Stevenson, 1982), $C_t = Co\ (1 - e^{-kt})$; where k is the decomposition constant, Co is the potentially mineralisable carbon (PMC), and C_t is the carbon mineralisation in time, t.

Results and Discussions

Non-puddled transplanting of rice following the strip planting approach (e.g. Haque et al. 2016) enhanced C sequestration in soil through decreasing decomposition rate of organic matter in soil during the rice growing season, and it reduced green-house gas emissions (Table 1 and Figure 1). Under rice soils, the highest cumulative CO_2 emission (346 kg C/ha) was recorded in CTHR during the rice growing period, closely followed by BPHR ($p > 0.05$). Cumulative C evolution under SPHR was similar to that of CTLR ($p>0.05$). The lowest C mineralization was recorded in SPLR treatment in rice field soils (Table 1; $p < 0.05$). The dynamics of other C pools also supported our results (Figure 1). Strip tillage followed by non-puddled transplanting produced the highest potentially mineralisable C (PMC), probably due to lower decay rate and

more organic matter deposited in soils under the treatment relative to other treatments ($p<0.05$). Bed planting followed by non-puddling had lower PMC ($p>0.05$) than those of SPHR while conventional tillage followed by traditional puddling (CT) had the lowest PMC value ($p<0.05$). The lower PMC in BPHR and CTHR may be attributed to high decay rate of PMC. Bed planting with increased residue retention had the highest decay rate of PMC (0.019 day^{-1}) in rice cultivated soils. The increase in soil C was associated with decreasing cumulative evolution of C as CO_2 and/or CH_4 under rice in rice based cropping systems (Figure 1). The cumulative C mineralisation in soils under SP and BP with HR were depressed compared to the current conventional soil disturbance with low residue retention. Conventional tillage practices ensure the constant exposure of the residues to air, moisture, soil and soil microbes, which accelerate the conversion of organic carbon to CO_2. Conversely, in SP and BP, residues retention or standing, and the roots are left intact which decreases the contact between soil microorganisms and the residue. Non-puddling of soils regardless of residue retention sequestered more C in soil of rice-based triple cropping system.

References

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Table 1. Cumulative CO_2 evolution and soil organic C in soil after five years at Alipur, Rajshahi

Treatments	Cumulative C evolution (at harvest; kg C/ha/season)	SOC (%)
BPHR	333	0.7
BPLR	268	0.51
CTHR	346	0.56
CTLR	263	0.44
SPHR	299	0.79
SPLR	251	0.62
$LSD_{0.05}$	55*	0.11*

*Significant

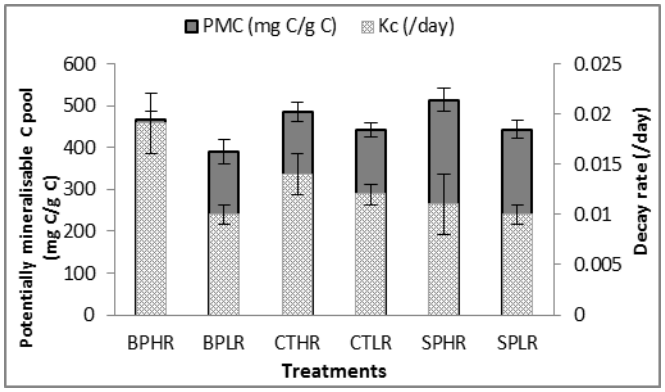

Figure 1. Potentially mineralisable C (PMC) and decay rate of PMC in Calcareous Brown Flood plain soil. Vertical bars represent standard error.