Long-term Effects of Soil Fertility Management on Carbon Sequestration in a Rice-Lentil Cropping System of the Indo-Gangetic Plains

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ABSTRACT

Enrichment of soil organic carbon (SOC) stocks through sequestration of atmospheric CO_2 in agricultural soils is important because of its impacts on soil quality, agronomic production, and adaptation to and mitigation of climate change. In a 21-year field experiment conducted under sub-humid tropical conditions in India, the impacts of crop residue carbon (C) inputs were assessed for the rice (*Oryza sativa* L.)-lentil (*Lens esculenta* Moench) cropping sequence. These impacts were evaluated in an experiment involving mineral fertilizers and manuring treatments on crop yield sustainability with reference to critical biomass requirements for maintenance of SOC in an Inceptisol. Application of farmyard manure (FYM) without and with mineral fertilizers increased C input and SOC concentration and stock. In comparison with the control, the 100% organic (FYM) treatment had significantly higher profile SOC (27.5 Mg ha^{-1}), and more C build up (55.0%) and C sequestration (6.6 Mg C ha^{-1}) to 1-m depth vis-à-vis the antecedent values in 1986. These parameters were also higher in 100% FYM treatment at a rate providing equivalent amount of the recommended dose of N followed by conjunctive use of FYM and mineral fertilizers. The SOC stock and rate of sequestration were positively correlated with cumulative C input, and with sustainable yield index (SYI) of upland rice and lentil. Higher grain yield (1.95 and 1.04 Mg ha^{-1} of rice and lentil, respectively) was obtained with the application of 50% organic (FYM)+50% recommended dose of fertilizer (RDF). In comparison, higher SOC sequestration rate was measured with the application of 100% organic (FYM). For every Mg increase in SOC stock in the root zone there was 0.16 Mg $ha^{-1}yr^{-1}$ and 0.18 Mg $ha^{-1}yr^{-1}$ yield increase of rice and lentil, respectively. For maintaining a stable SOC level (zero change due to cropping), a minimum quantity of 2.47 Mg C ha^{-1} yr^{-1} is required for this soil, climate, cropping system, and fertilization treatments. In order to achieve this quantity of C, 7.1 Mg of biomass is required to be produced every year versus average rice and lentil yields of 1.6 and 0.7 Mg ha^{-1}, respectively. The sole application of mineral fertilizers at 50% or 100% of the RDF did not maintain the SOC stock. Thus, application of FYM (or other organics) in conjunction with mineral fertilizers is essential to maintaining and enhancing the SOC stock in the rice-based cropping systems.