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High organic carbon input can accelerate global warming in rice paddy soil: increase unprotected soil organic carbon and CH4 emission

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Soil C sequestration is widely regarded as the most reasonable way to mitigate global warming. Traditionally, a high amount of organic carbon (OC) input is strongly recommended to increase soil organic carbon (SOC) stocks in croplands. However, according to the whole-soil saturation theory, stable SOC (mineral-associated SOC) accumulation can be limited at a certain point, relying on silt and clay contents. Most studies based on the theory were conducted in aerobic soil condition. This relationship is still uncertain in a rice paddy that makes up 10.8% of total arable land and has an anaerobic soil environment. In this study, we investigated high OC addition can enhance soil C sequestration in a rice paddy. We added different OC levels (0.5, 2.0, 2.9, and 4.6 Mg C ha^{-1} yr^{-1}) in rice paddy by incorporating cover crop biomass for nine years. SOC stock and soil saturation degree were determined. Unprotected, sand-associated, silt-associated, and clay-associated SOC were separated via density and size fractionation. Respired C losses (CO_2-C and CH_4-C) were monitored using the static closed chamber method. SOC stock did not linearly increase with higher amount of OC input. The carbon sequestration efficiency (i.e. the increase of SOC per unit of OC input) decreases with the amount OC added. Higher OM input significantly increased unprotected labile SOC content. Unprotected SOC (<1.85 g cm^{-3}) exponentially increased as the SOC saturation degree was higher. On the other hand, stable SOC content did not exhibit a linear relationship with the SOC saturation degree. The higher OC addition level exponentially increased respired C loss. In particular, C loss via CH_4 was more sensitive to high OC addition. We conclude that higher OC addition in rice paddy without consideration in terms of SOC stock saturation point can accelerate global warming by increasing labile SOC accumulation and CH_4 emission.