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Impact of traditional farming on soil CO_2 flux and C budget in the dry tropical cropland of southern India

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Carbon storage is one of the most important soil functions because the accumulation of soil organic carbon (SOC) improves soil fertility and mitigates climate change. Thus, a positive soil C budget is necessary for sustainable land management. In southern Indian croplands, where soil C stocks are generally low, local farmers traditionally thin the crop one month after broadcasting seeds of sorghum, which may affect the soil moisture dynamics and soil C dynamics. However, there is little quantitative data for the impact of above traditional farming on soil C dynamics in southern India. Our objective was to estimate the impact of the traditional farming on soil C dynamics, focusing on the soil CO_2 flux and C budget in southern India. Our field experiment was conducted in Tamil Nadu state from Sep 2015 to Jan 2017 (17 months) including two crop periods (from Sep to Jan) with four land management treatments (traditional farming plot (T), no thinning plot (NT), fixed density plot (FD) and bare plot (B)). We periodically measured the CO_2 efflux rate (a total of 25 times) with continuous environmental data such as temperature, rainfall and soil moisture. We estimated the total CO_2 flux as C output, based on the relationship between the CO_2 efflux rate and environmental data. We also applied farmyard manure (FYM) (1.1 Mg C ha^{-1}) on Sep 2015, according to the traditional amount in this area. We found that CO_2 efflux rate showed seasonal fluctuations with a tendency to increase during the rainy season and decrease during the dry season, though there was no clear difference in the CO_2 efflux rate between the treatments. According to the regression analysis, the CO_2 efflux rate was correlated with soil temperature in the T and FD plots, though it was correlated with soil moisture in the B plot ($p < 0.05$). In the NT plot, no significant relationship with environmental data was found. Total CO_2 fluxes during the experimental period were calculated as 1.5, 1.8 and 1.4 Mg C ha^{-1} in the T, FD and B plots, respectively. Because all aboveground plant biomass is generally removed for cow fodder and is therefore not applied to the cropland, C output in all treatments was larger than C input (1.1 Mg C ha^{-1} FYM). These results indicate that the soil C budget is negative for the two crop periods and the traditional farming is not sustainable at present. Thus, it is necessary to increase the frequency or amount of FYM application, and to find alternative C resources that are resistant to decomposition, e.g., biochar.