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Response in Soil Organic Carbon to Agricultural Manure Application: A Global Meta-Analysis

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Soil organic carbon (SOC) plays crucial roles in sustaining crop growth and mediating greenhouse gas emissions. Various measures were therefore adopted to increase SOC content in cropland, of which manure application is a commonly-used one. Recent studies proposed that environmental factors may govern the retention of organic matter in soil, by regulating its decomposition. However, the influences of these factors on the efficiency of manure application in SOC enhancement have not been well addressed. In this study, we assess the effects of climate and soil property on the SOC response to manure application, using a global meta-analysis of 311 field measurements reported in 87 references. We defined the SOC response (R_C) as the following equation, where C_M and C_0 were SOC concentrations in field plots with and without manure application, respectively.

$$R_C = \frac{(C_M - C_0)}{C_0} \times 100\%$$

The SOC response varied between -15.0% and 161.8% at the global scale, with the average and median values of 43.0 and 32.3%, respectively. Of which R_Cs in upland soils (i.e. 48.8±34.4%) were significantly ($p < 0.01$) higher than those in flooded soils (i.e. 28.6±19.5%). The response decreased significantly ($p < 0.01$) with mean annual precipitation (MAP) increase, while no significant relationship was found between R_C and mean annual temperature (MAT). This indicates that precipitation, rather than temperature, is the major climatic factor controlling the efficiency of manure application in SOC sequestration. We also found that R_C increased significantly ($p < 0.01$) with soil pH, and was negatively correlated ($p < 0.01$) with initial SOC concentration. This means that manure may have particularly high potentials to increase SOC in regions with high soil pH and low organic carbon. Our study presented a global assessment to the efficiency of agricultural manure application in SOC enhancement. These findings highlight that environmental factors should be carefully considered when assessing the contribution of manure application to SOC.