Effects of No-Till and Reduced Tillage Practices on Soil Organic Carbon in Croplands: A Comprehensive Mega-Analysis

Soil organic carbon (SOC) is a vital component of global carbon cycling and plays a crucial role in soil CO_2 emission. However, the effects of agricultural activities such as tillage on SOC are not fully understood. In this study, we conducted a mega-analysis of 24 individual meta-analyses to examine the impact of conservation tillage practices, including no-till (NT), reduced tillage (RT), and mixed NT+RT, on SOC. Our results showed that NT, RT and mixed NT+RT significantly enhanced SOC levels, with the RT showing the highest increase by 13.42% (0.126), followed by NT 10.76% (0.102) and NT+RT 7.42% (0.071). The effectiveness of these tillage practices was influenced by factors such as climate, experimental duration, crop type, crop residue management, soil texture, pH, nitrogen fertilizer rate, and irrigation type. NT increased SOC by 9.56% (0.091) in monocropping systems and 8.95% (0.085) in double cropping systems, with the most significant increase observed in maize by 15.56% (0.144). Additionally, NT increased SOC by 22.32% (0.201) at a soil depth of 0-10 cm and by 6.11% (0.059) at 10-20 cm. NT was effective in neutral by 12.87% (0.121) and alkaline 12.15% (0.114) soils but not in acidic soils. Furthermore, NT increased SOC by 11.96% (0.112) when crop residue was returned and by 9.32% (0.089) when residue was removed. RT was particularly effective in tropical climates, coarse and medium textured soils, and under nitrogen application and irrigation. Soil SOC was increased by 15.56% (0.144) in tropical climates, 18.90% (0.173) at a soil depth of 0-10 cm, 9.16% (0.087) in alkaline soils, 24.02% (0.215) in acidic soils, and 25.23% (0.225) in irrigated fields. Our findings indicated that conservation tillage can significantly enhance SOC. By adopting conservation tillage practices, farmers can improve soil health and contribute to climate change mitigation. This study is supported by the NSF and USDA CBG projects.