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Evaluation of carbon saturation across gradients of cropping systems diversity and soil depth

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Growing evidence indicates arable soils in the US Maize Belt are effectively carbon-saturated. We hypothesized that: 1) surface soil mineral-associated soil organic carbon (SOC) stocks in these systems are effectively carbon-saturated and 2) diverse cropping systems with greater belowground C inputs would increase subsoil SOC stocks because subsoils have large C saturation deficit. Using three long-term field trials in Iowa (study durations of 60, 35, and 12 years), we examined the effects of cropping system diversity (maize-soybean-oat/alfalfa-alfalfa or corn-corn-oat/alfalfa-alfalfa vs. maize-soybean rotation) on SOC content at different depths (0-100 cm) throughout the soil profile. Average annual C inputs were similar for both cropping systems, but the proportion of C delivered belowground was approximately twice as great in the extended rotations. Within and across cropping systems and the three field trial locations, there was a positive linear relationship between total SOC and the concentration of SOC in the mineral-associated fraction, indicating mineral-associated SOC stocks are not saturated. Organic C accumulation was observed at depth (15-100 cm) but not at the surface (0-15 cm) across all sites and rotations. These data suggest surface SOC stocks may have reached equilibrium rather than effective C saturation. In the absence of experiments that manipulate C inputs, the relationship between total SOC and the concentration of SOC in the mineral-associated fraction is frequently used as a proxy for C-saturation, and this relationship should be further explored.