Soil organic carbon dynamics in Pendleton long-term experiments

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The dryland winter wheat (*Triticum aestivum* L.), summer fallow (WW-SF) system using conventional tillage (CT) in the Pacific Northwest has created a significant loss of soil organic carbon (SOC) in the last century and, in the process, added significant amounts of carbon dioxide (CO_2) to the atmosphere. The loss in SOC is attributed mainly to insufficient carbon inputs (one crop in two years) coupled with intensive tillage. The repeated intensive tillage aerates the soil and brings crop residues into contact with microbes, thereby enhancing SOC oxidation and loss.

IMPACT

The results from these long-term experiments (LTEs) clearly indicate that soil organic carbon (SOC) was depleted in winter wheat, summer fallow (WW-SF) systems. The loss of SOC has significant negative impacts on ecosystem services and the regional climate. Minimum soil disturbance, along with intensification and diversification in cropping systems, may improve SOC accrual and hence the sustainability of dryland cropping in the Pacific Northwest.

In this study, we evaluated SOC in two long-term experiments (LTEs) established at Oregon State University's Columbia Basin Agricultural Research Center near Pendleton, OR. The crop residue LTE (CR-LTE) was established in 1931. It has nine treatments consisting of crop residue (fall burn, spring burn, and no burn) and fertility (0, 45, and 90 kilogram nitrogen per hectare per crop, manure, and pea vine) management practices under a WW-SF system. All plots were tilled using a moldboard plow, cultivated, and rod-weeded to control weeds. The wheat-pea long-term experiment (WP-LTE) was established in 1963. It has four treatments consisting of conventional tillage (fall plow and spring plow) and conservation tillage (minimum-till and no-till) systems under a wheat-pea rotation. We compared SOC levels in these two experiments to those in a nearby grassland pasture (GP) that has been maintained in native vegetation since 1931. The study site has a medium-textured soil (Walla Walla silt loam) and receives approximately 16.5 inches (420 mm) annual average precipitation. We took soil depth profiles at 0 to 10, 10 to 20, 20 to 30, and 30 to 60 centimeters (0 to 4, 4 to 8, 8 to 12, and 12 to 24 inches) from the CR-LTE, WP-LTE, and GP and analyzed them for SOC.

The grassland had the highest amount of SOC content in individual soil depths as well as in the 0- to 60-centimeter profile. SOC under grassland was 87.4 megagrams per hectare, which was considerably higher than levels observed under all WW-SF (CR-LTE) as well as under the continuous cropping (WP-LTE) systems.

Crop residue long-term experiment at at Columbia Basin Agricultural Research Center, near Pendleton OR . Photo by Stephen Machado.

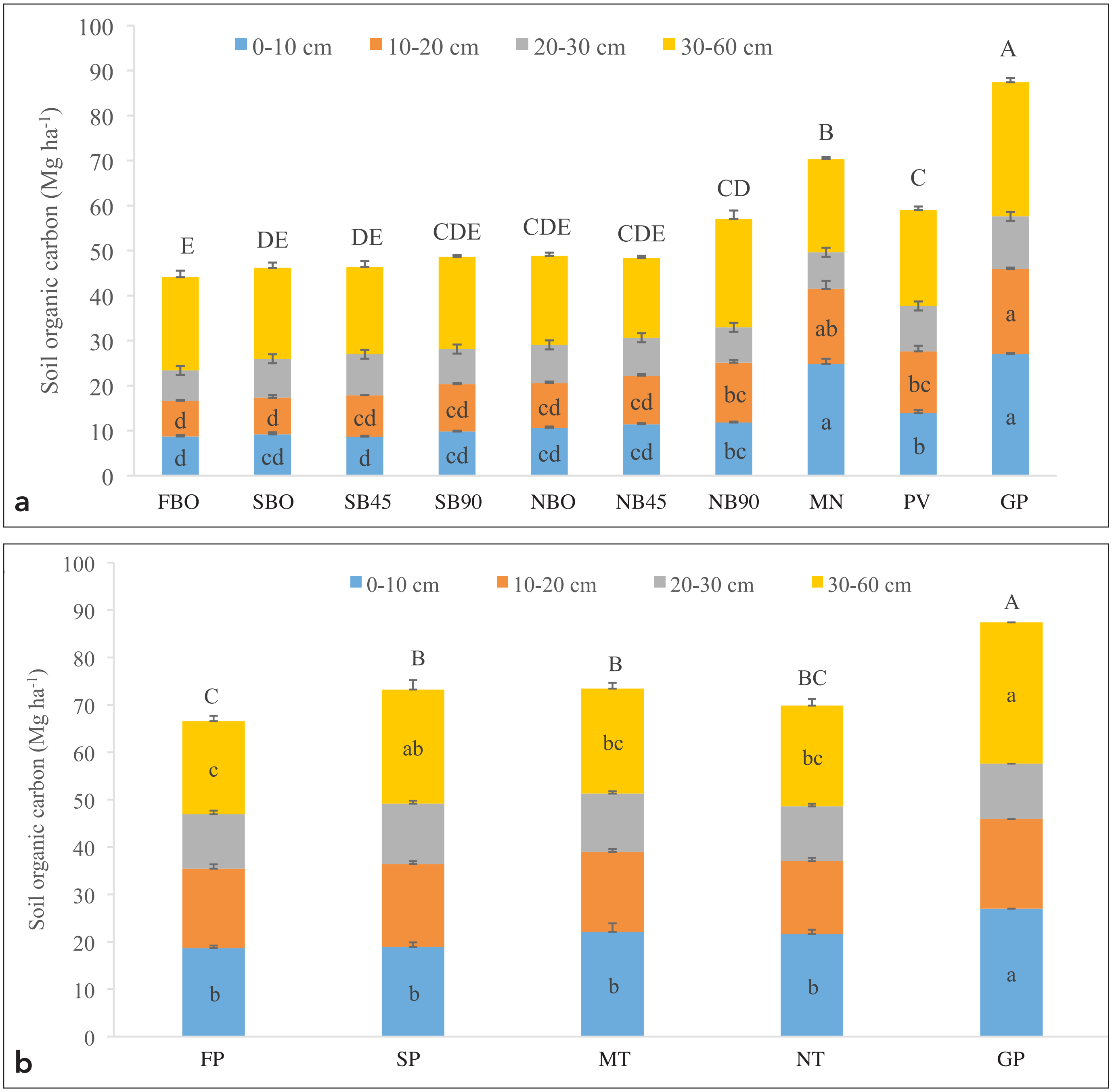

Figure 1. *Soil organic carbon content in soil profiles of (a) crop residue and (b) wheat-pea long-term experiments and a nearby undisturbed grassland in 2010. Segments with the same lowercase letters indicate no significant difference among treatments within a sampling depth, and those with the same uppercase letters indicate no significant difference among treatments in the 0- to 60-centimeter depth profile. Part a: FB = fall burn, SB = spring burn, NB = no burn, MN = manure, PV = pea vine, GP = grassland pasture. 0, 45, and 90 refer to kilogram nitrogen per hectare per crop. Part b: FP = fall plow, SP = spring plow, MT = medium-till, NT = no-till, GP = grassland pasture.*

All WW-SF systems were losing SOC in the 0- to 60-centimeter soil profile in the last century. SOC loss from the WW-SF systems was lowest under manure treatment, and the SOC in these systems was only 20% less than that under GP (Figure 1a). SOC under manure application was significantly higher than all other treatments in the WW-SF system. The loss of SOC under the WW-SF system was highest when residues were burned in the fall, with 68% and 50% less SOC in the 0- to 10-centimeter and 0- to 60-centimeter depths, respectively, compared to the GP SOC.

In WP-LTE, SOC content was 30% to 44% less than that of the grassland (Figure 1b). The SOC content was not significantly different among WP-LTE treatments in the 0- to 10-, 10- to 20-, and 20- to 30-centimeter depths. When the 0- to 60-centimeter profile was considered, however, SOC was not significantly different among spring plow, minimum-till, and no-till. All WP-LTE treatments increased SOC over time. The rate of SOC gain from 1995 to 2010 was 0.04, 0.49, 0.53, and 0.37 megagrams per hectare per year in fall plow, spring plow, minimum-till, and no-till systems, respectively, in the 0- to 60-centimeter soil depth.