Dual-Purpose Cover Crop Effects on Soil Health in Western Kansas No-Till Dryland Cropping

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Summary

Increasing interest in soil health has led producers in western Kansas to consider cover crops (CCs) for increased soil cover and improved soil properties. However, grain yield reductions following CCs in dryland cropping systems necessitate dual-purpose forage harvest to balance goals of environmental and economic sustainability. This study was initiated in 2015 near Brownell, KS, to investigate the effects of dual-purpose CC management in place of fallow on selected soil chemical and physical properties in a no-till winter wheat-grain sorghum-fallow cropping system. Mixed oat and triticale cover crops were either mechanically harvested as hayed forage to a height of 6 inches, mob-grazed with yearling heifers (weighing approximately 1000 lb each) stocked at 3 head/acre/day, or left standing (unharvested). Cover crop treatments were compared to chemically-controlled no-till fallow. Soil samples were collected following CC termination, but before winter wheat planting in 2019 and 2020. Results indicate that dual-purpose CCs had no effect on soil bulk density or porosity relative to unharvested CCs or the fallow treatment. Soil organic carbon was similar for standing and grazed CCs though carbon stocks were less for the hayed treatment. All CC treatments were similar to fallow. Indicators of soil structure—including mean weight diameter and large macroaggregates—were greater, while small macroaggregates were less for all CCs compared to fallow. These results suggest that dual-purpose CCs in no-till dryland cropping may replace fallow to provide forage for livestock while improving soil health. Still, careful management will be necessary to ensure adequate CC residues are retained such that, when CC growth is limited, grazing of CCs may be more desirable than haying in order to maintain soil properties.

Introduction

Integrating cover crops (CCs) to replace fallow in no-till dryland cropping systems in western Kansas has the potential to improve soil health by increasing soil carbon, reducing compaction, and enhancing soil structure. However, subsequent grain yield penalties due to reduced soil moisture following CCs represent a major barrier to adoption. Dual-purpose CCs may provide annual forage for livestock, which may offset losses in subsequent crop yield in order to balance goals of environmental and economic sustainability in dryland cropping. To our knowledge, limited information exists on the effects of dual-purpose use of CCs on soil properties. Concerns include reduced soil organic carbon (SOC) accrual, increased soil compaction, and degraded soil structure with CC haying and grazing, especially in no-till production systems.

Limited research findings from regions outside of western Kansas suggest that the effects of dual-purpose CCs on soil properties may be minimal. These results are promising and suggest that CC haying and grazing may be a good strategy for the dryland producers of this region. The objective of this experiment was to determine the effects of dual-purpose CCs on soil bulk density and porosity, organic carbon, as well as water stable aggregates (WSA).

Procedures

This study was initiated in 2015 at the Kansas State University HB Ranch near Brownell, KS, to investigate the effect of dual-purpose CCs in place of fallow on soil properties in a no-till dryland winter wheat-grain sorghum-fallow cropping system. Cover crops were a two-species mixture of oats and triticale at a seeding rate of 32 and 38 lb/a, respectively. The CCs were either mechanically harvested as hayed forage to a height of approximately 6 inches, mob-grazed with yearling heifers (weighing approximately 1000 lb each) stocked at 3 head/acre/day, or left standing. All CCs were chemically terminated by approximately the third week of June using glyphosate and 2,4-D in 2015, and with paraquat and carfentrazone thereafter from 2016 to 2020. This study was designed as a split-plot randomized complete block. Main plots were the three crop phases of the wheat-sorghum-fallow crop rotation, and split-plots were CC treatments. Hayed, grazed, and standing CCs were compared to chemically-controlled no-till fallow for a total of four treatments.

Soil samples were collected in 2019 and 2020 in the time following CC termination, but before winter wheat planting. Two intact soil cores of 2 inches in depth and 2 inches in diameter were randomly taken from each plot to determine soil bulk density and porosity. Bulk density was determined as mass of oven-dried soil divided by volume of the core, and porosity was determined using a constant particle density of 2.65 g/cm^3. Ten additional 2-inch cores were collected randomly throughout each plot for the determination of SOC concentration. Soil samples were mixed in the field, allowed to air-dry, and ground to pass through a steel sieve with 0.08-inch openings. Subsamples were ground to pass through a 0.01-inch screen, and SOC concentrations were determined by dry combustion after pretreating samples with 10% (v/v) hydrochloric acid to removed carbonates. Carbon stocks were calculated by multiplying concentrations by soil bulk density and the thickness of the soil layer. Additional samples were collected from the 0- to 2-inch soil depth with a flat shovel for the determination of WSA, an indicate of soil structure and erodibility. Samples were gently passed between sieves with 0.315- to 0.187-mm mesh and allowed to air-dry completely. Two sub-samples from each plot were used to estimate WSA by the wet-sieving method. Aggregate fractions were separated into large macroaggregates (>0.08-inch), small macroaggregates (0.08- to 0.01-inch), as well as microaggregates (<0.01-inch) and values were used to determine mean weight diameter. This report will summarize dual-purpose CC effects on selected soil chemical and physical properties averaged across the 2019 and 2020 sampling times. Statistical analysis was completed using PROC GLIMMIX of SAS ver. 9.3 (SAS Institute, 2012, Cary, NC) with treatment considered fixed and replication considered random. Differences were considered significant at $P \leq 0.05$.

Results

Haying and grazing of CCs had no effect on soil bulk density (Figure 1a) or porosity (Figure 1b) in the 0- to 2-inch soil depth compared to standing CCs or fallow in this no-till dryland cropping system. Soil near-surface bulk density averaged 1.13 g/cm^3 and porosity averaged 60.0%. This indicates that haying and grazing of CCs at similar cutting heights and stocking rates may have no effect or minimal effects on soil compaction in similar no-till systems. Soil organic carbon concentrations (Figure 2a) and stocks (Figure 2b) in the 0- to 2-inch soil depth with hayed CCs (1.51% or 3.66 ton/a) were less compared to the standing treatment (1.65% or 4.18 ton/a) and both were similar to fallow (1.52% or 3.86 ton/a). The grazed CCs (1.64% or 4.11 ton/a) were similar to standing CCs or fallow, and carbon stocks were greater compared to the hayed treatment. This indicates that grazing CCs may maintain or accrue SOC similarly to standing CCs in comparable dryland systems. However, mechanical forage harvest may have detrimental effects on SOC concentrations and stocks due to the limited residue retained following CC forage removal.

Mean weight diameter of WSA in the 0- to 2-inch soil depth was greater with all CCs (standing, grazing, or hayed) compared to fallow (Figure 3a). Mean weight diameter was 0.11 inch for the standing CCs, 0.10 inch for the hayed CCs, 0.12 inch for the grazed CCs, and 0.07 inch for fallow. This indicates that CCs have the ability to increase soil aggregation similarly when standing, hayed, or grazed. Additionally, all CCs were found to increase the proportion of large macroaggregates (>0.08 inch) compared to fallow (Figure 3b). The opposite was observed for small macroaggregates (0.08 to 0.01 inch) when all CCs had a lower proportion relative to the fallow treatment. Small macroaggregates were greater for standing CCs compared to the grazed CCs and both were similar to the hayed treatment. Microaggregates (<0.01 inch) were less for standing CCs compared to fallow. Hayed and grazed CCs were similar to standing CCs and fallow. These results of WSA indicate that hayed and grazed CCs have the potential to enhance soil structure and reduce erodibility in similar no-till dryland cropping systems.

In this study, dual-purpose CCs were found to have no effect on near-surface soil bulk density or porosity. However, mean weight diameter and the proportion of large macroaggregates were increased with all CCs treatments compared to fallow. Soil organic carbon stocks were less with hayed CCs relative to the grazed or standing treatments. These findings indicate that such dual-purpose strategies where CCs are grazed or mechanically harvested as hayed forage may provide similar benefits to soil health as unharvested standing CCs. Still, careful management will be critical such that when CC growth is limited, grazing CCs will be most beneficial compared to haying in order to maintain soil properties.

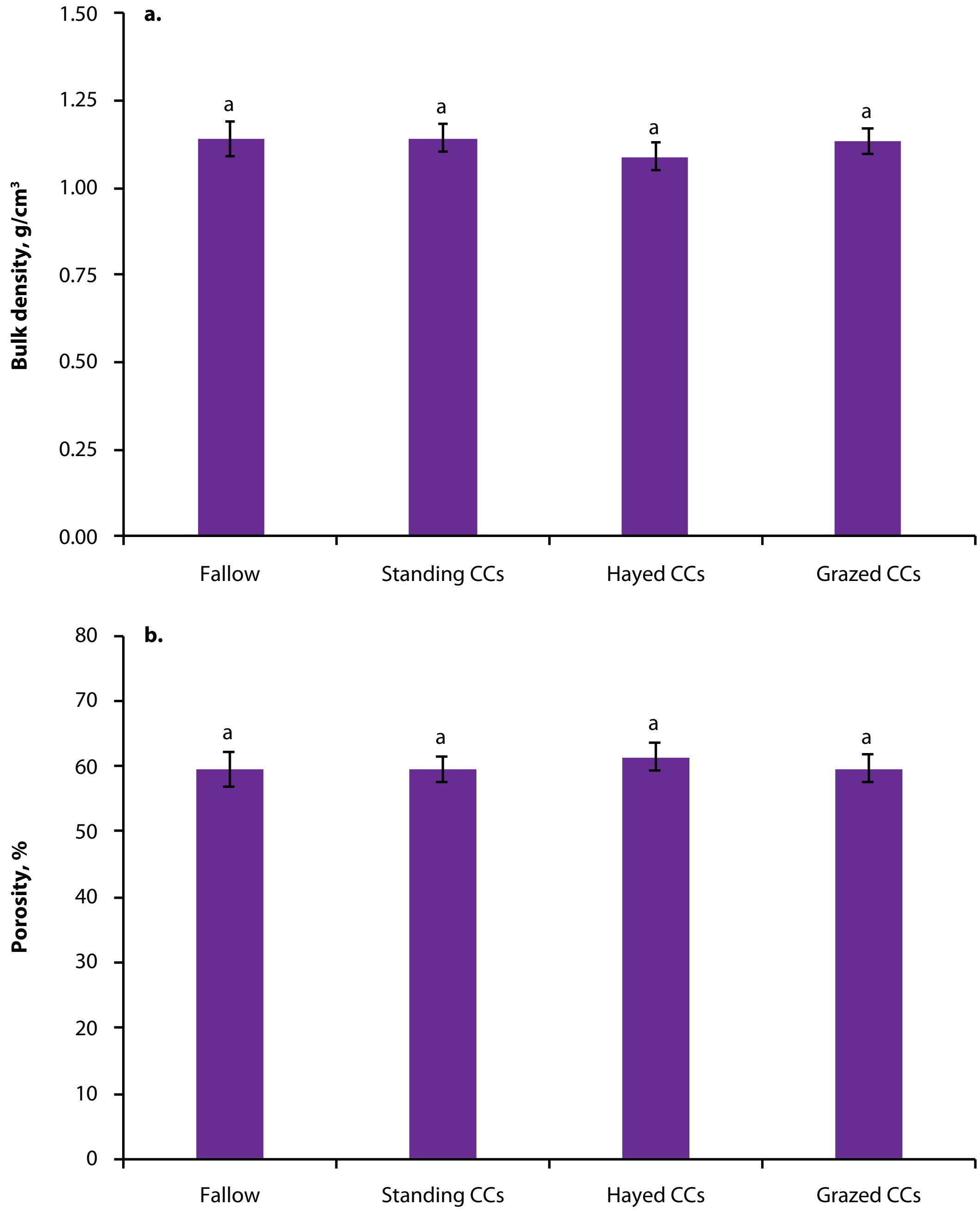

Figure 1. Cover crop (CC) management effect on soil bulk density (a) and porosity (b) in the 0- to 2-inch soil depth in a dryland cropping system in western Kansas. Error bars indicate standard error ($\alpha = 0.05$) and bars with the same letter are not significantly different ($\alpha = 0.05$).

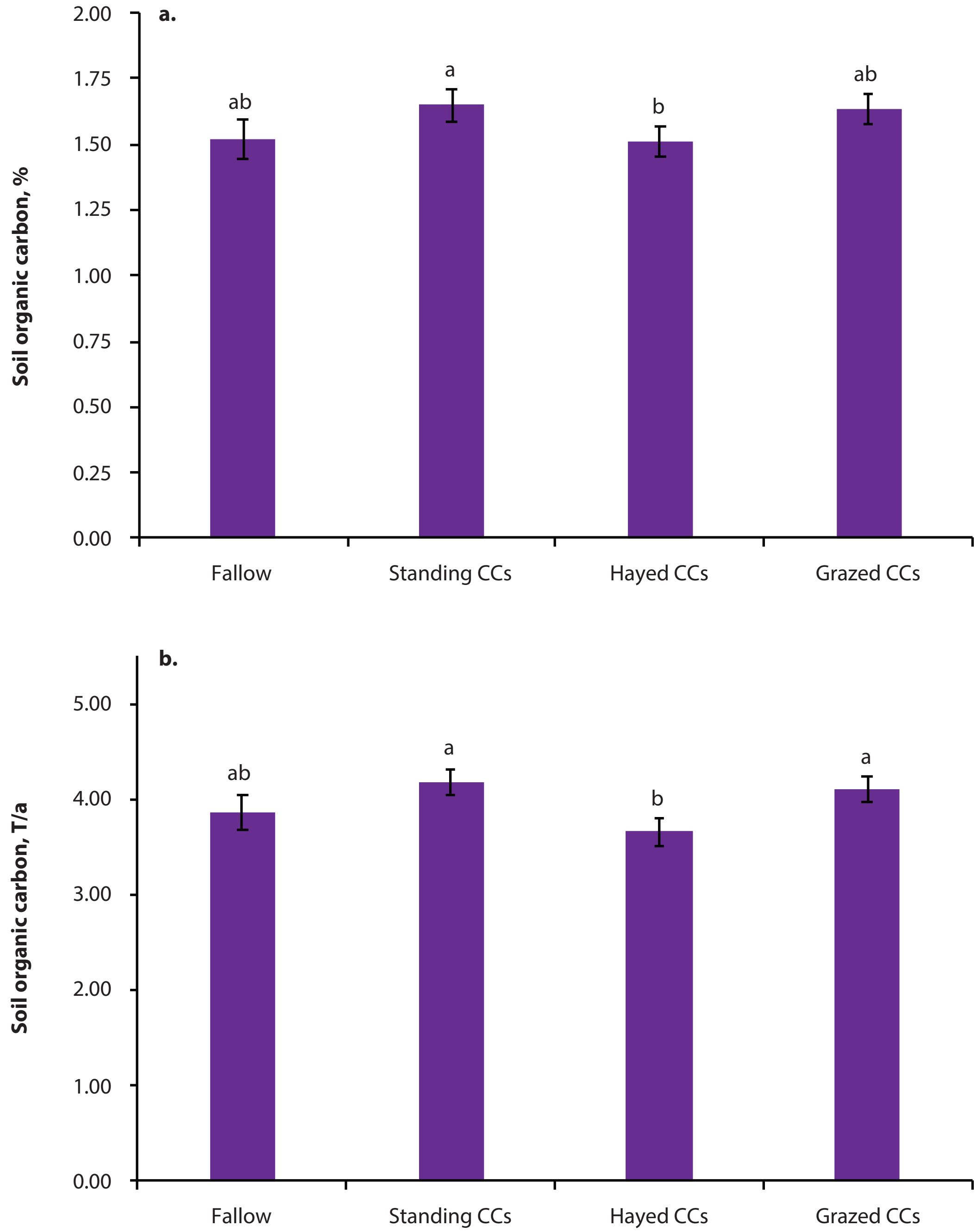

Figure 2. Cover crop (CC) management effect on soil organic carbon concentrations (a) and stocks (b) in the 0- to 2-inch soil depth in a dryland cropping system in western Kansas. Error bars indicate standard error ($\alpha = 0.05$) and bars with the same letter are not significantly different ($\alpha = 0.05$).

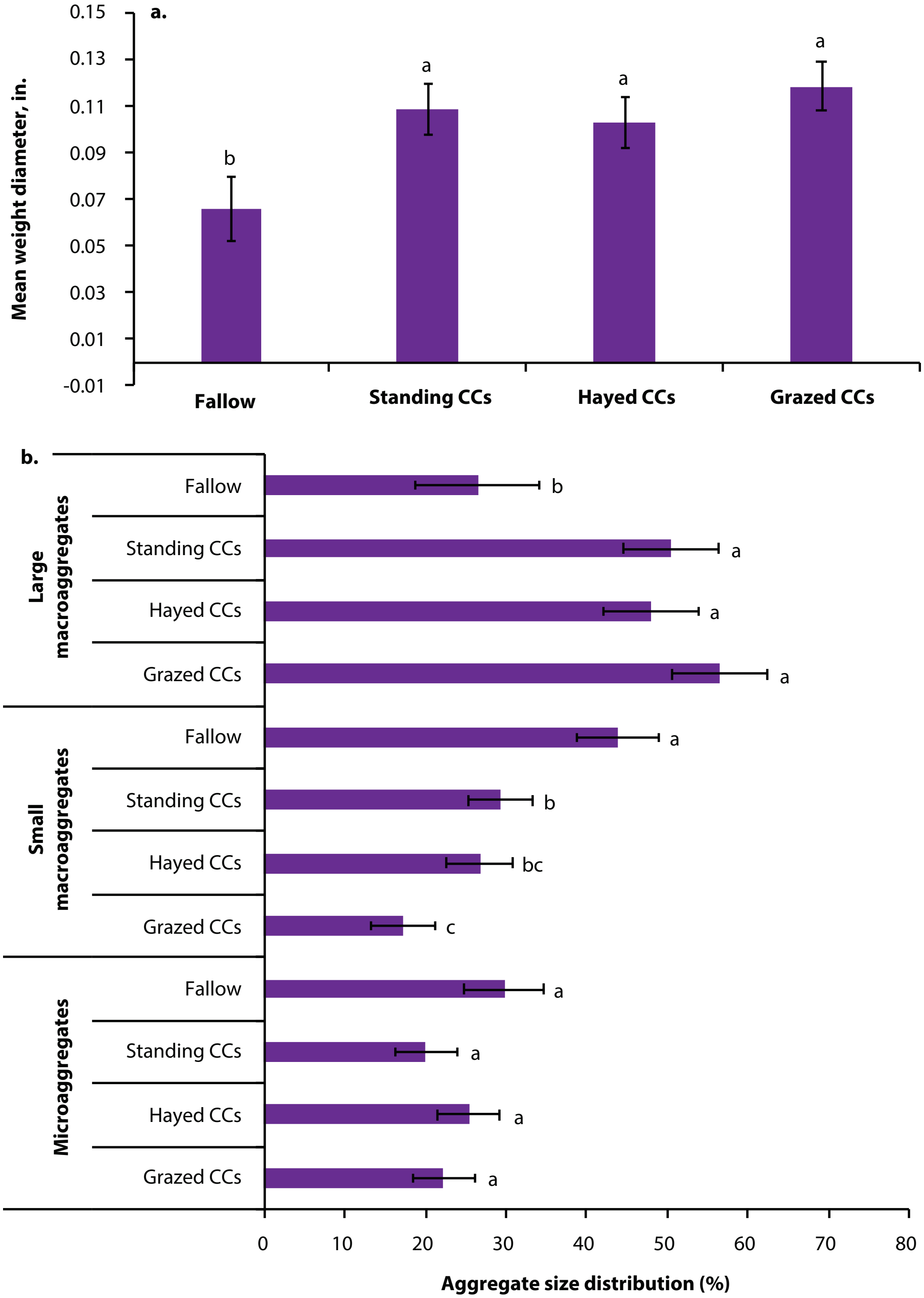

Figure 3. Effects of cover crop (CC) management on mean weight diameter (a) and distribution of large macroaggregates (>0.08 in.), small macroaggregates (0.08 to 0.01 in.) and microaggregates (<0.01 in.) (b) in the 0- to 2-inch soil depth in a dryland cropping system in western Kansas. Error bars indicate standard error (α = 0.05) and bars with the same letter are not significantly different (α = 0.05) within aggregates size fractions.