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Does Grazing Cover Crops Impact Soil Properties?

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Summary

Grazing of cover crops (CCs) by cattle could provide supplemental forage and additional revenue to offset grain yield losses when CCs are grown in semiarid rainfed cropping systems. However, grazing CCs could reduce the amount of residue retained on the soil surface and subsequently affect soil physical and chemical properties. This study evaluated effects of grazing CCs on soil bulk density, aggregate stability, and chemical properties using soil samples collected from three producer fields in west central Kansas that had paired grazed and non-grazed CC treatments, as well as adjacent native perennial pastures. Across sites, CC residue after grazing averaged 2650 lb/a compared to 3741 lb/a for the non-grazed CCs, representing a 29% decrease in CC biomass with grazing. Bulk density, aggregate size distribution, and mean weight diameter (MWD) were not different ($P > 0.05$) between grazed and non-grazed CCs. The MWD under perennial pasture was 0.148 in., approximately 2.9-fold greater than MWD with grazed (0.050 in.) or non-grazed CCs (0.051 in.). Soil pH and soil organic carbon (SOC) did not differ ($P > 0.05$) between the grazed and non-grazed CCs. Soil nitrate (NO_3-N), phosphorus (P), iron (Fe), manganese (Mn), and copper (Cu) concentrations with grazed or non-grazed CCs were greater than in pasture. Our findings showed grazing of CCs may be a management option to intensify NT cropping systems with little negative effects on soil bulk density, aggregate stability, or extractable nutrient concentrations.

Introduction

Integration of CCs into NT crop production has been recommended to regenerate soil properties degraded after many years of conventionally tilled, low-intensity cropping systems in the central Great Plains. Potential benefits of adopting CCs in NT cropping systems of west central Kansas include improved soil health through increased soil organic carbon, reduced compaction, enhanced soil nutrient cycling, as well as improved structure and water infiltration. However, subsequent crop yields following CCs have been mixed with CCs having either no effect or reducing yields in drier years in water-limited environments. This yield penalty presents a major barrier to adoption of CCs in the region. Notwithstanding, those few producers adopting CCs seek to overcome this economic loss through the incorporation of livestock to take advantage of supplemental forage provided by CCs. Value through grazing CCs may offset losses in subsequent crop yield in order to balance the goals of profitability and maintenance of soil health in dryland cropping. However, limited information exists on the effects of grazing CCs on soil properties. Concerns include reduced SOC accrual, increased soil compaction, and degraded soil structure with grazing, especially in NT production systems.

Previous research suggests grazing CCs may have nominal effects on soil properties and may be a good management option for the dryland producers of the central Great Plains. Still, on-farm research is needed to confirm the effect of grazing CC on soil properties in dryland NT cropping systems of this region. Therefore, the objective of this current research was to investigate CC grazing impacts on residue return, soil bulk density, aggregate stability, pH, and soil nutrient concentrations on producer fields in west central Kansas.

Procedures

This study was conducted on cooperative producer field located near Marquette in central Kansas and Hays in western Kansas for a total of two producer fields in the 2018–2019 growing season. The study was repeated on a different field in the 2019–2020 growing season near Marquette. The fields in Marquette were managed under a NT rainfed wheat-wheat-soybean (2018–2019) or wheat-sorghum-soybean (2019–2020) rotation. A winter CC mixture of triticale/rapeseed/radish was planted in the fall following the wheat phase ahead of soybean or sorghum in each rotation. The site near Hays was managed under a NT dryland wheat or triticale-sorghum-fallow rotation. Summer cover crops were planted immediately following triticale. The experiments at each study location had two treatments, grazed CCs and non-grazed CCs, in four replicated strips. The non-grazed CC treatments were fenced using electric wire fencing materials to prevent access to cattle during CC grazing. Cover crop grazing at Marquette in the 2018–2019 growing season occurred from December 17, 2018, through February 10, 2019, at a stocking rate of 5.4 animal unit months (AUM) per acre for 55 grazing days. Again, in 2019–2020, heifers grazed CCs from January 9 to February 17, 2020 with a stocking rate of 4.2 AUM/a for a total of 39 grazing days. At Hays, CC grazing spanned from August 24 to October 10, 2019, for 48 grazing days using lactating cows at a stocking rate of 5.2 AUM/a. Four locations within the grazed area, directly adjacent to each replicate of the fenced non-grazed CCs, were marked and used as four replicates (pseudoreplicates) for the grazed CC treatments. Prior to grazing, CC biomass was determined from two 6 ft^2 quadrats randomly placed in each replicated strip with all the aboveground CC biomass clipped at the soil surface. Freshly clipped sample weights were recorded, and samples were then dried at approximately 122°F in a forced-air oven until they reached a constant weight. These samples were then weighed to determine dry matter (DM). After termination of CCs, grazed and non-grazed CCs were sampled and DM was determined as described previously.

Soil samples were collected for the analysis of soil chemical and physical properties from the grazed and non-grazed CCs in the spring of 2019 and 2020 after termination of CCs and before soybean (Marquette, KS, in 2019) or sorghum planting (Marquette and Hays, KS, in 2020). Additional soil samples were taken from adjacent native perennial grass pastures in 2020 at both Hays and Marquette to compare soil properties to the CC treatments. Two intact soil cores of 6 inches in depth and 2 inches in diameter were randomly taken from each plot to determine soil bulk density. Samples were dried at 221°F for a minimum of 48 hours and bulk density was computed as mass of oven-dried soil divided by volume of the core. Ten additional 6-inch cores were collected randomly from each treatment for the determination of SOC and nutrient concentrations. Additional soil samples were collected from the 0- to 2-in. soil depth with a flat shovel for the determination of WSA. Samples were gently passed through sieves with 0.315- to 0.187-in. mesh and allowed to fully air-dry. Two sub-samples from each replicate were used to estimate WSA by the wet-sieving method.

Data analyses for CC biomass, bulk density, aggregate stability, SOC and available nutrient concentrations were performed using the PROC MIXED procedure in SAS v. 9.3 (SAS Institute, 2012, Cary, NC). Cover crop productivity data analysis was performed with CC management as a fixed effect while replication nested within location was considered random. For soil pH, bulk density, and available nutrient concentrations, CC management and sampling depth were considered fixed effects while replication nested within location was treated as a random effect in the model. Similarly, MWD were analyzed with CC management as a fixed effect and replication nested within location treated as a random variable in the model. The LSMEANS procedure of PROC MIXED was used for mean comparisons. Interactions and treatment effects were considered significant when F test P values were ≤ 0.05.

Results

In general, CC biomass post-grazing was less than non-grazed CCs. Averaged across sites, pre-grazed CC biomass was not different from post-grazed though both were less than the non-grazed CCs (Figure 1). This occurred because the annual grass CC species used in this study had significant regrowth after grazing, which resulted in additional growth to compensate for biomass removed by cattle consumption and trampling. Post-grazed CC biomass averaged 2650 lb/a compared to 3741 lb/a for the non-grazed treatment. This suggests that approximately 71% of the total available CC biomass produced was retained as residue on the soil surface after grazing. Therefore, careful grazing of CCs as done in this study could leave adequate residue cover to protect the soil and meet soil health goals.

A major drawback of CC grazing in NT systems is the potential for soil compaction, though this may depend on soil texture and, with some effects, alleviated by regular winter freeze-thaw cycles. Results from this study showed soil bulk density under grazed CCs was not different from the non-grazed CC treatment (Table 1). Soil bulk density was different ($P < 0.001$) among CCs and pasture (Table 1), possibly due to the remanent effects of past tillage operations before conversion to NT as well as the differences between temporary annual and permanent perennial rooting systems. Mean weight diameter of WSA and aggregate size distribution in the 0- to 2-in. soil depth was different among CCs and pasture. The MWD measured under perennial pasture was 2.9-fold greater than grazed or non-grazed CCs. Notwithstanding, the aggregate size distribution and MWD were not different ($P > 0.05$) between grazed and non-grazed CCs. Across sites, MWD averaged 0.050- and 0.051-in. with grazed and non-grazed CCs, respectively (Table 1).

Average soil pH under pasture was 6.71, which was greater than grazed (5.62) or non-grazed (5.76) CCs. Cattle grazing CCs had no negative effect on soil pH compared to the non-grazed treatment. The SOC concentration was not different between grazed or non-grazed CCs in this study. Across depths, SOC averaged 1.55% for grazed and 1.70% for non-grazed CCs, and both were less than that measured under pasture (Table 1). Similarly, soil fertility indicators including N, P, Fe, Mn, Zn, and Cu concentrations were unaffected by cattle grazing CCs compared to the non-grazed treatment. However, N concentrations measured under grazed or non-grazed CCs were 6-fold greater than in the pasture. Similarly, the P concentration was 4 times greater with CCs compared to the pasture. The significantly greater N and P concentrations measured in the annual production fields were expected due to regular applications of inorganic fertilizer (N and P) inputs compared to the non-fertilized perennial pastures. Despite the 1.5-fold greater SOC content measured in the pasture, micronutrients' (particularly Fe, Mn, and Cu) concentrations in the pasture were less than those measured in the grazed or non-grazed CCs. Based on these results, we conclude that grazing of CCs is a viable management option to intensify NT crop production to improve soil health and maintain or increase overall system profitability. Further research will be needed to determine the long-term effects of CC grazing in NT production systems.

Table 1. Soil physical and chemical properties in the 0- to 6-in. soil depth as influenced by cover crop management: no-till grain-based cropping systems with grazed cover crops, non-grazed cover crops, and perennial pasture

	Cover crop management		
Soil property	Grazed cover crops	Non-grazed cover crops	Pasture
pH	5.62 b†	5.76 b	6.71 a
Bulk density (g cm^{-3})	1.35 a	1.31 a	1.20 b
Total N (%)	0.15 c	0.17 b	0.23 a
SOC (%)	1.55 b	1.70 b	2.36 a
NO_3-N (ppm)	7.1 a	6.1 a	1.1 b
NH_4-N (ppm)	13.8 a	18.0 a	11.4 a
P (ppm)	48.2 a	46.6 a	13.4 b
Zn (ppm)	0.79 a	0.95 a	1.18 a
Fe (ppm)	56.8 a	53.3 a	33.4 b
Mn (ppm)	60.8 a	58.4 a	37.9 b
Cu (ppm)	1.3 a	1.3 a	1.0 b
Large macroaggregate (%)	29.2 b	32.2 b	68.9 a
Small macroaggregate (%)	43.1 a	43.4 a	21.8 b
Microaggregates (%)	27.7 a	24.5 a	9.3 b
MWD (inch)	0.050 b	0.051 b	0.148 a

†Means in a row followed by different letters indicate significant differences among cover crop management treatments at $\alpha < 0.05$.

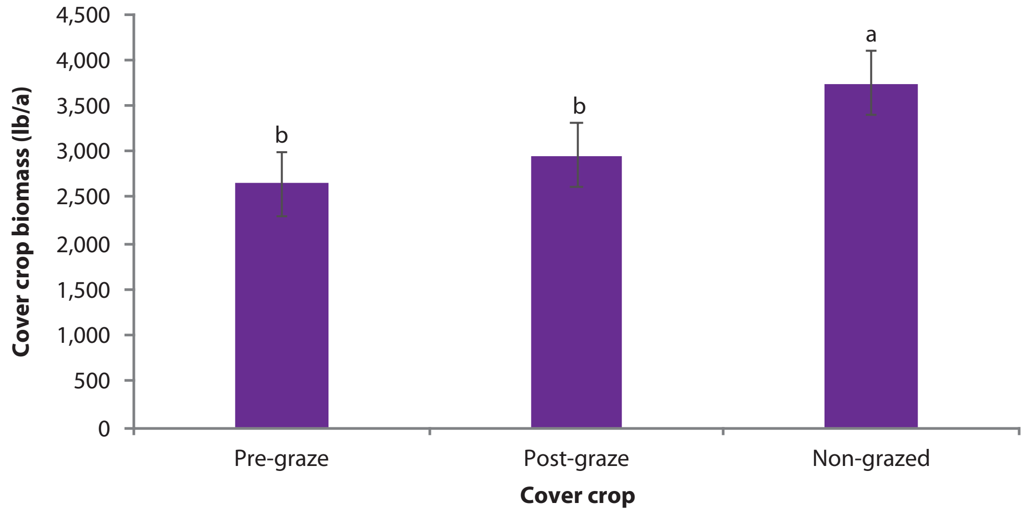

Figure 1. Cover crop productivity pre-grazing, post-grazing, and non-grazed, averaged across site-years. Means across site-years are averaged across 4 replications and 3 sites (n = 12). Different letters atop bars indicate significant differences among pre-graze, post-graze, and non-grazed cover crop biomass at $\alpha < 0.05$. Error bars represent standard error.