Effect of Long-Term Corn Residue Grazing on Soil Properties

Manbir K. Rakkar
Humberto Blanco
Mary E. Drewnoski
James C. MacDonald
Terry J. Klopfenstein

Summary with Implications

An experiment was conducted to evaluate the effect of long-term (16 years) corn residue grazing with cattle on soil compaction, soil structure, soil organic matter, and nutrients. Three treatments: 1) fall grazing (November through January; 1.8 to 2.5 AUM/ac), 2) spring grazing (February to middle April; 2.3 to 3.1 AUM/ac), and 3) control (no grazing) under a no-till irrigated corn-soybean system in eastern Nebraska were studied. Crop yields were increased and soil bulk density and cone index (parameters of soil compaction), wet soil aggregate stability (parameter of soil structural quality), and organic matter content were not affected by grazing during the fall. Spring grazing slightly increased crop yields while wet soil aggregate stability, bulk density, and organic matter content were unaffected. During spring grazing, only cone index was increased, but not above threshold levels. Crop residue grazing in the fall has no effect on soil and any effect from spring grazing is biologically unimportant.

Introduction

Corn residue grazing is an important forage option under increasing costs of feed grains and hay and decreasing grassland area. However, determining the impact of grazing corn residue on soils and crop yields is very important. Data from long-term grazing experiments are needed to better understand the impacts of residue grazing on soil properties and their relations with crop yields. This information can assist with developing integrated crop-livestock systems in Nebraska and in the Midwest. Particularly, little is known about the potential effects of cattle grazing on soil quality parameters in irrigated systems in the western Corn Belt. Thus, a study was conducted to determine the impact of cattle grazing on soil compaction, structural quality, organic matter, nutrients and to determine whether changes in soil properties due to grazing can impact corn and soybean yield in an irrigated no-till corn-soybean system after 16 years of residue grazing management in eastern Nebraska.

Procedure

This study was conducted in late spring 2015 on a long-term corn residue grazing experiment established in 1997. The experiment was established on 90 ac of irrigated cropland managed at the Agricultural Research and Development Center of the University of Nebraska-Lincoln located near Mead, NE. The soil is a Tomek silt loam (0 to 2% slope). The experiment had three treatments: 1) fall/winter grazing (November through late February), 2) spring grazing (late February to the middle of April), and 3) control (no grazing) replicated twice. Grazing treatments were applied using stocker cattle (500 to 700 lb BW). Fall grazing treatment had a stocking rate of 1.8 to 2.5 AUM/ac (1997-2015). From 1997-1999, spring grazing treatment had a stocking rate of 0.9 to 1.3 AUM/ac. Beginning in 2000, the stocking rate for spring grazing treatment was modified to 2.3 to 3.1 AUM/ac. The crop rotation at the experimental site was corn-soybean. Impacts of the three treatments on long-term crop yields were previously presented (2015 Nebraska Beef Report pp. 53-55). For the present study, only the corn phase plots, which had been managed under no-till since the experiment inception for 16 years, were studied.

To assess the impacts of grazing on soil compaction, indicators of soil compaction such as cone index and bulk density were studied. Cone index was measured using a hand cone penetrometer, which mimics the root penetration in the soil. The penetrometer was pushed into the soil at a rate of approximately 1 inch per second. Five measurements were performed per plot. The measurement soil depths were: 0-2, 2-4, 4-6, and 6-8 inches. The penetration resistance values were converted to cone index (MPa) by dividing penetration resistance with basal cone area. Bulk density refers to the mass of dry soil per unit volume of soil. It was measured using intact soil cores (2 inch by 2 inch) from the 0-2, 2-4, 4-6, and 6-8 inch soil depths. Two cores were collected per plot. The cores were trimmed, weighed, and oven dried at 221° F for at least 24 h to determine the gravimetric moisture content and bulk density of the soil.

Bulk soil samples collected from the 0-2 and 2-4 inch depth were used for the analysis of soil organic matter, nutrients, and wet aggregate stability (soil structural quality parameter). Soil samples were air dried, passed through 2 mm sieve, and analyzed for pH, organic matter, nitrogen, potassium, phosphorus, calcium, magnesium, and sulfur. To assess the impact of grazing on soil structure, wet aggregate stability was determined using 4.75-8 mm aggregates by the wet sieving procedure. The wet aggregate stability indicates the resistance of soil against external disruptive forces (i.e., raindrop impacts during erosion) as well as efficiency of soil to hold soil C and other nutrients. Cone index measurements and soil sampling were conducted on non-wheel trafficked positions within each plot.

Data on soil properties were analyzed with grazing treatments (spring grazing, fall grazing, and control) as main effect and replications as random effect using PROC MIXED in SAS. Treatment effects were considered significant at the 0.10 probability level.

Results

Fall grazing did not affect cone index (Figure 1) which mimics resistance to root penetration, bulk density (Figure 2) which indicates the amount of pore space in the

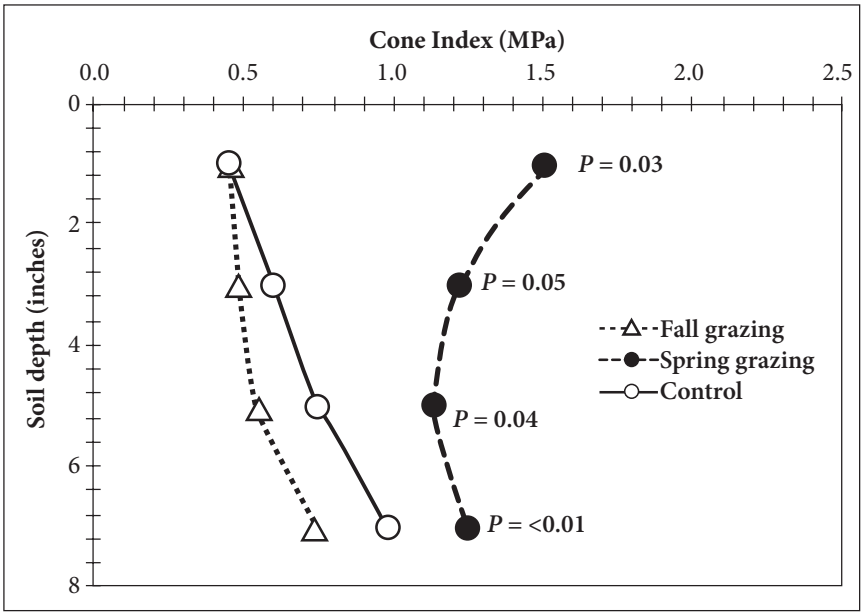

Fig. 1. Soil-depth distribution of cone index (soil compaction parameter) for the 0 to 8 inch depth as affected by 16 years of cattle grazing of corn residues under irrigated no-till system on a Tomek silt loam in eastern Nebraska. The *P*-values are reported for each depth interval.

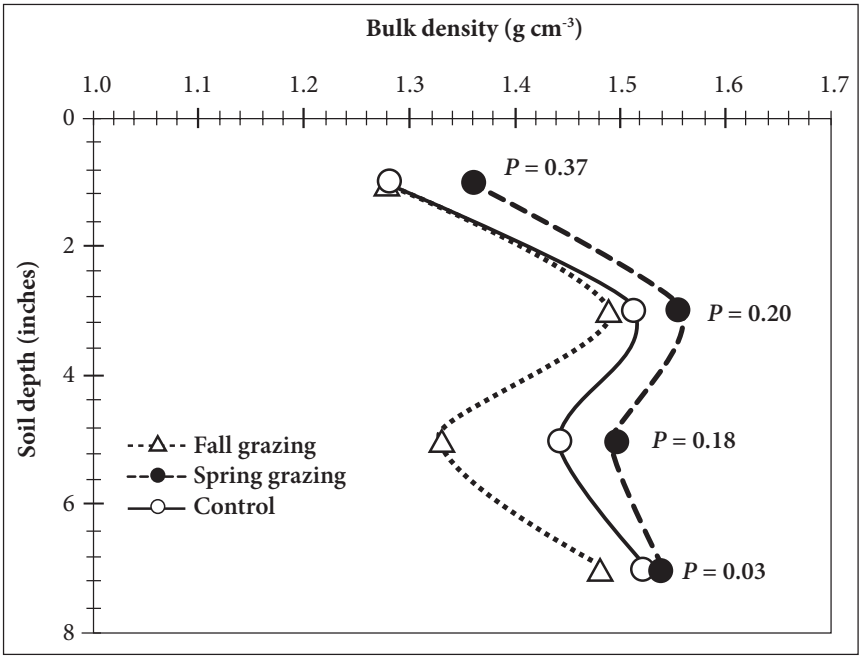

Fig. 2. Soil-depth distribution of bulk density for the 0 to 8 inch depth as affected by 16 years of cattle grazing of corn residues under irrigated no-till system on a Tomek silt loam in eastern Nebraska. The *P*-values are reported for each depth interval

soil and wet soil aggregate stability which is an indicator of the soils ability to resist water erosion. Both corn and soybean yields following corn grazing were significantly ($P < 0.10$) improved by fall grazing (2015 Nebraska Beef Cattle Report, pp 53-55). The spring grazing treatment was specifically designed to determine if heavy stocking in the spring after the soil is thawed would affect soil properties. Soybean yield increased while corn yield was unaffected by spring grazing. Soil bulk density (Fig. 2) and wet aggregate stability were not affected by spring grazing. Only cone index (Fig.1) was significantly increased. The values (1.2 to 1.5 MPa) are, however, below the threshold level of 2.0 MPa. The threshold level is the level where plant root growth is expected to be inhibited. Thus, this finding indicates that that even long term spring grazing at high stocking rates had no effect on soil properties of biological significance.

Concerning soil fertility, grazing treatments had no significant effect on soil organic matter concentration, but the numerical values were greater under fall and spring grazing than under control (Table 1). This indicates that long-term removal of corn residues by grazing did not have any negative effects on soil organic matter levels, which may be due to the following reasons. First, cattle grazing does not remove large amount of residue. The residue removal rate by cattle grazing is often <25%. In the current study, it was estimated that the stocking rates utilized would result in 10 to 13% removal of corn residue in the fall grazing treatment, while the residue removal rate in the spring grazing treatment would range between 6 and 9% in the first 3 years and between 16 and 22% in the last 11 years. Thus, significant amounts (≥ 3.2 ton/ac or >78%) of residue were present on the soil surface to protect soil from erosion and as a source of C to soil. Second, grazing cattle adds manure to soil, which can be a source of more stable C than crop residues. In addition, cattle trampling may incorporate the residues into the soil, preventing them from photo-oxidation. Such mechanisms reduce the decomposition rate of soil organic matter, which can help with maintaining the organic matter level in the soil.

Grazing treatments had no significant effect on soil pH and nutrient concentrations except for calcium and sulfur (Table 1). While one can assume that grazing

Table 1. Impact of 16 years of corn residue grazing on soil fertility and related soil chemical properties (averaged across 0-2 inch and 2-4 inch soil depth) on Tomek silt loam in eastern Nebraska[1]

Treatment	Organic matter	pH	Nitrate-N	Available P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	S
	%				ppm			
Fall grazing	4.2 ± 0.8	6.3 ± 0.4	5.6 ± 2.0	14.3 ± 7.5	354.9 ± 72.8	2337[b] ± 250	352.1 ± 73.0	10.6[b]± 1.7
Spring grazing	4.5 ± 1.0	6.4 ± 0.4	8.1 ± 5.4	18.5 ± 13.1	398.4 ± 90.9	3009[a] ± 477	499.0 ± 139.9	12.9[a] ± 2.5
Control	3.8 ± 0.6	6.7 ± 0.5	4.2 ± 2.2	22.8 ± 18.4	354.3 ± 58.6	2685[a] ± 481	417.3 ± 157.0	9.3[c]± 1.7
P-value	0.14	0.47	0.16	0.70	0.37	0.09	0.20	0.02

[1] Reported as mean ± Standard deviation
[abc]Means followed by different letters in a column indicate significant differences among treatments

should reduce the soil nutrients as grazing cattle remove nutrients with corn residues, it is also important to consider that most of the nutrients taken up by grazing cattle are returned to the soil as manure. In addition, the growing steers received supplements of minerals and protein. The retention of these nutrients in cattle is small and, in essence, cattle excreta acts as a fertilizer source to soil. These results concerning soil fertility and grazing suggest that corn residue grazing has no or positive effects on soil fertility.

Conclusion

The results of this study can have large implications for the development of integrated crop-livestock systems in the western Corn Belt in general and in Nebraska in particular. Our findings suggest that grazing of corn residues does not have detrimental effects on soil properties even in the long term under the conditions of this study. Overall, grazing of corn residues under no-till corn—soybean systems at the stocking rates targeted to remove 10 to 20 % of residue can provide additional feed for livestock in this region.

Manbir K. Rakkar, graduate student

Humberto Blanco, associate professor Agronomy and Horticulture, University of Nebraska—Lincoln, NE (UNL)

Mary E. Drewnoski, assistant professor Animal Science, UNL

James C. MacDonald, associate professor Animal Science, UNL

Terry J. Klopfenstein, professor Animal Science, UNL