WATER USE EFFICIENCY AND SOIL CHANGES AFTER LONG-TERM CROP ROTATION UNDER LIMITED IRRIGATION

P. Garcia Helguera, D. Ruiz Diaz, B. Olson, A. Tonon Rosa, K. Roozeboom
Kansas State University, Manhattan, KS
pgarciah@ksu.edu (785) 370 2797

ABSTRACT

Long-term crop rotation intensity and diversity can affect key soil properties. In semi-arid regions, the combined factors of rotation and soil properties may also affect the overall water use efficiency from either limited irrigation or rainfall. The objective of this study was to evaluate changes in soil properties, and water use efficiency of corn grown under different rotation intensity and diversity and limited/supplemental irrigation. A field experiment was conducted over seven years in Gothenburg, Nebraska, to compare different irrigated crop rotations including five rotation intensity/diversity. All plots were irrigated with an annual average of 150 mm/year, and 100 mm in 2021. After seven years, soil samples were collected in 2021 to include at least two full rotations for the 3-year rotation treatment. Soil samples were collected using a Giddings probe at six depths (0-5 cm, 5-15 cm, 15-30 cm, 30-60 cm, 60-90 cm, and 90-120 cm), and were analyzed for soil C. Grain yield was measured for every crop every year, data for corn yield is presented for the 2021 harvest season only. Corn grain yield in 2021 was numerically higher when following wheat in the rotation. Water use efficiency for corn in 2021 was higher when following winter wheat in the rotation. After seven years, soil organic matter was higher for rotations with more frequent corn in the rotation, and continuous corn and the C-C-W rotation showed significantly lower soil pH. Soil carbon in the soil profile was also generally higher for rotations with high biomass and carbon input.

INTRODUCTION

Nebraska relies heavily on its groundwater and surface water resources for agricultural production. Enhancing water use efficiency ensures the sustainable management of these resources, helping to avoid over-extraction and depletion. Effective crop rotation can optimize water use efficiency. Some crops may require more water than others, and by selecting crops with water requirements suited to the local climate, you can make better use of available water resources. This is especially important in semi-arid regions with limited irrigation or rainfall.

Changes in crop rotation can lead to various soil property improvements, including nutrient balance, pest and disease management, organic matter content, microbial activity, soil structure, pH adjustment, erosion control, and weed management. These benefits collectively contribute to healthier and more productive soils, which are essential for sustainable and high-yield agricultural practices.

The aim of this research was to assess changes in both soil characteristics and the efficiency of water use when cultivating corn under different levels of rotation intensity and diversity, in conjunction with restricted irrigation.

MATERIALS AND METHODS

A field study was established at Gothenburg, NE in 2015, and five rotation intensity/diversity were included (Table 1).

Table 1. In long-term crop rotation systems, all phases of the rotation are present every year.

Rotation/crops	Rotation/years	
1	Corn (C)	1
2	Corn - Wheat (C-W)	2
3	Corn - Soybean (C-S)	2
4	Corn - Corn - Wheat (C-C-W)	3
5	Corn - Sorghum (C-Sg)	2

All plots were irrigated with an annual average of 150 mm/year, and 100 mm in 2021, and the annual accumulated precipitation for 2021 at the study site was 589 mm.
Soil samples were collected in 2021, after seven years to include at least two full rotations for the 3-year rotation treatment. A Giddings probe was used to take soil samples at six depths (0-5 cm, 5-15 cm, 15-30 cm, 30-60 cm, 60-90 cm, and 90-120 cm).
Soil samples were analyzed for soil C using dry combustion.
Grain yield was measured for every crop every year, and the data for corn yield is presented for the 2021 harvest season only.

RESULTS AND DISCUSSION

Corn Yield and Water Use Efficiency

Corn grain yield in 2021 was numerically higher when following wheat in the rotation, likely due to the summer fallow after the wheat harvest, allowing for additional water storage and availability to the corn crop. (Figure 1) On the other hand, water use efficiency for corn in 2021 was higher when following winter wheat in the rotation (treatments with corn-wheat and corn-corn-wheat).(Figure 2)

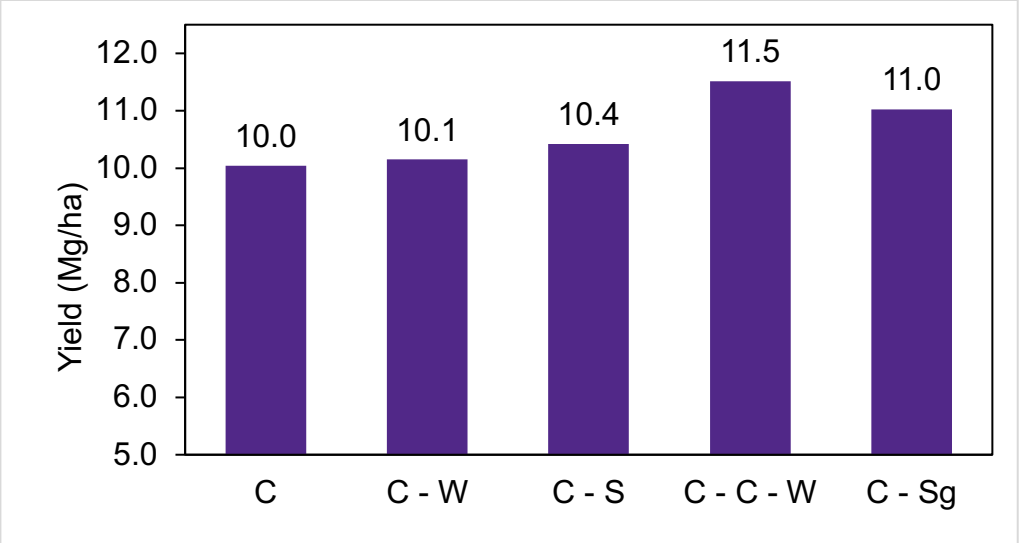

Figure 1. Corn Yield (Kg/ha) in 2021 after long-term crop rotation under limited irrigation.

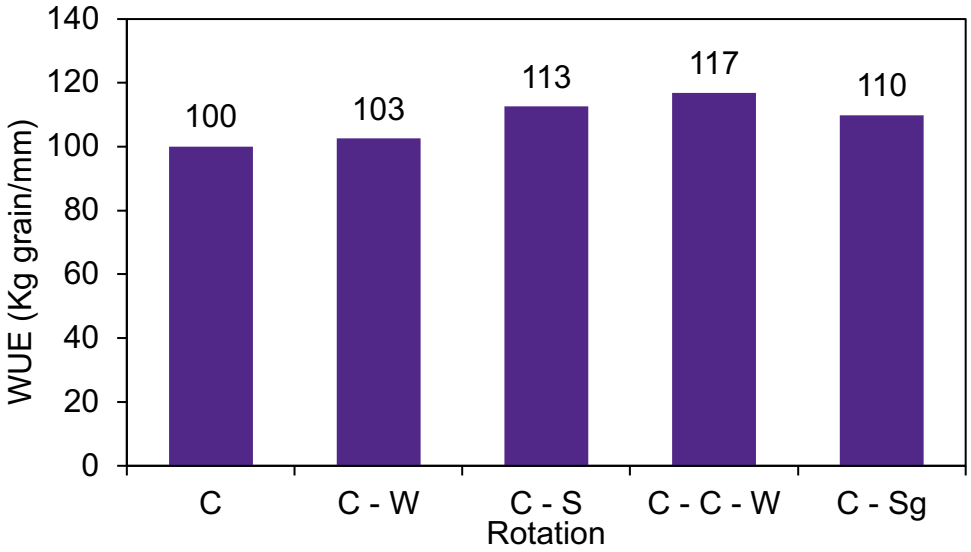

Figure 2. Water use efficiency expressed in Kg of grain/ mm water from irrigation.

After seven years (two full cycles for the 3-year rotation), soil organic matter was higher for rotations with more frequent corn in the rotation (C and C-C-W). (Figure 3).
Continues corn and the C-C-W rotation showed significantly lower soil pH after seven years. This was likely due to the higher total nitrogen fertilizer applied over this period, which will require additional/more frequent investment in lime application. (Figure 4).

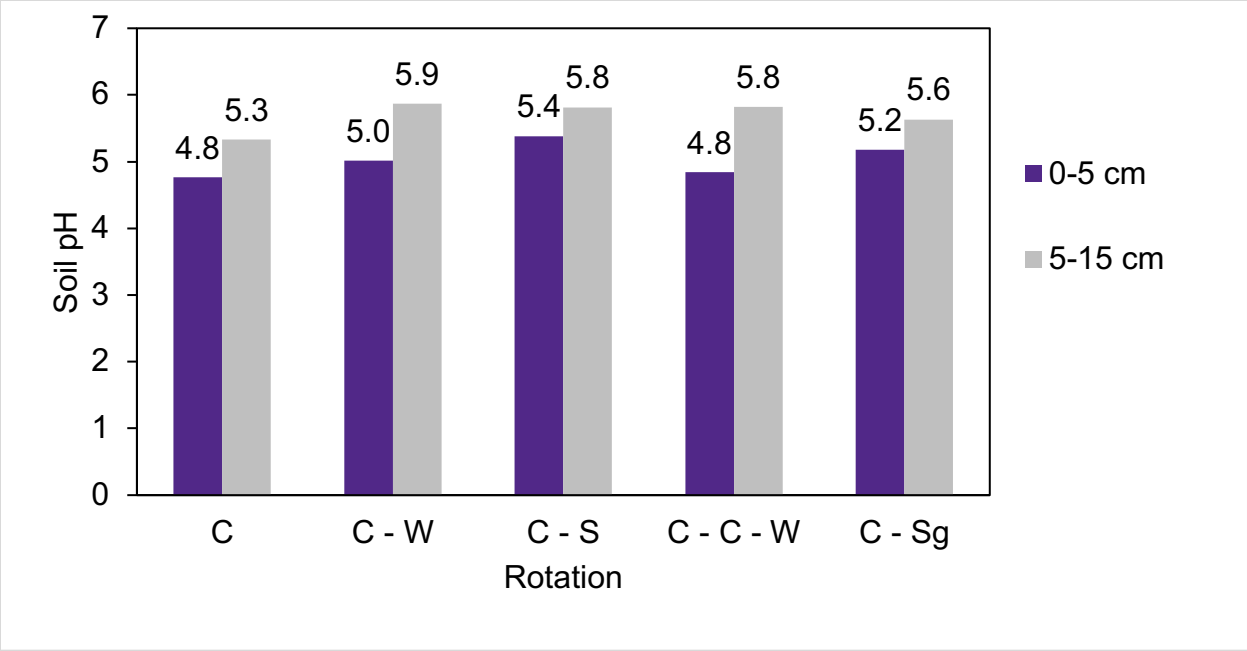

Figure 3. Soil pH at two depths for each long-term crop rotation. Values with different letters within each depth are statistically different at $p < 0.1$.

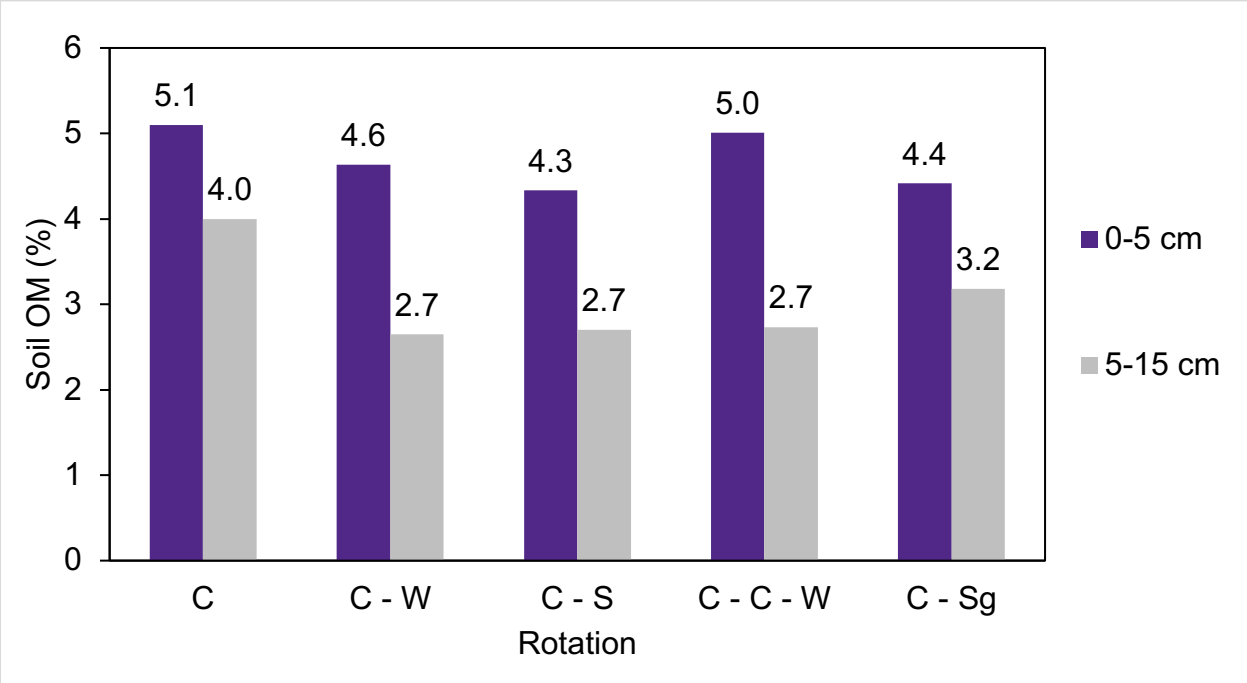

Figure 4. Soil OM at two depths for each long-term treatment crop rotation.

About soil carbon in the soil profile, it was also generally higher for rotations with high biomass and carbon input. (Figure 5).

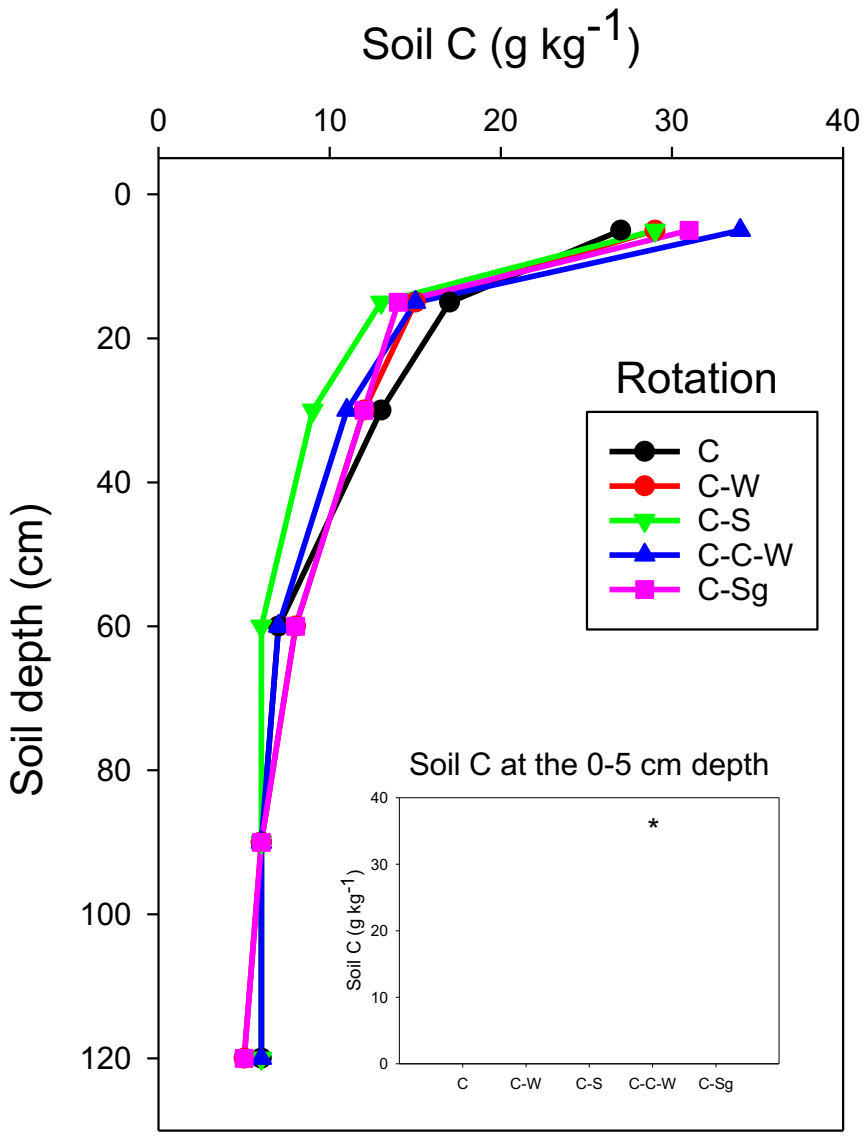

Figure 5. Soil carbon (g kg-1) at different depths after six years of crop rotation.

REFERENCES

Al-Kaisi et al., 2005. Soil carbon and nitrogen changes as influenced by tillage and cropping systems in some Iowa soils. Agric. Ecosyst. Environ., 105 (2005), pp. 635-647, 10.1016/j.agee.2004.08.002

Bowles, T. M., Mooshammer, M., Socolar, Y., Calderon, F., Grandy, A. S. (2020). Long-term evidence shows that crop-rotation diversification increases agricultural resilience to adverse growing conditions in North America. One Earth 2, 284–293. doi: 10.1016/j.oneear.2020.02.007.

Francis J. Pierce, Charles W. Rice ,1988. Crop Rotation and Its Impact on Efficiency of Water and Nitrogen Use. ASA Special Publications, 01 January 1988 https://doi.org/10.2134/asaspecpub51.c3.

M. Pala, J. Ryan, H. Zhang, M. Singh, H.C. Harris. Water-use efficiency of wheat-based rotation systems in a Mediterranean environment, Agricultural Water Management, Volume 93, Issue 3, 2007, pages 136-144, ISSN 0378-3774.

Norwood, C. (1994). Profile water distribution and grain yield as affected by cropping system and tillage. Agronomy journal, 86(3), 558-563.