Science Societies

Benefits of Including Alfalfa in Rotations With Annual Crops

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Alfalfa in rotation with annual crops aggressively scavenges nitro- gen in the soil and can significantly reduce nitrate contamination of groundwater. Photo courtesy of UNL CropWatch.

Increasing nitrate-nitrogen (NO3–N) contamination of groundwater has raised significant environmental and health concerns in Nebraska. One way to reduce the nitrate contamination of groundwater is to follow best nutrient management practices (BMPs). Including a perennial crop in the annual corn-based cropping system is one of the BMPs to potentially decrease NO3–N load to the groundwater.

Including alfalfa in rotations to reduce NO3–N leaching is a long-recognized concept. Several past studies have found that alfalfa aggressively scavenges nitrogen in the soil. However, the effect of alfalfa in the rotation on NO3–N, soil organic carbon (SOC), and water content in the vadose zone remained uncertain.

Therefore, we conducted a study to evaluate the impact of alfalfa in rotation with annual crops for rooting plus vadose zone to 24 ft depth (0 to 24 ft) on NO3–N and NH4–N concentration and soil organic carbon sequestration in Nebraska (https://doi.org/10.1002/jeq2.20473).

The objectives of this study were to determine the impact of alfalfa rotation compared with continuous corn after 20 years on (i) NO3–N leaching potential; (ii) NH4–N, SOC, total soil nitrogen (TSN), and soil organic nitrogen (SON) at 0 to 24 ft; and (iii) soil water for a subsequent annual crop. We hypothesized that for 0 to 24 ft with alfalfa rotation compared with continuous corn (i) NO3-N in 0 to 24 ft would be reduced; (ii) SOC, TSN, and SON would be increased; and (iii) soil water would be reduced in the root zone of a subsequent corn crop.

Experimental Measurements

The experiment was conducted at the Roman L. Hruska U.S. Meat Animal Research Center (USMARC) near Clay Center, NE. The soil was well-drained and deep Crete silt loam formed in loess. The experiment was a randomized complete block design consisting of six pairs of fields with greater than 12 of the past 20 years (2001–2020) in alfalfa rotated with either corn (one to nine years in past 20 years) or soybean (zero to one year in past 20 years) (alfalfa rotation) compared with continuous annual cropping dominated by corn following corn (continuous corn) rotated with either soybean (one to three years in past 20 years) or alfalfa (zero to three years in past 20 years).

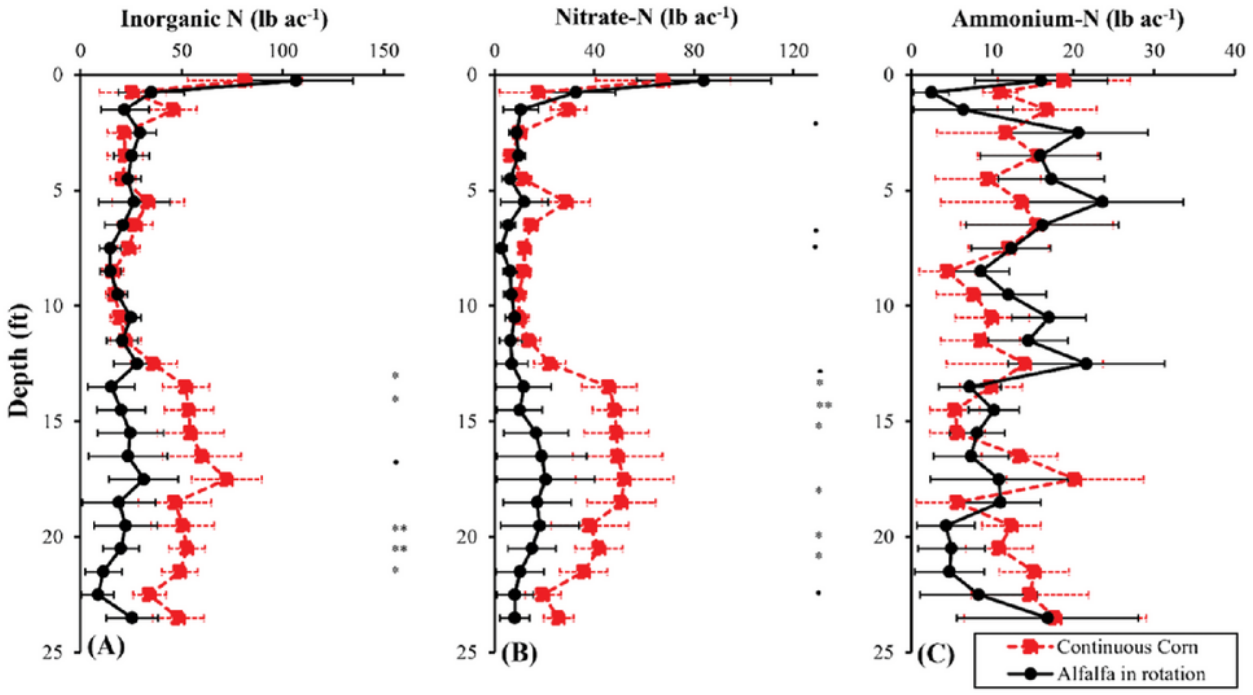
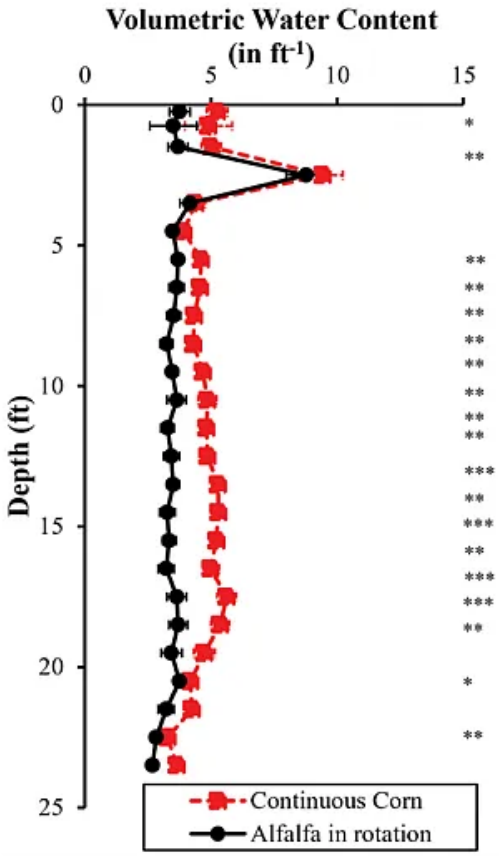


Figure 1. Inorganic N (lb N/ac) (a), nitrate-N (lb N/ac) (b), and ammonium-N (lb N/ac) (c) are shown by soil depth for continuous corn (red) and alfalfa rotation (black) treatments.

Soils from six pairs of alfalfa rotation vs. continuous corn observation points were sampled to a 24-ft depth in 1-ft increments. The uppermost 1 ft was divided into 0 to 6 inches and 6 to 12 inches. The soil samples were analyzed for NO3–N, NH4–N, SOC, TSN, SON, and water at 0 to 24 ft.



Results on Nitrate Leaching Potential and Soil Organic Carbon Sequestration

Figure 2. Volumetric water content (inches/ft) is shown by soil depth for continuous corn (red) and alfalfa rotation (black) treatments.

For the 0- to 24-ft depth, the alfalfa rotation compared with continuous corn had 26% less soil water (3.48 vs. 4.68 inches/ft) and 55% less NO3–N (328 vs. 735 lb N/ac), indicating less NO3–N leaching potential with less deep soil water percolation in the 0- to 24-ft soil depth (Figures 1 and 2). The cropping system and NO3–N concentration did not affect NH4–N in the vadose zone (Figure 1). The greater depletion of soil water and NO3–N with the alfalfa rotation was primarily below the rooting zone of corn, suggesting no negative implications for corn following alfalfa but greatly reduced potential of NO3–N leaching to the aquifer with the alfalfa rotation.

The alfalfa rotation compared with continuous corn had 47% higher SOC (47.3 tons/ac vs. 32.2 tons/ac) and 23% higher TSN (5.34 tons/ac vs. 4.34 tons/ac) in the zero to four feet depth. The higher SOC at 0 to 4 ft in the alfalfa rotation indicates long-term potential for SOC sequestration. Increasing alfalfa in cropping systems may have more potential to increase SOC and TSN if the SOC level is low relative to comparable field situations.

Summary

Rotation of annual crops with alfalfa is a highly effective means of reducing NO_3–N leaching to aquifers and to the lateral flow of water to seepage areas with cost-effectiveness dependent on the commodity values. The 55% less NO_3–N stock in the 0- to 24-ft soil depth and increased SOC, TSN, and SON in the agronomically important 0- to 4-ft soil layer with alfalfa in rotation may contribute to increased

productivity and sustainability. Water quality is important to the public, and implementation of improved management practices by increasing alfalfa in crop rotations could be an effective way to protect this valuable resource.

Acknowledgments

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Dig Deeper

Singh, A., Afzal, T., Woodbury, B., Wortmann, C., Iqbal, J. (2023). Alfalfa in rotation with annual crops reduced nitrate leaching potential, Journal of Environmental Quality, 52, 930–938. https://doi.org/10.1002/jeq2.20473
