End of Season Plant Available Soil Nitrogen within an Integrated Crop and Livestock System

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Introduction

Sustainable crop and livestock production systems depend on maintaining soil productivity and health through utilizing and enhancing natural soil processes. Sustainable systems also protect natural resources while maintaining or maximizing crop yield potential. Since a system's sustainability and productivity involves maintaining the soil organic matter and the processes that promote nutrient cycling, research at the North Dakota State University Dickinson Research Extension Center (DREC) is evaluating seasonal soil nitrogen (N) fertility while minimizing fertilizer inputs in an integrated crop and livestock system. The availability of soil N is the greatest limitation in crop production systems. An integrated system attempts to sustain N availability through crop rotations containing legumes, cover crops and utilization of livestock grazing and natural manure spreading by livestock while, limiting expensive external inputs as fertilizer. The objective of this study is to evaluate soil N cycling related to individual cropping components in an integrated crop and livestock system.

Materials and Methods

The study site is at the DREC Ranch near Manning, ND on a complex of Savage (fine, smectitic, frigid vertic Argiudolls), Daglum (fine, smectitic, frigid vertic Natrustolls), Vebar (coarse-loamy, mixed, superactive, frigid typic Haplustolls), and Parshall (coarse-loamy, mixed, superactive, frigid pachic Haplustolls) soils.

A diverse 5-year crop rotation provides both cash crops as well as annual forage summer grazing for livestock. The rotation includes: i) sunflower (SF); ii) hard red spring wheat (HRSW); iii) fall seeded winter triticale-hairy vetch (THV), spring harvested for hay/spring seeded 7-species cover crop (CC); iv) corn (C) (85-90 day var.); and, v) field pea-barley intercrop (PBY). The HRSW and SF are harvested as cash crops and grazing cattle harvested the PBY, C, and CC. The THV is hayed, fed back to the livestock in the fall, and the CC is seeded after bales are removed. Nitrogen fertilizer application and recommended amounts for all crops in the study are based on NDSU Soil Testing Laboratory results. Supplemental N fertilizer has not been applied since 2012 in the HRSW-R, and since 2013 for the HRSW-C. Using a randomized complete block design, with blocks arranged by soil type, all cropping treatments were replicated three times using no-till seeding and planting methods. As an undisturbed control site, triplicate native range grassland pasture plots, with similar soil type, are monitored. Vegetative pasture cover is dominated by western wheatgrass (*Pascopyrum smithii* (Rydb.) A. Love), blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths), little bluestem (*Schizachyrium scoparium* (Michx.) Nash), and Switchgrass (*Panicum virgatum* L.).

Monitoring of soil nitrogen fertility change, during the 2014 growing season, occurred by collecting eight equally spaced soil samples between late May and mid-October in each treatment field plot to a depth of 2 feet (24 inches), as recommended by the NDSU Soil Testing Laboratory and NDSU Extension Service. Monitoring of soil N fertility continued in the HRSW control and HRSW 5-year rotation fields, during 2015 and 2016 cropping seasons on a regular schedule between late May and mid-October. Once the crops were established, three 8 x 24 inch aluminum irrigation pipes were randomly driven into the ground to a depth of 2 feet in each plot to provide sampling areas where crop roots are excluded from N uptake. Root exclusion devices aided the establishment for an index of total N mineralized without plant uptake without impeding natural leaching, volatilization or immobilization processes in the N cycle. Soil sample analysis included ammonium-N (NH_4-N) and nitrate-N (NO_3-N) (NDSU Soil Testing Laboratory). During each growing season, there were a total of four to eight sampling times.

Results and Discussion

Three year end of season soil NO_3-N, NH_4-N and total mineral N (NO_3-N + NH_4-N) averages are depicted in Figure 1. This represents residual profile N (0-2ft; 0-60 cm) values collected in early to mid-October for the 2014, 2015 and 2016 growing seasons. Nitrate-N (NO_3-N) is higher in the rotation HRSW than in the continuous HRSW. The quantity of NO_3-N in the root exclusion areas (I) was 82 and 95 lbs. N/A for the C and R plots, respectively. This compares with 32 and 36 lbs. N/A where roots scavenged N in the C and R plots, respectively. The difference between root exclusion zones and cropped areas sampled represent the uptake of seasonally mineralized N by the HRSW crop. Hard red spring wheat normally requires 2.5 lbs. N to produce 1 bushel of grain. The differences in soil N between the rotation and continuous wheat indicates that the HRSW grown in the rotation has the potential for producing up to 5 bu./A more grain. However, actual potential yield may differ in western North Dakota due to other factors such as stored soil moisture conditions and in-season rainfall.

Ammonium-N (NH_4-N) levels did not differ greatly between treatments. This is because NH_4-N readily transforms to NO_3-N by soil microorganisms; therefore, the supply of NH_4-N remains relatively constant. When readily available, many crops including wheat utilize NH_4-N for their N requirement.

Total mineral N is the sum of NO_3-N and NH_4-N and represents the entire N available to the crop. The differences in the soil total mineral N values are influenced by the differences in soil NO3-N quantities.

Levels of the plant available N in the native grassland were lower than the amount measured in cropland. Nitrate-N levels were 8 lbs. N/A and NH4-N levels were similar to the cropland plots. One reason for the difference between native pasture and cropland is that organic matter does not turn over very rapidly in grasslands and most N is immobilized in plant tissues and residues. In addition, grassland soils are often drier than cropland soils because the established vegetation is continuously utilizing soil moisture as long as plant are growing. This can reduce the moisture needed for N transforming soil microorganisms to efficiently mineralize N from soil organic matter and plant residues.

Summary and Conclusions

The data shown above illustrate the effect of legumes in a cropping system on improving the soil N status. Where N-fixing legumes are present in the system, even though the plant biomass is harvested by haying or grazing, enough of the N-enriched plant materials and roots remain to provide additional mineral N to the soil as plant organic matter decomposes. Moreover, organic matter decomposition and nutrient cycling reduces the requirement for additional N fertilizer and can reduce crop production cost.

Note: To convert kg/ha to lb/A, multiply kg/ha by 0.893.

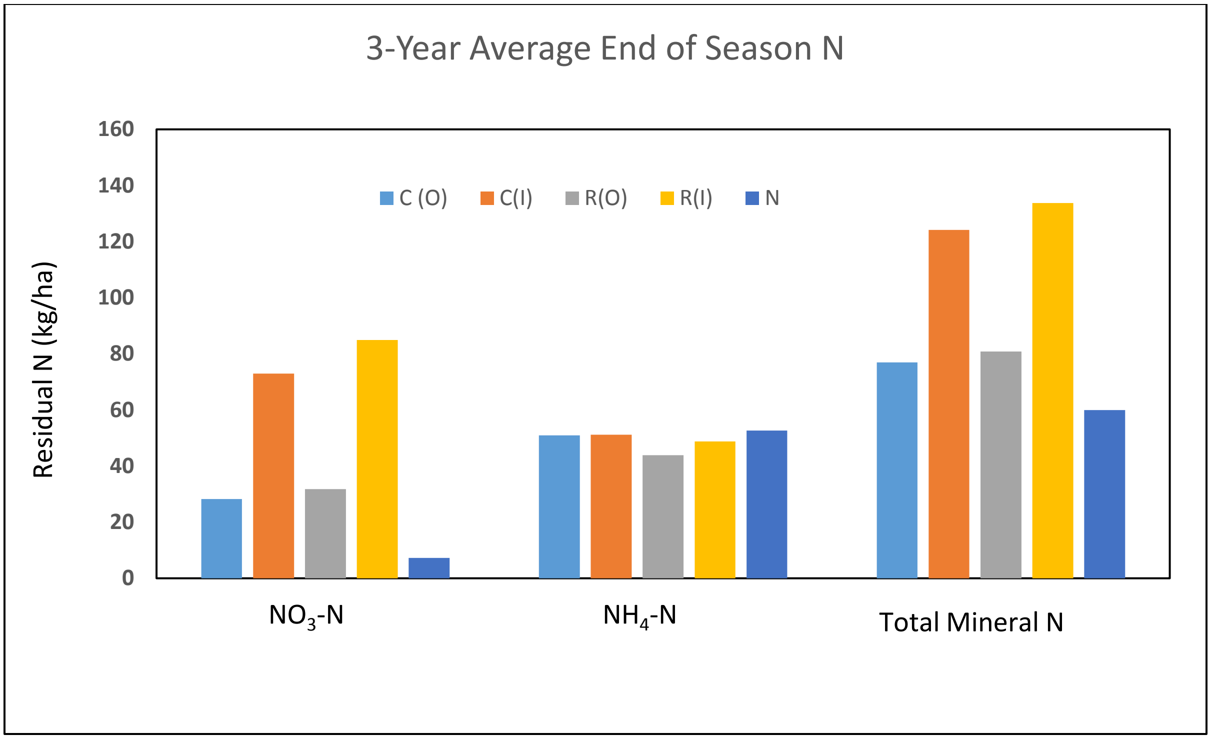

Figure 1. End of season, three-year average, NO_3-N, NH_4-N profile and total plant available mineral N in continuous HRSW (C) or HRSW in rotation (R) for soil samples collected inside (I) and outside (O) root exclusion areas. Native grassland (N) used as a comparison.