Seasonal Soil Nitrogen Mineralization within an Integrated Crop and Livestock System in Western North Dakota, USA

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Introduction

Throughout history, as people work the land for food production without regard for soil quality, soil becomes degraded. Depending on the initial soil quality, the amount of time needed to virtually deplete soil of its ability to produce food occurs at different rates. But, without managerial intervention, a soil's ability to produce nutrients for food production depletes to the point where very little can be grown effectively. Through man's ingenuity and science many soils that normally would be considered unproductive have been made very productive artificially, because of intervention technology including better and adapted crop varieties, weed and pest control, fertilizers, and irrigation. For a long time, man has known that depleted soils could be rejuvenated with the addition of organic matter and, intuitively, organic matter depletion is the primary reason soils become unproductive. Large farm equipment, readily available fertilizer and herbicides, irrigation, and genetically modified crop varieties have paved the way for farmers to abandon proven cultural practices that simultaneously maintain soil quality and produce acceptable yields.

Protecting natural resources while maintaining or maximizing crop yield potential is of utmost importance for sustainable crop and livestock production systems. Since soil organic matter and its decomposition by soil organisms is at the very foundation of healthy productive soils, systems research at the North Dakota State University, Dickinson Research Extension Center is evaluating seasonal soil organic matter, bulk density, and nitrogen fertility within a long-term integrated crop and livestock production system.

The purpose of our research is evaluate the effect of a complementing crop rotation that includes cash crops and crops grown for grazing by beef cattle that are subsequently sold in the systems evaluation. Within this complex integrated system, our research is measuring bulk density, soil derived N from organic matter, and N from legumes in the rotation.

Materials and Methods

- 2011-2014 Crop Rotation (4 Years) – Triple replicated 10.6 ha fields
- Sunflower (SF) ➡ Hard Red Spring Wheat (HRSW) ➡ fall seed winter triticale ➡ hairy vetch WT ➡ HV (spring harvest for hay) ➡ Cover Crop - 7-species (CC) ➡ Corn (C) (85-90 day var.) ➡ Field Pea-Barley intercrop (PBY).

  The HRSW and SF are harvested as cash crops and the PBY, C, and CC are harvested by grazing cattle.
- In the system, yearling beef steers graze the PBY and C before feedlot entry and after weaning, gestating beef cows graze the CC. Since rotation establishment, four crop years have been harvested from the crop rotation.
- Except C and SF, all other crops were seeded using a JD 1590 no-till drill. The HRSW, PBY, and CC were seeded at a soil depth of 3.8 cm and a row width of 19.1 cm.
- Corn and SF were planted using a JD 7000 no-till planter. Seed placement for the C and SF crops was at a soil depth of 5.1 cm and the row spacing was 0.762 m. The plant population goal/ha for C, SF, and wheat was 7,689, 7,244, and 50,587p/ha, respectively.
- During the 3rd crop year (2013), soil bulk density was measured (Table 1, Fig. 1 and Fig. 2)
- During the 4th crop year (2014), soil organic matter (OM) and available soil nitrogen were measured. Samples were collected from June 2 to October 14. Samples were analyzed for nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), total season mineral nitrogen (NO_3-N + NH_4-N), and cropping system NO_3-N.

- Soil nitrogen (N) and bulk density (BD) were measured in 3 replicated non-fertilized field plot areas within each 10.6 ha triple replicated crop fields. Within each plot area, 6 – 20.3 cm x 0.61 m aluminum irrigation pipes were pressed into the soil as enclosures to restrict root access to soil nitrogen (Fig. 3). Soil samples were taken as close to 2-week intervals as possible from both inside and outside the enclosures (Fig. 4). The crop rotation bulk density and N values were also compared to triple replicated perennial native grassland plot areas.

Table 1. Native range, spring wheat control, and crop rotation bulk density values

	Native Range	**Spring Wheat Control**	**Spring Wheat Rotation**	**Triticale Hairy Vetch/Cover Crop**	**Pea Barley**	**Corn**	**Sunflower**
Bulk Density (0-11 in)	1.375[b]	1.552[a]	1.545[a]	1.538[a]	1.49[a]	1.473[ab]	1.543[a]

[a-b]Means within a row with unlike superscripts differ ($P < 0.05$)

Results

- Grassland BD was less compared to all other crops except corn grown in rotation following cover crop ($P<0.05$). Control spring wheat BD did not differ from spring wheat grown in rotation ($P<0.05$) (Table 1).
- There was a trend for increasing N with increasing OM (Chart 1).
- Seasonal nitrate levels were greater within the root isolation cylinders compared to the cropped average. The difference is due to root scavenging of nitrate and plant uptake (Chart 2).
- When legume crops were compared to non-legume crops, the seasonal nitrate difference between inside and out of the isolation zones was similar to the cropped average (Chart 3).
- Growing N in the crop rotation can reduce fertilizer cost.


Fig. 1


Fig. 2


Fig. 3


Fig. 4

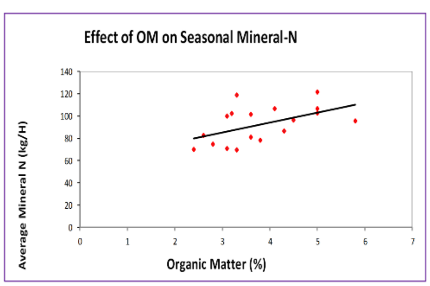

Chart 1

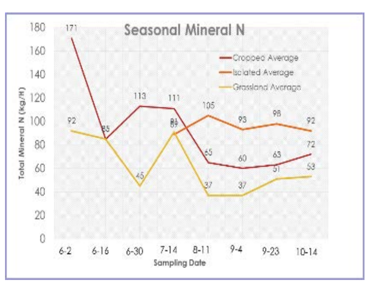

Chart 2

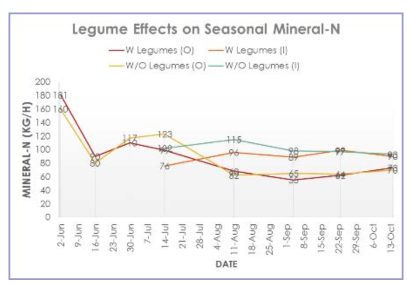

Chart 3