Effects of the Cropping System on Soil Physical Properties in an Integrated Crop and Livestock System

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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 soil organic matter as well as soil quality and soil health, research at the North Dakota State University Dickinson Research Extension Center (DREC) is evaluating an integrated crop and livestock system for nutrient cycling and changes in soil properties. Soil physical conditions influence the resilience of the soil to weather changes as well as the soil's ability to capture precipitation and resist degradation due to wind and water erosion. In 2017, the objective of this study was to evaluate differences in soil physical properties related to individual cropping components in an integrated crop and livestock system, specifically, changes in water infiltration, wind erodibility and aggregate stability.

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 is being utilized to provide both cash crops as well as 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 the PBY, C, and CC are harvested by grazing cattle. The THV is hayed and fed to the livestock. No supplemental fertilizer N is being applied. All cropping treatments are replicated three times in a randomized complete block arrangement with the blocks arranged by soil type. All of the crops are managed as no-till crops. Triplicate plots in nearby undisturbed grassland pastures with similar soils are also being monitored as a control in this study. The vegetative cover in the pasture 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.).

During July 2017, infiltration tests and bulk soil samples were collected to determine water stable aggregates and wind erodible aggregate fraction. Infiltration tests were conducted using a single ring infiltrometer (Bouwer, 1986) and air-dry and field moist aggregate stability was done as described by Kemper and Rosenau (1986). Wind erodible fraction was done using a rocker sieve with a 0.84 mm screen (Chepil, 1954). Statistical analysis was done using SAS v.9.4. The sampling and infiltration testing was done under extremely dry conditions due to the severe drought period that persisted throughout the 2017 growing season that affected much of North Dakota.

Results and Discussion

The results of the studies are shown in Table 1. The main comparisons were made between the continuous wheat and wheat in rotation which are shown in Table adjacent to each other. The various current crop year treatments are shown with the significance of the differences between mean values denoted by lower case letters.

Water Infiltration. No significant differences were observed in water infiltration rate between any of the crops in the rotation. However, rotation SW hand an average infiltration rate of 1.07 in/hr. compared to 0.75 in/ hr. for the continuous SW (27 mm/hr. vs. 19 mm/hr.). This was likely due to better aggregation (probably fine aggregation) for the rotation SW than the continuous SW. under the dry conditions this year. Visually, the continuous SW appeared to have a much more massive structure than the rotation wheat. It also visually appeared that the Rotation had better structure due to the crop diversity although the aggregates appeared to be very small.

Wind erodible fraction. No significant differences were observed between any of the crop treatments. However, the rotation SW had a 40.5% wind erodible fraction compared to the continuous SW which had a 28.3% erodible fraction. Again, this is likely due to the dry conditions where the continuous wheat crop had a massive structure compared to the rotation SW which had a lot of strong fine aggregates (<0.84 mm). It appears that the crop rotation promoted better aggregation due to the crop diversity even though the aggregates were very small.

Air-Dry Water Stable Aggregates. No significant differences were observed between any of the crop treatments. The rotation SW had a slightly higher level of water stable aggregates (92.6%) compared to the continuous wheat (91.2%). However the air-dry aggregate stability was relatively high (~90 % or higher) which may partially due to the extremely dry soil conditions due to the drought. Again the crop diversity in the rotation may have slightly promoted stronger aggregates and these observations seem to be interrelated with the observations for water infiltration and wind erodible fraction above.

Field-Moist Water Stable Aggregates. Because of the dry soil conditions at the time that the aggregates were collected, they appeared to be nearly as dry as the air-dry samples at the time they were processed. However, significant differences were observed for this study parameter. The lowest stability values were for sunflower while the highest values were for continuous spring wheat and corn. The aggregates from the continuous wheat were about 6 % higher (in absolute value)that for the rotation wheat. This may be due to aggregates from the rotation wheat containing slightly more inherent moisture than the continuous wheat which makes them slightly weaker and allowing them to break down to a small extent when additional moisture is added. On the other hand, the apparent massive structure of the soil in the continuous wheat under the hot dry conditions of 2017 may have resulted in aggregates that were cemented together with little influence of aggregating by organic matter due to diverse sources of crop organic matter input.

Summary and Conclusions

Water infiltration, wind erodibility and water stable aggregates were evaluate during the 2017 growing season. No significant differences were observed between any of the crops evaluated. However, numerically higher infiltration, wind erodible fraction and water stable aggregate values for the rotation spring wheat may be indicating that the crop rotations are having an impact on the soil quality in that more stable aggregates, although likely smaller in diameter, are found in the rotational wheat. Continuous wheat aggregation appears to be more massive (or not aggregating at all) contributing to the results observed. In general, smaller stronger aggregates appear to be present in the rotational wheat as compared to the continuous wheat indicating the positive effect of the crop rotation on soil structure. However, due to the extremely dry weather during 2017, the smaller but stronger aggregates could increase wind erodibility but also appear to enhance water infiltration.

References

Bouwer, H. 1986. Intake rate: Cylinder infiltrometer. *In* A. Klute (ed.) Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods. Agron. 9:825-844.

Chepil, W. 1954. Seasonal fluctuations in soil structure and erodibility of soil by wind. Soil Sci. Soc. Am. J. 18:1-13.

Kemper W. D., and R. C. Rosenau. 1986. Aggregate stability and size distribution. *In* A. Klute (ed.) Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods. Agron. 9:425-442.

Table 1. 2017 data for crop treatment effects on water infiltration, wind erodible soil fraction and air-dry and field-moist aggregate stability.

Crop	Water Infiltration Rate	Wind Erodible Soil Fraction	Air-dry Aggregate Stability	Field-moist Aggregate Stability
	in./hr.	%	%	%
Spring Wheat (C)	0.74 a	28.3 a	91.2 a	96.5 a
Spring Wheat (R)	1.07 a	40.5 a	92.6 a	90.4 ab
Sunflower	1.05 a	35.0 a	89.5 a	81.9 b
Triticale-Hairy Vetch	0.92 a	23.6 a	96.3 a	91.5 ab
Pea-Barley	0.83 a	32.5 a	89.6 a	89.8 a b
Corn	1.36 a	30.6 a	97.0 a	96.2 a