Bulk Density Comparison within a Crop Rotation in Western North Dakota

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ABSTRACT

Bulk density (BD) is a soil factor that affects plants and limits root growth. BD is influenced by; organic matter content, porosity, and soil structure. This study was designed to determine how BD, within a no-till crop rotation (spring wheat, triticale/hairy vetch/cover crop, corn, pea-barley, sunflower) differed between a continuous spring wheat control and native range. The BD evaluation is part of a long-term integrated cropping and beef cattle research project supported by a USDA/Sustainable Agriculture Research and Education grant being conducted at the Dickinson Research Extension Center Ranch Headquarters located southwest of Manning, North Dakota. The BD study evaluated 3 continuous spring wheat control fields, 15 crop rotation fields, and 3 native range study sites. The results indicated that compared to the spring wheat control, there was no BD difference between spring wheat in rotation, pea-barley, sunflower, corn and winter triticale/hairy vetch-cover crop ($P>0.10$). However, when native range was compared to all of the crops, BD of native range was less ($P<0.001$) except for corn that was similar to the native range ($P = 0.178$). The study shows that BD change is slow, but that change is beginning, as evidenced by the comparison between corn and native range.

SUMMARY AND CONCLUSIONS

The foundation research project is a long-term (10 year) investigation to determine the impact on soil quality, among other things, and how the crop rotation used in the study, along with no-till farming and grazing, are collectively improving crop yields while inputs are being reduced. Bulk density is one soil measurement that can be used to measure a soil's potential to limit root growth and penetration and is influenced by organic matter content, porosity, and soil structure. Based on our data, we conclude that the combination of no-till, crop rotation, cover crops, and cattle grazing are collectively resulting in soil quality improvement. The BD measured was not different when the spring wheat control was compared to the rotation crops, but when the rotation crops were compared to native range, corn was not different and pea-barley also tended to not be different. Earth worms are commonly found in healthy soils and contribute to healthy soils. We found earth worms in many of the soils as BD samples were collected and a few of the samples contained earth worms. We conclude that the cropping and grazing methods employed in the study are working and that we expect that BD will continue to decline becoming more like native range over time. How long this will take is unknown, but since change in soil characteristics occur slowly over time we would expect this to be many years.

IMPLICATIONS

Tillage has been proven to cause compaction and in return decreases soil aggregates, organic matter, decrease in oxygen and nitrogen. These problems result in loss of earth worms, microorganisms, and other biota that create pores in the soil and replenish the soil with the things that plants need to grow. Farming practices that inhibit biological activity in the soil contribute to declining soil quality and associated BD increase. Collectively, the practices to include no-till farming, crop rotation with the four adapted crop types (cool season grass – wheat, cool season broadleaf – pea, warm season grass – corn, and warm season broadleaf – sunflower), multi-species cover crop, and beef cattle grazing are supporting improvement in soil quality as evidenced by soil BD decline in corn and to some extent pea-barley fields compared to native range. These practices are expected to provide support for further decline in BD over time.

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Table 1. Root growth limiting bulk density values by soil texture. (9, 10, after 38)

Soil Texture	Root-Limiting Bulk Density (g/cc)
Sand	1.8 G/Cc
Fine Sand	1.75
Sandy Loam	1.7
Fine Sandy Loam	1.65
Loam	1.55
Silt Loam	1.45
Clay Loam	1.5
Clay	1.4

From Tree Root Growth Control Series: Soil Constraints on Root Growth, Kim D. Coder, University of Georgia, 1998, FOR98-10.

Table 2. Fields, soil texture, bulk density (BD) values taken at 0-4" and 7-11"

Sample #	Soil Texture	BD	Sample #	Soil Texture	BD
1913 S1 0-4"	Silty Clay Loam	1.32	1918 S2 0-4"	Silt Loam	1.5
1913 S1 7-11"	Silty Clay Loam	1.39	1918 S2 7-11"	Silt Loam	1.43
1913 S2 0-4"	Silt Loam	1.42	1918 S3 0-4"	Silty Clay Loan	1.45
1913 S2 7-11"	Silt Loam	1.38	1918 S3 7-11"	Silty Clay Loan	1.47
1913 S3 0-4"	Silty Clay Loam	1.47	1919 S1 0-4"	Silty Clay Loan	1.47
1913 S3 7-11"	Silty Clay Loam	1.39	1919 S1 7-11"	Silty Clay Loan	1.51
1914 S1 0-4"	Silty Clay Loam	1.43	1919 S2 0-4"	Silty Clay Loan	1.46
1914 S1 7-11"	Silty Clay Loam	1.37	1919 S2 7-11"	Silty Clay Loan	1.34
1914 S2 0-4"	Silty Clay Loam	1.62	1919 S3 0-4"	Silty Clay Loan	1.43
1914 S2 7-11"	Silty Clay Loam	1.35	1919 S3 7-11"	Silty Clay Loan	1.31
1914 S3 0-4"	Silty Clay Loam	1.46	1920 S1 0-4"	Silty Clay Loan	1.51
1914 S3 7-11"	Silty Clay Loam	1.45	1920 S1 7-11"	Silty Clay Loan	1.35
1915 S1 0-4"	Silty Clay Loam	1.56	1920 S2 0-4"	N/A	1.45
1915 S1 7-11"	Silty Clay Loam	1.42	1920 S2 7-11"	N/A	1.37
1915 S2 0-4"	Silty Clay Loam	1.47	1920 S3 0-4"	Silty Clay Loan	1.41
1915 S2 7-11"	Silty Clay Loam	1.41	1920 S3 7-11"	Silty Clay Loan	1.44
1915 S3 0-4"	Silty Clay Loam	1.46	1921 S1 0-4"	Silty Clay Loan	1.58
1915 S3 7-11"	Silty Clay Loam	1.33	1921 S1 7-11"	Silty Clay Loan	1.48
1916 S1 0-4"	Silty Clay Loam	1.49	1921 S2 0-4"	Silt Loam	1.56
1916 S1 7-11"	Silty Clay Loam	1.51	1921 S2 7-11"	Silt Loam	1.41
1916 S2 0-4"	Silty Clay Loam	1.49	1921 S3 0-4"	Silty Clay Loan	1.65
1916 S2 7-11"	Silty Clay Loam	1.51	1921 S3 7-11"	Silty Clay Loan	1.69
1916 S3 0-4"	Silty Clay Loam	1.54	1922 S1 0-4"	Silty Clay Loan	1.66
1916 S3 7-11"	Silty Clay Loam	1.44	1922 S1 7-11"	Silty Clay Loan	1.49
1917 S1 0-4"	Silty Clay Loam	1.47	1922 S2 0-4"	Silty Clay Loan	1.63
1917 S1 7-11"	Silty Clay Loam	1.49	1922 S2 7-11"	Silty Clay Loan	1.52
1917 S2 0-4"	Silty Clay Loam	1.4	1922 S3 0-4"	Silty Clay Loan	1.53
1917 S2 7-11"	Silty Clay Loam	1.45	1922 S3 7-11"	Silty Clay Loan	1.45
1917 S3 0-4"	Silty Clay Loam	1.53	1923 S1 0-4"	Silty Clay Loan	1.6
1917 S3 7-11"	Silty Clay Loam	1.47	1923 S1 7-11"	Silty Clay Loan	1.51
1918 S1 0-4"	Silt Loam	1.47	1923 S2 0-4"	Sandy Loam	1.69
1918 S1 7-11"	Silt Loam	1.46	1923 S2 7-11"	Sandy Loam	1.59

Table 3. Fields, soil texture, bulk density (BD) values taken at 0-4" and 7-11" (continued)

Sample #	Soil Texture	BD	Sample #	Soil Texture	BD
1923 S3 0-4"	Silty Clay Loam	1.64	1928 S3 7-11"	Sandy Loam	1.66
1923 S3 7-11"	Silty Clay Loam	1.54	1929 S1 0-4"	Sandy Loam	1.63
1924 S1 0-4"	Sandy Loam	1.73	1929 S1 7-11"	Sandy Loam	1.55
1924 S1 7-11"	Sandy Loam	N/A	1929 S2 0-4"	Sandy Loam	1.6
1924 S2 0-4"	Sandy Loam	1.47	1929 S2 7-11"	Sandy Loam	N/A
1924 S2 7-11"	Sandy Loam	1.5	1929 S3 0-4"	Sandy Loam	1.64
1924 S3 0-4"	Sandy Loam	1.57	1929 S3 7-11"	Sandy Loam	1.54
1924 S3 7-11"	Sandy Loam	1.55	1930 S1 0-4"	Sandy Loam	1.67
1925 S1 0-4"	Sandy Loam	1.63	1930 S1 7-11"	Sandy Loam	1.61
1925 S1 7-11"	Sandy Loam	1.66	1930 S2 0-4"	Sandy Clay Loam	1.66
1925 S2 0-4"	Sandy Loam	1.58	1930 S2 7-11"	Sandy Clay Loam	1.62
1925 S2 7-11"	Sandy Loam	1.47	1930 S3 0-4"	Silt Loam	1.6
1925 S3 0-4"	Silty Clay Loam	1.63	1930 S3 7-11"	Silt Loam	1.53
1925 S3 7-11"	Silty Clay Loam	1.62	67B-21 S1 0-4"	Sandy Loam	1.14
1926 S1 0-4"	Silty Clay Loam	1.59	67B-21 S1 7-11'	Sandy Loam	1.26
1926 S1 7-11"	Silty Clay Loam	1.57	67B-21 S2 0-4"	Silty Clay Loam	1.07
1926 S2 0-4"	Silty Clay Loam	1.63	67B-21 S2 7-11'	Silty Clay Loam	1.11
1926 S2 7-11"	Silty Clay Loam	1.67	67B-21 S3 0-4"	Silty Clay Loam	1.27
1926 S3 0-4"	Silty Clay Loam	1.42	67B-21 S3 7-11'	Silty Clay Loam	1.52
1926 S3 7-11"	Silty Clay Loam	1.47	69B-16 S1 0-4"	Silty Clay Loam	1.3
1927 S1 0-4"	Silty Clay Loam	1.62	69B-16 S1 7-11'	Silty Clay Loam	1.33
1927 S1 7-11"	Silty Clay Loam	1.44	69B-16 S2 0-4"	Silty Clay Loam	1.41
1927 S2 0-4"	Sandy Clay Loam	1.67	69B-16 S2 7-11'	Silty Clay Loam	1.16
1927 S2 7-11"	Sandy Clay Loam	1.71	69B-16 S3 0-4"	Silty Clay Loam	1.22
1927 S3 0-4"	Sandy Loam	1.71	69B-16 S3 7-11'	Silty Clay Loam	1.36
1927 S3 7-11"	Sandy Loam	1.54	81B-19 S1 0-4"	Sandy Loam	1.63
1928 S1 0-4"	Sandy Loam	1.6	81B-19 S1 7-11'	Sandy Loam	1.6
1928 S1 7-11"	Sandy Loam	1.57	81B-19 S2 0-4"	Sandy Loam	1.56
1928 S2 0-4"	Sandy Loam	1.6	81B-19 S2 7-11'	Sandy Loam	1.58
1928 S2 7-11"	Sandy Loam	1.65	81B-19 S3 0-4"	Sandy Loam	1.54

Table 4. 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")[b]	1.375^{b}	1.552^{a}	1.545^{a}	1.538^{a}	1.49^{a}	1.473^{ab}	1.543^{a}

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

Table 5. Bulk density statistical contrasts P-Values for Table 4

Contrasts:	Crops	SEM	P-Value
Native Range	Corn	0.0394	0.178
versus	Spring Wheat	0.0394	0.001
	Pea-Barley	0.0394	0.06
	Sunflower	0.0394	0.001
	Triticale-H-Vetch/cover crop	0.0394	0.001
	Spring Wheat Control	0.0394	0.000
Spring Wheat Control	Corn	0.0394	0.407
versus	Spring Wheat	0.0394	1.000
	Pea-Barley	0.0394	0.725
	Sunflower	0.0394	1.000
	Triticale-H-Vetch/cover crop	0.0394	1.000
	Native Range	0.0394	0.000

Table 6. Crop yields

	2011	2012	2013	Average
Corn	15.00	55.30	88.90	52.74
Spring Wheat	30.10	45.10	34.30	36.50
Pea-Barley	-	3.11	4.52	3.82
Sunflower	891	1590	1959	1480
Triticale-H-Vetch	2.71	1.59	0.00	1.43
Cover Crop	0.00	4.25	2.84	2.36
Spring Wheat Control	28.03	55.70	45.17	42.97

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Lauren Pfenning and Doug Landblom collecting bulk density samples.

Songul Senturklu and Lauren Pfenning collecting bulk density samples.

Corn soil structure with roots