Aggregate Sizes and Stability in Cultivated South Dakota Prairie Ustolls and Usterts

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ABSTRACT

Soil structural stability often decreases as the intensity of cultivation increases. The effect of three different management systems (grass, no-till, and till) on soil aggregate stability and sizes were studied in six Ustolls and two Usterts on central South Dakota farms. Soil structure was morphologically described throughout the profile. Stability of dry and wet aggregates in the topsoil was tested by dry and wet sieving. Most structural changes were observed in the top 0 to 0.20 m. Granular structure was dominant under grass, whereas plates, blocks, and compacted layers were most common in conventionally tilled and no-till soils. The largest mean weight diameters (MWD) of dry aggregates were found in no-till soils (10 mm vs. 7 in till and 6 in grass). Wet aggregate stability was higher in grass (87%) than in cultivated soils (70%). After about 10 yr of no-till management, no-till soil aggregates were significantly more stable (5% for wet and 32% for dry aggregates) than till aggregates only in the top 0 to 0.05 m. The structural stability of cultivated soils was greater in Usterts than in Ustolls.

Tillage operations tend to break down aggregates and reduce soil structural stability. Crusts and compacted layers are common in cropped soils. Blocky and platy structures replace the granular structure of the prairie when soil with reduced stability is subjected to the external forces associated with modern farming practices such as high axle loads (Wiermann et al., 1999). No-till systems may modify soil structure toward the original structure of the prairie by eliminating tillage (Kladivko et al., 1986; Arshad et al., 1999). Evidence of changes in soil structure was observed within 5 to 10 yr of conversion from till to no-till (VandenBygaart et al., 1999a).

Soil structure can be characterized by a variety of methods (Dexter, 1988), and different methods have indicated changes in soil structure due to agricultural management practices (Coughlan et al., 1991; Boersma and Kooistra, 1994). The description of some visible features is a rapid approach that can be used for an initial global evaluation of structure. Pedality describes the structure as strength, size, shape, and arrangement of peds (Brewer, 1964). A pedality index based on scores for size, grade, and type of structure in relation to some measurable property was proposed by Peerlkamp (1959). More recently, Bouma and Anderson (1973), Bouma, (1992), and Lin et al. (1999) have developed this concept with special emphasis to hydraulic properties.

In the case of the morphological description of the structure of air-dry soils, pedality refers to dry aggregates. Dry aggregation is an important phase of structure genesis in arid and semiarid soils, where it is transient, formed only periodically at the surface. Dry aggregation determines the resistance of the soil to wind erosion since aggregates and particles >1 mm are less susceptible to wind transport. Dry stability measures the strength of aggregates subjected to fracture and abrasion. Slight differences in structural stability can be detected by dry sieving (repeated if necessary). Dry sieving has shown decreased macroaggregate stability after tillage (Chepil, 1962; Degens et al., 1996).

On the other hand, measurements of stability to water are generally used to estimate structural changes due to cultivation, because water is the main agent of aggregate breakdown in agricultural soils. At the macroaggregate scale, wet sieving traditionally provides a measure of size and stability of aggregates produced by the scouring action of water. Results of wet sieving tests may or may not include the effect of initial slaking depending on initial soil moisture content. Rapid immersion of air-dry aggregates may cause slaking, which may give a finer separation of water stability in soils with different cropping histories (Haynes, 1993).

This study evaluated the effects of management practices on soil pedality, aggregate size, and aggregate stability of croplands when compared with grasslands in central South Dakota. In central South Dakota, conversion from grassland to cropland occurred during the latter part of the nineteenth century and early part of the twentieth century. Intensive tillage operations for seedbed preparation have occurred annually on most of this land. During the last 20 yr many producers have started to use no-till systems (USDA-NRCS, 2003). In both till and no-till fields, dominant crops are annual species with reduced root development when compared with perennial grasses. Annual crops may limit the potential for no-till to improve soil structure, especially when noncontrolled traffic and large equipment are used, as is common in central South Dakota. We applied different methods for showing changes in soil structure in fields under different management practices testing the following hypotheses:

1. The pedality of grasslands is greater than the pedality of croplands because of prevalent strong, fine, granular peds;
2. The pedality of no-till soils is greater than the pedality of tilled soils due to reduced disturbance by cultivation;
3. Dry and wet aggregate stabilities are greater in grasslands than in croplands and greater in no-till than in tilled soils.

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Abbreviations: MWD, mean weight diameter.

MATERIALS AND METHODS

Experimental Design

The experiment was a completely randomized block design with three treatments (management systems) and eight replications (sites). Ustolls were present at six sites and Usterts were present at two sites (Table 1). Seven soil series were considered in the study (Table 2). Highmore silt loams were present at two sites. At each site three fields with different management systems were selected on farms scattered along the Upper Missouri River in central South Dakota. Management systems were grouped in three categories (no-till, till, and grass). Grasslands (grass) had never been tilled and were used for forage production (pasture or hay). Dominant grass species were bromes (*Bromus spp.*), wheat grasses (*Agropyrum spp.*) and Kentucky bluegrass (*Poa pratensis* L.). Conventional-tilled fields (till) had been tilled (chisel plowing + tandem disking) to a depth of 0.07 to 0.20 m for >80 yr. No-till management systems had been applied for 6 to 16 yr (average 10 yr) after long-term cultivation with conventional tillage. Most common crops were spring or winter wheat (*Triticum aestivum* L.), corn (*Zea mays* L.), and soybean [*Glycine max* (L.) Merr.].

Sampling

Sampling was repeated in four areas in each field at each site (Table 1), on the same soil series and with similar topography for the three treatments. Soil profiles were sampled to 1- to 1.5-m depth with a hydraulic 75-mm diam. soil probe and morphologically compared using standard procedures (Soil Survey Staff, 1998). Soil cores were air-dried and stored for further analyses (texture and organic C).

Soil samples for measuring dry and wet aggregate size and stability were collected at 0 to 0.05 m below the surface litter, and at the 0- to 0.20-m depth, with a spade. All measures of dry and wet aggregate stability were repeated three times for each sampling date. Samples for dry aggregate stability measurements were collected once in spring. Sampling for wet aggregate stability was repeated three times in two consecutive years both in spring (1999 and 2000), and in fall (1999). Samples were thoroughly mixed and pooled by treatment at each location, air-dried at room temperature, and stored until analysis without any presieving, grinding, or removing of organic particles.

Particle-Size Distribution, pH, and Organic Carbon

The fine earth (<2-mm diam.) from each horizon of the soil cores was air-dried and ground before textural analysis. Particle-size distribution was determined by the pipette method (Gee and Bauder, 1986) after removal of organic matter without removing carbonates. Soil pH was determined by the glass-electrode method on a 1:1 soil/water volume (Watson and Brown, 1998). Organic C was determined by dry combustion of total C (Nelson and Sommers, 1982) followed by subtraction of inorganic C (Wagner et al., 1998). Soil organic C was determined in the fine-earth fraction of each horizon and in aggregates separated by dry and wet sieving (Eynard, 2001).

Table 1. Set up of the experiment and an outline of an ANOVA.

Parameter		Number
Treatment structure	one-way treatment	
Design structure	randomized complete block design	
Treatments	management systems	3
Replicates	locations	8
Experimental units	farm fields	24 = 3 × 8
Sampling units	field areas	96 = 24 × 4

ANOVA

Source	Degrees of freedom
Treatments	2
Blocks	7
Experimental error	14
Sampling error	72
Total	95

Table 2. Soil series sampled in the study (Soil Survey Staff, 1998)

Soil series	Classification
Lowry	coarse-silty, mixed, superactive, mesic Typic Haplustoll
Uly	fine-silty, mixed, mesic Typic Haplustoll
Reeder	fine-loamy, mixed, superactive, frigid Typic Argiustoll
Highmore	fine-silty, mixed, superactive, mesic Typic Argiustoll
Williams	fine, smectitic, frigid Typic Argiustoll
Millboro	fine, smectitic, mesic Typic Haplustert
Promise	very-fine, smectitic, mesic Typic Haplustert

Pedality

Soils were morphologically described using the NRCS methods (Soil Survey Staff, 1998). The morphological description of soil structure was quantified in relation to hydraulic soil properties, based on the scale of Lin et al. (1999), modified as in Table 3. Pedality was calculated as the product of grade, size, and type of structure. Grade refers to degree of evidence in place and durability of aggregates. Wedges were observed in Vertisols and rated according to thickness. Very fine wedges were considered to have hydraulic properties similar to granules, whereas thicker wedges were considered similar to blocks or prisms. Size was rated independently of type (fine <10 mm, medium 10–50 mm, coarse >50 mm), except for platy structures. The scale for plate thickness was 1/10 less than for the other structure types. Only very thin plates received maximum points because a platy ped orientation is unfavorable to vertical flow and root penetration.

Dry Aggregate Stability

In this study, dry aggregate stability was expressed as size distribution of dry aggregates and as amount of large macroaggregates (e.g., >1 mm). Both these parameters can be used as a measurement of aggregate stability when mechanical stresses are applied to the soil during sampling and aggregate-size separation.

Two different procedures of mechanical dry sieving were applied. Samples taken at the 0- to 0.05-m depth were dry sieved through a rotary sieve (Chepil, 1962), after air-drying and hand breaking them to pass a 20-mm screen. Eight size

Table 3. Scores for quantifying morphological features of soil structure in relation to water transmission (modified after Lin et al., 1999).

Morphological feature	Class	Score
Structure grade	massive	0
	weak	1
	moderate	5
	strong	25
	single-grained	50
Aggregate size	>50 mm (>5 mm if platy)	1
	10–50 mm (1–5 mm if platy)	3
	<10 mm (<1 mm if platy)	18
Structure type (shape)	massive	0
	platy	1
	prismatic, blocky, wedge >10 mm	10
	granular, single-grained, wedge <10 mm	30

fractions were collected (0–0.5, 0.5–1, 1–2, 2–3, 3–5, 5–9, 9–12, and 12–20 mm) to calculate the aggregate MWD. Mechanical sieving has the advantage of results being operator independent. In the case of rotary sieves, results are independent of sample size, but number of sieves and opening sizes are fixed at the construction of the rotary sieve (Chepil, 1962). The amount of aggregate breakdown depends on the number and size of sieves, which are easy to change when using flat sieving (Chepil, 1962). The dry aggregate stability of the top 0.20 m of soil was determined by dry sieving through a portable flat-sieve shaker (Model RX-24, Tyler CE Inc., Mentor, OH) equipped with a nest of two (0.20 m-diam.) sieves with openings of 2 and 1 mm, respectively. Air-dry soil samples of 200 to 300 g were gently broken by hand to pass a 25-mm sieve before shaking for 2 min. The soil retained on each sieve was collected and weighed at 15-s intervals. The residual 2- to 25-mm fraction was repeatedly sieved to measure the rate of disintegration of this coarse fraction expressed as slope of the disruption lines (Russell and Feng, 1947; Chepil, 1952). The initial amount of 2- to 25-mm aggregates was measured by the intercept of the disruption lines. Dry aggregate stability was expressed as the percentage of aggregates retained on the 1-mm screen after the first 15 s of shaking over the total sieved soil sample.

Wet-Aggregate Stability

Wet-aggregate stability was measured on air-dried 1- to 2-mm aggregates from the 0- to 0.05- and 0- to 0.20-m depths that were premoistened to saturation in a vapor chamber. The single-sieve mechanical procedure of Kemper and Rosenau (1986) was used by shaking for 5 min in deionized water.

In separate tests of wet-aggregate stability, air-dried 1- to 2-mm aggregates from 0- to 0.20-m depth were directly immersed in deionized water on a 0.25-mm screen at atmospheric pressure and room temperature. Aggregates were soaked for 3 min and then shaken for 3 min according to the procedure of Kemper and Rosenau (1986).

Wet-stable aggregation was expressed as a percentage (105°C oven-dry weight) of stable macroaggregates on the initial sample weight without correcting for sand.

Statistical Analysis

Data were analyzed using the SYSTAT 9 statistical program (SPSS, 1999). Orthogonal contrasts were made between the grass and cultivated treatments and between the no-till and till treatments. Means grouped by management system and soil order were compared by *t* tests. Data were separately analyzed for all sites (eight replications), for Ustolls (six replications) and for Usterts (two replications). Soil series within each soil order showed similar trends. We pointed out differences between orders when management related effects on soil aggregates were in disagreement. For wet aggregate stability, the average over the three determinations at different sampling times was calculated after testing the absence of significant interaction ($P \leq 0.05$) between management system and time.

Table 4. Differences between Ustolls ($N = 6$) and Usterts ($N = 2$) in means of pedality, and structural type, grade and size averaged over depths (0–0.80 m) and sites in central South Dakota.

Management	Property	Ustolls	Usterts	Probability‡
		Scores		
Grass	pedality†	2261	6075	$P \leq 0.011$
	type	13.2	22.0	$P \leq 0.008$
	grade	11.0	18.6	$P \leq 0.006$
	size	8.8	11.7	NS
No-till	pedality	835	1218	NS
	type	9.8	11.9	NS
	grade	7.6	9.8	NS
	size	4.6	5.9	NS
Till	pedality	269	1757	$P \leq 0.022$
	type	9.1	15.2	$P \leq 0.001$
	grade	4.6	14.1	$P < 0.001$
	size	6.9	3.6	$P \leq 0.006$

† Pedality values are means calculated from individual experimental units and differ from (mean type × mean grade × mean size) products.
‡ NS indicates $P > 0.10$.

RESULTS AND DISCUSSION

Pedality

Pedality was better developed in grass fields than in cultivated fields in the top 0.40 m in both Usterts and Ustolls (Table 4 and 5). At depths >0.40 m, structural changes due to management were less marked, although in Ustolls the difference in pedality between grass and cultivated soils was significant to 0.60 m (643 in grass vs. 137 in no-till and 131 in till, $P \leq 0.009$). The difference in pedality between grasslands and croplands decreased with depth (interaction depth × management, $P \leq 0.023$), as vegetation, faunal activity, traffic, and fragmentation by tillage decreased below the topsoil. Due to higher content of clay (Table 6) and the formation of wedges in Usterts, the pedality rating tended to be greater in Usterts than in Ustolls, especially in grassed and tilled fields (Table 4). However, comparisons of pedality between management systems in both soil orders showed similar trends (Table 4 and 5). Significant management differences in all properties of peds (type, grade, and size) were present in the top 0 to 0.20 m of both Usterts and Ustolls (Table 5). Granular peds and fine wedges dominated in the top 0.20 m in grass soils,

Table 5. Management differences of Ustolls ($N = 6$) and Usterts ($N = 2$) in means of pedality and structural type, grade, and size rating averaged over depths in the top 0 to 0.20 m in central South Dakota. Probabilities of significant differences in the contrasts between grass and cultivated soils (A) and between no-till and till (B) are reported in the last two columns.

Soil order	Parameter	Grass	No-till	Till	A	B
Ustolls	pedality†	4330	1639	420	$P \leq 0.032$	NS‡
	type	18.9	9.5	8.8	$P \leq 0.027$	NS
	grade	13.7	10.5	4.1	$P \leq 0.008$	$P \leq 0.017$
	size	12.4	6.6	4.3	$P \leq 0.013$	NS
Usterts	pedality	8486	134	1433	NS	NS
	type	25.3	7.3	16.5	$P \leq 0.013$	$P \leq 0.036$
	grade	19.4	2.0	8.6	$P \leq 0.040$	NS
	size	15.5	4.6	7.7	$P \leq 0.021$	NS

† Pedality values are means calculated from individual experimental units and differ from (mean type × mean grade × mean size) products.
‡ NS indicates $P > 0.10$.

Table 6. Clay and sand content, pH, and organic C in the top 0 to 0.20 m of soil in Ustolls (N = 6) and in Usterts (N = 2) of central South Dakota. Probabilities of significant differences in the contrasts between grass and cultivated soils (A) and between no-till and till (B) are reported in the last two columns.

Soil order	Soil property	Units	Grass	No-till	Till	A	B
Ustolls	clay	g kg^{-1}	247	253	235	NS†	NS
	sand	g kg^{-1}	239	274	311	NS	NS
	pH		7.1	7.1	7.0	NS	NS
	organic C	g kg^{-1}	23.7	17.6	14.66	$P < 0.001$	NS
Usterts	clay	g kg^{-1}	551	607	578	NS	NS
	sand	g kg^{-1}	40	36	34	NS	NS
	pH		7.9	7.7	8.0	NS	$P \leq 0.074$
	organic C	g kg^{-1}	23.8	20.3	23.5	NS	NS

† NS indicates $P > 0.10$.

whereas blocky or platy shapes dominated in the cultivated (no-till and till) sites, similar to other soils (Sparrow et al., 1999). Large plates and blocks were generally observed below the 0.10-m depth in both no-till and conventionally tilled fields but rarely in grass fields. These soil structures are related to tillage pans and compression from heavy equipment. Size, grade, and type all contributed to the high pedality observed in grass. Ped type was not the primary factor for differences in pedality, similar to the findings reported by Sparrow et al. (1999). VandenBygaart et al. (1999b) recorded a change from platy to granular peds in the top 0.04 m 11 yr after conversion from till to no-till. In Ustolls and Usterts of this study, different types of structures due to different management systems were found only in the top 0 to 0.20 m, primarily between grass and cultivated systems (Table 5).

The characterization of structure as reported above assumes that the preferable structure is that of the natural vegetation, that is, the granular structure of the mid grass prairie in central South Dakota. The rating scale needs to be adjusted to the geographic area under study as pointed out by Bouma (1992). In the Upper Missouri River Basin fine, strong, and stable peds appear desirable. The soil structure found in managed grasslands supports the importance of perennial species to maintain and/or enhance favorable soil conditions for plant growth. The grass was grazed or hayed in the farms of this study, but soil structure was not degraded when compared with cultivation and annual cropping.

In this study, the strongest peds were described as structural units without distinguishing a primary and a secondary structure. The structural grade results from adhesion and cohesion of individual particles and aggregates as a function of moisture content (Bouma and Anderson, 1973). In this study air-dry soil samples were examined so that structural grade and size refer to the dry strength and dominant dry size of aggregates. Under grass, peds were significantly finer (size) and stronger (grade) than in cultivated fields in the top 0- to 0.50-m depth (Fig. 1).

Dry-Aggregate Stability

Results of both rotary dry sieving and flat dry sieving (Table 7) confirmed pedality data. In both Ustolls and Usterts the disruption line intercepts obtained by flat sieving samples from the top 0.20 m of soil were smaller in grass than in cultivated soils. The comparison between management systems of aggregate MWD obtained by rotary sieving showed significant differences between grass and cultivated systems and between till and no-till in Ustolls. Aggregates formed under grass were finer (smaller in size) than in cropland in the top 0.05-m depth, as already observed with the morphological description of structure. Mean weight diameters indicated, in both Ustolls and Usterts, a larger size of aggregates in the surface soil of no-till when compared with tilled fields where fragmentation during cultivation peri-

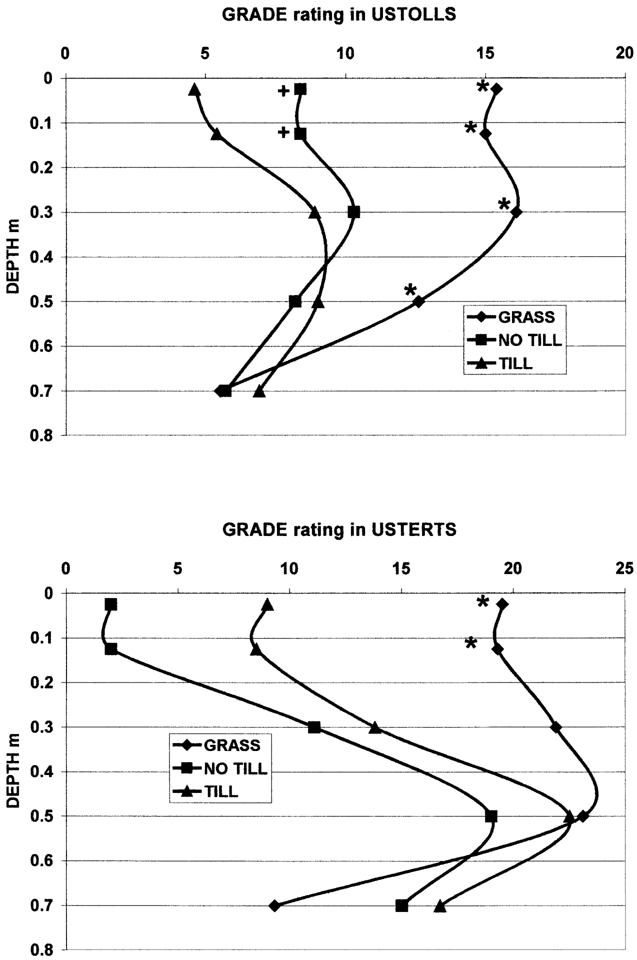

Fig. 1. Mean structural grade rating as a function of soil depth in Ustolls (N = 6) and Usterts (N = 2) of central South Dakota. Asterisk (*) indicates a significant difference between grass and cultivated soils $P < 0.05$. Plus (+) indicates a significant difference between no-till and till soils $P < 0.05$.

Table 7. Parameters of dry aggregate sizes and stability in Ustolls ($N = 6$) and Usterts ($N = 2$) of central South Dakota. Probabilities of significant differences in the contrasts between grass and cultivated soils (A) and between no-till and till (B) are reported in the last two columns.

Soil order	Parameter	Units	Grass	No-till	Till	A	B
Ustolls	MWD†	mm	4.6	8.7	6.6	$P \leq 0.002$	$P \leq 0.032$
	intercept‡	$g\ g^{-1}$	0.72	0.81	0.78	$P \leq 0.016$	NS¶
	DAS§	$g\ g^{-1}$	0.80	0.87	0.84	$P \leq 0.036$	NS
Usterts	MWD	mm	8.2	10.3	7.5	NS	NS
	intercept	$g\ g^{-1}$	0.84	0.90	0.87	$P \leq 0.037$	$P \leq 0.090$
	DAS	$g\ g^{-1}$	0.93	0.85	0.92	NS	NS

† MWD = mean weight diameter in the top 0.05 m of soil expressed in mm.

‡ Intercept = intercept of the disruption line in the top 0.20 m of soil expressed in g of 2–25 mm aggregates per g of dry-sieved soil at time 0 s.

§ DAS = dry aggregate stability measured as the percentage of dry stable macroaggregates >1 mm in the top 0.20 m of the soil.

¶ NS indicates $P > 0.10$.

odically occurs. Similar responses were indicated by the disruption line intercepts obtained by flat sieving samples from the top 0.20 m of soil, although differences between no-till and till were not significant. In both Ustolls and Usterts the disruption line intercepts were smaller in grass than in cultivated soils. Small size of grass dry peds resulted in greater rate of disintegration of 2- to 25-mm dry aggregates in grass than in cultivated soils of Ustolls and consequent lower dry-aggregate stability, that is, the >1-mm fraction from flat sieving (Table 7).

Wet-Aggregate Stability

Wet-aggregate stability of 1- to 2-mm air-dry aggregates was higher in grass than in no-till and till, and decreased in the order grass, no-till, and till (Table 8). Differences between intensive tillage and no-tillage systems were significant at the 0.05-m depth for prewetted aggregates, but not at the 0- to 0.20-m depth. At the 0- to 0.20-m depth prewetted aggregates of Usterts under grass management were not significantly more stable to wet sieving than aggregates from cultivated soils.

Two factors are likely to have contributed to the different separation between tillage systems in different measurements. The first factor is the effect of sampling depth, since stratification of organic matter can occur in the absence of intensive tillage, and structural improvements by no-tillage systems are often limited to the top 0- to 0.05-m in the short term (Beare et al., 1994; Six et al., 2000a, 2000b). The second factor is the instability caused by slaking stresses when air-dry aggregates are wet sieved without prewetting. Structural changes in no-till systems may or may not improve the stability of aggregates to slaking (Six et al., 2000a, 2000b). Decreased stability from grass to cultivated treatments can be related to loss of organic matter upon cultivation (Eynard, 2001), since textural characteristics and base saturation (indicated by pH values of 7 to 8) were not significantly different between management systems (Table 6).

Significantly higher wet-aggregate stability was observed in Usterts when compared to Ustolls for all management systems. The stability of nonprewetted aggregates in Usterts was higher than in similarly managed Ustolls, in particular for no-till (32 vs. 65%, $P \leq 0.002$) and till (25 vs. 65%, $P \leq 0.001$). Greater aggregate stability can be expected in Usterts when compared to Ustolls as a consequence of a higher clay content, higher base saturation, and the formation of stable aggregates by flocculated clay with Ca^{2+} and organic matter bridging. Average clay content in Usterts was 58 vs. 25% in Ustolls ($P < 0.001$). In all soils, the percentage of coarse and very coarse sand was <10% of the total sand, but in Ustolls finer sand fractions and silt were significantly greater than in Usterts ($P < 0.001$). The mean pH in Usterts was 7.9 vs. 7.1 in Ustolls ($P < 0.001$).

CONCLUSIONS

Aggregates formed under perennial grasses were stronger than those formed under cultivated annual crops in South Dakota. Aggregates were fine and granular in grasslands, whereas large blocks and plates were present both in no-till and till systems. Differences were mainly found in the top 0 to 0.20 m, although structural changes due to cultivation were evident to a depth of 0.50 m. After an average of 10 yr after the conversion from intensive tillage, only the top 0.05 m of no-till fields showed a slight structural improvement, quantified by a 5% increase in wet aggregate stability of prewetted aggregates. Other features of aggregation were not significantly different in no-till vs. till, except for a 32%

Table 8. Wet-aggregate stability at 0- to 0.05-m depth of 1- to 2-mm prewetted aggregates and at 0- to 0.20-m depth of 1- to 2-mm air dry aggregates in Ustolls ($N = 6$) and in Usterts ($N = 2$) of central South Dakota. Probabilities of significant differences in the contrasts between grass and cultivated soils (A) and between no-till and till (B) are reported in the last two columns.

Aggregates	Soil order	Grass	No-till	Till	A	B
			$g\ g^{-1}$			
From 0.05 m depth, prewetted	Ustolls	0.91	0.85	0.81	$P < 0.001$	$P \leq 0.026$
	Usterts	0.93	0.91	0.89	$P \leq 0.001$	$P \leq 0.029$
From 0.20 m depth, prewetted	Ustolls	0.95	0.89	0.87	$P < 0.001$	NS†
	Usterts	0.97	0.98	0.98	NS	NS
From 0.20 m depth, air-dry	Ustolls	0.73	0.32	0.25	$P < 0.001$	$P \leq 0.076$
	Usterts	0.81	0.65	0.65	$P \leq 0.052$	NS

† NS indicates $P > 0.10$.

greater dry MWD of aggregates in the top 0.05 m of no-till in the absence of fragmentation by conventional tillage operations. Similar trends of structural changes in South Dakota prairie soils due to cropping practices were observed in both soil orders considered in this study, although water stability of aggregates in Usterts was higher than in Ustolls. The morphological description of the structure was effective for an immediate indication of pedality. The application of different sieving procedures was useful for further characterizing aggregate sizes and stability of agricultural soils.

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