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Erosion Potential of a Torrertic Paleustoll after Converting Conservation Reserve Program Grassland to Cropland

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ABSTRACT

Extensive cropland areas were covered by the Conservation Reserve Program (CRP) in the semiarid southern Great Plains. Because soils were highly erodible, would erosion again become a problem when CRP land was converted to cropland? The erosion potential due to tillage methods used to convert CRP grassland to cropland was determined on Pullman clay loam (Torrertic Paleustoll). Tillage methods were no-, sweep, disk, and moldboard + disk tillage with CRP grass retained or removed (mowing and baling), and grass burning followed by sweep or disk tillage. Wind erosion potential was based on percentage of >0.84-mm diam. and mean weight diameter (MWD) of dry aggregates at 2 to 3 yr after converting to cropland. Water erosion potential was based on MWD and percentage of <0.25-mm water-stable aggregates, and water stability of 1- to 2-mm aggregates at crop planting and harvest. Few differences due to tillage methods were significant. For dry aggregates, more than 60% were >0.84-mm diam. and MWD was >10 mm with all tillage methods, indicating a low wind erosion potential. Wet aggregate stability and MWD values at some sampling times indicated water erosion could occur. Although erosion potential was low, continued use of residue-incorporating tillage could lead to greater potentials. Because of initially low potentials, CRP land on Pullman and similar soils could be converted to cropland by any tillage method. Then, a conservation tillage system (e.g., no-tillage) could be implemented before erosion by wind or water became a serious problem.

ONE OBJECTIVE of the Conservation Reserve Program (CRP) was to reduce erosion by taking highly erodible land out of crop production (Federal Register, 1987). The CRP was widely accepted in the western, semiarid portion of the southern Great Plains, with many producers seeding and maintaining perennial grass on land during the CRP contract period. Because the grass controlled erosion, would erosion again become a problem when CRP grassland was converted to cropland?

Gilley and Doran (1998) determined soil erosion by water in Mississippi, Nebraska, and South Dakota at sites more humid than the semiarid portion of the southern Great Plains. The CRP land was disked or moldboard plowed before determining erodibility by applying water with a rainfall simulator. Initially, after tillage, erosion was similar on the former CRP land and where conventional tillage was used. The erosion-control effectiveness, however, lasted <1 yr when the former CRP land was left fallow. The rapid decline was attributed to reduced surface cover and organic material. Because different regions were involved, the question remained, "Would erosion again become a problem when CRP grassland was converted to cropland in a semiarid region?"

Soils in semiarid portions of the southern Great Plains range from loamy sands to clay loams. The wind erosion potential often is high on dryland because of limited plant growth and failure to use conservation tillage that involves crop residue retention on the soil surface. A grass cover helps control wind erosion by reducing wind speed at the soil surface to below that needed to dislodge particles from the soil mass. Without such cover, erosion potential is affected by surface soil aggregate size and stability. These, in turn, are affected by soil organic matter and $CaCO_3$ content, texture, and water content at time of tillage, and stage of crop residue decomposition (Chepil, 1955; Fryrear and Skidmore, 1985). Dry surface aggregates help control wind erosion (Armbrust et al., 1982), with those >0.84 mm in diam. generally considered nonerodible (Chepil, 1942). From 60 to 75% of the aggregates should be >0.84 mm in diam. to control erosion (Woodruff and Siddoway, 1965; Fryrear, 1984).

The water erosion potential generally is lower than the wind erosion potential in the southern Great Plains, but water erosion occurs during occasional intense storms. Water "erosion is a surface boundary process, and the stability of aggregates at the immediate soil surface greatly influences the soil's susceptibility to erosion" (Reichert and Norton, 1994). Aggregate dispersion leads to surface sealing and crusting (Le Bissonnais et al., 1995). Fine soil particles <0.125-mm diam. are primarily responsible for seal formation that retards infiltration (Loch, 1989), which increases runoff and the erosion potential. Aggregate dispersion also produces particles easily transported by water (Le Bissonnais et al., 1995). Large stable aggregates increase surface roughness, thus reducing potentials for runoff and water erosion (Teixeira and Misra, 1997). A grass cover reduces water erosion by dissipating energy of raindrops,

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Abbreviations: CRP, Conservation Reserve Program; MWD, mean weight diameter; NT, no-tillage; RT, reduced tillage; ST, sweep tillage; DT, disk tillage; B-DT, burn and disk tillage; B-ST, burn and sweep tillage; MB-DT, moldboard plow plus disk tillage.

thus reducing aggregate dispersion and surface sealing. Grass also slows surface water flow, thus increasing time for infiltration, and absorbs energy of flowing water, thus reducing particle transport capacity.

Aggregate mean weight diameter (MWD) had little effect on runoff and soil loss, except that prewetting resulted in greater MWD and less soil loss for a stable Oxisol (Reichert and Norton, 1994). However, erosion was less for a clay with high MWD than for a sandy loam and a clay loam with low MWD (Teixeira and Misra, 1997).

A study was conducted near Bushland, TX, to determine which grass management and tillage methods were most effective for converting CRP grassland to cropland. One objective was to evaluate grass management and tillage method effects on wind and water erosion potentials, which are presented in this report. Wind erosion potential was based on dry aggregate size distribution (percentage >0.84 mm in diam. and MWD) and water erosion potential was based on water-stable aggregate MWD and size distribution, and aggregate stability.

MATERIALS AND METHODS

The study was conducted in a producer's field ≈7 km west of the USDA-ARS, Conservation and Production Research Laboratory, Bushland (Potter Co.), TX (35°11′N, 102°5′W, 1180 m above mean sea level). Average annual precipitation at Bushland is 475 mm (Conservation and Production Research Laboratory, 1939–1996, unpublished records). The study site was on Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll) having a surface slope <0.5%. The soil contains 170 g kg^{-1} sand, 530 g kg^{-1} silt, and 300 g kg^{-1} clay; contains ≈11.0 g kg^{-1} organic carbon; and has a pH of ≈7.0 in the 0- to 0.15-m depth. The soil is slowly permeable because of ≈390 to 430 g kg^{-1} montmorillonite and illite clay at the 0.13- to 0.45-m depth (Taylor et al., 1963). As a result, rain may cause runoff, but the water erosion potential is low because of the low surface slope. The K-value for the soil is 0.37 (Pringle, 1980). Rainstorms, although often intense, generally are of short duration, thus contributing to the low water erosion potential. No evidence of water erosion was noted in the producer's field. In nearby fields without a growing crop, surface residues, or a tillage-roughened surface, wind erosion has been noted during months when the potential is greatest in the region (March and April). The I-value for Pullman soil is 38 (Pringle, 1980).

Under terms of the CRP contract, the producer established Plains bluestem grass [*Bothriochloa ischaemum* (L.) Keng.] in 1986 on 172 ha of land previously used for dryland winter wheat (*Triticum aestivum* L.) and grain sorghum [*Sorghum bicolor* (L.) Moench] production. Conversion of CRP grassland to cropland on part of the land for this study was done in October 1994 (Area 1), March 1995 (Area 2), September 1995 (Area 3), and June 1996 (Area 4). The areas were adjacent to each other. Each area consisted of two adjacent blocks, one with CRP grass retained and the other with grass removed (mowed and baled) before starting the tillage methods, which were replicated three times. Grass was mowed at ≈5 cm above the soil surface and 8 Mg ha^{-1} dry matter (grass and some weeds) were removed from Area 1 plots. Similar amounts were removed from plots of other areas. The 5-cm mowing height resulted in some dry matter remaining on the plots. Therefore, somewhat more than 8 Mg ha^{-1} of dry matter was on plots where vegetation was retained.

Tillage methods were randomly assigned to each block. On blocks where grass was retained, methods were no-tillage (herbicides only); reduced tillage (sweep tillage once for each crop, then herbicides); sweep tillage; disk tillage; moldboard plow (once), then disk tillage (moldboard-disk); grass burned, then disk tillage (burn-disk); and grass burned, then sweep tillage (burn-sweep). The same tillage methods, except those for which grass was burned, were used on blocks where grass was removed. Because of the generally dry soil and grass type (bunch), sweep tillage plots were disked once to dislodge grass and loosen the soil before using a sweep implement for subsequent operations. Use of sweep tillage returned some grass to the soil surface that was incorporated with soil by disk tillage. After initial tillage, the same method was used for subsequent crops, except that moldboard plowing and burning were not repeated. Tillage depth was 0.10 to 0.15 m for all methods. Typical amounts of crop residues incorporated by each tillage operation are 10% with a sweep implement, 50% with a disk implement, and 90% with moldboard plowing (Anderson, 1968). In this study, mean surface residue cover at sorghum planting time was 8% with moldboard-disk tillage, 21% with disk tillage, 43% with sweep and reduced tillage, and 54% with no-tillage.

Plots were 14 m wide and 46 m long, which permitted using commercial implements for field operations. Implements were an offset disk (Model 1870, Crust Buster, Dodge City, KS[1]), a sweep plow (Richardson Model AE-4-15-1, Sunflower Manufacturing Co., Inc., Beloit, KS), and a moldboard plow (Massey-Ferguson Model 55, AGCO, Norcross, GA). Grain sorghum was planted with a six-row John Deere (Deere and Co., Moline, IL) Max-Emerge planter (Model 7300), and wheat was planted with a John Deere drill (Model 750).

Planned initial crops were grain sorghum on Area 1 (planted in 1995), wheat on Area 2 (planted in 1995), grain sorghum on Area 3 (not planted in 1996 because of drought, but planted in 1997), and wheat on Area 4 (planted in 1996). Crops on Areas 1 and 2 were grown in a winter wheat-grain sorghum-fallow rotation, with 300 to 330 d of fallow between each crop. The rotation results in two crops in 3 yr. Through 1997, two crops were grown on Areas 1 and 2, and one crop on Areas 3 and 4. Sorghum was planned for Areas 1 and 4 in 1998, but was not planted because of a drought.

Samples for determining dry aggregate size distribution were obtained from Area 2 plots in May 1997 and from Area 1 and 4 plots in April 1998 (Area 3 plots were not sampled) before planting sorghum in June each year. Bulk soil was obtained from the 0- to 2-cm depth at three positions per plot and composited into one sample that weighed ≈5 kg. Clods >2 cm in diam. were included in the samples. Sampling was with a flat-bottomed spade with soil placed in shallow pans to minimize crushing. When air dry, soil was separated into six size ranges of aggregates with a rotary sieve (Chepil, 1962) having five sieves (0.42-, 0.84-, 2.0-, 6.4-, and 18.3-mm openings). Maximum size was 76.2 mm, which was the opening of the sieving apparatus. From these results, aggregate size distribution and MWD were determined according to Kemper and Rosenau (1986).

Before initially performing tillage on each area and at planting and harvest of all crops, bulk soil samples from the 0- to 2-cm depth were obtained with a flat-bottomed spade at three positions per plot and composited into one sample. The soil

[1] The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by the USDA-Agricultural Research Service.

Table 1. Percentage of >0.84 mm in diameter and mean weight diameter (MWD) of dry aggregates of soil taken before planting grain sorghum where CRP grassland was converted to cropland near Bushland, TX.

			Tillage method†							
Factor	Year–area	Grass‡	NT	RT	ST	DT	B-DT	B-ST	MB-DT	Mean§
>0.84 mm, %	1997–2	Retained	65.3a¶	65.4a	69.5a	68.8a	63.1a	68.7a	65.4a	66.5a
		Removed	61.6b	68.7a	65.8ab	65.4ab	–	–	65.5ab	65.4a
	1998–1	Retained	77.6a	72.0a	74.1a	68.0a	71.3a	70.7a	75.0a	73.3a
		Removed	75.1a	71.4a	68.3a	73.7a	–	–	76.6a	73.0a
	1998–4	Retained	75.6a	75.8a	76.8a	73.3a	77.8a	73.9a	78.7a	76.0a
		Removed	74.4a	73.9a	77.2a	72.9a	–	–	72.6a	74.2a
MWD, mm	1997–2	Retained	11.6ab	11.7ab	12.9a	12.9a	10.1b	13.2a	11.6ab	12.1a
		Removed	10.7a	12.9a	11.6a	11.2a	–	–	11.2a	11.5a
	1998–1	Retained	20.7a	17.0a	18.4a	14.8a	18.1a	16.7a	19.5a	18.1a
		Removed	21.0a	17.0a	16.6a	20.0a	–	–	21.5a	19.2a
	1998–4	Retained	19.5a	17.6a	17.7a	17.5a	19.5a	17.4a	19.9a	18.4a
		Removed	18.5a	17.7a	19.3a	18.7a	–	–	16.6a	18.2a

† Tillage methods were: NT, no-tillage; RT, reduced tillage; ST, sweep tillage; DT, disk tillage; B-DT, burn and disk tillage; B-ST, burn and sweep tillage; MB-DT, moldboard plow plus disk tillage.
‡ Grass management: Retained, all grass retained until tillage methods were started; Removed, grass removed by mowing, raking, and baling before tillage methods were started.
§ Mean values followed by the same letter for a given year and area for grass retained or removed are not significantly different at the $P = 0.05$ level, based on a two-tail t test.
¶ Values followed by the same letter(s) in a row are not significantly different at the $P = 0.05$ level based on Duncan's Multiple Range Test.

was passed through a wire mesh having 12.7-mm square openings, mixed thoroughly with 1 to 2 L retained for determining soil properties, and air dried. Later, duplicate subsamples were wetted under vacuum, then sieved in water to determine water-stable aggregate size distribution and to calculate MWD according to Kemper and Rosenau (1986). Sieve openings were 0.25, 1.0, 2.0, and 4.0 mm. A portion of the bulk soil also was ground to obtain 1.0- to 2.0-mm aggregates. Duplicate subsamples were used to determine aggregate stability by Kemper's (1965) procedure. Water-stable aggregate size distribution, MWD, and aggregate stability were determined to infer the water erosion potential. Values for duplicate subsamples were averaged before statistically analyzing the data.

Data from each block (grass retained or removed) and each sampling were analyzed separately by the ANOVA procedure for a completely randomized experiment (SAS Institute, 1989). Duncan's multiple range test was used to separate treatment means when the F-value indicated differences at the $P=0.05$ level. A two-tail t-test was used to determine whether differences between mean values resulting from grass retention and removal, and for changes between successive samplings (water-stable aggregates) were significant.

RESULTS AND DISCUSSION

Wind Erosion Potential

Wind erosion potential was estimated from the total percentage of dry aggregates >0.84 mm in diam. and from the MWD calculated from percentages of dry aggregates in different size ranges. Values for these aggregate factors are given in Table 1.

Evidence of low wind erosion susceptibility is provided by the percentages of >0.84-mm diam. dry aggregates. The percentages differed only for Area 2 in 1997 where CRP grass was removed before starting the tillage methods. The percentage was lowest (61.6) with no-tillage and highest (68.7) with reduced tillage, but these values were not different from those for some other tillage methods (Table 1). All values were in or above the range of 60 to 75% of >0.84-mm diam. (nonerodible) dry aggregates required to control wind erosion on large, bare, smooth, unprotected fields, as indicated by Woodruff and Siddoway (1965) and Fryrear (1984). Mean values resulting from grass retention or removal were not significantly different.

Although use of MWD as a measure of wind erosion potential has no precedent in the literature (J. Tatarko, Manhattan, KS, 1998, personal communication), use of MWD indicates at least relative differences in wind erosion potential resulting from treatments applied to land. The MWD of dry aggregates differed due to tillage methods only for Area 2 plots for the block where grass was retained before initially performing tillage (Table 1). Lowest MWD (10.1 mm) resulted from the burn-disk method; the highest (13.2 mm) from the burn-sweep method. Values with some other methods were not different from these values. Mean values did not differ because of grass retention or removal.

All percentages of >0.84-mm and MWD values of dry aggregates were significantly greater ($P \geq 0.003$ in all cases) in 1998 (both areas) than in 1997. The differences are attributed to differences in amount and distribution of precipitation and frequency of soil freezing. Precipitation (rain or snow) from 1 January until sampling totaled 182 mm (eight events) in 1997 and 95 mm (12 events) in 1998. Although precipitation was greater before sampling in 1997 than in 1998, a period of intense rain followed by *wet* snow resulted in greater consolidation of the surface soil in 1998, which contributed to the higher percentage of >0.84-mm and greater MWD of dry aggregates.

Both winters before sampling for this study were relatively mild (based on unpublished data, Conservation and Production Research Laboratory, Bushland, TX). During winter and early spring (after 1 January), minimum air temperature was ≤0°C on 82 d in 1997 and 76 d in 1998, which possibly resulted in surface soil freezing on some days (surface soil temperatures were not measured). Temperature at the 5.0-cm soil depth, however, was ≤0°C only on 6 d in 1997 and none in 1998, suggesting that soil freezing in 1997 may have resulted in disintegration of soil clods and, in turn, lower percentages of >0.84-mm and lower MWD of aggregates than in 1998.

Time of sampling coincided with time of greatest potential for wind erosion (March and April). Wind erosion, however, was not observed on any plot in any year. With the percentage of >0.84-mm dry aggregates being >60 and a minimum MWD of about 10 mm, Pullman soil apparently has low susceptibility to wind erosion at 2 to 3 yr after terminating grass on former CRP areas.

The percentage of >0.84-mm diam. and MWD of dry aggregates indicated a low wind erosion potential on Pullman soil at 2 to 3 yr after converting CRP grassland to cropland. Continued use of crop residue-incorporating tillage (clean tillage) for crop production under dryland conditions, however, could lead to a greater wind erosion potential. Severe wind erosion has occurred on some fields on this soil under clean tillage conditions such as those resulting from some tillage methods used in this study. Also, long-term use of one-way disk and stubble mulch tillage for dryland wheat on Pullman soil resulted in <60% of >0.84-mm diam. and MWD below 7.5 mm for dry aggregates where wheat-fallow and continuous wheat cropping systems were compared (Unger, 1982).

Dry aggregate MWD ranged from 7.7 mm with no-tillage to 11.5 mm with sweep tillage at planting of dryland grain sorghum (at the end fallow after irrigated wheat) (Unger, 1984). These results suggest the wind erosion potential would be greater with no-tillage. Use of no-tillage, however, resulted in crop residues being retained on the soil surface, which provided protection against erosion. Therefore, where the potential exists, using a no-tillage cropping system would be effective for controlling wind erosion.

Soil water content, grass and weed control, and crop establishment and yield results of this field study showed that use of no-tillage was not the most effective method of converting CRP grassland to cropland (Unger, 1999). Grass and weed control with no-tillage plots was poor in some cases because plants often were under water stress because of limited precipitation. Also, some seedling establishment problems occurred because of limited precipitation and failure of the planting slot in the densely-rooted sod to be properly closed. Better grass and weed control and seedling establishment generally were achieved in tillage plots. Therefore, because the wind erosion potential was low with all tillage methods during the first 2 to 3 yr after terminating grass, sufficient time would be available to convert to a conservation tillage system (for example, no-tillage) without incurring serious wind erosion.

Water Erosion Potential

Water erosion potential was not determined directly, but inferred from water-stable aggregate MWD and size distribution, and from aggregate stability.

The MWD results with time after conversion to cropland generally were similar on all areas and on blocks where grass was retained or removed. Hence, results are given and discussed primarily for Area 1. Other areas are discussed when results supported or deviated greatly from results for Area 1.

The CRP grassland area was uniformly managed prior to initiation of the study. Hence, MWD differences on Area 1 at the initial sampling (Table 2) probably were due to random variation. At later samplings, MWD differed only at sorghum harvest in 1995 with grass removed, but the difference was only 0.4 mm. The MWD differed at a few samplings on other areas, but the differences were small. The generally small differences at a given sampling indicate tillage methods had little effect on water erosion potential.

Compared with the small differences due to tillage methods, most mean differences between successive samplings were greater, both with grass retained or removed (Table 2). With grass retained, a small mean decrease (0.5 mm) occurred after the initial sampling followed by a 1.2-mm mean decrease between sorghum planting and harvest in 1995. A gain of 2.0 mm occurred between sorghum harvest and wheat planting the next year, which resulted in the mean being similar to the initial value (not different, based on *t* test). A decrease of 1.0 mm occurred between wheat planting and harvest. Although actual values differed, the results were similar where grass was removed. Also, although the magnitude differed, changes between samplings on other areas were similar to changes on Area 1.

It has long been known that soil aggregation and, hence, aggregate MWD between samplings vary because of factors such as soil water content at sampling, tillage, sampling procedure, precipitation, and type, amount, and length of time that vegetation was on the land (Wilson and Browning, 1946). As discussed above, tillage methods had no effect on MWD in most cases. Therefore, probable reasons for the differences include soil water contents at sampling, precipitation amount and distribution, and crops grown. Another probable cause is soil freezing and thawing, which can cause aggregate disintegration at relatively high soil water contents (Edwards, 1991; Mostaghimi et al., 1988).

Although Loch (1989) showed that <0.125-mm materials had the greatest effect on surface seal development, <0.25-mm materials are important also. When tillage methods were started on the different areas, amounts of <0.25-mm soil materials ranged from 26 to 35%. The percentages usually increased by the time the first crop was planted and increased further during the growing seasons. Percentages ranged from 52 to 60 after sorghum harvest and from 33 to 44 after wheat harvest. Few differences due to tillage methods were significant (data not shown). Increases in percentages of <0.25-mm materials after terminating CRP grass indicate that a surface seal could develop, which could lead to increased runoff and the potential for water erosion.

Water stability percentages of 1- to 2-mm aggregates from Area 1 differed because of tillage methods only at sorghum planting with grass retained (Table 3). For aggregates from Area 2, percentages differed at the initial, wheat harvest, and sorghum planting time samplings, with the maximum difference being 11 percentage units at sorghum planting where grass was removed (data not shown). Mean differences between successive samplings were greater than differences due to tillage

Table 2. Mean weight diameter (MWD) of water-stable aggregates of soil from Area 1 plots where CRP grassland was converted to cropland near Bushland, TX.

Condition–Time	Date	Tillage method†							
		NT	RT	ST	DT	MB-DT	B-DT	B-ST	Mean
		mm							
Grass retained									
Initial	October 1994	2.8a‡	2.3ab	2.7a	2.0b	2.0b	3.0a	2.6ab	2.5§
Plant sorghum	June 1995	1.6a	2.3a	2.3a	1.8a	1.8a	2.0a	2.2a	2.0
Harvest sorghum	November 1995	1.5a	0.5a	0.5a	0.5a	0.6a	0.6a	0.5a	0.8
Plant wheat	October 1996	2.6a	3.3a	3.1a	2.9a	2.8a	2.4a	2.8a	2.8
Harvest wheat	July 1997	1.9a	2.2a	2.0a	1.6a	1.9a	1.6a	1.7a	1.8
Grass removed									
Initial	October 1994	3.1a	2.4b	2.9ab	3.2a	2.4b	–	–	2.8
Plant sorghum	June 1995	1.9a	2.1a	2.2a	1.7a	1.8a	–	–	1.9
Harvest sorghum	November 1995	0.8a	0.6ab	0.4b	0.5b	0.6ab	–	–	0.6
Plant wheat	October 1996	2.3a	3.1a	2.6a	2.5a	2.9a	–	–	2.7
Harvest wheat	July 1997	1.4a	1.6a	2.0a	1.6a	1.9a	–	–	1.7

† Tillage methods were: NT, no-tillage; RT, reduced tillage; ST, sweep tillage; DT, disk tillage; B-DT, burn and disk tillage; B-ST, burn and sweep tillage; MB-DT, moldboard plow plus disk tillage.
‡ Values followed by the same letter(s) in a row are not significantly different at the $P = 0.05$ level based on Duncan's Multiple Range Test.
§ All differences between successive mean values in the column with grass retained or grass removed (separately) are significant at the $P = 0.05$ level, based on a two-tail t test.

methods in most cases on all areas, which also was the case for MWD differences.

Initial percentages of water-stable aggregates for all areas were similar, with averages ranging from 86 to 88 with grass retained and from 84 to 88 with grass removed. Similar initial percentages for all areas indicate aggregates had a high inherent stability not affected by seasonal variations. The subsequent changes in stability undoubtedly were influenced by soil water content, precipitation, vegetation on the land, and soil freezing and thawing, which also was considered to be the case for MWD. Because the results were similar on all areas, they are discussed primarily only for Area 1.

On Area 1 with grass retained, mean aggregate stability declined 4 percentage units from the initial sampling until sorghum planting and an additional 15 units until sorghum harvest. A subsequent increase of 15 units until wheat planting was followed by a decrease of 15 units until wheat harvest. These changes followed a pattern similar to that for MWD changes, but the increase after sorghum harvest did not raise the mean percentage to the initial mean value (the means differed significantly). Results with grass removed were similar to those with grass retained, which were contrary to results of Gilley and Doran (1998) for studies under more humid conditions. Soil and climatic conditions undoubtedly contributed to the different results for the different regions.

Mean aggregate stability percentage (67) after wheat harvest on Area 1 at <3 yr after converting the CRP grassland to cropland was similar to the mean percentages on Pullman soil where dryland wheat was grown for ≈40 yr (68% for wheat-fallow and 70% for continuous wheat) (Unger, 1969). On the basis of this comparison, the potential for water erosion at <3 yr after terminating the CRP grass was similar to that where dryland wheat was grown for many years.

Although the potential exists, water erosion seldom occurs on Pullman soil with surface slopes <1%. With greater slope (1–3%), low aggregate stability could lead to water erosion. Pullman clay loam has a 530 g kg^{-1}

Table 3. Water stability of 1- to 2-mm soil aggregates from Area 1 plots where CRP grassland was converted to cropland near Bushland, TX.

Condition–Time	Date	Tillage method†							
		NT	RT	ST	DT	MB-DT	B-DT	B-ST	Mean
		%							
Grass retained									
Initial	October 1994	88a‡	86a	86a	87a	86a	85a	86a	86§
Plant sorghum	June 1995	86a	82bc	84ab	80c	81bc	82bc	82bc	82
Harvest sorghum	November 1995	72a	67a	66a	64a	69a	69a	62a	67
Plant wheat	October 1996	79a	83a	81a	83a	84a	81a	84a	82
Harvest wheat	July 1997	73a	66a	66a	67a	68a	65a	67a	67
Grass removed									
Initial	October 1994	88a	88a	88a	86a	86a	–	–	87
Plant sorghum	June 1995	82a	81a	83a	79a	81a	–	–	81
Harvest sorghum	November 1995	68a	69a	66a	66a	72a	–	–	68
Plant wheat	October 1996	77a	79a	76a	79a	80a	–	–	78
Harvest wheat	July 1997	69a	65a	65a	69a	66a	–	–	67

† Tillage methods were: NT, no-tillage; RT, reduced tillage; ST, sweep tillage; DT, disk tillage; B-DT, burn and disk tillage; B-ST, burn and sweep tillage; MB-DT, moldboard plow plus disk tillage.
‡ Values followed by the same letter(s) in a row are not significantly different at the $P = 0.05$ level based on Duncan's Multiple Range Test.
§ All differences between successive mean values in the column with grass retained or grass removed (separately) are significant at the $P = 0.05$ level, based on a two-tail t test.

silt content. As a result, stability of aggregates wetted in air, rather than under a vacuum as for this study, is <20% (Unger, 1969). This can lead to aggregate disintegration during a rainstorm, thus resulting in surface sealing and potentially major loss of water and soil because of runoff. Aggregate disintegration and the resultant surface smoothing also increase the potential for wind erosion, which usually is a greater threat than water erosion on Pullman and similar soils in the southern Great Plains.

The cyclic nature of aggregate stability, as occurred in this study, suggests the erosion potential could be less or greater at other times during the crop rotation. Retention of crop residues on the soil surface, as with use of no-tillage, would reduce the potential. Therefore, because the potential exists, although erosion was not a problem during the first few years after terminating the CRP grass, this study suggests any tillage method can be used to terminate the grass. Then, a conservation tillage system (e.g., no-tillage) could be implemented before the potential for water erosion became serious.

Implications for Management

Results of this study showed the wind erosion potential was low with all tillage methods at 2 to 3 yr after converting the CRP grassland to cropland. The potential, however, undoubtedly would increase with time with continued use of clean tillage methods. Wind erosion has occurred on Pullman soil under conditions of low surface residue amounts and a relatively smooth surface.

A potential for water erosion was found at some stages of the winter wheat-grain sorghum-fallow rotation. On the basis of water-stable aggregate MWD, percentage of <0.25-mm water-stable aggregates, and percentage of stable 1- to 2-mm diam. aggregates, the water erosion potential was greatest after sorghum harvest. Because grain sorghum on dryland provides limited surface cover, runoff and soil loss have been greatest during fallow after sorghum for this rotation in other studies on Pullman soil (Jones et al., 1994).

Although the erosion potential presently is low, good management practices should be used to keep it low where CRP grassland is converted to cropland. The winter wheat-grain sorghum-fallow rotation involving no-tillage on dryland is well-adapted to the region (Jones and Popham, 1997; Unger, 1994). Use of no-tillage, however, was not the most effective method for converting CRP grassland to cropland on Pullman soil (Unger, 1999) because of poor grass and weed control attributable to plant water stress resulting from limited precipitation and seeding-slot closure problems. This study, however, showed the wind and water erosion potential to be similar and relatively low with all tillage methods during the first 2 to 3 yr after terminating the grass. Therefore, any tillage method could be used to terminate the grass on Pullman and similar soils in the region. Sufficient time then still would be available to convert to a conservation tillage system (for example, no-tillage) without incurring potentially serious wind and water erosion.

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