Australian Journal of Crop Science

AJCS

AJCS 7(8):1198-1204 (2013) ISSN:1835-2707

Land use effects on aggregation and erodibility of Luvisols on undulating slopes

Boško Gajić[1]*, Angelina Tapanarova[1], Zorica Tomić[1], Branka Kresović[2], Dragan Vujović[1], Borivoj Pejić[3]

[1]Institute of Soil and Melioration, Faculty of Agriculture, Belgrade University, Nemanjina 6, 11 080 Belgrade, Serbia
[2]Maize Research Institute, Slobodana Bajića 1, 11 185 Belgrade–Zemun, Serbia
[3]Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21 000 Novi Sad, Serbia

***Correspoding autor: bonna@agrif.bg.ac.rs**

Abstract

The aim of this study was to investigate the effects of land use changes on the aggregate size distribution, soil structural stability, and soil erodibility in Luvisols on Central Serbia's rainfed farms at a depth of 0.00–0.30 m. Six sites, selected for the study, contained adjacent land uses of natural grassland and arable land that have undergone conversion from grassland for more than 10 years. The inherent problems of Luvisols include weak structured surface horizons susceptible to structure deterioration, where tilled when wet or when heavy machinery is used. Aggregate size distribution and soil structural stability in the topsoil was tested by soil dry and wet sieving. Soil erodibility was assessed with the USLE-K factor. The natural grassland served as a control against which to assess changes in soil properties resulting from the removal of natural vegetation or cultivation of soil. The results showed that conversion of natural grassland to dry land farming led to a significant degradation of the soil structure. Aggregate separation by dry-sieving indicated that the natural grassland had significantly fewer unfavorable cloddy aggregates (>10 mm) and more agronomically most valuable aggregates (0.25–10 mm) than the arable soils. The mean weight diameter of dry aggregates (MWDdry) was greater in the grassland (~7.0 mm) compared to the arable soils (9.7 mm). The arable soil had significantly lower (1.03) structure coefficient (Ks) than grassland soils (2.77). Higher percentages of water stable aggregates (WSA) >0.25 mm were found under natural grassland (~50 %) than in arable fields (~41 %). In addition, grassland soil had significantly higher mean weight diameter (0.92 mm) of wet stable aggregates (MWDwet) than arable soils (0.81 mm). Tillage of the unaltered grassland significantly increased the soil erodibility measured by the USLE-K factor. The USLE-K factor was approximately by 17% greater in the arable soil than in the grassland, indicating the vulnerability of the arable soil to water erosion. In summary, the results showed that the tillage of the grassland degraded the soil structure, leaving soils more susceptible to the erosion in the temperate climate zone. This suggests that land disturbances should be avoided in the grasslands in the study region of the Central Serbia.

Keywords: aggregate-size distribution, aggregate stability, land use change, Luvisols, soil erodibility.
Abbreviations: erodibility factor (K- factor); structure coefficient (Ks); organic carbon (OC); mean weight diameter (MWD); mean weight diameter of dry aggregates (MWDdry); mean weight diameter of wet aggregates (MWDwet); soil organic matter (SOM); soil organic carbon (SOC); wet-stable aggregates (WSA).

Introduction

Luvisols are soils that generally have poor structure. The surface Ae horizon, which comprises the main part of the Ap (ploughed) horizon, has a weak, plate-like structure that pulverizes readily when dry and puddles when tilled wet. This leads to the development of hard crusts that interfere with seedling emergence, water infiltration into the soil and water storage and availability and consequently accelerate surface runoff and soil erosion. The subsurface AB and B horizons have unfavourable, strong sub-angular to angular blocky peds, firm and compacted. This structure can impede water flow in soils and restrict root growth (Filipovski and Ćirić, 1969; Broesma et al., 1997). Land-use strongly influences soil properties, such as aggregate size distribution and stability, especially in the Ap horizon, through the type of duration of crops, and the frequency and intensity of tillage. According to Broersma et al. (1997), crops affect soil structure differently because of diverse rooting habits, type of organic matter, rizosphere processes, and amount of additions, and providing surface soil protection. Soil structure is a key indicator of soil quality, and also of the entire agricultural system, because it is related to many properties and processes responsible for agricultural productivity and environmental integrity. Namely, the optimal soil structure supports plants with sufficient water supply, aeration and release of available nutrients (Alvarez et al., 2012). In addition, soil aggregation protects organic mater (Lützow et al., 2006) and supports soil fertility since it reduces soil erosion and mediates soil aeration, water infiltration rates, and water holding capacity (Oades, 1984). Unsuitable changes in land use due to human activities cause serious soil degradation worldwide. Conversion of natural grassland ecosystems to arable land leads to aggregation decline in topsoil and decrease of aggregate-binding agents (Spohn and Giam, 2010). Six et al. (2000) found that tillage has changed the distribution and stability of soil aggregates. Zobeck et al. (2003) reported that dry soil aggregate-size distributions can be used to derive specific important aggregate parameters and indexes useful in making soil management decisions and erosion predictions. The conversion of native pasture to dryland farming significantly decreases soil aggregate stability and negatively affects soil erodibility (Haghighi et al., 2010). According to De Gryze et al. (2006), aggregate stability is an important aspect of soil quality; it determines root penetration, organic matter stabilization, susceptibility to compaction, soil erodibility, etc. Evrendilek et al. (2004) observed that conversion of the grassland into the cropland in southern Taurus Mountains of the Mediterranean region increased soil erodibility by 46.2% during a 12-yr period. Afshar et al. (2010) also investigated the impact of land use change on degradation of silty clay and silty clay loam in a 0–30 cm soil layer in western Iran. The results revealed that the conversion of permanent grass to cropland leads to increased erosion in hilly regions and affects considerably the soil properties. In recent years, many authors have used the USLE-K factor as an indicator of soil erosion (e.g. Evrendilek et al., 2004; Khormali et al. 2009), because it is a measure of soil susceptibility to erosion. Although the effects of conversion of natural grassland ecosystems to arable land on different soil properties have been studied widely throughout the world, the long-term (>10 years) effects of tillage practices on aggregate size distribution, aggregate stability and soil erodibility have not been extensively studied, especially in agro-ecosystems under rainfed conditions in temperate-continental regions on the undulating hilly topography. We hypothesized that soils under native grass and conventional tillage would behave differently in terms of aggregate size distribution, aggregate stability and erosion. Therefore, the major objective of this research was to evaluate the effects of different land use on soil structure and erodibility in temperate-continental ecosystems of the Central Serbia. Better understanding of how soil structure and erodibility are affected by different management practices is of importance in identifying agricultural practices for sustainable crop production.

Results and Discussion

Basic properties of soils

Table 1 shows average values of soil properties for each of the two land-use types. As expected, no significant difference in soil particle size distribution was found between land-use types. The pH did not vary too much in the site, and land-use change had no effect on this property. The results indicated that the SOM content was significantly affected by land use in the surface 0–0.30 m layer. Soil under a rainfed farming system (during the first 10 years after conversion of the sites) had significantly lower SOM compared to grassland soils (1.75% versus 2.27%). Crop biomass inputs under field cropping were not sufficient to maintain OC with conventional tillage.

Aggregate distribution for the whole soil by dry sieving

The results obtained from dry sieving showed significant differences in the distribution of dry aggregates between the grassland and arable soils (Fig. 1). Dry aggregates were distributed mainly in the larger diameter classes in both land-use systems. The grassland had a significantly smaller proportion of cloddy aggregates (>10 mm) and larger proportions in agronomically most valuable aggregates (0.25–10 mm) than the arable soil. The higher content of clods >10 mm in the arable soils than in natural grassland are attributed to the increased compaction, resulting from threading during tillage (Gajić et al., 2010). The grassland had a significantly larger proportions in the 5–3, 3–2, 2–1, 1–0.5 and 0.5–0.25-mm classes than the arable soils. There were no significant differences in the amount of 10–5 mm aggregates obtained by dry sieving between the grassland and arable soils, although this content was greater for grassland. More than 33% of the dry aggregates in the grassland but only 20% of those in the arable soil were 1–5 mm. Grassland showed significantly higher content of dry microaggregates < 0.25 mm than arable soils at depth 0–0.30 m depth (34% higher in grassland soils). These differences can be attributed to tillage practices. These results confirm earlier observations that the dry aggregate-size distribution is affected by the change in land use. Cotching et al. (2002) reported similar results for Dermosols in N Tasmania. They found a significantly higher content of dry aggregates >9.5 mm in the upper 75 mm layer of cultivated soils than in the same depth zone of long-term pasture. The results of this study are comparable to those of Håkansson et al. (1988), who observed that intensive soil tillage increased the size of structural aggregates in clay and loam soils of Sweden, as a result of increased clodding. Eynard et al. (2004), studying aggregate sizes and stability in central South Dakota Ustolls and Usterts, under different management systems (grass, no-till, and till), reported that granular structure was dominant under grass, whereas plates, blocks and compacted layers were most common in conventionally tilled and no-till soils. In contrast to our results, Broersma et al. (1997), studying the effects of diverse cropping systems on aggregation of a Gray Luvisolic soil in Canada, reported that topsoil (0–0.15 m) of the continuous legume had fewer large aggregates (12.7–38.1 and 6.4–12.7 mm) and more small aggregates (2.4–6.4, 0.84–2.4, 0.42–0.84 and <0.42 mm) than the other cropping systems after dry sieving. Furthermore, there were significant differences in *Ks* between grassland and arable soils in the top 0–0.30 m depth (Table 2). The *Ks* for arable soils is ~63% lower compared to grassland soils. According to the classification proposed by Shein et al. (2001), *Ks* values of grassland soils are characteristic of soils with good structure. The plough (Ap) horizon of arable soils, with the average *Ks* = 1.03, still shows the satisfactory structure according to Shein et al. (2001).

Aggregate distribution for the whole soil by wet sieving

Figure 2 shows the distribution of the wet-stable aggregate size classes (average % of stable aggregates on the initial sample mass without correcting for sand) as affected by land-use changes. As expected, there were significant differences in the distributions of WSA between grassland and adjacent arable soils in the surface 0–0.30 m layer. A higher percentage of WSA in grassland than in arable soil is in line with other studies, although measurement procedures varied among studies. There are not many large-sized aggregates (>3 mm) in any of the investigated Luvisols, as may be observed in Fig. 2, where only an average of ~10% of aggregates is over 3 mm. The WSA were distributed mainly in the smaller diameter classes. The conversion of natural grassland to arable soils decreased significantly the content of wet-stable macroaggregates, i.e. >2.00 mm aggregates. The grassland soils had significantly larger proportion in the 3–2 mm, 2–1 and 1–0.5 mm ranges and smaller proportions in the <0.25 mm ranges than arable soils. In contrast, there were no statistically significant differences in the distributions of WSA with sizes of 3–5 mm and 0.5–0.25 mm between arable soil and grassland.

Table 1. Some soil physical and chemical properties in the surface soil layer (0–0.30 m) from grassland and arable soils (mean ± standard error)

	Land use	
Soil properties	Nature grassland (n = 6)	Arable soil (n = 6)
Sand (%)	33.1 ^{a†} (±8.2)	41.7 ^{a}(±3.5)
Coarse sand (%)	16.6 ^{a} (±8.4)	21.3 ^{a} (±3.4)
Very fine sand (%)	16.5 ^{a} (±8.5)	20.4 ^{a} (±3.5)
Silt (%)	41.1 ^{a} (±6.7)	34.9 ^{a} (±7.0)
Clay (%)	25.8 ^{a} (±4.2)	23.4 ^{a} (±2.0)
Soil texture	Loam	Loam
Soil organic matter (%)	2.27 ^{a} (±5.8)	1.75 ^{b} (±7.9)
Structure code	3	4
Permeability class	4	4
pH_{H2O}	6.24 ^{a} (±0.5)	6.07 ^{a} (±1.1)

† The means followed by the common lower case letter in the rows do not differ statistically at 5% probability level according to Tukey's test.

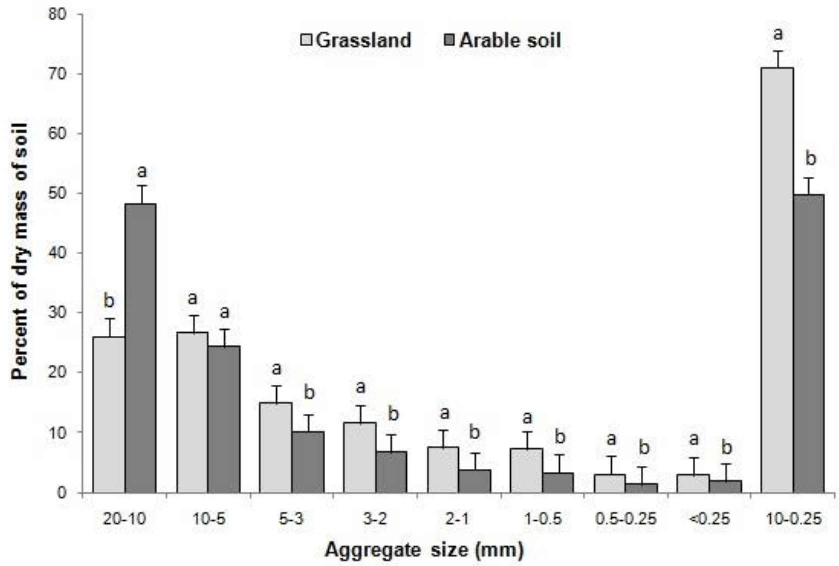

Fig 1. Aggregate distribution of whole soil obtained by dry-sieving the soils according to land use in the 0–0.30 m layer. Columns followed by the same letter were not significantly different at P<0.05. Error bars represent the standard deviation of six replicates.

Similar results were reported by Evrendilek et al. (2004) who observed significant differences between grassland and tilled soils in terms of water-stable aggregate size distribution in Typic Haploxeroll soils in the southern Mediterranean region of Turkey. Results from this study are in disagreement with the observations of Broersma et al. (1997) who found that macro-aggregates (>2.0 mm) are the most frequent aggregate fraction (~50.0%) in a grassland than in a cultivated Gray Luvisolic soil (22–27%) from Canada. Pinheiro et al. (2004) also observed more macro-aggregates of >2 mm than aggregates of <2 mm after wet sieving in a Red Latosol from Brazil. The reduction of large aggregates in the tilled Luvisols may be attributed to the physical disturbance of soil and the low stability of macro aggregates. Ayoubi et al. (2012) claimed that binding agents, such as fungal hyphae and plant roots stabilize large aggregates but are temporary and unstable. According to Blair (2000), the breakdown of the larger aggregates can lead to the pore blockages through the soil, reducing infiltration and leading to an increased erosion risk. In the literature, the researchers (Imeson and Verstraten, 1989) reported that aggregates <0.25 mm were efficient in enhancing crusting and soil erosion. More than 58% of the WSA in the grassland but only 49% of those in the arable soil were <0.25 mm. Consequently, tilled Luvisols were more likely to have soil loss by erosion because they had a significantly greater number of small WSA (<0.25 mm) than grassland.

Mean weight diameter for dry and wet aggregate distributions

Table 3 shows the average values of aggregation indices MWDwet, MWDdry, differences in the MWD's (Δ MWD) and the wet-sieving MWD to dry-sieving MWD ratio for grassland and arable soils in the top 0–0.30 m depth. The MWD for the grassland as determined by dry sieving and wet sieving was significantly smaller than for the arable soils (Table 3). Dry aggregates formed under grass were finer (smaller in size, MWDdry ~7 mm) than in arable soils (MWDdry ~10 mm). In the natural grassland, the average MWD of the WSA was 0.92 mm. It decreased to 0.81 mm during the first 10 years after conversion of the sites (Table 2). This results in a loss of 12% of the initial MWD. The loss of the MWD of the WSA from the grassland sites is caused by a loss of the proportion of wet stable macroaggregates (aggregates >5 mm) (Fig. 2). The reduction of MWD values following tillage was also reported by other workers for other soils and climatic conditions but to a much greater extent after long-term cultivation of virgin soils than in our study. For example, in the Typic Haploxerolls of Iran (typical Mediterranean climate) Emadi et al. (2009) found that the

Table 2. Effects of two adjacent land use types on structure coefficient (Ks) and USLE-K factor.

Land use	Ks	USLE – K factor
Nature grassland (n = 6)	2.77 [a†]	0.33 [b]
Arable soil (n = 6)	1.03 [b]	0.40 [a]

†The means followed by different letters in the columns differ statistically at 5% probability level according to Tukey's test.

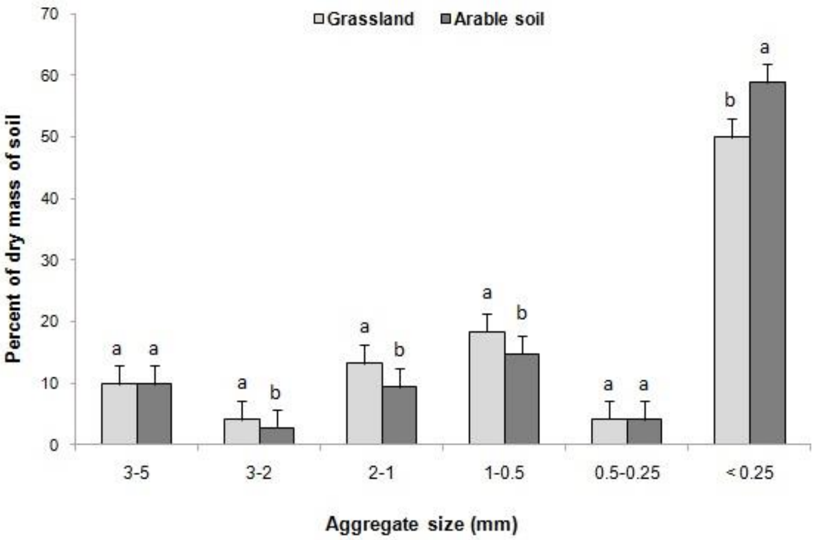

Fig 2. Aggregate distribution of whole soil obtained by wet-sieving according to land use in the 0–0.30 m layer. Columns followed by the same letter were not significantly different at P<0.05. Error bars represent the standard deviation of six replicates.

MWD of wet-stable aggregates declined by 67% from virgin pasture soil after ~20 y of crop rotation. Also, Broersma et al. (1997) reported significantly higher (~87%) MWD of WSA in cultivated Canadian Luvisolic soil compared to the grass. According to Piccolo et al. (1997), higher values of MWDwet indicate the dominance of less erodible, large aggregates of the soil. The differences in the MWD's (Δ MWD) between the dry sieving and the wet sieving techniques are considerably larger for arable soils than for grassland (8.93 vs. 6.06). A smaller difference in MWD's indicates a higher stability of the soil aggregates. The quotient of the dry versus the wet MWD gave reverse results. Namely, tillage resulted in a 62% reduction in the ratio of the dry versus the wet MWD compared to the grassland. Accordingly, the aggregates under the arable soils showed greater propensity to slake compared to the grassland.

Previous studies showed that soils with a higher MWDwet and WSA are likely to have a greater resistance to soil degradation and erosion (Broersma et al., 1997; Evrendilek et al., 2004; Khormali et al., 2009). Accordingly, the grassland soils in this study showed a relatively firm structure, capable of resisting the erosive force of rain.

Soil erodibility

As shown in Table 2, the USLE K-factor, as an indicator of soil erodibility, differed significantly between the arable soils and the grassland soils. This factor is lower in the grassland (0.33) than in the 0–0.30 m layer in the adjacent arable soils (0.40). The lower the K-factor values, the higher the potential of the soil to erode. The magnitude of changes in the USLE K-factor observed in our study is much lower than the values reported by Evrendilek et al. (2004) for Mediterranean highland soils (46.2%). The higher magnitude of change of the USLE K-factor in the Mediterranean agro-ecosystems compared to the undulating ecosystems of Central Serbia could be attributed to the differences in climate, intensity of tillage, variations in sampling depth and soil type. According to Khormali et al. (2009), the erodibility of a certain soil is closely related to its particle size distribution, organic matter content, permeability, and structure. The Luvisols under grassland and the arable Luvisols had similar contents of sand, silt and clay in the 0–0.30 m layer. The arable Luvisols had significantly lower SOM content than the adjacent grassland soils. Accordingly, for investigated Luvisols, the difference in soil erodibility is mainly the result of variations in soil structure of which changed distribution and stability of soil aggregates are the most important factors. The higher K-factor values in the arable soils, therefore, could be mainly due to the lower aggregate stability and MWDwet and lower organic matter content. These results are in agreement with those found by other authors, where a removal of permanent grass vegetation, loss of SOM**,** and decreases in WSA and wet MWD in the conversion process of grassland to arable land have contributed to the soil erodibility increase (Evrendilek et al., 2004).

Materials and methods

Description of the study area

The study area is located close to Vrnjačka Banja town, in Central Serbia (44°35'N, 20°55'E). Soil, at the selected experimental sites, classified as silty-clay Luvisols (FAO, 2006), developed from fine-textured lacustrane deposits from Pleistocen. The landscape is undulating, with altitude ranging between 220 and 450 m and gradients of up to 8%. The area is highly susceptible to soil erosion and landslides (Spatial Plan of the Municipality of Vrnjačka Banja, 2011). The erosion in the study area is caused by improper land-use change and inappropriate cultivation practices over a long time period. The climate of the study area is temperate-continental with the influence of mountain climate. The long-term mean annual precipitation is ~750 mm and mean annual

Table 3. The mean weight diameter (MWD) of dry- and wet-sieved whole soil, and differences and ratio between these values as indices of soil structural stability under grassland and arable soils.

Land use	MWDdry (mm)	MWDwet (mm)	Change in MWD†	
			Δ MWD (dry – wet)	MWD ratio (dry : wet)
Nature grassland (n = 6)	6.98 [b]‡	0.92 [a]	6.06 [b]	0.13 [a]
Arable soil (n = 6)	9.74 [a]	0.81 [b]	8.93 [a]	0.08 [b]

† Change in MWD assessed by comparing the ratio of wet to dry sieving, or the difference between dry and wet sieving. ‡ The means followed by different letters in the columns differ statistically at 5% probability level according to Tukey's test.

air temperature is 10.5°C (30-year average). Most precipitation (about 75%) falls during the spring and summer season (April–October).

Soil sampling

Six sites were selected for sampling on the farms scattered around Vrnjačka Banja town. Each sample site includes a perennial grass plot (grassland) and till plot (arable soil). The two plots are close to each other, with a maximum distance of 100 m and comparable in all other features (morphological and geo-pedological). All plots are 0.7 to 2.0 ha in size. We selected only sites that had not suffered a land-use change in the past 10+ years. The perennial grass sites were represented by native vegetation and were used only for hay production. The prevailing species in the grass vegetation were Kentucky bluegrass (*Poa pratensis* L.), rough meadowgrass (*Poa trivialis* L.), Orchard grass (*Dactylis glomerata* L.), and Bermuda grass (*Cynodon dactylon* L.). Conventional tillage (mouldboard ploughing + tandem disking + harrowing) was done to a depth of 0.25–0.30 m for >10 yr along the maximum gradient. The most common crops were winter wheat (*Triticum aestivum* L.) and corn (*Zea mays* L.), cultivated in a rotational manner. Wheat straw and other crop residues were collected and used as animal feed or animal bedding. Stubbles were burned after harvesting in this region. Information of land use history was obtained by interviews of farmers and landowners. About 1.5–2.0 kg of fresh soil was collected from three small pits (repetition) about 0.3 x 0.3 x 0.2 m depth randomly located in each plot (within a distance of about 15 m from each other) with the aid of spade to maintain the soils relatively in their natural aggregates. Samples of each plot were combined to gain one mixed sample per plot, kept in polythene packs and transported to the laboratory for analyses. The mixed samples were homogenized, air-dried for 1 week. Air-dried samples were gently broken by hand and passed through a 20-mm sieve. Therefore, lab analyses were performed on six composite samples from each of the two land uses, summing up twelve samples. Because the main purpose of this study was to assess the change in soil properties, results from surface perturbations samples were collected only at the depth of 0.0–0.3 m (the approximate plow horizon – Ap). The soil surface structure was assessed in the field during soil sampling.

Laboratory analysis

A 200 g air dried sub-sample of each bulk soil sample was crushed, passed through a 2 mm sieve (fine earth fraction) for particle size distribution and soil reaction (pH), and through a 0.5-mm sieve for organic carbon (OC). Particle size distribution was determined by Robinson's pipette method (Gee and Bauder, 1986); the sand fraction was separated by wet-sieving, oven-dried, and then fractionated by dry sieving (USDA textural classes). Soil pH was measured with a glass electrode in a 1:2.5 soil-water suspension. Soil organic carbon (SOC) was determined using the Walkley-Black wet digestin method (Nelson and Sommers, 1982). The percent of soil organic matter (SOM) was obtained by multiplying %OC by a conversion factor 1.724, following the standard practice that organic matter is composed of 58% carbon (Brady and Weil, 1999).

Dry aggregate size distribution was determined using the dry-sieve method by Savinov (Shein et al., 2001). The air-dried soil sub-samples (approximately 4.5–6 kg) were shaken through a nest of sieves having rectangular holes with equivalent diameters of 10, 5, 3, 2, 1, 0.5, and 0.25 mm, and a pan underneath. The aggregate fraction that remained on each sieve or pan was oven-dried (105°C), weighed, and expressed as a percentage of total dry soil sample mass. The size distribution of air-dry aggregates was characterized by mean weight diameter. The mean weight diameter, in mm, was estimated using the following equation (van Bavel, 1949):

$$\text{MWDdry} = \sum_{i=1}^{n} \bar{X}_i W_i \;, \qquad (1)$$

where MWDdry is the mean weight diameter (mm), n corresponds to the number of aggregate size fractions considered in the analysis, $\bar{X}_i$ is the arithmetic mean diameter of aggregates that potentially can stay in the i th and i + 1 sieves (in this case: $\bar{X}_1$ = 15.00 mm, $\bar{X}_2$ = 7.50 mm, $\bar{X}_3$ = 4.00 mm, $\bar{X}_4$ = 2.50 mm, $\bar{X}_5$ = 1.50 mm, $\bar{X}_6$ = 0.375 mm and $\bar{X}_7$ = 0.125 mm), and W_i is the proportion in mass (mass of aggregates in the i th size fraction (g)/total soil mass (g)) of the aggregates (oven-dry basis). High values of MWDdry indicate more cohesive soil conditions and less susceptibility to wind erosion.

The dry aggregate size distributions were also used to compute a structure coefficient (Ks) (Shein et al., 2001). Structure coefficient was estimated using the following equation:

$$\text{Ks}=a/b, \qquad (2)$$

where "a" is the amount of agronomically most valuable structural aggregates (Shein et al., 2001), i.e., aggregates with a diameter between 0.25–10 mm, and "b" is the total amount of aggregates >10 mm and <0.25 mm. Shein et al. (2001) suggested three classes of Ks >1.5, 1.5–0.67 and <0.67 for soils of good, satisfactory, and unsatisfactory structure with respect to soil fertility. Soil aggregate stability was determined by the modified Savinov wet sieving procedure (Shein et al., 2001). A 50 g of the sample composed of eight dry aggregate size fractions (>10, 10–5, 5–3, 3–2, 2–1, 1–0.5 and 0.5–0.25 mm) was put on the first sieve of the sequential nest and gently moistened for 10 min to avoid sudden rupture of aggregates. Subsequently, the sieve was moved up and down in water for about 5–6 cm with 15 repetitions. The sieves in the nest had equivalent diameter of 10, 5, 3, 2, 1, 0.5, and 0.25 mm. After wet sieving, the resistant aggregates on each sieve were oven-dried (105^{o}C) and weighed. The wet-stable aggregate fraction less than 0.25 mm was determined from the difference between the original total sample and the fraction that remained on all the sieves. Aggregate stability was expressed as a percentage of mass WSA (105^{o}C oven-dry weight) that remained on each sieve relative to the total sieved sample mass without correcting for sand. The sieving data was used to calculate the mean weight diameter (MWD) of wet-stable aggregates as indices of soil aggregation. The MWDwet was determined using Eq. (1). In this analysis, the upper size limit for WSA was determined by measuring the diameter of the largest aggregate remaining in the largest sieve (3 mm mesh opening) (in this case: $\bar{X}_1$ = 4.00 mm, $\bar{X}_2$ = 2.50 mm, $\bar{X}_3$ = 1.50 mm, $\bar{X}_4$ = 0.375 mm, and $\bar{X}_5$ = 0.125 mm). Higher values of MWDwet imply greater stability of aggregates while lower values indicate lower stability.

Soil aggregate stability index was calculated as MWDwet/MWDdry (Silva et al., 2007); an index of 1 represents perfect structural stability. Index of relative aggregate stability was determined as a difference between the MWD after dry and wet sieving (De Boodt et al**.,** 1961).

The soil erodibility (USLE-K factor) was based on the equation suggested by Wischmeier and Smith (1978) and calculated from mean analytical results determined from soil samples. The soil structure codes and profile permeability classes were obtained from National Soils Handbook No. 430 (USDA, 1983) and shown in Table 1.

Statistical analysis

Analysis of variance (ANOVA) was used to compare the impact of the two land-use types on soil properties. The LSD procedure was performed to compare averages of the soil properties at $p < 0.05$. Data analyses were carried out using the software package StatGraphics (1992).

Conclusion

In the temperate-continental regions of Central Serbia, the removal of the native grassland and its subsequent conversion to cultivated fields for 10 years has led to significant changes in aggregate size distribution and stability of structural aggregates within the 0.00–0.30 m soil layer of the Luvisols. The aggregate distributions obtained by soil dry sieving indicated that the continuously tilled soils had significantly ($P \leq 0.05$) more unfavourable cloddy aggregates (>10 mm) and fewer agronomically most valuable aggregates (10–0.25 mm), particularly those of 3–2 mm, 2–1 mm, and 1–0.5 mm size. The MWDdry was higher in till than in grass, while the Ks was lower in till than in grass. In contrast, wet sieving indicated that the grassland had significantly greater amounts of stable macroaggregates >0.25 mm, and overall aggregates stability, compared to arable soil. According to the statistical analysis, the conversion of native grassland to arable soils significantly decreased the average MWDwet and soil aggregate stability index (by 12% and 63%, respectively). The results of this study showed that the arable soils were more susceptible to water erosion than the grassland soils. The erodibility (USLE-K factor) of the arable soils is by 17% greater than that of the grasslands. Based on our results, changes in land use from natural grassland to dry land farming influenced not only the soil structure and erodibility, but also the SOC content in these Luvisols. On average, arable land use significantly decreased the SOM amount by 23% compared to natural grassland in the top 0–0.30 m, in such a short time of clearance, i.e. for 10 years. In conclusion, when these grasslands are converted to agricultural land without using proper practices of securing organic matter and soil stability, they are easily endangered. The inclusion and expansion of grass in management systems is the best means of maintaining SOC in the surface horizon of weakly structured Luvisols, improving or maintaining structure, and minimizing their erosion potential.

Acknowledgements

This work was supported by the Ministry of Science and Technological Development of the Republic of Serbia (Contract Nos. 43009 and 43007). The authors thank the local farmers for their cooperation during the field experiments.

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