Relational Analysis of Aggregate Size Distributions and Soil Organic Carbons of the Eroded Sediments

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INTRODUCTION

Role of the soil organic carbon on aggregate formation is widely known from early studies opposite to that on aggregate breakdown. Although, soil susceptibility to detachment and transport sub-processes of erosion is generally controlled by aggregate breakdown mechanism (De Ploey and Poesen, 1985; Farres, 1987; Le Bissonnais and Singer, 1993; Hairsine and Hook, 1994; Morin and Van Winkel, 1996, Ramos et al., 2003). Especially in fragile ecosystems like semi-arid environments, soil organic carbon content plays a very crucial role in protecting the soils against the aggregate breakdown by erosion processes (Saygin et al. 2014; Saygin et al. 2015).

OBJECTIVES

In terms of soil erodibility assessment, studies on relationship between disintegration of soil aggregates and soil organic carbon have been limited under erosive conditions. In order to investigate these relationships, interrill erosion processes of rain-splash transport (RST) and raindrop impacted flow transport (RIFT) were simulated in laboratory conditions by using the soils of three different land uses (cropland, grassland and forest, textural compositions of which were classified as Clay, Sandy clay loam and Clay loam, respectively), taken from a semi arid catchment, located in Ankara, Turkey.

MATERIAL AND METHOD

The rainfall simulations were conducted with the soils of ***three different land uses under three slope gradients (9, 15 and 20%) and two rainfall intensities (80 and 120 mm h^{-1}) with three replicates for saturated conditions***. Totally, 18 different sub-group simulations with three replicates were performed in laboratory conditions (Figure 1).

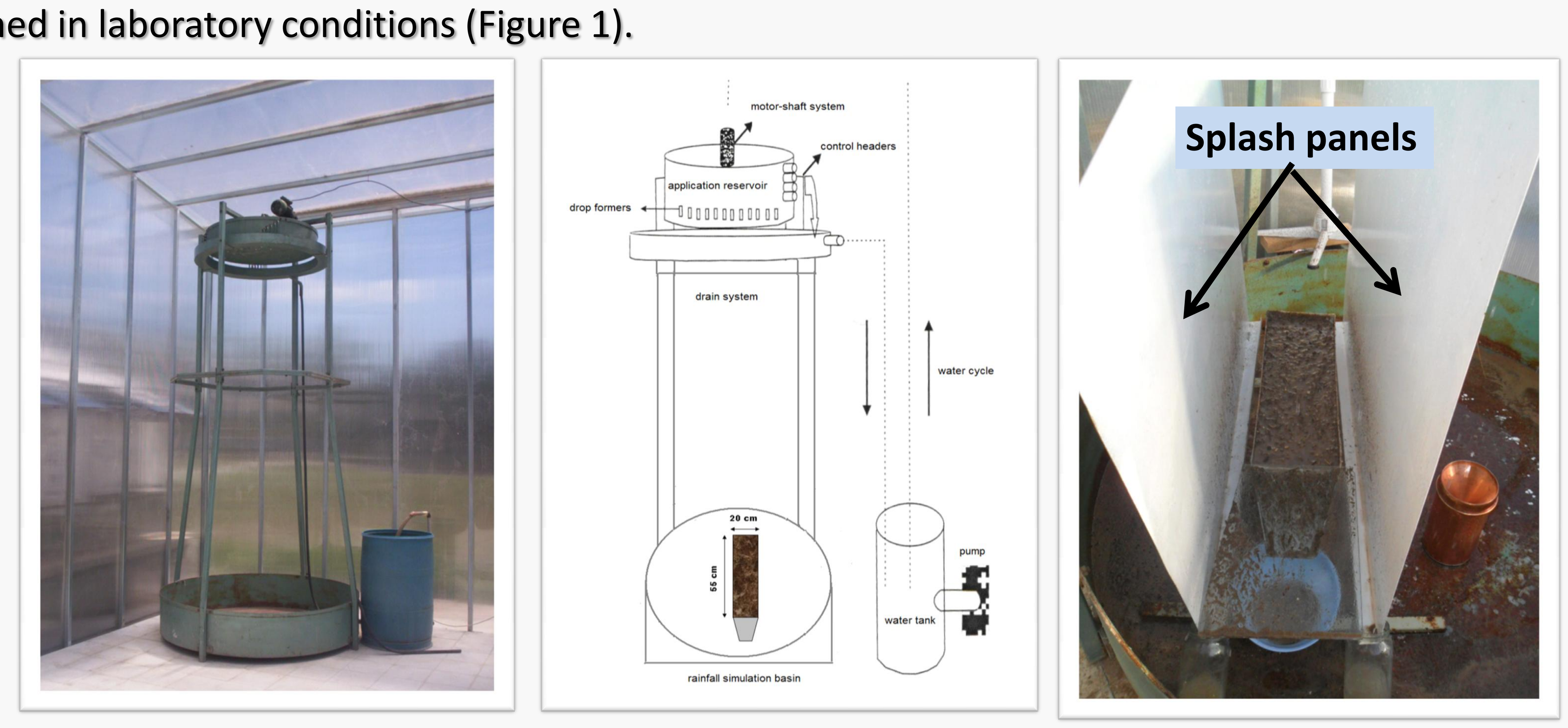

Figure 1. Rainfall simulator (left), schematic view of the experimental design (center) and experimental setup in laboratory (right).

The eroded sediments by both RST and RIFT were collected every 5 min during 60 min in each sub-group rainfall simulation. ***The collected 1143 sediment samples*** from 18 different sub-groups were dried to measure ***Aggregate Size Distributions (ASD).***

Mean Weight Diameter (MWD, mm) values, the most widely used index for relating aggregate size to stability (van Bavel, 1949), were calculated from the ASD (Eq. [1]. According to the obtained MWD values for each simulated condition, ***OC content of the eroded sediments*** corresponding to the dominant aggregate size class were measured for ***1143 samples*** (Nelson and Sommers, 1982). Later, the collected data were tabulated as an average of each sub-group simulation and statistical analyses were performed. The two-way analysis of variance (ANOVA) (MINITAB 15.1.1) and the Duncan's multiple range test (MSTATC) were used for group comparisons.

$$MWD = \frac{\sum_{i=1}^{i=n} m_i \times d_i}{\sum_{i=1}^{i=n} m_i} \quad \text{Eq. [1]}$$

Where, *MWD* is the mean weight diameter (mm) of the aggregates after their disintegration, "i" is the sieve size class, m_i is the soil aggregate amount above the *"i^{th}"* sieve size (g), and d is the sieve diameter for *"i^{th}"* sieve (mm).

RESULTS

Results indicated that the values of MWD and OC in the eroded sediments by RST and RIFT changed significantly (**P < 0.01) with the interaction term of rainfall intensity x slope gradient x land use. The highest MWD values and OC contents obtained from all sub-group of simulations (Table 1) were measured for forest soils (*P < 0.05). Cropland and grassland soils produced similar MWD values (Table 1). Based upon the initial soil conditions before rainfall simulation, cropland soils had initially higher clay contents than grassland; however, grassland soils had initially higher OC contents (Table 1).

Table 1. Comparison of MWD values (mm) and OC contents (%) for RST sediments (*P<0.01).

Slope Gradient (%)	Rainfall Intensity (I) (mm/h)	MWD Values Land use (LU)			Organic Carbon Contents Land use (LU)		
		Cropland	Grassland	Forest	Cropland	Grassland	Forest
9	80	0.36 C **b** ^{B*}	0.39 A **b** ^{B}	0.87 B **b** ^{A}	0.96A **a** ^{B}	1.06 A **a** ^{B}	2.20 A **b** ^{A}
	120	0.45 B **a** ^{B}	0.46 A **a** ^{B}	0.93 A **a** ^{A}	0.29A **b** ^{C}	0.81 A **b** ^{B}	2.47 A **a** ^{A}
15	80	0.45 A **b** ^{B}	0.40A **b** ^{C}	0.90 B **a** ^{A}	0.51 B **a** ^{C}	1.13 A **a** ^{B}	2.31 A **a** ^{A}
	120	0.49 A **a** ^{B}	0.48 A **a** ^{B}	0.75 B **b** ^{A}	0.27 A **b** ^{C}	0.87 A **b** ^{B}	2.37 A **a** ^{A}
20	80	0.41B **b** ^{B}	0.41 A **b** ^{B}	1.00A **a** ^{A}	0.49 B **a** ^{C}	1.01 A **a** ^{B}	2.28 A **a** ^{A}
	120	0.48 AB **a** ^{B}	0.48 A **a** ^{B}	0.63 C **b** ^{A}	0.30 A **a** ^{C}	0.94 A **a** ^{B}	2.18 B **a** ^{A}

*Capital letters was used for comparison of slope steepness; bold lower case letters for comparison of rainfall intensities; superscript letters for comparsion of land use types.

- ➢For the RST sediments, variation in slope gradient had significant effects on MWD values, except for grassland soils. But, the variation in slope gradients had no statistically significant effect on the OC contents of these sediments (P > 0.05) (Table 1).
- ➢More intensive rainfall conditions for all land uses and slope gradients led to lower MWD values of the eroded sediments (Table 1).
- ➢The OC contents of these sediments were also affected by the intensity variations for the soils of cropland and grassland. Land use had more significant interactions with MWD values and OC contents of the eroded sediments than did intensity and slope gradient for the RST and RIFT processes.

Observed main differences between the RST and RIFT processes were:

- ✓ increases in the rainfall intensity led to significant variations in the MWD values of the RST sediments more than those of RIFT,
- ✓ the effect of variations in the slope gradient were not statistically significant (P > 0.05) on MWD and OC values of the RST sediments compared to those of RIFT sediments for most of the controlled conditions of the experimental design.

Comparison of the variations with the initial soil conditions,

- ❖RST process resulted in approximately 76, 50 and 63 % reduction in MWD values for cropland, grassland and forest, respectively.
- ❖The reduction rates for RIFT process were found similar to those of RST process. These were approximately 75, 46 and 62 % for cropland, grassland and forest, respectively (Figure 2).
- ❖When the initial OC contents were compared to the measured OC contents of the eroded sediments, 23, 66 and 59 % reductions were observed in OC by the RST process for cropland, grassland and forest, respectively.
- ❖The OC contents of the transported sediments by the RIFT process from cropland were found higher 14 % than initial conditions before rainfall simulations.
- ❖Oppositevly, the OC contents of the eroded sediments from grassland and forest by the RIFT process were found 69 and 64 % lower than the initial conditions (Figure 2).

Findings indicated that land use transformation and soil erosion had dramatically significant effects on the sediment associated OC transporting and aggregate disintegration.

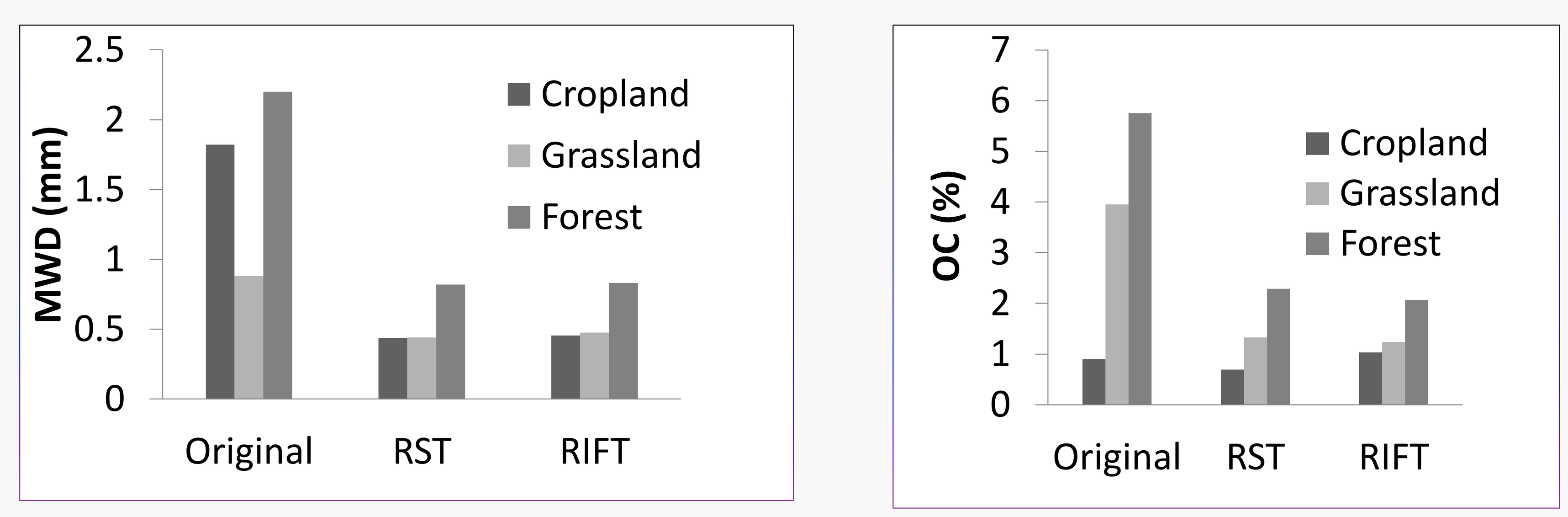

Figure 2. Process-based comparison of MWD values (left) and OC contents (right).

CONCLUSION

In the light of these results, the MWD values of the eroded sediments by the RST and RIFT processes were, to a great extent, similar and statistically the same, showing no changes with land use, slope gradient or rainfall intensity. However, the variations in the OC contents of these aggregates were statistically significant (*P < 0.05) with effects of land use, slope gradient and rainfall intensity evident. Increases in MWD values of incoming sediments, especially from undisturbed land uses (i.e. forest and grassland) gave rise to considerable transport of soil organic carbon.

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