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Sediment and Runoff Measurement in Different Rangeland Vegetation Types using Rainfall Simulator

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Abstract Soil erosion is an abstruse phenomenon which contains segregation and transmission of soil particles and runoff from rainfall and infiltration. Runoff and sediment generation was compared using rainfall simulator in grassland (*St. parviflora-Br. tomentellus*) and shrubland (*As. parrowianus-As. gossipinus*). For this purpose, vegetation map was supplied for two vegetation types four main aspects and two slope classes (12%-20% and 20%-40%) and corresponding work units were accordingly determined Three points were selected in each unit and rainfall simulator set inside them through a randomized pattern. The intensity of rainfall simulation was 1.6 mm min^{-1} with 10 minute duration and then runoff and sediment were measured. One soil sample (depth of 0–40 cm) was collected and assessed for pH, OM, EC, P, K, Ca, Mg and texture in the laboratory at the vicinity of the study area. The results of Duncan test and multiple regressions showed that grassland had more runoff and sediment than shrubland, but initial time of runoff in grassland was less than shrubland. Also aspects, slopes and soil characteristics (EC, Ca, Clay, P) had significant effects on runoff, sediment and initial time and they had linear correlation with runoff and sediment.

Key words: *Rainfall simulation, Rangeland, Runoff, Vegetation type*

1 INTRODUCTION

The estimation of runoff and sediment generation is one of important in scientific researches in hydrological processes, soil erosion and soil water transport processes (Leia *et al*., 2006). Soil erosion during rainfall is a complex phenomenon resulting from soil detachment by raindrop impact and transport of particles by rain splash and surface flow. The relative importance of these processes is related to different factors such as rainfall intensity and duration, runoff depth and velocity, soil texture and antecedent moisture, soil permeability, land slope (slope length and steepness), type and density of vegetation cover, litter, surface roughness and land use (Assouline and Ben-Hur, 2006; Sheridan *et al.*, 2008 and). Land cover influences the occurrence and the intensity of runoff and sediment (Wei *et al.*, 2007). Always vegetation canopy has played a

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key role in protecting surface from erosion (Pizarro *et al.*, 2006; Marques *et al.*, 2007; Wei *et al*, 2007). Zhou *et al.* (2006) found that soil erosion was negatively linearly correlated with vegetation coverage in the loess hilly area. Soil properties are always affected by land uses or vegetation. Furthermore, the accumulation of litter under plants contributes to increased surface roughness, higher infiltration rates, and decreased runoff generation thresholds (Gyssels *et al.*, 2005; Mao *et al.*, 2006). The loss of surface vegetation cover and low organic content decrease the infiltration rate significantly because the direct kinetic energy impact of raindrops on a bare surface promotes the development of surface sealing (Yasser *et al.*, 2002; and Mills Fey, 2004; Kato *et al.*, 2009;). Reduction of the infiltration rate increases overland flow generation and surface erosion, which results in the increase of sediment and soil (Seeger, 2007; Kato *et al.*, 2009). Casermeiro *et al.* (2003) stated that runoff generation and sediment production are directly dependent on vegetation, but different plants of Mediterranean shrubland show different results to simulations. Most watersheds in developing countries have not been equipped by water and sediment measurement devices. However, the necessity for information about the rate of runoff and sediment is inevitable (Vahabi and Nikkami, 2008). A commonly used method for infiltration rate, runoff and sediment measurement is rainfall simulator (Leia *et al.*, 2006).

Some studies showed that rainfall simulations are considered to be a useful and suitable tool for comparison and quantification of different runoff and erosion processes and identification of parameters that are expected to influence them at different plot and event magnitude scales (Stroosnijder, 2005). Barthes and Roose (2002) stated that the results of experiments using rainfall simulator had high similarity with the results of field studies. On grasslands in North America, Mediterranean ecosystems, the relationship between the surface vegetation cover and infiltration rate has been examined by means of field rainfall simulation experiments. Rainfall simulators can successfully estimate soil loss from natural rainfall events with low intensity.

In the field the rainfall simulations, especially the ones on micro plot scale (≤ 1 m^2) are predestined to quantify the following processes: infiltration, runoff generation, detachment, the incipient runoff concentration and the corresponding suspended sediment transport (Seeger and Ries, 2002; Stroosnijder, 2005; Seeger, 2007). This is the reason why rainfall simulations have been used as well for parameterization and calibration of physically based models. Duiker *et al.*, (2000) used a rainfall simulator with 60 mm/h intensity over 0.75 m^2 plots on 30% slopes in southern Spain to evaluate the permeability and erodibility of the soils. The results showed that the amount of soil erosion has high correlation with the amount of silt and very fine sand. Vahabi and Nikkami (2008) showed that within 30 min rainfall, runoff and amount of soil erosion did not show any relation with the organic carbon content. Azmoodeh *et al.* (2010) compared runoff and soil erosion in forest soils and dry farming and garden soils. Results showed that runoff was highest in native forest while the lowest was from garden land. Sediment yield was increased from forest to farming and garden land, respectively. Rabiee *et al.* (2011) used the rainfall simulator to investigate runoff and sediment generation in Hiv watershed. Wildhaber *et al.* (2012) tried to quantify the influence of vegetation and soil structure stability on soil erosion and runoff in a subalpine grassland area by using a portable rainfall simulator (with a 1 m^2 plot). They find that with increasing vegetation, soil structure

stability increases and sediment yield decreases exponentially and vegetation cover of 50% is already sufficient in subalpine terrain to stabilize a 45° slope and to decrease the soil loss through water erosion. Martínez-Murillo *et al.* (2013) studied the hydrological and erosional response of badlands in the Mediterranean environments. Results show that rainfall intensity, runoff coefficient, and slope angle have a positive influence on sediment concentration and sediment detachment but in the case of rock fragment cover, its influence was variable according to the soil cover percentage. Liu *et al.* (2014) to studying the effects and interactions of factors that influence runoff and sediment yield induced by contouring failure, rainfall simulation experiments were conducted, with two micro topography indices (row grade and field slope), two ridge geometry indices (ridge height and ridge width), and two levels of rainfall intensity. The results showed that all of the factors considered except for row grade exerted significant influences on runoff and sediment yield ($p = 0.01$). Rainfall intensity was the most important factor for runoff, with a contribution of 68.1%, followed by ridge height, field slope, and ridge width. The objectives of this study were: (1) To reveal and quantify effects of vegetation types (shrubland and grassland), slopes and aspects on runoff and sediment generation. (2) To recognize the importance soil characteristics that has significant correlation with runoff and sediment generation. (3) To derive the related models for the estimation of runoff and sediment generation in Lashgardar protected area, Hamadan province, and west of Iran. Due to the large impact of vegetation and soil characteristics on hydrological processes and soil loss and influence of topography on vegetation, this study was carried out in work units with cover and topographic variables. As regard, this area is one of the protected areas in the province and its ecosystem is of particular interest and so far no study has been done in the field of erosion and sediment, then evaluation of runoff and soil erosion in this area is necessary to provide management recommendations.

2 MATERIALS AND METHODS

2.1 Study area

The field of study is located in the protected area of Lashgardar in catena mountain of Zagros, Hamadan- Iran. The climate is Mediterranean semiarid-cold and semi humid, which means relatively dry summers and mild snowy and rainy winters; with average annual precipitation of slightly over 320 mm. More than 90% of the annual rainfall falls between December and April. At the time of the experiment, the soil water content was less than field capacity. The dominant vegetation types are: *Stipa parviflora-Bromus tomentelus* and *Astragalus parrowianus-As. gossipinus.* Study areas have been subjected to medium grazing by domestic livestock (Sheep and goats).

Figure 1 Mounted rainfall simulator in the field

2.2 Rainfall simulator

According to this fact that the accurate measurement of soil erosion rates under natural

rainfall conditions is both time consuming and costly; thus rainfall simulator has been used extensively as a cost effective method for soil erosion prediction across a wide range of land-uses including agriculture, forestry and rangelands. Moreover simulators have ability to collect data quickly and the ability to investigate many processes and treatments (Croke *et al.,* 2006; Loch, 2000; Sheridan *et al.,* 2008). Rainfall simulators allow soil loss and runoff to be generated under repeatable conditions (Sharpley and Kleinman, 2003).

The portable non-pressurized rainfall simulator selected for this research was developed, modified, and lightweight based on the design of the Soil Conservation and Watershed Management Research Institute, Iran (Figure 1). The basic unit of the simulator is a Plexiglas container with two plates; had an area of 625 cm^2 (0.25m×0.25m), at the top and bottom connected with a frame of 0.04 m height as shown in Figure 2. The lower raindrop-former plate contains 216 nozzles of 0.5 mm diameter. Water is led from a barrel manually to cylinder of the nozzle. Four adjustable legs, 0.75 m in height, help to mount the system horizontally on various land slopes. Drops form by gravity and atmospheric pressure controlled. The nozzle is designed to distribution of drops as similar as possible to natural rainfall. The around of simulator was covered with a windscreen (plastic sheets) to minimize/avoid influence of wind on the constant intensity of simulated rain. The surface runoff and sediment from the plot was hand-measured using a volumetric cylinder at 1-min intervals then sediment separated from run of by filtering method in the laboratory; following this, the infiltration rate was calculated by subtracting the surface runoff rate from the rainfall intensity of the simulated rain. To minimize the influences of antecedent soil moisture, which may affect the runoff generation and infiltration rate, comparative sets of rainfall simulation experiments, were conducted on the same day. Each small plot used for the rainfall simulation experiments had an area of 625 cm^2 (0.25 m × 0.25 m). Its upslope and lateral boundaries were edged by 15 cm-high metal walls, which were pushed 5 cm into the soil to minimize surface soil disturbance. The gaps between the wall and the soil were filled with fine soil particles to avoid water leakage. At the downside boundary of the plot, a metal flume was inserted laterally 5 cm into the soil to avoid the leakage of inflow and to permit measurement of the surface flow rate from the plot.

2.3 Sampling method

To specify the locations of the plots, slope and vegetation type maps were prepared from a 1:25,000 topography map and field survey respectively. The slope map with two common slope classes of 8-20 (slope < 20%) and 20-40% (slop >20%), vegetation type map with two types (*Stipa parviflora-Bromus tomentellus and Astragalus parrowianus-Astragalus gossypinus*) and aspect map with four aspects (north, east, south and west) were overlaid, resulting in 16 different working polygons (16 sites). In each site three replications were identified; on the other hand we had 48 samples (simulators/plots) at the study area (2slope * 2veg.type * 4aspect * 3rep. = 48 sites). Simulator was established on each site in a systematic-randomized method. All 48 runoffs and sediments produced were collected and measured in the laboratory. In each site five transects (100 m) and five plots (2.5 m^2) at each transect were used sake assessment vegetation factors (Fattahi *et al.,* 2009). Soil samples (composite) at a depth of 0-40 cm were taken from each site near the simulator to investigate

soil properties and they analyzed in laboratory. Soil properties are shown in Table 1 for all sites. At the laboratory soil pH, total phosphorus content (P), total potassium (K), total nitrogen (N), organic matter (OM), electrical conductivity (EC) and texture (clay, silt, sand) were measured in each of the soil samples. Antecedent soil moisture in all plots was measured from the first 20 cm depth by time domain reflectometry before the start of each experiment.

2.4 Data acquisition and Statistical analysis

Rainfall data from Malayer synoptic meteorological station at the distance 5km of the study area were collected to study rainfall intensities. Based on intensity duration–frequency (IDF) curves; rainfall intensity for 25 year return period were estimated (data provided by the meteorology organization of Hamedan – Iran). One rainfall intensity 96±3 mm/h and having 10 min duration is the most frequent rainfall in the area that produced by the rainfall simulator (according to the natural rainfall intensity of the study area).

To compare mean of runoff and sediment and initial time among unites analysis variance one way and homogeneity Duncan test was used. Relationship between dependent (runoff and sediment) with independent variables (soil and topographical factors) was investigated by multivariate regression analysis. We used the 'Multi-Regression Enter' method that suitable (Kalantari, 2002) for quantity and explanatory (quality) variables such as runoff and aspect respectively. The correlation matrix and multi-variable regression method were applied to determine the degree and type of correlation between variables.

3 RESULTS

3.1 Specifications of sampling sites

The results of plot specifications mean such as slope, aspect, soil depth, vegetation cover, litter, gravel, bare soil percentage, runoff, sediment, initial time and soil properties have listed in Table 1.

3.2 Runoff

In the study area grassland has more runoff than shrubland (Table 1) and in both of them slope>20% almost has twice more runoff than slope<20%. In grassland at both slope west and east aspect have most and least runoff, respectively; while in shrubland, west and east have most and least runoff, respectively (Table 1 and Figure 2).

3.3 Sediment

Based on Table 1, grassland has more sediment than shrubland and sediment generation at slope > 20% is almost tenfold of slope <20% and in grassland is threefold of shrubland. In grassland, west and east have most and least sediment, respectively; while in shrubland the amount of maximum and minimum of sediment in aspects of two slops are conversely (Figure 3).

Table 1 The measured factors of sampling sites

Vegetation Type	Slope	Aspect	Vegetation cover (%)		Litter (%)	Gravel (%)	Bare soil (%)	Clay (%)	Silt (%)	Sand (%)	EC	pH	Ca	mg	k	P	OM	Run off	Sediment	Initial time
			Shrub	grass																
Shrubland	< 20	North	60	5	10	14	11	20	22	58	0.09	7.86	44	10.5	48	16.8	1.44	100	0.13	5.3
Shrubland	< 20	East	70	10	12	3	5	26	33	41	0.14	7.25	61.25	14.25	45	17.22	1.5	60.25	0.024	5.06
Shrubland	< 20	South	55	13	5	12	15	22	38	40	0.09	7.60	58	12.02	44.46	17.01	1.34	93	0.03	4.57
Shrubland	< 20	West	30	12	8	38	12	22	26	54	0.09	7.51	24.83	10	40.17	18.62	0.78	77	0.028	4.05
Average			**53.75**	**10**	**8.75**	**16.75**	**10.75**	**22.5**	**29.75**	**48.25**	**0.10**	**7.55**	**47.02**	**11.70**	**44.41**	**17.41**	**1.27**	82.56	0.043	**4.75**
Shrubland	> 20	North	58	4	8	20	10	15	19	66	0.12	7.41	60.75	6.5	37.75	16.8	1.30	181	0.69	3.45
Shrubland	> 20	East	62	5	10	18	5	32	28	40	0.13	7.75	46	7.5	98.5	25.62	1.57	120	0.012	4.45
Shrubland	> 20	South	35	12	10	35	8	23	29	48	0.13	7.09	52.5	11.75	29.75	17.85	1.26	117	0.104	4.45
Shrubland	> 20	West	30	10	10	35	15	30	44	26	0.07	7.70	26.5	5.5	24	17.64	1.08	116	0.22	4.08
Average			**46.25**	**7.75**	**9.50**	**27.00**	**9.50**	**25.00**	**30.00**	**45.00**	**0.11**	**7.49**	**46.44**	**7.81**	**47.50**	**19.48**	**1.30**	129	0.26	**4.11**
Grassland	< 20	North	-	62	12	16	10	22	22	56	0.07	7.02	23.75	9.25	22	26.88	1.44	70	0.05	4.45
Grassland	< 20	East	-	75	10	10	5	34	17	46	0.11	7.90	75	21.18	56	47	1.7	60.5	0.02	4.8
Grassland	< 20	South	-	67	6	13	14	32	33	35	0.11	7.81	50	8	44.25	37.17	1.65	68	0.1	4.3
Grassland	< 20	West	-	58	10	20	12	34	19	44	0.10	7.86	68.6	19.2	56.5	44.04	1.19	92	0.115	4
Average			**-**	**65.50**	**9.50**	**14.75**	**10.25**	**30.50**	**22.75**	**45.25**	**0.10**	**7.65**	**54.34**	**14.41**	**44.69**	**38.77**	**1.50**	72.63	0.07	**4.39**
Grassland	> 20	North	5	60	5	15	15	24	30	44	0.08	7.90	59	21	35.3	8.82	1.47	151	0.98	3
Grassland	> 20	East	6	65	4	8	17	38	33	28	0.11	7.70	76	7.5	26.5	23	1.6	94	0.14	3.04
Grassland	> 20	South	-	63	5	16	16	27	33	40	0.09	7.67	59.6	19.75	31.75	21.63	1.1	198	1.01	2.45
Grassland	> 20	West	3	57	5	20	15	22	34	26	0.09	7.70	31	9.02	28.2	8.08	0.98	202	1.151	2.3
Average			**3.50**	**61.25**	**4.75**	**14.75**	**15.75**	**27.75**	**32.50**	**34.50**	**0.09**	**7.74**	**56.40**	**14.32**	**30.44**	**15.38**	**1.29**	161.25	1.07	**2.70**

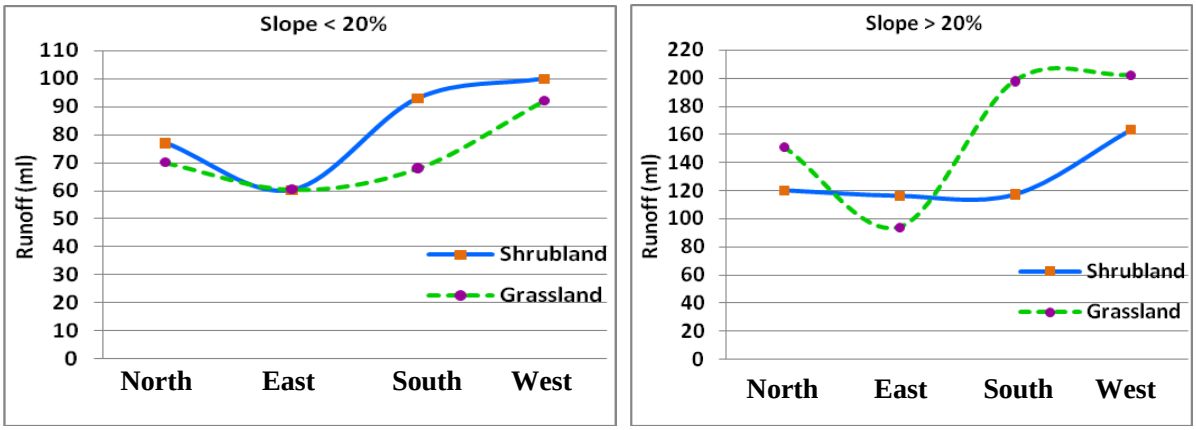

Figure 2 Runoff production at study slopes

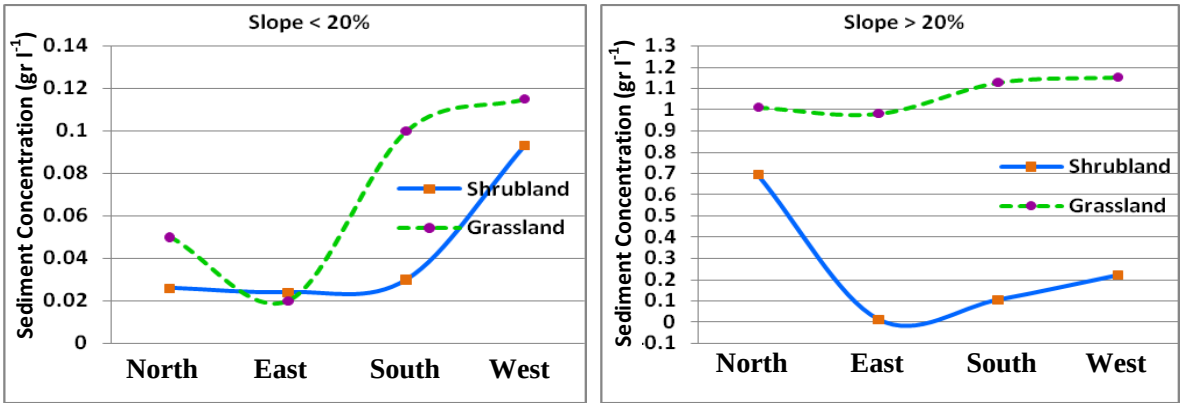

Figure 3 The sediment generation at study slopes

3.4 Initial time of runoff

Initial time at slope > 20 is less than slope < 20% and also in grassland is less than shrubland. In both vegetation types (grassland and shrubland) at slopes, west and east aspect has least and most initial time, respectively. In both of vegetation type initial time at slope < 20% is less than slope > 20%, especially in grassland (Table 1 and Figure 4).

3.5 Correlation of runoff and sediment generation with soil characteristics

The results of linear correlation between soil characteristics with runoff and sediment generation using coefficient of correlation (R) have shown in Table 2 and 3. The rainfall intensity was 96±3 mm/h. At this intensity the efficient variables are vegetation cover, EC, OM, P, clay content and slope. Based on Figure 4 at slop > 20% the initial time of runoff at grassland is less than shrubland and effect of aspect on runoff in both of vegetation type is same. The initial time of runoff at slop>20% is less than slope < 20%.

According Tables 2 and 3, some soil factors have more drastic and significant correlation with runoff and sediment. Fitted model for runoff and sediment for grassland and shrub land with significant level has shown in Table 4.

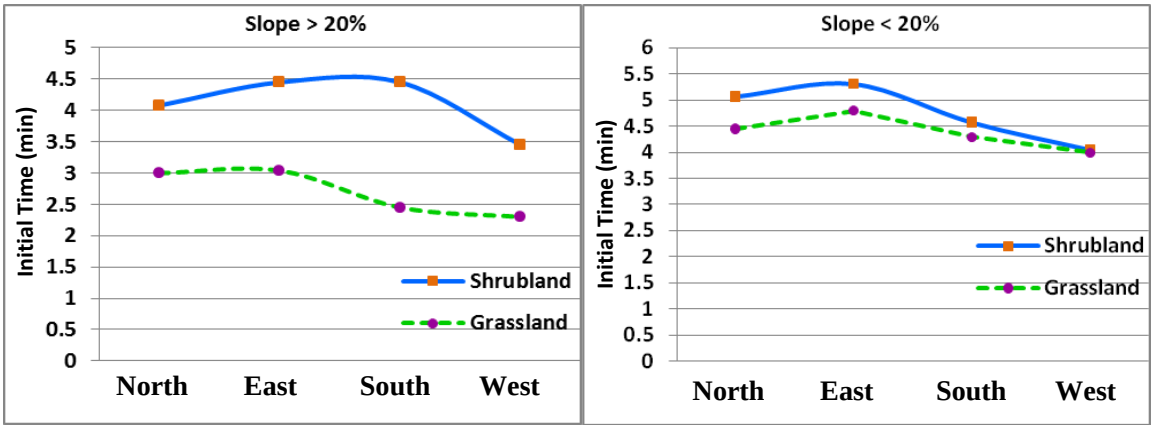

Figure 4 Initial time of runoff at both slopes

Table 2 Linear coefficient correlation between soil chemical characteristics and runoff

Dependent variables / Vegetation type	pH	EC	OM	P	K	Mg	Ca	Clay	Silt	Sand
Grassland	0.35	-0.57**	-0.78**	-0.64**	-0.40	0.05	-0.66**	-0.54**	0.53*	0.49
Shrub land	0.61*	-0.73**	-0.82**	0.38	-0.62**	-0.64**	-0.59**	-0.60*	0.215	0.25

** Significant correlation at confidence 99% * Significant correlation at confidence 95%

Table 3 Linear coefficient correlation between soil characteristics and sediment

Dependent variables / Vegetation type	pH	EC	OM	P	K	Mg	Ca	Clay	Silt	Sand
Grassland	0.48	0.20	-0.78**	-0.66**	0.56**	-0.34	-0.59**	-0.65**	0.37	-0.52*
Shrub land	0.33	-0.73**	-0.81**	-0.32	-0.47*	-0.50*	-0.62**	-0.65**	-0.38	0.27

** Significant correlation at confidence 99% * Significant correlation at confidence 95%

Table 4 Fitted models for runoff and sediment

Vegetation type	Variable	Fitted model	Sig.	r
Grassland	**Runoff**	$Qw = 256.83 - (39.28OM) - (0.25Ca) - (0.22P) - (97.08EC) - (0.70Cly)$	0.99	0.73
	Sediment	$Qs = 0.845 - (0.112OM) - (0.002P) - (0.0014Ca) + (0.0013K) - (0.002Cly)$	0.99	0.90
Shrub land	**Runoff**	$Qw = 235.9 - (32.65OM) - (241.5EC) - (1.25Mg) - (0.24K) - (0.0.3Ca) - (0.44Cly)$	0.99	0.93
	Sediment	$Qs = 0.568 - (0.093OM) - (0.64EC) - (0.002Cly) - (0.0008Ca)$	0.99	0.85

Here, Qw and Qs are the amount of runoff (ml/plot) and sediment yield (g/plot), pH is the potential of Hydrogen, Ec is electrical conductivity, P is the phosphorus, Ca is the calcium, OM is the organic matter, Mg is the magnesium and cly is amount of clay in soil samples. The runoff and sediment equations in grassland and shrubland with high determination coefficient of 0.73, 0.90, 0.93 and 0.85 ($p<0.01$) are appropriate models for predicting runoff and sediment generation in grassland and shrubland. In these models, R indicates that percentage of the observed dissipation in dependent variables (runoff and sediment) can be justified by the independent variables and the coefficients of correlation (Tables 2 and 3) indicate the model's high predictive capability.

4 DISSCUTION

Soil erosion is a complex and multifaceted process which involves a host of factors and conditions with combinations, variations, and interactions that substantially affect the observed soil loss (Leia *et al.,* 2006; Assouline and Ben-Hur, 2006). Prediction of soil erosion is largely based on models derived from measurements of soil loss from natural runoff or rain simulators (Gray *et al.,* 2008). Always vegetation cover has played a key role in protecting surface from erosion (Pizarro *et al.,* 2006; Wei *et al.,* 2007). Vegetation cover is the best environmental factor for decrease in runoff and sediment. (Kato *et al.,* 2009; and Mills and Fey, 2004). It is related to the above and underground organs of plants. Vegetation cover decreases kinetic energy of rainfall, improves the soil structure, create macro and micro pores, increase the infiltration rate and consequently decreases runoff and sediment.

The results of this study show that soil erosion has negatively linearly correlated with vegetation cover. Other researchers have confirmed this result (Zhou *et al.,* 2006; Gyssels *et al.,* 2005 and Wei *et al.,* 2007 have reported this as well). Based on Table 1 and Figure 2, 3 and 4, however in generally grassland has more vegetation cover percentage than shrubland but has more runoff and sediment significantly, whereas initial time of runoff in grassland is less than shrubland; on the other words, the observations of this study indicate that vegetation type strongly influences runoff and sediment generation. The important reasons for decreasing runoff and sediment in shrubland rather than grassland in the study area are:

1) The shrubs are *As. Parrowianus* and *As. gossypinus*. They have dense canopy cover and proper root distribution system. Water infiltration under this shrub canopy will depending on the above factors, which affect the through fall distributions and the depth to which stem flow infiltrates via root channels (Fattahi and *et al.,* 2009).

2) The litter in shrubland is more than grassland. Litter directly protects the surface soil from splash erosion, rather weakens the kinetic energy of raindrop and slows runoff velocities. Also litter conserves surface rainwater due to its strong moisture holding capacity because of its contribution in humus formation and consequently decreasing runoff and sediment generation. Also Marques *et al.,* 2007; Assouline and Ben-Hur, 2006 and Wei *et al.,* 2007 have reported as well. In generally litter production and organic matter accumulation could reduce soil-water loss.

3) The gravel percentage in shrubland is more significantly than grassland (Table 1). In shrubland at slope < 20% south aspect has almost twice more shrub vegetation than west aspect, nevertheless haven't significant different in runoff generation and also about east and south aspect at slope > 20%. These processes have accordance with result of Croke

et al., 2006 and Loch, 2000. Gravel and stone increase the infiltration rate to some extent by protecting the bare soil surface from raindrop impact and by damming surface flow. Gravels with the rough surface condition can trap the part of the volume of runoff that gradually infiltrate to the soil. Consequently decrease runoff and sediment generation. Thus, not only the vegetation cover but also the gravel and stone cover should be considered as factors that influence infiltration, runoff and sediment. As for similarity of climate, geology, land use and management system in the study area, the some of reasons for these results related to soil vegetation properties and their reciprocal effects vegetation. Coefficients of correlation of all soil variables (except of pH, silt and sand content) were negative, which indicates inverse effect on the runoff and sediment (Vahabi and Nikkami 2009). In both grassland and shrubland, some of soil characteristics such as OM, Ec, P, Ca, Mg (just for shrubland) and Clay have significant negative correlation with runoff generation (Table 3); i.e. increase of these factors decrease the mount of runoff and sediment and between them OM has the most correlation. This result has repugnance with results of Duiker *et al.*, 2000 and Vahabi and Nikkami 2009; because their research had done with longer rainfall duration than this study and it will cause the more effect of soil physical properties on runoff and sediment. Effective soil factors on sediment are same factors that have correlation with runoff generation by difference that Ec hasn't significant correlation with grassland and also K as a new factor has correlation with sediment in grassland. Soils under good plant cover conditions may improve by accumulating organic material, enhancing soil aggregate stability, increasing infiltration capacity and decreasing erosion potential (Dunj *et al.*, 2004).

Land slope can Effect on runoff and sediment generation. This is probably due to: 1) effect of slope on initial time and speed of runoff at aspect 2) effect of slope on pedogenesis process, soil physiochemical characteristics, infiltration rate, roughness surface and vegetation cover at small plot scale such as rainfall simulator. The results of this research showed that slope changes have strongly and significantly effect on the runoff and sediment yield (Vahabi and Nikkami 2009). In both vegetation type, slope > 20% has more runoff and sediment than slope < 20% but about initial time of runoff is inversely. At slope < 20% in shrubland the mount of runoff in several aspects very diverse; on the other hand, runoff thoroughly affected by aspects but at grassland these changes are minor. At slope > 20% the changes of runoff in several aspects of grassland is more drastic; whereas at shrubland the effect of aspect on runoff changes is lesser. In both slopes and vegetation types, east and west aspects have the least and most runoff and sediment, respectively barring shrubland at slope > 20%, wherein north has most sediment. Nevertheless runoff and sediment, there is no distinct or regular scheme for initial time. So it seems that initial time is function of more factors than runoff and sediment and it has abstruse procedure and also we can not find distinct or regular scheme for initial time in both slopes and vegetation types. The high values of correlation coefficients for factors (Table 3 and 4) and R for equations (Table 5) indicate their high potential in simulating runoff and sediment generation by rainfall simulator. As shown in results, all of models are linear and also various factors have used in models. The models have exhibit only by soil factors, which have high significantly level (99%) and they anticipate runoff and sediment high confidence (Table 5; R values). Also these results indicated that rainfall simulator is a useful and suitable

option for estimating runoff and sediment generation in plot-scale and its status is very similar with field conditions. Other researchers such as Sharpley and Kleinman, 2003; Seeger and Ries, 2002; Stroosnijder, 2005; Barthes and Roose, 2002; have also drawn similar conclusions.

5 CONCLUSION

Results indicate that shrubland has less runoff ad sediment than grassland, which is due to dens canopy cover, root activities, soil characteristics and these factors affected by aspect and slope of landscape.

In this research, vegetation cover was recognized as the most efficient factors determining sediment yield. Vegetation plays a significant role in the soil porosity and accumulation of fine particles and protecting soil surface from erosion. The results showed that vegetation cover is the most dominant factor determining runoff and sediment and it affect the soil properties affect the runoff and sediment. Based on correlation coefficient and equations rainfall simulations on a small plot are valuable for giving a clear view on the processes occurring on the site.

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7 REFERENCES

Assouline S. and Ben-Hur, M. Effects of rainfall intensity and slope gradient on the dynamics of interrill erosion during soil surface sealing. Catena. 2006; 66: 211-220.

Azmoodh, A., Kavyan, A., Solaimani, K. and Vahab Zadeh, Gh. Comparing run off and soil erosion in forest, dry farming and garden land uses soils using rainfall simulator. J. Soil, 2010; 24(3): 490-500.

Barthes B. and Roose E. Aggregate stability as an indicator of soil susceptibility to runoff and erosion; Validation at several levels. Catena. 2002; 47: 133-149.

Casermeiro, M.A. and Molina, J.A. De la Cruz Caravaca, M.T., Hernando Massanet, M.I. and Moreno, P.S. Influence of scrubs on runoff and sediment loss in soils of Mediterranean climate. Catena. 2003; 57: 91-107.

Croke, J., Mockler, S., Hairsine, P. and Fogarty, P. Relative contributions of runoff and sediment from sources within a road prism and implications for total sediment delivery. Earth Surf. Proc. Land., 2006; 31 (4): 452-468.

Duiker, S.W., Flangman, D.C. and Lal, R. Erodibility and infiltration characteristics of five major soils of south-west Spain. Catena. 2000; 45(2): 103-121.

Dunj, G., Pardini, G. and Gispert, M. The role of land use–land cover on runoff generation and sediment yield at a microplot scale, in a small Mediterranean catchment. J. Arid Environ. 2004; 57: 99-116.

Fattahi, B., Aghabegi Amin, S., Ildoromi, A., Maleki, M., Hasani J. and Sabetpour T. Investigation of some environmental factors effective on Astragalus gossypinus in Zagros mountainous rangelands. J. Rangeland. 2009; 3: 216-230.

Fattahi, B., Maleki, M. and Asadian Gh. Identifying ecological characteristics on habitat of "*Astragalus parrowianus*" and

"*Astragalus gossipinus*". Malayer University, Malayer-Iran. 2009; 82 P.

Gyssels, G., Poesen, J., Bochet, E. and Li, Y. Impact of plant roots on the resistance of soils to erosion by water: a review. Prog. Phys. Geog. 2005; 29 (2): 189-217.

Kalantari, K. Data processing and analysis in socio-economic research. Sharif Publication, Tehran-Iran. 2002; 388 P.

Kato, H., Onda, Y., Tanaka, Y. and Asano, M. Field measurement of infiltration rate using an oscillating nozzle rainfall simulator in the cold, semiarid grassland of Mongolia. Catena 2009; 76: 173-181.

Leia, T., Panc, Y., Liua, H., Zhand, W. and Yuand, J. A run off-on-ponding method and models for the transient infiltration capability process of sloped soil surface under rainfall and erosion impacts. J Hydrol. 2006; 319: 216-226.

Liu, Q.J., Shi, Z.H., Yu, X.X. and Zhang, H.Y. Influence of micro topography, ridge geometry and rainfall intensity on soil erosion induced by contouring failure. Soil Till. Res. 2014; 136: 1-8.

Loch, R.J. Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu Mine, Tarong, Queensland. Aust. J. Soil Res. 2000b; 38: 299-312.

Mao, R., Meng, G. and Zhou, Y. Mechanism of plant roots on soil erosion control. Research of Soil and Water Conservation, 2006; 13(2): 241-243 (in Chinese with English abstract).

Marques, M.J., Bienes, R., Jiménez, L. and Pérez-Rodríguez, R. Effect of vegetal cover on runoff and soil erosion under light intensity events, Rainfall simulation over USLE plots. Sci. Total Environ. 2007; 378: 161-165.

Martinez-Murillo, J.F., Nadal-Romero, E., Regüés, D., Cerdà, A. and Poesen, J. Soil erosion and hydrology of the western Mediterranean badlands throughout rainfall simulation experiments. Catena, 2013; 106: 101-112.

Mills, A.J. and Fey, M.V. Effects of vegetation cover on the tendency of soil to crust in South Africa. Soil Use Manage. 2004; 20: 308-317.

Pizarro, R., Araya, S., Jorda´n, C., Farı´as, C., Flores, J.P. and Bro, P.B. The effects of changes in vegetative cover on river flows in the Purapel river basin of central Chile. J. Hydrol. 2006; 327: 249-257.

Rabiee, M.R., Feiznia, S. and Peyrowan, H.R. Study runoff and soil Lose in map units of Hiv watershed, measurements and comparision at the rainfall simulator scale. Geosciences, 2011; 20(80): 57-62.

Seeger M. Uncertainty of factors determining runoff and erosion processes as quantified by rainfall simulations. Catena. 2007; 71: 56-67.

Seeger, M. and Ries, J.B. Runoff generation on abandoned fields in the Central EbroBasin-results from modeling. Environmental Change and Water Sustainability. Institute Pirenaico de Ecología, CSIC and Zaragoza. 2002; 83-97.

Sharpley A. and Kleinman P. Effect of rainfall simulator and plot scale on overland flow and phosphorus transport. J. Environ. Health. 2003; 32: 2172-2179.

Sheridan, G.J., Noske P.J., Lane, P.N.J. and Sherwin Ch.B. Using rainfall simulation and site measurements to predict annual

interrill erodibility and phosphorus generation rates from unsealed forest roads: Validation against in-situ erosion measurements. Catena.2008; 73: 49-62.

Stroosnijder, L. Measurement of erosion: is it possible? Catena. 2005; 64: 162-173.

Vahabi, J. and Nikkami D. Assessing dominant factors affecting soil erosion using a portable rainfall simulator. Int. J. Sediment Res., 2008; 23: 376-386.

Wei, W., Chen, L., Fu, B., Huang, Z., Wu, D. and Gui L. The effect of land uses and rainfall regimes on runoff and soil erosion in the semi-arid loess hilly area, China. J. Hydrol. 2007; 335: 247-258.

Wildhaber, Y.S., Bänninger, D., Burri, K. and Alewell, Ch. Evaluation and application of a portable rainfall simulator on subalpine grassland. Catena, 2012; 91:56-62.

Yasser, H., Albergel, J., Pe´pin, Y., Asselin, J., Nasri, S., Zante, P. and Berndtsson, R. Comparison between rainfall simulator erosion and observed reservoir sedimentation in an erosion-sensitive semiarid catchment. Catena. 2002; 50: 1-16.

Zhou, Z., Shangguan, Z. and Zhao, D. Modeling vegetation coverage and soil erosion in the Loess Plateau Area of China. Ecol. Model., 2006; 198: 263-268.

اندازه‌گیری رسوب و رواناب در تیپ‌های مختلف مرتعی با استفاده از شبیه‌ساز باران

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چکیده فرسایش خاک یک پدیده پیچیده است که شامل جدا شدن و انتقال ذرات خاک توسط رواناب ناشی از بارندگی می‌باشد. در این مطالعه تولید رواناب و رسوب در دو تیپ گیاهی علف‌زار و بوته زار با استفاده از شبیه ساز باران مورد مقایسه قرار گرفت. برای تعیین واحدهای کاری پوشش‌گیاهی منطقه به دو تیپ گیاهی و هر تیپ به چهار جهت اصلی و دو کلاس شیب (۱۲-۲۰ درصد و ۲۰-۴۰ درصد) تقسیم بندی گردید. اندازه‌گیری رواناب و رسوب در هر واحد کاری و با سه بار تکرار انجام شد. نقاط اندازه‌گیری به صورت تصادفی مشخص گردیدند. شدت بارندگی ۱/۶ میلی متر بر دقیقه با تداوم ۱۰ دقیقه برای تولید رواناب و رسوب به کار گرفته شد. نمونه‌های خاک از عمق (۰-۴۰ سانتی‌متر) جمع آوری و پارامترهای اسیدیته، مواد آلی، هدایت الکتریکی، فسفر، پتاسیم، کلسیم، منیزیم و بافت در آزمایشگاه اندازه‌گیری گردیدند. نتایج آزمون دانکن و رگرسیون چند متغیره نشان داد که تیپ گیاهی علف‌زار رواناب و رسوب بیشتری نسبت به بوته زار تولید می‌کند، اما زمان شروع رواناب در علف‌زار کمتر از بوته زار است. همچنین جهت جغرافیایی، شیب و پارامترها هدایت الکتریکی، کلسیم، رس و فسفر تاثیر معنی‌داری بر رواناب، رسوب و زمان شروع رواناب داشتند. این پارامترها دارای یک رابطه خطی با رواناب و رسوب بودند.

کلمات کلیدی: تیپ گیاهی، رواناب، شبیه ساز باران، مرتع