JOURNAL OF THE FACULTY OF FORESTRY ISTANBUL UNIVERSITY
İSTANBUL ÜNİVERSİTESİ ORMAN FAKÜLTESİ DERGİSİ
ISSN: 0535-8418 e-ISSN: 1309-6257
Online available at / Çevrimiçi erişim
http://dergipark.ulakbim.gov.tr/jffiu - http://dx.doi.org/10.17099/jffiu.95610
Research Article / Araştırma Makalesi

Sediment-bound soil nutrient loss under simulated rainfall

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Received (Geliş): 08.04.2016 - **Revised (Düzeltme):** 24.05.2016 - **Accepted (Kabul):** 06.06.2016

Abstract: Soil erosion is not only the loss of soil particles, but also the loss of sediment-bounded nutrients and elements. One the principle methods of the assessment of soil erosion and nutrient loss, is to use rainfall simulators. The aim of this study was to evaluate the role of land-use, slope gradient and direction on the loss of soil nutrients in Kechik Coupled Watershed Site in Golestan Province using rainfall simulation. In order to determine the sediment's content of potassium, nitrogen and phosphorous, flame photometry, Kjedalhl and spectrophotometry methods were used. To estimate organic carbon, the Walkey-Black method was exercised. Given the results, the highest obtained values of nitrogen loss was attributed to the agricultural land-use. This follows rangeland and forest; although, with a slight difference. Potassium loss was greatest in the rangelands by 0.15 t.ha-1, and agriculture and forest ranked second and third. Soil nutrient loss in terms of phosphorus, was maximum in the forest land-use and then respectively, agriculture and rangelands. Soil organic carbon loss was maximally measured in the forest, rangeland and agriculture, respectively. In this study, two slope classes of 0-20 and 20-40 was considered in the forest and rangeland land-uses, while the classification of slope gradient in agricultural land-use was in different two classes of 0-15 and 15-30. According the findings, soil nitrogen, phosphorus and organic matter loss was highest in case of the second slope gradient class (20-40% in rangelands and agricultural fields; 20-40 % in forest land-uses) of all land-uses and aspects. Interestingly, soil potassium loss was greatest in the first slope class. Northern slope directions had the highest soil nutrient loss compared with the southern direction in all land-use types. The findings of this study put emphasis on the land-use management and primarily underlines the role of agricultural land-uses.

Keywords: Nutrient loss, land-use, kechik, erosion, BSTF1, Golestan

Yağış simülasyonu modeli kullanarak toprak ve besin maddesi kayıplarının hesaplanması

Özet: Toprak erozyonu sadece toprak parçacıkları kaybı değil, aynı zamanda besin ve elementlerin de kaybıdır. Toprak erozyonu ve besin kaybını ölçmek için yağış simülatörleri kullanmaktır. Bu çalışmanın amacı, arazi kullanımı ve eğim parametrelerini kullanarak Gülistan Eyaleti- Kechik su havzasında yağış simülasyonu modeli kullanarak toprak ve besin kaybını hesaplamaktır. Sedimentlerdeki potasyum, azot ve fosfor içeriğini belirlemek için, Kjedalhl ve spektrofotometri yöntemleri kullanılmıştır. Organik karbon tahmini için ise Walkey-Black Metodu kullanılmıştır. Sonuçlar göz önüne alındığında, azot kaybının en yüksek olduğu alanlar tarımsal arazilerdir. Bunu; küçük bir fark ile meralar ve orman izlemektedir. Potasyum kaybı 0.15 t.ha-1 ile en fazla meralarda görülmüş, tarım ve orman alanları ise ikinci ve üçüncü sırada yer almıştır. Fosfor yönünden toprak besin kaybı, sırasıyla, tarım ve meralar daha sonra orman arazisi kullanımında maksimum olarak ölçülmüştür. Bu çalışmada, orman ve mera arazi kullanımlarında kullanılan eğim sınıfları 0-20 ve 20-40 olarak; tarımsal arazi kullanımında ise 0-15 ve 15-30 olarak kabul edilmiştir. Bulgular, topraktaki azot, fosfor ve organik madde kaybının ikinci eğim sınıfında en yüksek olduğunu göstermiştir. Bu çalışmanın bulguları başta arazi kullanım yönetimine vurgu yapmakta; tarımsal arazi kullanımlarının etkisini ele almaktadır.

Anahtar Kelimeler: Besin kaybı, arazi kullanımı, Kechik, Erozyon, BTF1, Gülistan

To cite this article (Atıf): Sheikh, V.B., Shalamzari, M.J., Farajollahi, A., 2017. Sediment-bound soil nutrient loss under simulated rainfall. *Journal of the Faculty of Forestry Istanbul University* 67(1): 37-48. DOI: 10.17099/jffiu.95610

1.INTRODUCTION

On a global scale, major causes of anthropogenic soil degradation and erosion are believed to be overgrazing, deforestation, improper management of agricultural land, harvesting firewood and urban land development. All of these causes could be considered as subsets of poor land management and imprudent land use changes (Braimoh and Vlek 2008). Soil erosion not only means loss of soil particles, but also loss of soil nutrients.

On one hand, soil erosion results in local problems such as less crop yield, increased cost of agricultural inputs, sparse vegetation and biodiversity (Owens and Collins 2006). On the other, by leaving poor soil on the other hand, it will lead to other problems like filling dams, blocked drainage and water transport channels, destruction of infrastructures, reducing water quality and higher cost of treatment, nutrition-oriented phenomenon (eutrophication) and damage and destruction of aquatic ecosystems (Blanco-Canqui and Lal 2008). Soil erosion and loss of its nutrient sources can be great financial burdens for governments and nations. Risks of soil erosion to food security are severe in developing countries because of their inappropriate agricultural practices, and low adaptive capacity to restore degraded soils and replace depleted nutrients. These risks may be exacerbated by the projected climate change in the arid and semi-arid regions of the developing countries (Lal et al. 2014).

Soil erosion includes the processes of detachment of soil particles from the soil mass and subsequent transport and deposition of those sediment particles on land surfaces. Erosion is the source of 99% of the total suspended solid loads in waterways around the world. Sediment is also an important vehicle for the transport of soil-bound chemical contaminants from nonpoint source areas to waterways. According the USDA, soil erosion is the source of 80% of the total phosphorous and 73% of the total Kjeldahl nitrogen in the waterways of the US, and worldwide. Sediment also carries agricultural pesticides. Solution to nonpoint source pollution problems invariably must address the problems of erosion and sediment control (Ritter and Shirmohammadi 2000).

Agriculture accounts for about three quarters of sedimentation globally. About 80% of agricultural lands are plagued by moderate-to-severe erosion (Hester and Harrison 2012). Soil erosion is often accelerated by agricultural activities. As sediment acts both as pollution factor and pollution carrier. Soil loss can be considered a nonpoint pollution process (Giorgini and Zingales 2013). During recent decades, the runaway horse of land-use conversion in Iran into, in most cases, non-productive agricultural fields, has resulted in severe soil erosion and has turned this country to one of the pioneers of soil loss worldwide.
The first step in managing or reducing soil erosion, is being aware of its magnitude and distribution. The main method used in the quantification of erosion are experimental approaches and models that estimate erosion at different scales. In Iran, several models have been used for estimating soil erosion in Iran, although these methods have not been developed and calibrated for the condition of this country. However, most countries of the world, in the broad field of land management, are trying to get hand on suitable approach of soil erosion assessment. Among different techniques invented for soil erosion, it seems rainfall simulators might have produced the closest condition to the field.

Rainfall simulators are research tools designed to apply water in a form similar to natural rainstorms. They are useful for many types of soil erosion and hydrological experiments. However, rainstorm characteristics must be simulated properly, runoff-erosion data analyzed carefully, and results interpreted judiciously to obtain reliable information for the conditions to which simulated rainstorms are applied. The major advantages of rainfall-simulator research are fourth-fold: it is more rapid, more efficient, more controlled, and more adaptable than natural rainfall research. Researchers can measure hydrological or soil erosion characteristics of newly developed cropping and management practices in a relatively short time. Simulate storms can be applied for selected durations on selected treatment conditions, and measurement from a few such storms often can indicate conclusively at least relative differences for those treatment (Society and Lal 1994).

Given the importance of land use and factors influencing soil erosion and sediment-associated nutrient loss, erosion rate in each land use was determined by means of a rain simulator designed in Gorgan University of Agricultural Research and Natural Resources, entitles as BSTF1. In this study, two important factors influencing soil erosion and nutrient loss, i.e. slope and aspect, were considered in each land use so that by achieving accurate level of erosion and nutrient loss based on ground truth. It was hypothesized that soil nutrient loss would significantly different in different land-uses. Likewise, this study has been conducted on the presumption that slope classes and slope directions would significantly alter runoff, and thus soil nutrient loss.

2. MATERIAL AND METHOD

2.1 Study Area

Kechik watershed, in Golestan Province, Iran, encloses an area of about 3600 ha. This small watershed is one of sub-sections of *Qarnaveh* watershed. The latter watershed itself, from the administrative classification perspective, belongs to *Maraveh Tappeh* district, *Kalaleh* County, in the farthest end of Golestan province. The watershed lies between 55° 52’ 10’’ to 55° 57’ 10’’ eastern longitude and 37° 42’ 15’’ to 37° 46’ 15’’ northern latitude. Location of the study area can be found in Figure 1.

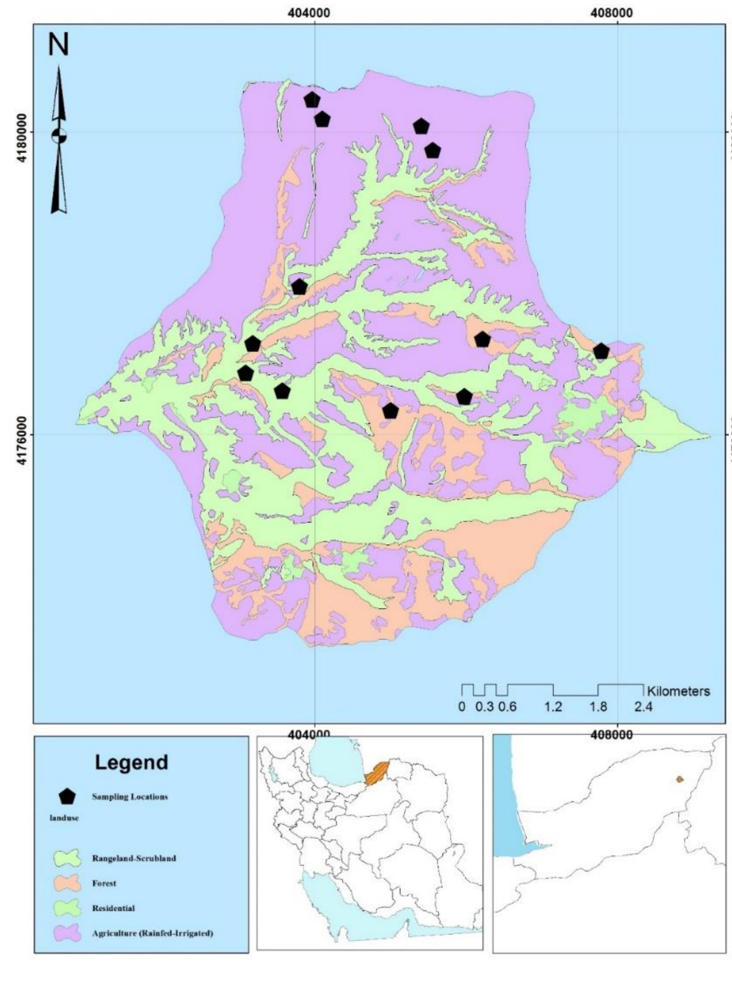

Figure 1. Location of the study area
Şekil 1. Çalışma alanı konumu

The Kechik watershed is characterized by a very nutrient-rich soil which is undergoing heavy agricultural activities in recent decades. Based on direct observations and conversations with locals, it became clear that the major crops, in autumn and spring cultures are wheat and rapeseed, while during the summer to take advantage of the seasonal rainfall, crops such as melons and watermelons are sown. Almost all fertile lands are plowed for cropping and this has shrunk forests only to small patches in higher slopes where it is not possible for agricultural machineries to prepare the ground. Other patches of forest are found in the conservation areas. In some areas, pines woodlands are found which are the remnant of the past afforestation project. Rangelands are mostly found on steep and impassable slopes overlooking the valleys. **Hata! Başvuru kaynağı bulunamadı.** illustrate the land-uses in the Kechik Watershed.

2.1 Landuse map

Landsat images were used to extract land-use map of the area. This study applied supervised classification-maximum likelihood algorithm in ENVI to detect land use, using multispectral satellite data obtained from Landsat 7 for the years 1986, 2010 and 2011 respectively. The watershed was classified into four major land cover/use classes namely Agriculture, rangeland, residential areas, and forest lands. Resultant land cover/land use and overlay maps generated in ArcGIS 10. Digital elevation map, with the resolution of 30m, was also acquired from the ASTER GDEM NASA website.

2.2 Sampling Positions

Sampling was conducted in random positions in three land-uses viz. agriculture, forest and rangeland. Two slope classes was considered namely 0-15 and 15-30. However, as forest areas has diminished above 20% slope gradient, this classification was adjusted in this case to the 0-20 and 20-40, in which 20-40% slope occurred to include forest patches. Two slope directions were evaluated. Southern look including the eastern and northern aspects and Northern look including southern and western slope directions were also taken into account. An overview of the slope and aspect map could be found in Figure 1.

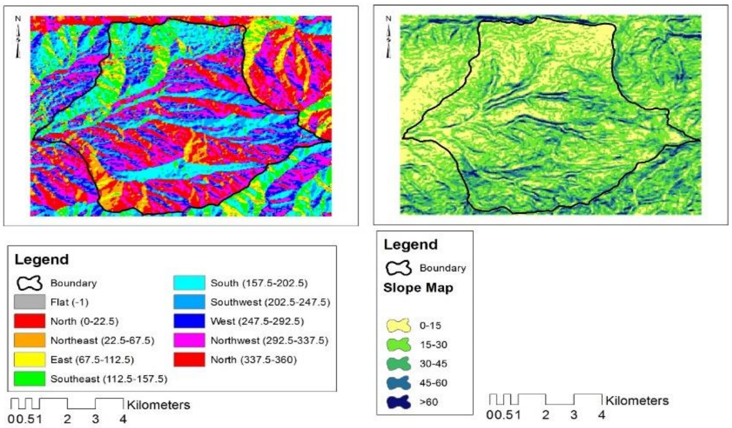

Figure 1. Slope Direction Map of the area (left). Slope Gradient Map (in percentage) (Right)
Şekil 2. Bakı haritası (solda), Eğim haritası (sağda)

2.3 Rain Simulator

In view of the importance of rainfall simulators for the assessment of rainfall-runoff, and thus erosion, processes and their influential factors, and given that no similar and suitable device is being produced in the country, it was attempted to design and construct a field-based portable rainfall simulator. This device, being manufactured under the name of BSTF1, has the following characteristics. It has the capability of simulating rainfall over a plot of 2 x 1 m. from a huge variety of commercially-available spraying nozzles, Vjet80100 has been used which is normally applied in most of the similar versions designed elsewhere. In order to reach a suitable raindrop diameter, a height of fall of about 2.2 m was considered to reach terminal velocity similar to natural condition. For the sake of simplicity to carry and establish the device in under the field condition, it has been highly attempted to use light-weight and detachable parts. In the design and construction of the devices, beside increasing reliability, it was attempted to minimize cost, size, weight, time, manpower required to install and use, the loss of water and electrical energy required. A schematic view of the device is provided in Figure 2.

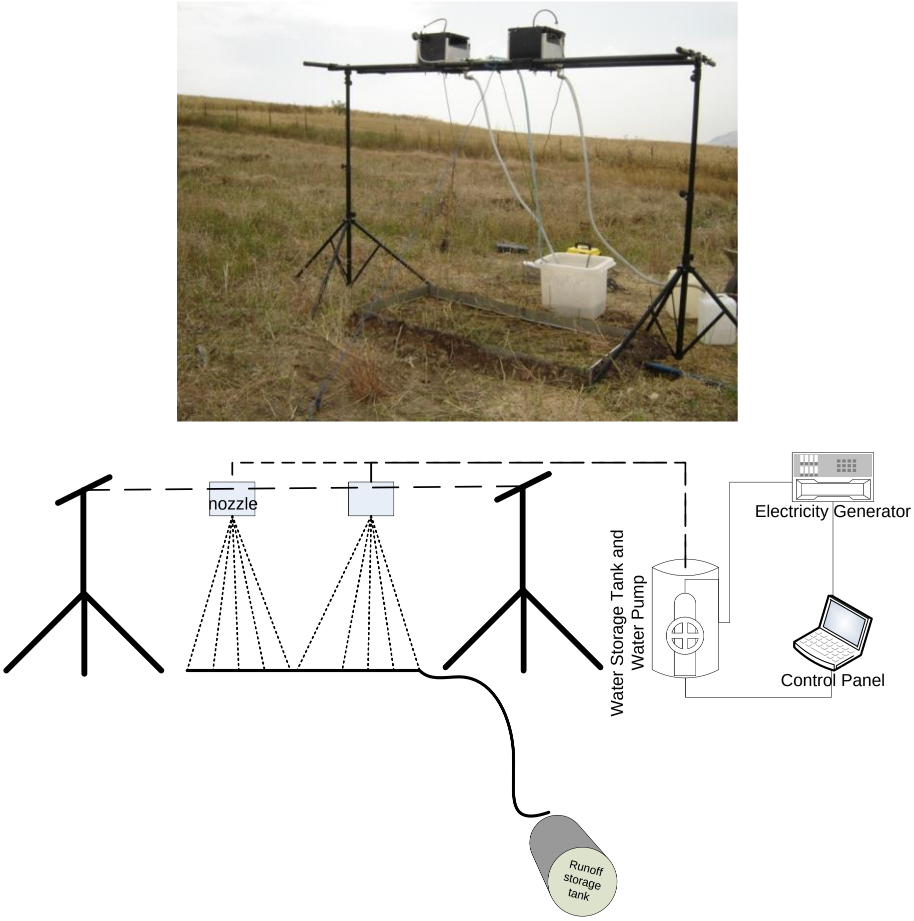

Figure 2. Schematic view of the BSTF1. Above, the actual device established in the lab and below, the general structure of the BSTF1
Şekil 3. BSTF1’in şematik görünümü

2.3 Sampling Procedure

Historical rainfall distribution series for the region allowed for the selection of the high-frequency simulated rainfall event with an intensity of 80 mm h^{-1} and a 30-min duration. Thus, a rain simulator under controlled conditions was set up in order to produce fast, reliable, efficient, replicable and cost-effective data for soil studies. Data series were generated by applying a fully randomized design with two (2) repetitions per land-use, per slope gradient, per slope direction. Thus, a total of 24 sampling journeys were carried out in a 3-month period (running from June 2015 to September 2015) on rectangular experimental plots (2 m × 1 m). Other co-variables such as near-saturated infiltration, vegetation density, initial moisture, soil texture, surface gravel percentage and etc. were also recorded for each plot. In terms of runoff simulation, total runoff volume and instant runoff were recorded by means of a graded cylinder and a stopwatch. Collected runoff was then thoroughly mixed, and two bottles with 1.5 liter volume were filled from the mixed runoff. It was then transferred to the lab, where the samples were stabled for 48 hours and then filtered with the Whatman40 filter papers. The filtrates were then dried up in the oven for 24 four extra hours and weighed.

Soil organic carbon, nitrogen, phosphorous, and potassium was respectively measured according to the Walkey and Black (1934), Kjeldahl (Bremner et al. 1996), spectrophotometry (Avila-Segura et al. 2004) and flame photometry(Brown and Lilleland 1946) procedures. Data were then converted to ton per hectare for different land-uses, slope classes and slope directions. Normality of the values, homogeneity of variance and group comparisons were then carried out via Shapiro-Wilk, Levene's, and Duncan's methods.

3. RESULTS AND DISCUSSIONS

3.1. Physical characteristics of the plots

Along with rainfall simulations and runoff collection, plot characteristics in terms of sediment yield, initial soil moisture content (SC %), vegetation (VC %) and litter cover (LC %), runoff initiation time (RIT) and infiltration rate (RIT) were also recorded. Results, divided for the land-uses, slope classes and aspects are provided in **Hata! Başvuru kaynağı bulunamadı.**. It must be noted that from 24 experimental plots, three has not produced runoff and have been excluded from the results. As given, agriculture, compared with rangeland and forest land-uses, have produced higher volumes of runoff and greater sediment. Rainfall simulations, in case of the forest land-use, have been performed in the understory vegetation covers in open-canopy forest**.** Runoff production and sediment yield in the forest have been higher compared with that of the rangeland. Moisture content percentage, which has been measured in the top-five centimeter of the soil profile, was significantly low, which is due to harsh, dry and hot climatic condition of the area during the sampling period. Vegetation cover in the forest and rangeland areas was greater than the agriculture, but no significant changes occur in case of surface litter cover. Since, subsequent to the harvest period and prior to the next sowing time (early season canola is followed by growing cucurbits), remarkable volumes of crop residues remain on the surface, no noteworthy differences exist in this term between the land-uses. Runoff initiation time in agricultural fields is smaller than forest and rangeland. Rangeland, in this regard, has the greater runoff initiation time. On the other hand, infiltration rate, which has been measured through the application of the double-ring method, was significantly lower in the agricultural areas than the other two land-uses. As with the slope classes and aspects, there was no significant differences for total runoff, vegetation cover, litter cover, and runoff initiation time. However, plots installed on higher slope gradients have resulted in shorter runoff initiation time and higher values of sedimentation. Likewise, northern plots have produced higher values in terms of sediment yield.

Table 1. averaged physical parameters of experimental plots
Tablo 1. Deneme alanlarının ortalama fiziksel parametreleri

	Sed. (gr.l)	Rf(l)	SM%	VC%	LC%	RIT(min)	Inf.(mm.h)
Land-use							
Agriculture	9.7	13.4	6.9	6.9	20.0	11.1	4.4
Forest	5.9	7.0	66.7	66.7	18.3	13.3	6.15
Rangeland	5.3	4.1	37.9	37.9	29.3	18.3	7.58
Slope Classes							
Class I	5.8	8.1	4.4	29.7	25.0	15.2	6.16
Class II	8.0	8.6	4.2	30.5	22.7	12.2	5.94
Aspect							
Northern	8.8	8.5	3.7	37.0	23.9	13.6	4.8
Southern	5.4	8.3	4.9	22.5	23.1	12.9	4.9

3.2. Result of the one-way ANOVA

Data analysis has been carried out in the form of factorial ANOVA using R software. This test requires the satisfaction of two primary conditions. First normal distribution of parameters and second homogeneity of variance. The first criterion was tested by the Shapiro-Wilk test and the result are provided in Table 1. The Shapiro–Wilk test utilizes the null hypothesis principle to check whether a sample $x_1...x_n$ came from a normally distributed population. The user may reject the null hypothesis if p-value is below a predetermined threshold. In case of phosphorous and potassium, values were converted by the inverse and logarithmic functions, respectively. Data homogeneity of variance was confirmed according to the Levene's test, and the results are provided in

Table *2*.

Table 1. Results of the Shapiro-Wilk test of normality and the type of data conversions
Tablo 2.Shapiro-Wilk normallik testi ve ceri çevirimin tipleri

Shapiro-Wilk test of normality	N	P	K	OC
P-value prior to data conversion	0.08	0.02	0.05	0.41
Type of conversion		inverse	log	
P-value subsequent to conversion	0.08	0.43	0.51	0.41

Table 2. Levene's test of data homogeneity of variance
Tablo 3. Levene testi sonuçları

Data homogeneity of variance	N	P	K	OC
P(>F)	0.44	0.66	0.55	0.81

The results of the factorial ANOVA for the effects of land-use, slope and aspect on soil nutrient loss under simulated rainfall are provided in **Hata! Başvuru kaynağı bulunamadı.**. As given in the table, land-use has significantly changed soil nutrient loss at the 99% confidence level. The effect of slope on nitrogen, phosphorous and organic matter loss has been significant at 90% and 95%, respectively. However, potassium does not seem to be affected by the increase in slope gradient. Unlike land-use and slope, aspect has not affected the loss of soil nutrients in a significant manner.

Table 3. Analysis of variance for the effects of land-use, slope and aspect on soil nutrient loss under simulated rainfall
Table 4. Arazi kullanımı, eğim ve bakı için simule edilen yağış altında toprak besin maddesi kaybının varyans analizi

	df	SS	MS	F-value	P-value	Sig.
Nitrogen						
Land-use	2	0.471	0.235	12.380	0.005	**
Slope	1	0.074	0.074	3.910	0.088	+
Aspect	1	0.010	0.010	0.052	0.491	ns
Phosphorous						
Land-use	2	4.820	2.410	30.670	0.000	**
Slope	1	0.380	0.370	4.83	0.063	+
Aspect	1	0.160	0.160	2.130	0.018	ns
Potassium						
Land-use	2	0.860	0.430	53.460	0.000	**
Slope	1	0.012	0.012	1.750	0.226	ns
Aspect	1	0.000	0.000	0.088	0.774	ns
Organic Matter						
Land-use	2	0.000	0.000	27.550	0.000	**
Slope	1	0.000	0.000	7.470	0.029	*
Aspect	1	0.000	0.000	0.078	0.788	ns

** Significant at 99% | * significant at 95% | + significant at 90% | ns not significant

3.2. Group Comparisions

The Tukey test was applied to find means that are significantly different from each other. Figure 3. Effects of land-use on the loss of different soil nutrients under simulated rainfall and the statistical mean comparisons. Results show that the highest nitrogen loss has occurred in the agricultural fields and there is no difference for rangeland and forest land-uses. Phosphorous and organic matter loss has been significantly changed at the 95% level among the three land-uses. Yet, potassium loss maximally occurs in the rangeland areas, while there is no difference between the other two land-uses. On the other hand, maximum and minimum phosphorous loss happens in the forest and rangeland conditions, respectively. Forest and rangelands, on the contrary, have produced the highest and lowest values of soil organic matter loss, respectively.

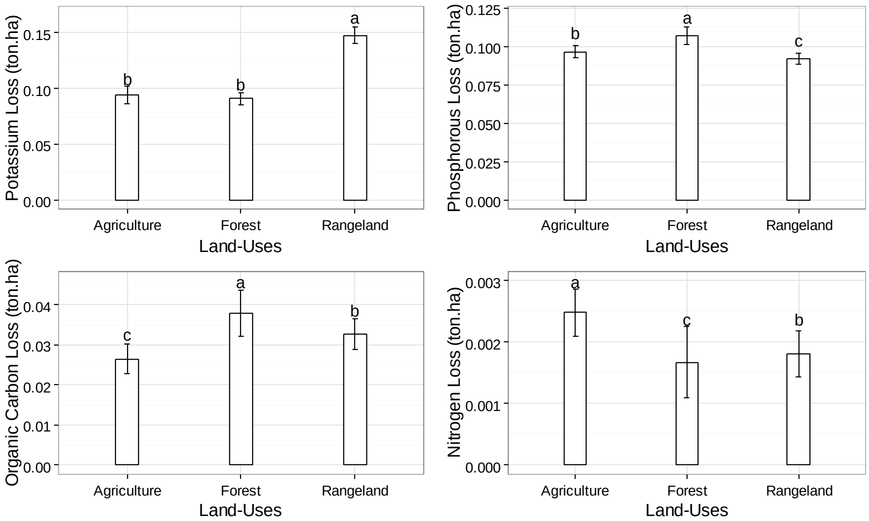

Figure 3. Effects of land-use on the loss of different soil nutrients under simulated rainfall
Şekil 4. Yağış altında arazi kullanımın farklı toprak besin maddesi kayıplarına etkisi

The results of simulated rainfall and loss of nutrients in different slope classes is presented in Figure 5. According to the results, the highest loss of nitrogen, phosphorus and organic matter occurs on the second slopes class. Unlike others, the highest amount of potassium loss corresponds to slope class I. The comparison at the 95% confidence shows, slope solely has significant effect on the organic matter.

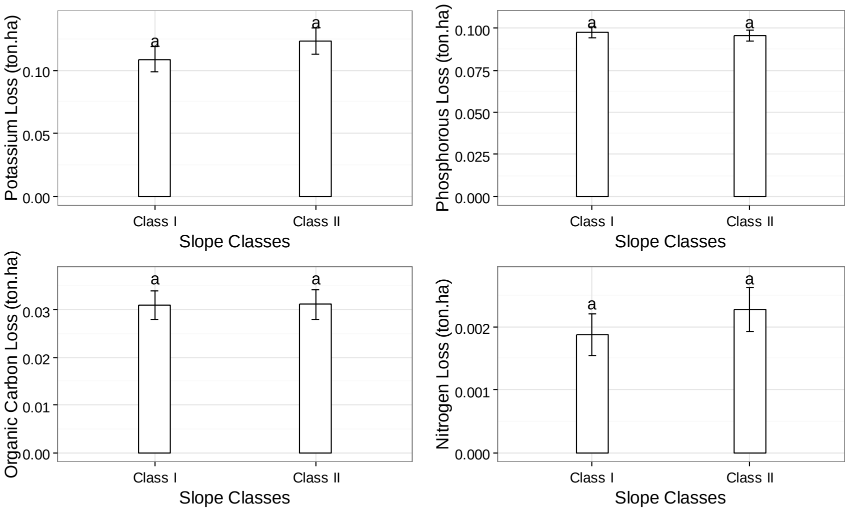

Figure 5. Effect of slope gradient on the loss of different soil nutrients under simulated rainfall
Şekil 6. Yağış altında eğimin kullanımın farklı toprak besin maddesi kayıplarına etkisi

Aspect and the three land uses has not significant impact on the losses of nitrogen, phosphorus, potassium and organic matter. But according to Figure 7, it can be seen that the loss of organic matter on the northern slope is slightly higher.

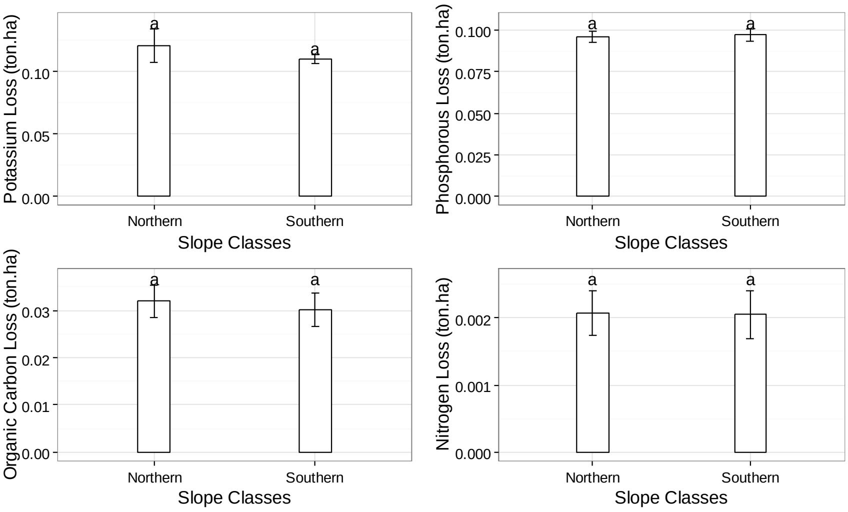

Figure 7. Effect of aspect on the loss of different soil nutrients under simulated rainfall %
Şekil 8. Yağış altında bakının kullanımın farklı toprak besin maddesi kayıplarına etkisi

3.3. Nutrient loss correlations

The correlation of the average amounts of measured factors in each plot with nutrient loss and soil organic carbon levels can be seen in Table 5. According to the results, only N losses significantly correlated with sediment production in each plot at 99%. Loss of potassium and nitrogen at 99% were correlated with the volume of runoff positively and negatively, respectively. But the percentage of vegetation has significant correlation with nitrogen at the level of 95% and organic carbon losses at the level of 90%. Based on the results provided in Table 5, runoff initiation time is negatively correlated with the vegetation cover at the 90%. Results in Table 5 also showed that vegetation cover is negatively correlated with the runoff initiation time at 99% confidence. Runoff volume was also negatively correlated with the total runoff volume. It could be concluded that vegetation cover lags runoff initiation, and thus affect total runoff volume and nitrogen loss. Sediment loss significantly increases with the runoff volume which shows higher erosion for higher runoff production.

Table 5. The association of major soil nutrients with an average values of physical plot characeristics
Table 6. Ana toprak besin maddeleri ile fiziksel deneme alanlarının özeliklerinin ortalama değeri arasındaki ilişki

	Sediment yield (gr.l)	***Runoff volume (l)***	***Vegetation cover (%)***
K	-0.31	-0.51^{**}	0.07
P	0.16	0.1	0.35
N	0.69^{**}	0.64^{**}	0.55^{**}
OC	-0.26	-0.4	0.45^{+}

3.4. Land-use effect

The effect of land use on the loss of nitrogen, phosphorus and potassium, along with loss of soil organic matter was studied. The results showed that land-use has a significant effect at 1% on Loss of these elements and organic matter. The difference between land-uses has occurred depending on the type of lost element and material. Results showed that the highest losses of nitrogen, phosphorus, potassium and organic matter corresponds respectively to the land-uses of agricultural, forest, pasture and forests. Liu et al. (2014) and

Janeau et al. (2014) have also found that land-use conversion significantly affect soil erosion, and thus nutrient loss.

The relationship between the various elements with runoff and sediment yield shows that the N losses correlates positively with the sediment production and runoff volume; while negatively correlating for the two elements phosphorus and potassium as well as organic carbon. This can be the result of the effects of intense rainfall over short-term for soil nutrient loss. Another reason is the removal of top soil layer in the initial rainfall and sediment mixing from the underlying layer, which causes less nutrient loss with the continuation of precipitation. This agrees to the findings of Girmay et al. (2009), except for nitrogen. The most important positive relationship holds between runoff and sediment production with nitrogen; with agriculture as the highest producer of available nitrogen in the resulting sediments. The most important reason for this anomaly is the use of nitrogen fertilizers in agricultural lands that leads to severe loss with runoff and sediment (Xi-Yuan et al. 2011; Sharpley, 1997).

As noted, the loss of phosphorus and organic matter in forest were significantly different from other land-uses. The main reason for the high level of organic matter loss in forest can be attributed to the presence of large amounts of litter. Interestingly, Hartanto et al. (2003) has noted to the role of litter covering the forest floor in preventing erosion and nutrient loss. However, in the long-run and by the decomposition of the litter, higher levels of organic carbon enters runoff. The high levels of phosphorus in runoff from forest with average 2.09 mg.l pertains to the high levels of soil phosphorus content.

In terms of potassium loss, the highest values were observed for the rangeland areas (as 22mg.l), which was significantly different from the other two land-uses. Forest and agricultural land-uses, with an average of about 0.1 kg per hectare in any rainfall event, had no significant difference. Due to the fact that rangelands have produced less sediment and runoff volume than the other two uses, high level of potassium loss in these areas might be related to the high potassium content in the soil top layer. Girmay et al. (2009) states that soil nutrient loss may be the result of soil richness in the elements of interest.

3.5. Slope effect

Slope is one of the primary factors affecting both runoff production and sediment yield. as noted, in this study, two slope classes of 0-20 and 20-40% has been considered in the agricultural fields and rangelands, while this classification changes into 0-15 and 15-30% for the forest areas because of the especial distribution of forest land-uses in the area. Slope classes have considerably differently affected runoff production and sediment yield in all land uses. Here, the loss of N, P and k has significantly changed in different slope classes at the 90% significance level. In case of rangeland and agriculture, sediment and runoff production has been higher in the second slope class. Vahabi and Nikkami (2008) has also found positive correlation between slope gradient and runoff and sediment yield. Increase in the runoff volume in this study has been concomitant with higher sediment values. However, except nitrogen loss, higher runoff and sediment yields corresponds with less nutrient loss. By the removal of the soil top layer, less rich soil profiles outcrop, which leads to the reduction of nutrient loss. Similar results have been reported by (Liu et al. 2014; Huang et al. 2013).

3.6. Effect of slope direction

The effect of slope direction mainly is related to the difference in the sunshine received in the slopes facing the sun compared the opposite aspects. Due to the increased level of energy input to the former slope direction, the rate of organic matter decomposition, evaporation rate and the accumulation of nutrients are also different. The footprint of the effects of slope direction on sediment loss could be found (Zachar 1982); yet, no significant relationship was found for the loss of nutrients, especially nitrogen and organic matter. Slope direction, here, has had no effect on the loss of the nutrients of interest, still loss from the northern aspects is slightly higher than the southern aspect. It appears that agriculture, forest and rangeland, in both aspects, experience no changes with regard to soil nutrient loss. Unlike to the findings of this study, Bochet and García-Fayos (2004) in the study of the effects of slope directions on erosion, found that soil moisture content, available phosphorous and nitrogen, as well as soil organic matter changes significantly between different aspects. In the northern aspect, higher values were obtained in terms of vegetation cover, runoff initiation lag time, and litter in comparison with the southern aspect. However, the loss of rich soil in the northern aspect has caused insignificant higher values of soil nutrient loss in these areas.

4. CONCLUSION

The results of the current study show the significant effects of land-use and slope on the loss of the major soil nutrients, including: nitrogen, phosphorous, potassium and organic matter. Although, the role of slope directions has not been proved meaningful. The main implication of the current study, is the necessity of the role of land management in controlling erosion and nutrient loss. Numbers obtained, provide a clear picture of the adverse consequences of land conversion into agricultural field. Short term benefits gained by growing agricultural crops do not justify the long-term devastating effects on the ecosystem of the area. High frequency of flash floods and sediment concentration, implies not only the loss of invaluable soil nutrient sources, but also it results in the destruction of infrastructures and local wildlife. So, these areas must be of the highest priority for land managers. On the other hand, slope management through soil conversion practices and conservative agriculture could meaningfully reduce erosion and nutrient loss in the area. As the slope class II has produced the highest amount of runoff production, sediment and nutrient yields. However, by the removal of the soil rich horizons, less loss would occur in the higher slope gradients and that's why lower slope gradients must also be managed with the same priority.

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