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Effects of Olive Mill Waste Applications on Runoff and Soil Losses under Artificial Rainfall Conditions

Toprak Yüzeyine Uygulanan Zeytin Atığı Uygulamasının Yapay Yağmurlayıcı Koşulları Altında Yüzey Akış ve Toprak Kaybı Üzerine Etkileri

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Key Words:

Cover rate, olive mill waste, runoff, soil loss, rain simulator

ABSTRACT

Soil, one of the most important natural resources is, lost by water and wind erosion. Addition of organic materials into the soils is commonly used for reducing soil and water losses. In this study, loam, sandy loam, loamy sand and clay loam soil samples, passed thought 8 mm sieve were placed into erosion pans with a size of sized as 30x45x15 cm. Olive mill waste was applied to soil within the erosion pans at 4 different covering ratios (0, 25, 50, and 100%). An artificial rainfall with intensity of 40 mm $h^{-1}$was applied. After artificial rainfall applications, runoff and soil losses were calculated. The results clearly indicated that runoff and soil losses from the erosion pans decreased significantly by increasing rate of olive mill waste coverage. It was obtained that addition of olive mill wastes even with a rate of 25% was effective surface cover for reducing runoff and soil losses.

Anahtar Sözcükler:

Örtü oranı, zeytin atıkları, yüzey akış, toprak kaybı, yapay yağmurlayıcı

ÖZET

En önemli doğal kaynaklarımızdan olan topraklarımız, su ve rüzgâr erozyonu ile kaybolmaktadır. Toprak kayıplarını azaltmak için topraklara çeşitli organik materyaller ilave edilmektedir. Bu araştırmada, 30x45x15 cm boyutlu erozyon tavalarına, 8 mm'den elenmiş tınlı, kumlu tınlı, tınlı kum ve killi tın bünyeli toprak örnekleri yerleştirilmiştir. Zeytin atığı dört farklı örtü oranında (% 0, 25, 50 ve 100) toprak yüzeyine serilerek uygulanmışlardır. Tavalara saatte 40 mm yoğunlukta yapay yağış uygulanmıştır. Yağış uygulamalarından sonra elde edilen yüzey akış ve toprak kaybı hesaplanmıştır. Araştırma sonuçlarına göre; zeytin atığı örtü oranı, yüzey akışı ve toprak kayıplarını önemli düzeylerde azaltmıştır. Bu araştırmada zeytin atığı uygulamasının çok düşük yüzey kaplama oranında bile yüzey akış ve toprak kayıplarının azaltılmasında etkili olduğu belirlenmiştir.

INTRODUCTION

Erosion is not only the transport of detached soils in simple terms; it is also a very complex mechanical function in nature. For the protecting soils, against water erosion, various types of organic materials (plant wastes, paper mill wastes, tobacco wastes, etc.) are commonly applied to soil. Organic materials on soil surface protect soil from erosion and organic materials mixed with soil improve soil structure, and increase soil fertility (Akalan, 1974).

Taysun (1986) applied 33, 66 and 100% of stone cover (2-3 mm diameter), 150, 300, and 450 g m^{-2} of straw mulch, and 15, 30 and 45 g m^{-2} of PVA (solve within 2 liter pure water) on soil surface into erosion trays sized of 30x45x15 cm and sloped of 9%. He reported that straw mulch and PVA applications were more efficient than stone cover on decreasing runoff and soil losses. Benkobi et al., (1993) applied 0, 25, 75 and 100% rates of straw mulch, stone cover and straw mulch + stone cover on parcels, and applied 100 mm h^{1}

artificial rainfall on erosion parcels, and found that straw mulch + stone cover treatment was more effective on reducing soil erosion as compared to the other treatments. Lacey (2000) applied wood wastes to erosion parcels, sized 20x5 m and sloped of 9%, with unmixed and mixed conditions under natural rainfall conditions. It was reported that unmixing of wood wastes was more effective than that of mixing into the soil on controlling soil losses.

Grismer and Hogan, (2005) reported that mulching materials reduced runoff and soil losses, significantly. Shipitalo and Bonta, (2008) found that applied paper mill sludge on soils decreased runoff 4-6 times, and decreased soil loss 98 % as compared with the control. Jordan et al., (2010) emphasized that wheat mulch applications were effective on reducing runoff and soil losses, and increasing infiltration and roughness of soils. Similar results were reported by Nyakatawa et al., (2010) that mixtures of wastes, wood chips and waste paper decreased runoff and soil losses.

Garcia-Lozano et al., (2011) compared the effectiveness of olive leaves and alperujo (extraction from olive wastes) applications to soil for controlling erosion, and reported that olive mill wastes were more effective on reducing runoff and soil losses and increasing infiltration than that of alperujo. Won et al., (2012) stated that rice straw mulching decreased runoff and soil losses ($p<0.05$). Donjadee and Chinnarasri, (2013) also reported that mulching reduced runoff from 71 to 33% and soil losses from 82 to 31%, respectively. Okeyo et al., (2014) underlined that mulching and reduced tillage practices decreased soil losses in short term 48-71%, and decreased soil losses in long term 7-41%, respectively. It was also reported by some other researchers that surface mulching reduced runoff and soil losses, significantly (Taysun, 1986; Tezcan, 1992; Uysal et al. 2012).

MATERIAL and METHODS

Soil Sampling and Analyses

In this study, 4 surface soil samples (0-30 cm) with different textures taken from Menemen and Bornova plains were used. About 50 kg soil samples from each location was taken and dried under laboratory condition. A small portion of soil samples were passed through 2 mm sieve for determining soil's physical and chemical properties (Richards, 1954), and the rest was passed through 8 mm sieve for using in erosion experiment (Mollenhauer and Long, 1964). Skeleton (Anonymous, 1993), bulk density (Hunt and Gilkes, 1992), moisture percentage (Gardner, 1986), texture (Gee and Bauder, 1986), clay and silt rates (%) (Neal, 1938), dispersion rate (%) (Middleton, 1930), percolation rate (%) (Lal, 1988), erosion rate (%) (Akalan, 1967), pH (Pansu and Gautheyroux, 2006), soluble salts (%) (Anonymous, 1993), lime (%) (Nelson, 1982) and organic material content (%) (Nelson and Sommers, 1982) were analyzed. In addition, aggregate stability of soil samples was determined using Yoder type wet sieving methods analysis (Kempler and Rosenau, 1986).

Prepared of Experimental Treatments

The 7 cm coarse gravel (1-16 mm diameter) was placement under the erosion pans sized 30x45x15 cm and sloped of 9% (Yönter ve Uysal, 2014). After laying a permeable clothe on the coarse gravel layer, soil samples sieved from the 8 mm were placed then different coverage rates of olive mill wastes (0, 25, 50 and 100%; 1-2 mm in thickness) were added to soil surfaces.

Artificial Rainfall Experiments

In this study, 40 mm h^{-1} of artificial rainfall which is similar to the erosive rainfall intensity commonly occurs in the Mediterranean region (Zanchi and Torri, 1980), was applied from 2.50 m height during 1 hour (Taysun, 1986; Yönter, 2010) using a laboratory type rainfall simulator (Bubenzer and Meyer, 1965). The State of Meteorological Services, reported the highest rainfall intensities in 2010 year as 43 mm and 34.2 mm between 18^{00} to 19^{00} and 19^{00} to 20^{00} hours in Menemen, respectively (DMİ, 2013). The runoff start time was measured and recorded using a stopwatch. During the artificial rainfall, runoff and soil losses were recorded with taken in each 10 minute intervals. Tap water was used (EC: 875µS/cm; SAR: 2.50) in the experiment.

Parameter Measurement and Analysis of the Data

Containers were left for 24 hours for settlement of sediment within the containers and then runoff was flushed down by a plastic pipe to the cups and 0.01 was weighed on a precision balance and then recorded for every10 minutes. After being transferred to the glass beaker, sediments were dried at 105 ^{0}C and recorded (Taysun, 1986; Yönter ve Uysal, 2007; Yönter, 2010). This study was conducted in a total of 32 experimental erosion pans. Data were analyzed using SPSS statistical software package (Anonymous, 1999).

RESULTS and DISCUSSION

Physical and chemical properties of olive waste and soil samples used in the experiment are given in Tables 1 and 2. Skeleton percent of soil samples was low varied from 0.05 to 11.00 and classified as "fewer". Skeleton material in the soil keeps the soil surface from raindrop erosion by breaking the kinetic energy of the rainfall. (Taysun, 1986; Yönter ve Taysun, 2004). Bulk density varied from 1.28 to 1.60 g cm^{-3}. The lowest clay rate was found in soil no: 4 (1.61%); whereas the highest clay rate was found in soil no: 3 (16.86%). Increasing clay rates shows that sand + silt percent's increases, while clay percent decreases, therefore, it's indicates the susceptibility to erosion of the soils (Taysun, 1989). The lowest silt rate was found in soil no: 4 (0.68%); whereas the highest clay rate was found in soil no: 2 (3.42%). It is considered that silt rates of soils, which are greater than 2.50, are not susceptible to erosion (Taysun, 1989). Suspension percent's varied from 5.44 % to 19.44%, and dispersion percent's varied from 14.44% to 63.32%, which are the most important indicators of erosion in soils. Dispersion rates varied from 16.30% to 63.56%, while erosion rates varied from 11.12% to 96.00% in soil samples. It is considered that if dispersion rate in soils greater than 15%, and erosion rate in soils greater than 10%, soils can be erodible, if not, soils can be resist. (Akalan, 1974; Taysun, 1989). In the study, the lowest aggregate stability was found in soil no: 3 (18.06%); whereas the highest aggregate stability was found in soil no: 4 (46.30%). Since Bornova plain soil has high clay content, aggregate stability was also high. Soil reaction was slightly alkaline and varied between 7.55 and 7.73. Water soluble salt content of the experimental soils varied from 0.017% to 0.052%, and showed no salinity. Lime content changed between 3.5% and 18.10%. Organic matter contents in the experiment soils varied between 0.88 and 2.40%. According to results, 1 and 2 number of soils is moderate humus classes, 3 number of soil is poor humus classes, and 4 number of soil is very poor humus classes, respectively (Schlichting und Blume, 1965). On the other hand, olive waste was light alkaline, containing low amounts of soluble salt and high amounts of organic matter (Table 2).

Table 1. Some physical and chemical properties of the experimental soils.

Parameters	Sample no			
	1*	2*	3*	4**
pH	7.70	7.64	7.55	7.73
Soluble Salts (%)	0.028	0.018	0.017	0.052
Lime content (%)	5.5	4.1	3.5	18.10
Organic Matter (%)	2.40	2.30	1.70	0.88
Sand (%)	50.40	66.40	82.40	35.68
Silt (%)	38.00	26.00	12.00	26.00
Clay (%)	11.60	7.60	5.60	38.32
Textural Class	Loam	Sandy loam	Loamy sand	Clay loam
Bulk Density (g cm^{-3})	1.32	1.35	1.60	1.28
Clay Rate (%)	7.62	12.16	16.86	1.61
Silt Rate (%)	3.28	3.42	2.14	0.68
Suspension (%)	17.44	19.44	5.44	10.32
Dispersion (%)	27.44	35.44	17.44	63.32
Dispersion Rate (%)	63.56	54.85	31.19	16.30
Erosion Rate (%)	94.00	96.00	62.00	11.12
Skeleton (%)	0.78	0.05	9.88	11.00
Aggregate Stability (%)	26.30	23.88	18.06	46.30

(*: Soils taken from Menemen Plain; **: soil taken from Bornova Plain)

Table 2. Chemical properties of olive mill waste.

Parameters	Olive mill waste
pH	7.79
Soluble Salts (%)	0.036
Organic matter (%)	57.0
N (%)	1.512
P (ppm)	0.11
K (ppm)	0.64
Na (ppm)	672
Ca (ppm)	4.21
Mg (ppm)	0.28
Cu (ppm)	18.15
Mn (ppm)	169
Zn (ppm)	82.27
Fe (ppm)	1430
Bulk Density (g cm^{-3})	0.17
Moisture (%)	6.66

Runoff and soil losses are given in Table 3. The results indicated that, olive mill waste reduced runoff (0.5% to 96%) and soil losses (69% to 100%) as compared to the control. Our findings were agreed with the results reported by the others (Shipitalo and Bonta, 2008; Donjadee and Chinnarasri, 2013; Okeyo et al., 2014). Garcia-Lozano et al., (2011) reported that olive mill waste reduced runoff and soil loss, while it increased infiltration, significantly. It was also reported that organic materials applied to the soil decreased runoff and soil loss, while it increased drain, significantly (Taysun, 1986; Benkobi et al., 1993; Grismer and Hogan, 2005; Jordan et al., 2010; Nyakatawa et al., 2010; Yönter ve Uysal, 2015; Yönter, 2016). Olive mill waste application rates reduced runoff (R = -0.590**) and soil losses (R = -0.574**), significantly in the study (Table 4). Similar statistical results of this research were reported (Garcia-Lozano et al., 2011; Won et al., 2012).

CONCLUSIONS

The results of this study indicated that, olive waste application reduced runoff and soil loss. Spreading olive waste even at low coverage rate (25%) over the soil surface is an effective practice for controlling runoff and soil losses.

Table 3. Runoff and soil losses.

Cover Rate (%)	Soil Samples No											
	1			2			3			4		
	RST	R	SL	RST	R	SL	RST	R	SL	RST	R	SL
0	910	16.59c	203.49c	217	13.67c	76.68b	75	4.02b	26.30b	57	21.01b	71.25b
25	400	16.47c	62.37b	160	9.57b	14.11a	183	0.95a	0.33a	148	1.15a	0.34a
50	126	14.64b	13.59a	82	0.99a	-	165	1.08a	-	64	0.78a	-
100	138	2.60a	0.18a	110	1.24a	-	78	1.09a	-	65	1.16a	-

[RST: Runoff starting time (second); R: Runoff (mm h^{-1}); SL: Soil loss (g m^{-2})]

Table 4. Correlations between cover rates, runoff starting times, runoff and soil losses.

Correlations		Cover rate	Runoff starting time	Runoff	Soil loss
Cover rate	R p N	1.000 32	-	-	
Runoff starting time	R p N	-0.375* 0.05 32	1.000 32	-	
Runoff	R p N	-0.590** 0.01 32	0.485** 0.01 32	1.000 32	
Soil loss	R p N	-0.574** 0.01 32	0.879** 0.01 32	0.709** 0.01 32	1.000 32

(**:p<0.01;*:p<0.05; R:coefficient of correlation; p: significant level; N: number of samples)

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