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Araştırma Makalesi
(Research Article)

Comparing of the Effects of Liquated Humic Substance (LHS), Polyacrylamide (PAM) and Polyvinylalcohol (PVA) on Runoff and Soil Losses *

Sıvılaştırılmış Hümik Madde (SHM), Poliakrilamid (PAM) ve Polivinilalkol'ün (PVA) Yüzey Akış ve Toprak Kayıpları Üzerine Etkilerinin Kıyaslanması

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ABSTRACT

Objective: The aim of this study is to determine the effects of liquated humic substance, polyacrylamide and polyvinylalcohol on runoff and soil losses by using a laboratory type rain simulator.

Material and Methods: In this study, the 7 cm coarse gravel was placed into the erosion pan, which sized 30x45x15 cm, sloped of 9 %. After laying a permeable clothe on the coarse gravel layer, soil samples which were thought to the 8 mm sieve, were placed into the erosion pan. Liquated humic substance, PAM and PVA solutions (0, 1, 2 and 4 ml l^{-1}; 100 ml) were sprayed uniformly on soil surface by a hand type pump with 2 replicated. 40 mm h^{-1} of artificial rainfall was applied during 1 hour by a laboratory type rainfall simulator. The runoff start time is measured with a stopwatch. Runoff and soil losses were calculated and tabulated.

Results: In this study**,** liquated humic substance, PAM and PVA treatments decreased runoff and soil loss significant levels.

Conclusions: Runoff and soil loss were decreased by using these solutions Therefore, liquated humic substance, PAM and PVA solutions can be use reducing the erosion easily.

Keywords:

Runoff, soil loss, humic substance, polyacrylamide, polyvinylalcohol.

ÖZ

Amaç: Bu çalışmada, sıvılaştırılmış hümik madde, poliakrilamid ve polivinilalkol'ün laboratuvar tipi bir yapay yağmurlayıcı kullanarak yüzey akış ve toprak kayıpları üzerine etkilerini belirlemek amaçlanmıştır.

Materyal ve Metot: Bu araştırmada, % 9 eğimli 30x45x15 cm boyutundaki erozyon tavalarına 7 cm kaba çakıl yerleştirilmiştir. Kaba çakılın üzerine geçirgen bir bez serildikten sonra, 8 mm elekten geçirilen toprak örneği yerleştirilmiştir. Sıvılaştırılmış humik madde, PAM ve PVA çözeltileri (0, 1, 2 ve 4 ml l^{-1}; 100 ml) toprak yüzeyine bir el tipi pompa ile 2 tekrarlı olarak eşit dağılacak şekilde püskürtülmüştür. 1 saat süresince laboratuvar tipi yapay yağmurlayıcı ile 40 mm h^{-1} yapay yağış uygulanmıştır. Yüzey akış başlangıç zamanları bir kronometre ile ölçülmüş ve kaydedilmiştir. Yüzey akış ve toprak kayıpları hesaplanmış ve çizelgeler haline getirilmiştir.

Bulgular: Bu çalışmada**,** sıvılaştırılmış hümik madde, PAM ve PVA uygulamaları yüzey akış ve toprak kayıplarını önemli düzeylerde azaltmıştır.

Sonuç: Yüzey akış ve toprak kayıpları bu çözeltilerin kullanılmasıyla azalmıştır. Bu nedenle, sıvılaştırılmış hümik madde, PAM ve PVA çözeltileri erozyonun azaltılmasında kolaylıkla kullanılabilir.

Anahtar Sözcükler:

Yüzey akış toprak kaybı, hümik madde, poliakrilamid, polivinilalkol.

INTRODUCTION

In Turkey, the huge amounts of soils are lost by erosion based on irregular precipitation and runoff caused by the topographic structure. Some methods are being applied to minimize soil erosion. One of these methods is to give organic materials to the soil. To prevent soil erosion, kinds of polymers have been used since 1950's (Chepil, 1954). Levy et al. (1992), found that polyacrylamide applications increased permeability and decreased soil loss, significantly. Uysal et al. (1995), reported that polyvinylalcohol (PVA) and polyacrylamide (PAM) applications decreased runoff and soil loss. Teo et al. (2001), found that increasing polymers decreased soil loss, significantly. Flanagan et al. (2003) applied PAM (0, 20 and 80 kg ha^{-1}) on silty loam textured and sloped soils and applied simulated rainfall (69 mm h^{-1}) and reported that PAM applications decreased runoff by 40 and soil loss by 83 %. Takuma et al. (2003), applied a soil conditioner (E-soiru) on fine textured soils under simulated rainfall and found that soil conditioner decreased soil losses by 39-92 %. Cochrane et al. (2005) applied phosphogypsum (PG), polyacrylamide (PAM), and PG+PAM) on sandy Alfisol soils (Typic Paleudalf) under simulated rainfall conditions (25 mm h^{-1}; 2 hour). They reported that soil conditioners decreased runoff by 35 % and soil losses by 90%. Sepeskhah and Bazrafshan (2006), reported that PAM applications are more effective in reducing soil losses than in reducing surface flows. Yönter and Uysal (2011a, b) found that PAM and PVA applications under simulated rainfall conditions decreased runoff and soil losses, significantly. Piccolo and Mbagwu (1997) found that humic substances (100 and 200 kg ha^{-1}), decreased soil losses by 40 %. In other study, Piccolo et al. (1997) sprayed humic substances (0, 3, 6, 30 and 60 g l^{-1}) on soil surfaces (2x0.5x0.01 m sized at sloped by 15%) and applied simulated rainfall (40 mm h^{-1}) by rain simulator. According to this study, humic substances decreased soil losses by 36%, significantly (p=0.05). Margherita et al. (2006) reported that 25 kg m^{-2} of fresh waste water treatment slurry, composting waste water treatment slurry and fresh waste water treatment slurry+humic substance applied on Xeric Torriorthent soils at slope 15% increased aggregate stability while decreased soil erosion. Ritchey et al. (2012) applied 20 kg ha^{-1} PAM, 0.3 kg ha^{-1} ammonium laurate sulfate (ALS), 5 tons ha^{-1} liquated humic substance and 5 tons ha^{-1} gypsum on erosion parcels (1x1 m sized). Researchers reported that liquated humic substance decreased runoff by 51 % and soil losses by 37 %, respectively. Sinkpehoun and Yönter (2018) applied liquated humic substances (0, 5, 10, 20 and 40 ml l^{-1}) on loam soil samples placed into the splash erosion tray (30x30 cm) under simulated rainfall (40 mm h^{-1}). Researchers reported that humic substances reduced runoff (24-45%), soil losses by runoff (7-97%) and by splash (3-37%), significantly.

The aim of this research is to determine the effects of different doses of humic substance, polyacrylamide and polyvinylalcohol solutions, sprayed uniformly on a soil surface with a hand pump, on runoff and soil losses under simulated rainfall conditions.

MATERIALS and METHODS

Soil sampling and analyses

In the study, one soil sample was taken from the experimental field of Ege University, Agriculture Faculty (38°27'12.46"N-27°13'27.99'E). Soil sample was taken from a depth of 0-30 cm and dried under laboratory conditions. Skeleton (Anonymous, 1993), bulk density (Hunt and Gilkes, 1992), texture (Gee and Bauder, 1986), clay and silt rates (%) (Neal, 1938), dispersion rate (%) (Middleton, 1930), erosion rate (%) (Akalan, 1967), pH (Pansu and Gautheyroux, 2006), soluble salt (%) (Anonymous, 1993), lime content (%) (Nelson, 1982) and organic material content (%) (Nelson and Sommers, 1982) were analyzed in soil samples. In addition, aggregate stabilities of soil samples made according to Yoder's wet sieving methods made and were calculated (Kempler and Rosenau, 1986). Liquated humic substance, polyacrylamide (PAM) and polyvinylalcohol (PVA) in this study were used as the examination materials.

Prepared of experimental treatments:

In the study, the 7 cm coarse gravel (1-16 mm diameter) was placed into the erosion pan, which sized 30x45x15 cm, sloped of 9 %. After laying a permeable clothe on the coarse gravel layer, soil samples which were thought to the 8 mm sieve, were placed into the erosion pan (Piccolo et al., 1997; Yönter ve Uysal, 2016). Then, liquated humic substance, PAM and PVA solutions (0, 1, 2 and 4 ml l^{-1}; 100 ml) were sprayed uniformly on soil surface by a hand type pump with 2 replicated (Piccolo et al., 1997).

Artificial rainfall experiments:

In this study, 40 mm/h of artificial rainfall, which is similar to the natural rainfall intensities in the Mediterranean region (Zanchi and Torri, 1980), from 2.50 m height (Figure 1), was applied during 1 hour by a laboratory type rainfall simulator with Veejet 80100 nozzle (Bubenzer and Meyer, 1965; Taysun, 1986; Yönter, 2010). In addition according to data of TSMS, the highest rainfall intensities in 2010 year were measured 43 mm and 34.2 mm between 18^{00} to 19^{00} and 19^{00} to 20^{00} hours in Menemen district, respectively (TSMS, 2013). Then, the runoff start time is measured and recorded with a stopwatch (Taysun, 1986; Yönter and Uysal, 2007; Yönter, 2010). During the artificial rainfall, runoff and soil loss were taken in each 10 minutes. Also tap water in the experiment was used (EC: 875 µS cm^{-1}; SAR: 2.50).

Parameter measurement and analysis of the data:

After artificial rainfalls, containers were left for 24 hours in order for the sediment to settle in the containers. After settled the sediment, runoff was flushed down by a plastic pipe to the cups and recorded runoff amounts. After being transferred to the glass beaker, sediments were dried in an oven at 105 ^{0}C and were recorded (Taysun, 1986; Yönter and Uysal, 2007; Yönter, 2010). This study was conducted

in a total of 24 experimental plots as split experiment design. Data were analyzed by SPSS statistical software package (Anonymous, 1999) using statistical analysis was performed. Groups of the average subject were determined using Duncan test.

RESULTS and DISCUSSION

Some physical and chemical properties of the soil sample used in the study are given in Table 1.

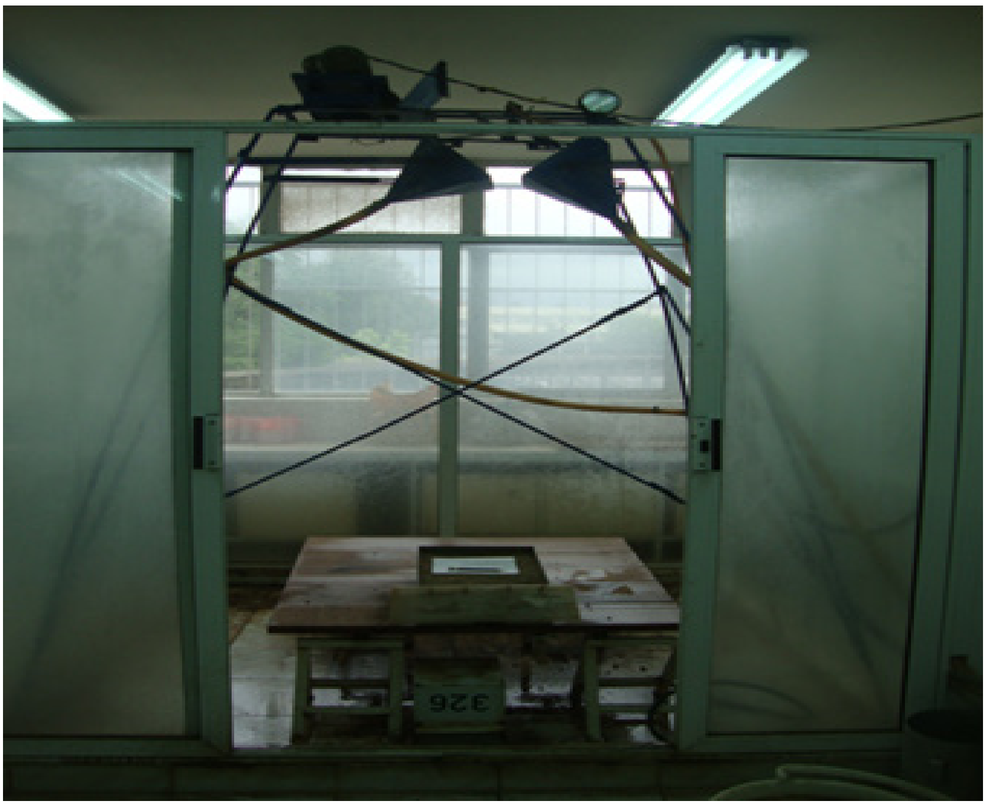


Figure 1. Laboratory type a rainfall simulator.
Şekil 1. *Laboratuvar tipi bir yağış benzetici.*

Table 1. Some physical and chemical properties of soil sample.
Çizelge 1. *Toprak örneğinin bazı fiziksel ve kimyasal özellikleri.*

Skeleton (%)	Bulk Density (g cm^{-3})	Sand (%)	Silt (%)	Clay (%)	Texture	Clay Rate (%)	Silt Rate (%)	Suspension Percentage (%)
3.16	1.22	33.52	21.44	45.04	Clay	1.22	0.48	5.04
Dispersion Percentage (%)	**Field Capacity (%)**	**Dispersion Rate (%)**	**Erosion Rate (%)**	**Aggregate Stability (%)**	**pH**	**Soluble Salt (%)**	**Lime (%)**	**Organic Content (%)**
66.48	27.77	7.58	4.68	38.65	7.74	0.063	14.90	4.27

According to Table 1, Skeleton materials of soil samples are fewer classes. Skeleton material in the soil keeps the soil surface from raindrop erosion by breaking the kinetic energy of the rainfall. (Akalan, 1974; Taysun, 1986; Yönter and Taysun, 2004). The bulk density of soil sample is 1.22 g cm^{-3}. In general, infiltration is being high due to soil organic matter and a good porosity and runoff is reduced in soils (Akalan, 1974; Taysun, 1989). In terms of strength to erosion, it is desirable that the clay ratio in the soil approaches. However, this ratio varies between 1 and 3 in erosion-resistant soils, where the clay rate is 1.22 and soil is relatively susceptible to erosion (Akalan, 1974; Taysun, 1989). The silt rate of soil samples is low. It is considered that silt rates of soils, which are greater than 2.50, are not susceptible to erosion (Taysun, 1989). The dispersion rate and erosion rate of soil samples were found low. 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). Organic matter is quite high with the amount of clay in the soil being insufficient and therefore the aggregate stability is high. The reaction of the soil sample is of the slightly alkaline class. According to water soluble salt percentage, there is no salinity problem in soil samples. The soil sample is in the calcareous class. The soil sample is in the humus class (Schlichting and Blume, 1966).

Runoff start times, runoff and soil losses:

The runoff and soil loss values obtained from the study are given in Table 2.

Table 2 show that, humic substances, PAM and PVA applications started runoff later than control treatments in this study. PVA was found more effective than HS and PAM in delaying runoff start times. As a result, runoff decreased by 3-36 %, 3-32 % and 4-19 % in humic substance, PAM and PVA treatments compared with control, respectively. Humic substance, PAM and PVA were effective in reducing runoff compared with control. Based on decreasing runoff, soil losses were decreased in all treatments. Humic substance decreased soil losses 0.8-29 %, PAM decreased soil losses 0.6-44 %, and PVA 5-24 %, respectively. PAM found more effective than other treatments in decreasing soil losses. Some researchers found that humic substances decreased runoff and soil losses significantly (Piccolo and Mbagwu, 1997; Piccolo et al, 1997; Ritchey et al, 2012; Sinkpehaun and Yönter, 2018). Similarly, some researchers also found that PAM and PVA as soil conditioners decreased runoff and soil losses significantly (Levy et al, 1992; Uysal et al, 1995; Flanagan et al, 2003; Yönter and Uysal, 2011a, b).

Table 2. Runoff and soil loss values obtained from parcels treated with liquated humic substances, PAM and PVA.

Çizelge 2. *Sıvılaştırılmış hümik madde, PAM ve PVA uygulanmış parsellerden elde edilen yüzey akış ve toprak kayıpları.*

HS (ml l^{-1})	Runoff start times (sec)	Runoff (mm $hour^{-1}$)	Soil loss (g m^{-2})
Control	**685b**	**13.09a**	**66.51a**
1	710b	12.65a	65.99a
2	845b	12.23a	65.23a
4	1348a	8.32b	47.14b
Mean values*	968	11.07	59.45
PAM (ml l^{-1})	**Runoff start times (sec)**	**Runoff (mm $hour^{-1}$)**	**Soil loss (g m^{-2})**
1	713b	12.67a	66.09a
2	868b	12.26a	65.30a
4	1573a	8.84b	37.30b
Mean values*	1051	11.26	56.23
PVA (ml l^{-1})	**Runoff start times (sec)**	**Runoff (mm $hour^{-1}$)**	**Soil loss (g m^{-2})**
1	700c	12.52ab	63.31a
2	983b	12.90ab	64.52a
4	1773a	10.61b	50.78b
Mean values*	1152	12.01	59.54

(HS: Humic Substance; PAM: Polyacrylamide; PVA: Polyvinylalcohol; *: without control)

Table 3. Correlations between HS, PAM and PVA treatments, and measured parameters in the experiment.
Çizelge 3. *Denemede ölçülen parametreler ile HM, PAM ve PVA uygulamaları arasındaki korelasyonlar.*

	HS	**RST**	**Runoff**	**Soil loss**
HS	1.000	0.942**	-0.930**	-0.902**
RST		1.000	-0.966**	-0.954**
Runoff			1.000	0.976**
Soil loss				1.000
	PAM	RST	Runoff	Soil loss
PAM	1.000	0.935**	-0.933**	-0.893**
RST		1.000	-0.966**	-0.979**
Runoff			1.000	0.977**
Soil loss				1.000
	PVA	RST	Runoff	Soil loss
PVA	1.000	0.951**	-0.757*	-0.880**
RST		1.000	-0.788*	-0.939**
Runoff			1.000	0.789*
Soil loss				1.000

(**: 0.05; *: 0.01 significant levels; N: 20; HS: Humic Substance; PAM: Polyacrylamide; PVA: Polyvinylalcohol RST: Runoff Start Times;).

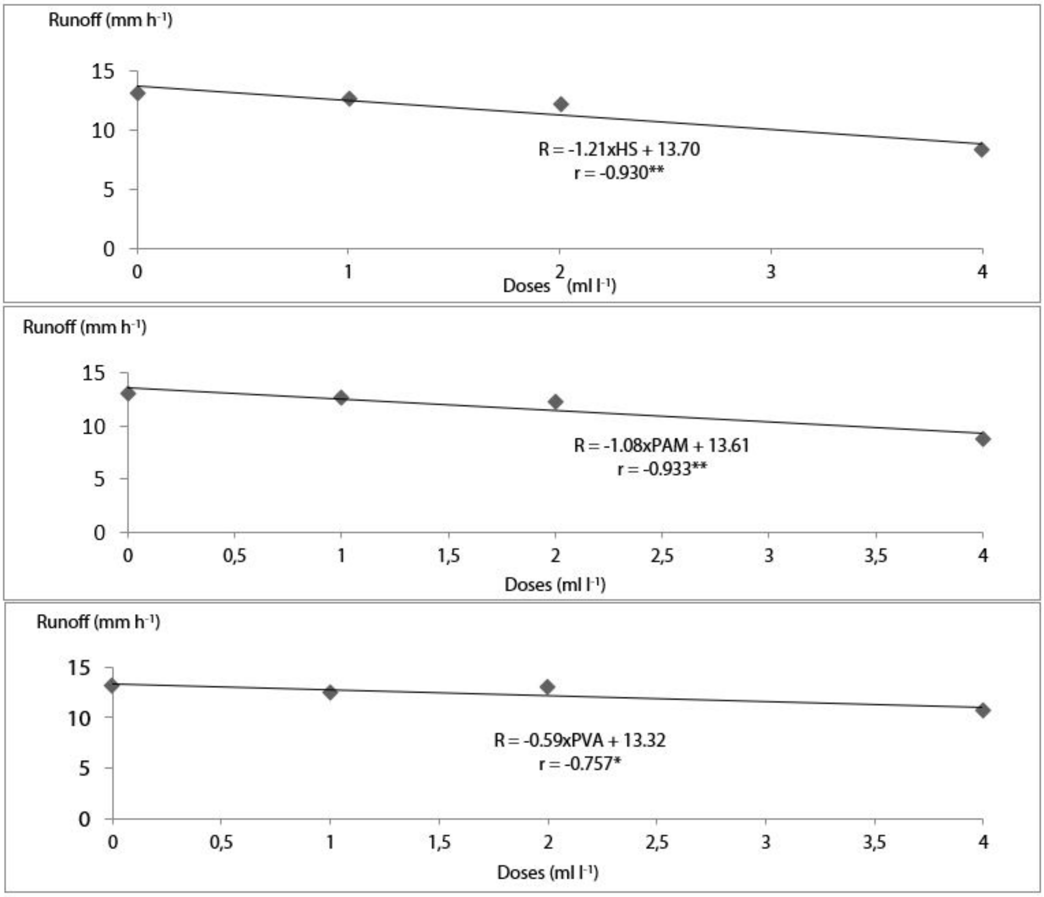
Statistical evaluation of data obtained from study:

Correlations of this experiment were given Table 3 and regression equations of runoff and soil losses were also given Figure 2 and 3.

Humic substance treatments decreased runoff (r = -0.930**) and soil loss (r = -0.902**). Some researchers found that humic substances decreased soil loss, significantly (Piccolo and Mwagbu, 1997; Piccolo et al., 1997; Sinkpehaun and Yönter, 2018). PAM treatments decreased runoff (r = -0.933**) and soil loss (r = -0.893**) to p <0.01 significance level. Also PVA treatments decreased runoff (r = -0.757*) and soil loss (r = -0.880**) to p<0.05 and p <0.01 significance levels. Similar results have been noted in some studies (Levy et al, 1992; Flanagan et al., 2003; Yönter and Uysal, 2011a,b).

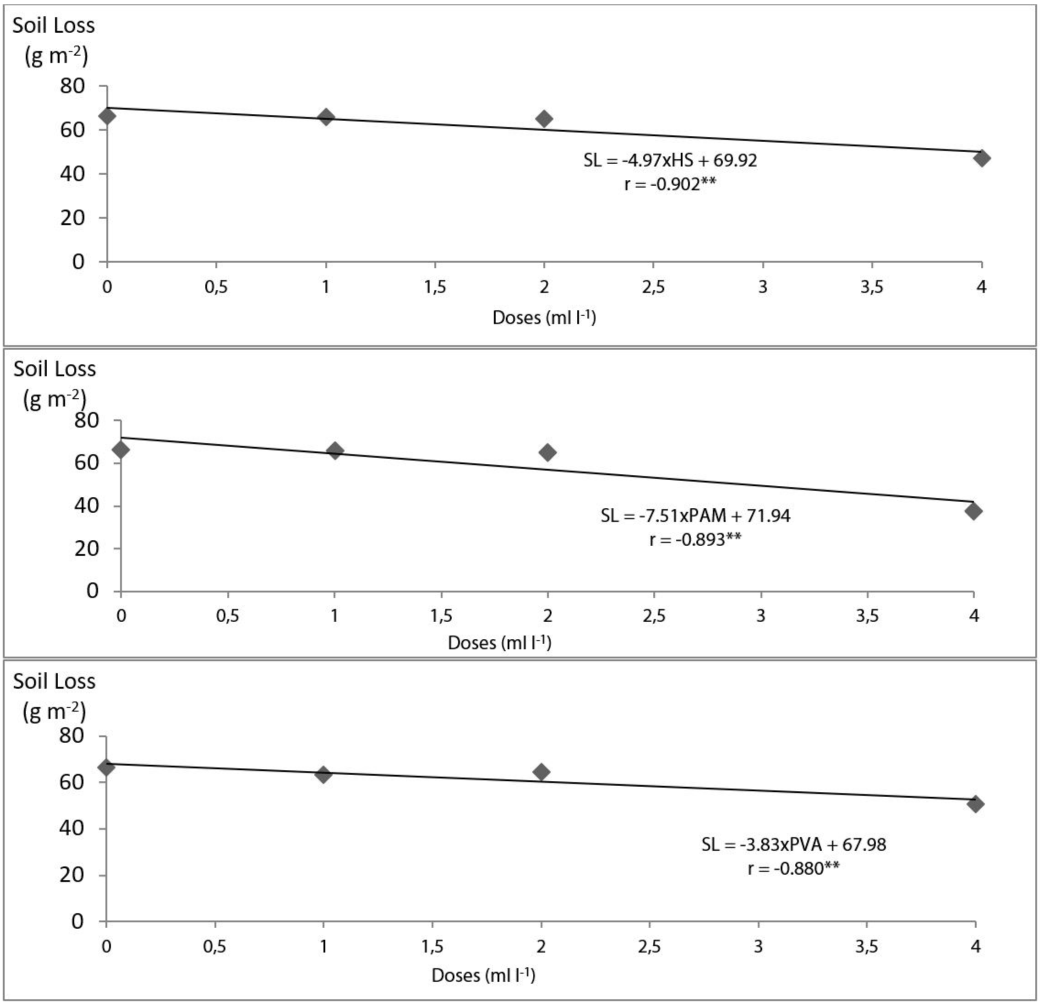
CONCLUSION

According to the results obtained from this research, some soil stabilizers as humic substance, PAM and PVA decreased runoff and soil loss, significantly. As a result, it has been determined in this study that liquated humic substance, PAM and PVA applications on soil surface can reduce the erosion mostly and significantly. Therefore, even at very low rates of soil stabilezers can be used reducing soil erosion, easily under heavily rainfall conditions on lands.



(R: Runoff; HS: Humic substance; PAM: Poliacrylamide; PVA: Polivinylalcohol)

Figure 2. Regression equations of runoff in the experiment.
Şekil 2. *Denemede yüzey akışlara ait regresyon eşitlikleri.*



(SL: Soil loss; HS: Humic substance; PAM: Poliacrylamide; PVA: Polivinylalcohol)

Figure 3. Regression of equations of soil losses in the experiment.
Şekil 3. *Denemede toprak kayıplarına ait regresyon eşitlikleri.*

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