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DETERMİNATION OF SURFACE FLOW AND SOIL LOSS WITH WEPP HILLSLOPE MODEL IN NORTHERN TURKEY

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Abstract: Soil erosion is an important form of land degradation. Erosion modeling is valuable tool for predicting soil degradation and runoff under different agricultural practices and was used in this study to evaluate different tillage practices with the The Water Erosion Prediction Project (WEPP) hillslope model. Previously measured runoff and sediment delivery data were collected from fallow and cropped plots with a wheat, lentil and tobacco rotation. On the fallow plots, two cultivation methods were used, parallel and perpendicular to the slope. The fallow plots were used to estimate the soil erodibility parameter values for the WEPP model for interrill erodibility, rill erodibility, critical shear, and saturated hydraulic conductivity. Individual events variability in model performance was evaluated with a long term set of data that contained both for wet and dry years. A sensitivity analysis was also conducted for the model parameters. On the up and down the hill tillage plot, average runoff and soil loss for individual events for observed and estimated values were 2.40 and 4.98 mm, and 0.09 and 0.28 kg /m^2. Similarly, on the contour-till plot, event-based runoff and soil loss data from actual and estimated values were 3.05 and 7.26 mm, and 0.1 and 0.26 kg/m^2 sediment delivery. In the same manner, on the rotation cropping plot, event-based runoff and soil loss data from observed and estimated values were 1.67 and 3.97 mm, and 0.06 and 0.18 kg/m^2 sediment delivery.

Keywords: Soil loss, natural runoff plots, runoff, WEPP model, Turkey

1. INTRODUCTION

Recent studies show that soil degradation is a serious environmental problem in Turkey as well as other countries of the world (Koçman et al., 1995;Türkeş & Erlat, 2005; Pamuk et al., 2004;Türkeş and Tatlı, 2009; Kömüşçü & Erkan, 2011;Karabulut, 2015). There is a strong correlation between the soil, climate and ecosystem (Schmengler, 2011). Areas where communities depend on intensive agriculture are also the areas at risk to major soil degradation (Oztas & Fayetorbay, 2003; Schmengler, 2011), with soil erosion being the most common cause. Soil erosion is believed to have contributed to the downfall of many ancient civilizations (Lowdermilk, 1953) and is and still is considered a serious environmental issue (Elliot & Arnold, 2001; Saavedra, 2005). In arid and semi-arid regions, desertification and a loss of soil nutrients are the major factors underlying soil degradation (Bationo et al., 2007; Cobo et al., 2010). Erosion reduces soil fertility, impacts soil hydrological processes, and can limit agricultural land use (Brown et al., 1994). Environmental legislation and policies can also influence socio-economic development in Turkey and elsewhere, (Batterbury & Warren, 2001; Schmengler, 2011). Conflict over land use and soil conservation is ongoing in Turkey where agriculture supports 23.2% of the population (Report on the Agricultural Industry of Turkey, 2013; (Sun et al., 2014).

Rain drop impact dislodges soil, and if the intensity is great enough to cause runoff, detached particles are carried from the hillslope. The eroding soil is transported into small channels called rills that are also sources of sediment (Romero & Stroosnijder, 2002; Saavedra, 2005; Wickenkamp et al., 2000). Some of the eroded sediments may be deposited along gentle areas of the landscape while others are redistributed in creeks, rivers or reservoirs (Foster, 2004). Upland erosion is one of the main processes in basin dynamics as it is usually the main source of sediment that provides downstream nutrients, provides sediment for river channel process and contributes to reservoir sedimentation (Brown & Wolf, 1984; Tefera & Sterk, 2010).

Soil and water conservations planners need methods to determine the distribution of soil erosion and identify where soil erosion is greatest risk on a complex landscape. In assessing the landscape effects of soil erosion, it is necessary to identify the locations, the extent, and the severity of soil erosion (Catari Yujra & Saurí i Pujol, 2010; Jetten et al., 1999). Soil erosion is a function of factors such as the topography, the land use, local climate and the distribution of soil properties within a basin. These factors are needed by contemporary models to estimate the distribution and severity of soil erosion (Zhang, 2005, 2004).

Erosion models are used to predict the effects soil and climatic properties, topography and land use, such as agricultural crop management, on surface runoff, soil loss and water quality. The earliest widely used soil erosion model was the Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978). The USLE incorporated factors for climate, soil, topography, crop management and conservations practices into predicting soil erosion. The Erosion Productivity Impact Calculator-EPIC (Sharpley & Williams, 1990) incorporated the USLE into a landscape tool and added a runoff component and crop growth to predict soil erosion and soil productivity loss due to erosion on a watershed scale. The EPIC model was enhanced to include nutrient delivery to develop the Soil and Water Assessment Tool-SWAT (Arnold et al., 1998). The Chemicals, Runoffs, and Erosion from Agricultural Management Systems-CREAMS (Knisel, 1980), was the first physically-based soil erosion model that estimated runoff and associated soil erosion and nutrient delivery for a single runoff event. The Water Erosion Prediction Project (WEPP) was developed by initially linking the process-based hydrology and erosion models from CREAMS with the plant growth model from EPIC into a continuous simulation erosion model. Both the WEPP Model and the SWAT model are widely applied. The SWAT model is better suited to evaluating larger watersheds to identify critical areas of soil loss or nutrient delivery, whereas the WEPP model is better suited to evaluating management impacts on runoff and soil erosion at a field scale (Moreira et al., 2010). In order to apply predictive erosion models to complex basins, it is critical to compare observed and predicted data from nearby studies (Beven, 1995). WEPP, as a model that has been developed in different climate and soil conditions, is widely used in the world and it is very important to use this model objectively in the conditions of Turkey in order to accurately test the success of estimation. To this end, this thesis aims to evaluate the estimation success of WEPP Hillslope model by using the previously measured sediment yield and flow data along a homogeneous dip slope on which various management versions including tobacco, wheat, and lentils through perpendicular plowing and contour plowing. The measured real-based data and the data estimated by the model were compared within the scope of the study.

2. AREA OF STUDY

The Middle Black Sea Transitional Zone Agricultural Research Institute where the study was conducted is located in the Upper Yeşilırmak Basin, 10 km west of Tokat city in Turkey (Fig. 1). The study area is located at latitude 40°19'40" and longitude 36°26'92" with an elevation of 601 m (Oguz et al., 2006).

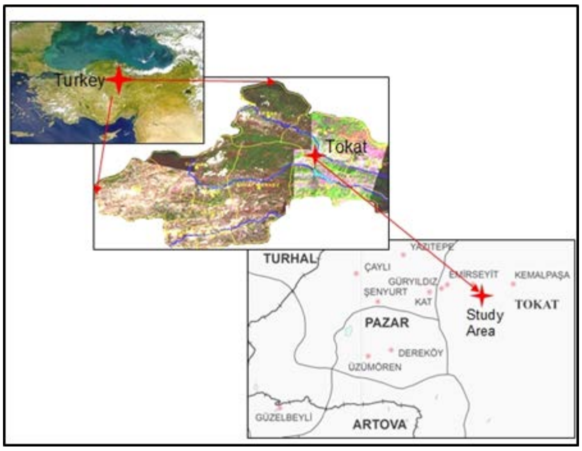

Figure 1. Site location map

The dominant soil for the study area is the Akis Soil Series. The soil is classified as Entisol and represent fairly deep soil with A and C horizons that were formed on a parent material of marl and limestone. The texture is clayey loam in upper horizons, and clay in lower parts of the profile with a clay content of 45% (Durak, 1994).

Vegetables and field crops are cultivated on the lower elevation plain and near-plain areas. Because the cropped areas often extend up the valley sides to steeper slopes, erosion can be severe in this region.

The province is dominated by steppe (continental) climate from the Black Sea to Central Anatolia. Typically, summers are hot and dry, and winters are cold and rainy. According to the precipitation data obtained from the Tokat Meteorology Station, from 1980-2015 the average annual rainfall varied between 313.3 and 592.9 mm, with November the wettest month (105 mm). There are average 250 wet days in a year and the highest precipitation observed in spring and autumn. Between 1980 and 2015, the lowest average temperature was observed in January at -10.7ºC while highest average temperature occurred in July at 36.5ºC. Average annual temperature is 12.5ºC. Based on these data, the temperature regime is Mesic and the soil moisture regime is Ustic.

Three long term erosion plots at the study site have been monitored for 1975-1995 years. The plots are 3 m wide and 22.1 m long, with slopes of 9%. One of those plots has been in continuous fallow, with had hand tillage carried out as required to prevent vegetation growth (the "Fallow" plot). A second plot has also been in fallow, but hand tillage is carried out on the contour (the "Contour" plot). The third plot has been growing crops typical of the region, including tobacco, wheat and lentils (the "Cropped" plot). The weather, runoff and sediment yields were recorded for all runoff events for the 21 years of record.

3. MATERIAL and METHODS

3.1. Methods

3.1.1. Soil Sampling and Analysis

Soil samples were taken to determine soil properties which are required to run WEPP model from 0-20 cm topsoil depth in Akis Soil Series. The samples were dried at room temperature, then dry sieved through a 2 mm mesh for the analysis.

Sand, silt and clay fractions of soil were determined by the Bouyocous hydrometer method (Bouyoucos, 1951) while the modified Walkey-Black method was used for organic matter determination (Nelson et al., 1982). Hydraulic conductivity of the soil was measured from intact soil samples by with a constant head permeameter (Richards, 1954). Cation exchange capacity was determined by using the 1.0 N ammonium acetate (pH = 7.0) method (Jackson, 1958).

3.2. Standard USLE Parcels (Plot K, P and C)

Plots where the erosion susceptibility (K) factor and the soil protection measures (P) factor as part of the universal equation are explored. Care was taken to keep the plots consistently free of vegetation. The plots were spaded starting from the lower part of the plot at a depth of 15-18 cm. After spading, soil was harrowed starting from the lower portion of the plot to the upper portion. The furrows were formed by means of a hand marker at a depth of 8-10 cm and 18-20 cm intervals parallel to the slope for plot K, and perpendicular to the slope in plot P.

The cover and management (C) factor indicates the combined effects of variations in crops or other vegetation coverage and tillage systems, as well as the corresponding changes in rainfall erosivity within a year. In sloped agricultural fields (C factor) throughout the Tokat region, wheat, chickpea, lentil, etc. are cultivated under a three crop rotation. Because it was thought that flax was a popular plant in Tokat, a crop rotation involving wheat, flax and lentil was started during the trial period. Later due to the realization of waning interest in flax, a triple crop rotation involving wheat, tobacco and lentil was initiated. Factor C was determined separately for each plant species and for each year of application. Soil for these plots were also, spaded and harrowed with furrows formed parallel to the slope by means of a hand marker at 18-20 cm intervals and 8-10 cm depth in which lentils were planted.

3.2.1. WEPP Hillslope Model

The Water Erosion Prediction Project (WEPPmodel) is a process based model originally developed in the United States to replace the Universal Soil Loss Equation (Laflen et al., 1991) The WEPP model mathematically describes the processes that contribute to erosion including daily plant growth and senescence, residue decomposition, evapotranspiration, and soil water balance. When there is a rainfall or snowmelt event, WEPP estimates the runoff, erosion, sediment transport, and sediment delivery from the hillslope or for watersheds up to about 400 ha (Flanagan & Nearing, 1995). WEPP summarizes runoff, erosion and sediment delivery by runoff event, annual, or average annual time frames.

On the hillslope, WEPP predicts erosion from rain drop splash and shallow overland flow, or interrill erosion, and from concentrate flow, or rill erosion. Interrill erosion is predicted from rainfall and runoff by:

$$D_i = K_i \, i \, q \qquad (1)$$

Where D_i is interrill detachment in kg m^{-2} s^{-1}, K_i is interrill erodibility, a soil property in kg s m-4, i is rainfall intensity (m s^{-1}) and q is the runoff rate (m s^{-1}). Additional factors that address slope steepness, rill width, ground cover and surface roughness are also considered within WEPP when predicting interrill erosion (Flanagan & Nearing, 1995).

Rill erosion is predicted within WEPP by a hydraulic shear model:

$$D_r = K_r(\tau - \tau_c)(1 - \frac{G}{T_c}) \qquad (2)$$

Where D_r is the detachment rate in a rill after accounting for entrained sediment (kg m^{-2} s^{-1}), K_r is the rill erodibility (s m^{-1}), τ is the net hydraulic shear of flow in the rill (Pa) having accounted for shear lost through surface plant residue and roughness, τ_c is the critical shear which must be exceeded by τ before rill erosion will occur, G is the transport rate of sediment in the rill from upstream rill erosion and interrill erosion (kg s^{-1} m^{-1}), and T_c is the transport capacity of the rill flow, a function of sediment size distribution and density and hydraulic shear (kg s^{-1} m^{-1}) (Flanagan & Nearing, 1995).

The WEPP model has two versions, a hillslope version that predicts runoff and sediment delivery from a hillslope plot with a unit width (1 m), and a watershed version that links hillslope polygons, channels, and channel impoundments to predict runoff and sediment delivery from each hillslope, channel segment, and impoundment (Flanagan & Nearing, 1995).

The WEPP Hillslope version requires four input files: a climate file, slope, vegetation management, and soil. The WEPP Windows interface assists in building these input files and in allowing users to specify not only runoff and erosion output files, but also daily values for more than 70 variables that are calculated internally during a WEPP run.

3.2.1.1. Climate File

The climate file can either describe a single storm, or more commonly daily weather conditions for 1 to 999 years. The daily weather values include maximum, minimum and dew point temperatures, wind speed and direction, solar radiation and humidity. On days with precipitation, the file provides the precipitation depth, duration, peak rainfall intensity, and time from the start of the storm to the peak intensity.

If no observed weather data are available, a complementary climate file builder distributed with WEPP, CLIGEN, can be used to build the climate file from climate statistic observed at a nearby weather station.

3.2.1.2. Soil File

The soil file contains the physical and hydrological properties of the soil including the texture (clay, sand), organic matter content, water holding field capacity, interrill and rill erodibility and critical shear, hydraulic conductivity, cation exchange capacity and rock fragment content (diameter > 2 mm). A soil profile with multiple horizons can be described up to 2 m deep. The WEPP model User Summary provides methods for estimating erodibility parameter values based on soil textural properties (Flanagan & Livingston, 1995). For soils with greater than 40% clay content, baseline hydraulic conductivity can be estimated from:

$$K_b = 0.0066e^{\frac{244}{clay}} \qquad (3)$$

Where K_b is the "baseline" effective saturated hydraulic conductivity (mm h^{-1}), and clay is the clay content of the soil (mm h^{-1}). Interrill erodibility for cropland soils with less than 30% sand can be estimated by

$$K_i = 6054000 - 55130\, clay \qquad (4)$$

Where K_i is interrill erodibility (kg s m-4). Rill erodibility for soils with less than 30% sand can be estimated from:

$$K_r = 0.0069 + 0.134e^{-0.20\, clay} \qquad (5)$$

Where Kr is the rill erodibility (s m^{-1}). For soils with less than 30% sand, critical shear is 3.5 Pa.

3.2.1.3. **Slope File**

The slope file contains information on the width, length and aspect of a hillslope, and pairs of values describing the slope steepness for different distances down the hill.

3.2.1.4. **Vegetation Management File**

Data file of WEPP has several sections including: plant growth, tillage operations, initial conditions, surface effects, contour, drainage and management applications. Output is insensible to most parameters included except surface and contour conditions. Three plots were investigated and designated as plots K, P and C complementing the variables of Universal Soil Loss Equation

3.2.2. Preparing WEPP Input Files

Using the CLIGEN database, the long-term climate data from 1975-1995 period were estimated. Some soil parameters were measured in laboratory and some soil properties were estimated from WEPP User Summary (Flanagan & Livingston, 1995). The key soil properties and predicted erodibility values are summarized in Table 1.

Table 1. Soil properties of the study site observed or estimated from equations 3 – 5

Property	Value	Units
Sand Content	25.85	%
Clay Content	44.56	%
Organic Matter	2.5	%
Cation Exchange Capacity	18	meq/100g of soil
Rock Content	0.0	%
Interrill erodibility	3.597,400	kg-s/m^4
Rill erodibility	0.0069	s/m
Critical shear	3.5	Pa
Hydraulic Conductivity	1.58	mm/h
Initial saturation	75	%
Albedo	0.23	-

3.2.3. Assessment of the Model

Several statistical methods and techniques are employed in assessing model simulations. Of them, the primary one is the root mean square error (RMSE) (Thomson & Schmidt, 1982). Ideal RMSE value is 0.

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{n}(\text{Oi}-\text{Pi})^2}{n}} \qquad (6)$$

Where,

Q_i= value of the parameter simulated,

Pi_p= value of the parameter observed

n = sample size

The Nash-Sutcliffe Model Efficiency Coefficient (E_{NS}) is an effective measurement formula used in assessing the predictive power of simulations (Nash & Sutcliffe, 1970).

$$E_{NS}=1-\frac{\sum(O-Y)2}{\sum(Y-Q)} \qquad (7)$$

Where, Y and O are the mean observed and predicted values respectively, and Q is the observed time at discharge. The closer to an E_{NS} of 1 the more precise the model. In addition, a t-test was performed at 95% confidence interval.

4. RESULTS

4.1. Surface Runoff

In this study, long-term event-based surface runoff data from plots K, P and C during the 1975-1995 period were evaluated. The relationship between observed and predicted event- based runoff data is shown in Figures 2-4 for all management systems.

Using a 112 observed surface runoff events, the model predicted a total of 100 more events of less magnitude in K parcel. Observed surface runoff averaged 2.43 mm while predicted flow averaged 4.98. Most of the error occurred in low flow range between 0-1 mm (Fig. 2). Observed data for Plot K, did not generate significant surface runoff events aligning with the model predicting values of near or at zero (Fig. 2). The correlation coefficient between observed and predicted surface runoff data is an $R^2 = 0.49$ (Fig. 2). Observed and simulated data are distributed over the 1:1 line, implying that data predicted by the model are higher than the observed for K parcel during 1975-1995. In particular, the model failed to simulate the small runoff (< 1 mm). This type of response was also observed by (Soto and Díaz-Fierros, 1998) were runoff events (< 1 mm) were simulated with no runoff, and (Grønsten & Lundekvam, 2006), were small runoff events (< 5 mm) were mostly missed. While no runoff was observed in 1978, 1979 and 1980, the model estimated runoff predictions during springtime for this period. Several <1 mm event-based episodes were observed, but the model did not (Fig. 2).

One reason why the model over predicts or under predicts is the surface hydrology. Hydraulic conductivity, rill, interrill and shear stress are the most important hydrological parameters employed by the model for simulation. The model employs the modified Green-Ampt-Mein-Larson equation (Mein & Larson, 1973; Kidwell et al., 1997) to calculate hydraulic conductivity. This equation takes into account the infiltration due to ponding on the surface. The precipitation data observed and predicted by CLIGEN during the 1975-1995 period varies. Compared to the observed data, the model predicted precipitation on some dry days, and made no prediction on some wet days. In particular, during winter and spring, the water content of soil increased causing the model to predict surface runoffs greater than the observed data.

In Australia, Croke & Nethery (2006) assessed surface flow using the RUSLE, WEPP and TOPOG models. The Model predicted 27 surface runoffs versus 52 observed data. In addition, the model made varying predictions for low-intensity precipitations, and over predicted medium- and high-intensity precipitations. Albaradeyia et al., (2011) predicted the surface runoff using the WEPP model based on climate data for the 2003-2005 period. This study showed that the model under predicted the surface runoff compared to observed values.

In plot P, among the input data files created for the 1975-1995 period, the crop management file was revised as it was the only difference from the parameters for plot K. In the crop management file, all inputs entered in plot K were the same, the only exception was ploughing was perpendicular to slope and had a gradient of 2%.

Plot P predicted 22 surface runoff events versus 66 observed events. Observed surface runoff was recorded as 3.05 mm while the simulation predicted 7.26 mm. Observed surface runoff data in the study are quite low in value, and the WEPP model did not predict runoff values smaller than 0.5 mm (Fig. 3). The event-based surface runoff data for plot P are highly variable

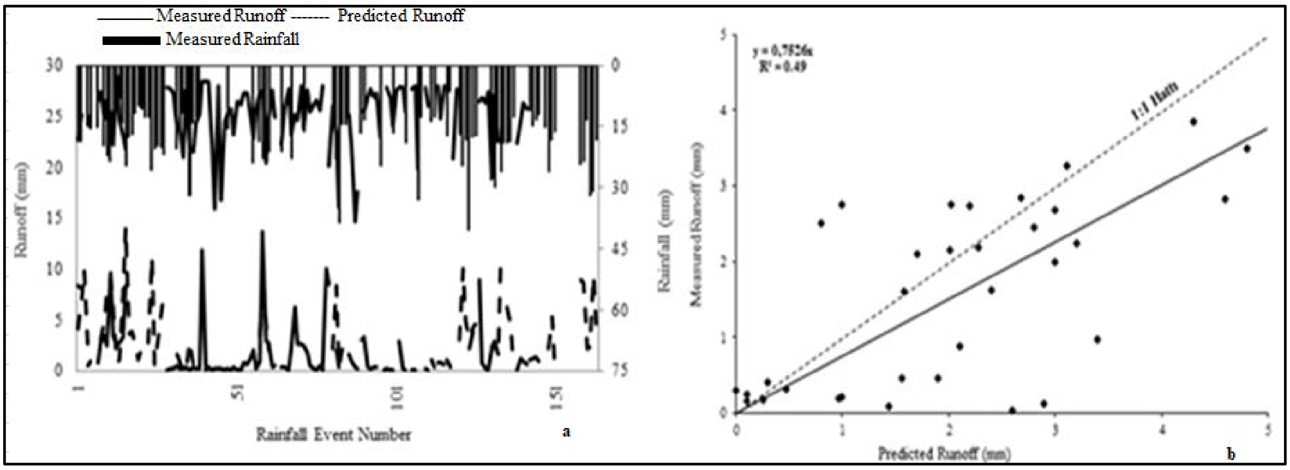

Figure 2.Graphical representation of the relationship between observed and predicted surface runoff in K Plot

and was similarly calculated in the model outputs. The descriptive relationship between observed and predicted surface runoff data was evaluated graphically in Figure 3 (R^2=0.35). Figure 3 shows that data are distributed both below and above the 1:1 line. Yair & Raz-Yassif (2004), assessed surface runoff resulting from low precipitation in arid and semi-arid regions under conservative tillage practices. This study calculated predicted values exceeding observed values.

This study showed that the model under predicted the surface runoff compared to observed values.

Observed and predicted surface runoff, soil water and moisture content, precipitation characteristics such as the amount and intensity of individual precipitations as well as maximum and minimum temperature are major factors affecting the surface runoff (Tuset et al., 2016).Temperature in the WEPP Hillslope model, is used to estimate freeze and snowfall. The infiltration capacity of soil has a direct effect on surface runoff especially if the soil is frozen or on the other hand when ridges are formed by ploughing perpendicular to the slope, which may slow down surface runoff and accelerate infiltration (Schmengler, 2011). Studies reveal that tillage perpendicular to slope alters many soil properties, primarily the surface roughness. In models such as the WEPP Hillslope model focus on surface roughness and presumed that a high level of surface roughness would induce reduction in surface runoff and soil loss. Soil depressions and ridges reduce the magnitude of the surface runoff, and slow down conveyance and relocation of soil particles (Darboux et al., 2004).

In plot C where conventional tillage is used to cultivate wheat, tobacco and lentils, observed and predicted surface runoff is 1.67 and 3.97 mm respectively. In observed data showed 21 years, the model estimated 46 separate events, while some days without surface runoff (Fig. 4). R^2 correlation between observed and predicted event-based surface runoffs data of 0.46. Data for plot C ranges between 0 and 1 mm, suggesting that the model simulated greater than the observed value (Fig. 4). The data are distributed above the 1:1 within the 0-1 mm range. Higher surface runoff compared to the observed value is primarily due to crop rotation. In the study, a crop rotation involving winter wheat, tobacco and lentil was examined. During wet seasons, the surface was left uncovered, then ploughed at the end of the winter for planting of winter wheat. This method allowed suitable conditions for surface runoff. In June, two months after the wheat is harvested, the soil is tilled again for September, and the plots are left bare of vegetation. One of WEPP's primary drivers of soil loss and runoff is cover percent and storm event. Because this plot was left fallow for the rainy season, WEPP may have over predicted the surface runoff.

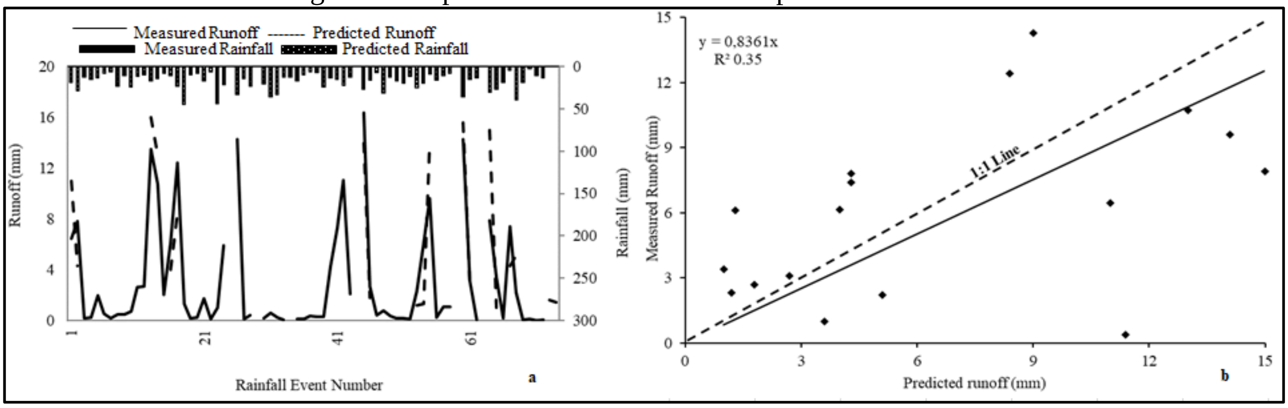

Figure 3. Graphical representation of the relationship between observed and predicted surface runoff in P Plot

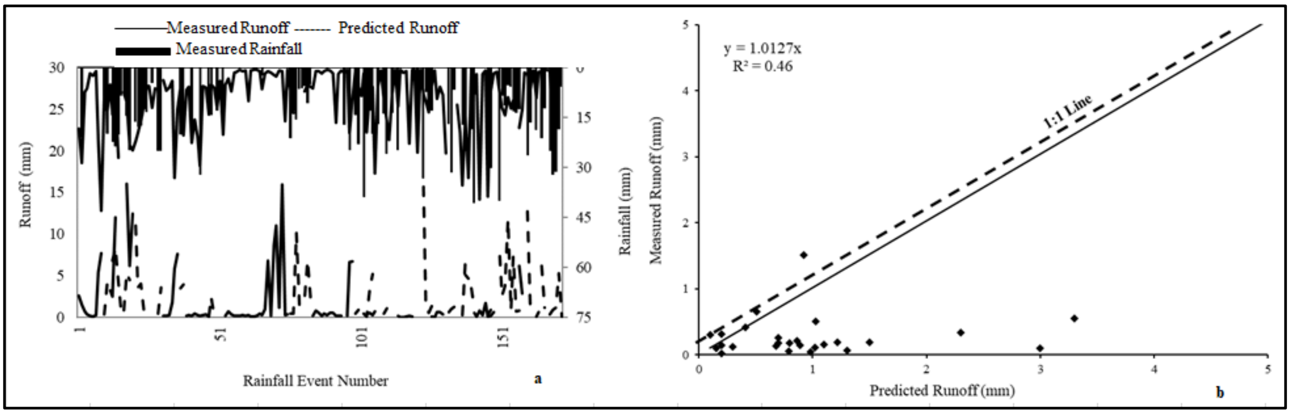

Figure 4. Graphical representation of the relationship between observed and predicted surface runoff in C Plot

Wei et al., (2014), assessed surface runoff and soil loss in an agricultural area where wheat and peas were cultivated. They reported that wheat + sea buckthorn, wheat + contour ploughing, wheat + minimum tillage, and wheat + downward slope reduced surface runoff and soil loss. Jakab et al. (2013), investigated the effect of tillage on surface runoff and soil loss for event-based precipitation. For event-based precipitation under conditions of seed bed preparation; infiltration rate decreased by 36% with an increase of 5% in surface runoff and 13% in soil loss.

The relationship between observed and predicted event-based surface runoff data was statistically assessed and the results are presented in Table 2. According to the student's t test, since t-calculated< t-critical, relationship between observed and predicted surface runoff data is insignificant ($p>0.05$). RMSE value is 1.13, and E_{NS} is 0.87 (Table 2).

4.2. Soil Loss

The relationship between observed and predicted event-based soil losses in plots K, P and C between 1975 and 1995 is given in Figure 5, Figure 6 and Figure 7. In plot K, the model under predicted the number of individual soil loss events (92 versus 121). Overall the observed soil loss generated 0.09 kgm^{-2}, while the simulation predicted 0.29 kgm^{-2}. The model failed to predict soil loss resulting from precipitation greater than 20 mm, and predicted greater soil loss compared to observed values for precipitations ranging between 15 and 20 mm (Fig. 5). The data has an R^2 value of 0.30.

The P plot model predicted 24 soil loss events versus 67 observed 0.1 kgm^{-2} and a 0.26 kg/m^2, respectively. Event-based soil loss values are zero or close to zero, and the model did not simulate this data (Fig 6). However, the model is quite successful in

Table 1. Statistics of event-based surface runoff data

Statistical Description	SURFACE RUNOFF					
	Plot K		Plot P		Plot C	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
Average runoff (mm)	0.12	0.09	0.13	0.20	0.30	0.30
Standard D.	0.21	0.06	0.25	0.16	0.34	0.32
Skewness	2.79	0.62	2.98	0.68	1.74	0.88
RMSE	3.12		1.89		1.13	
ENS	0.56		0.59		0.87	
t- calculated	0.82		0.19		0.43	
t-critical (two tailed)	2.01		2.36		2.02	

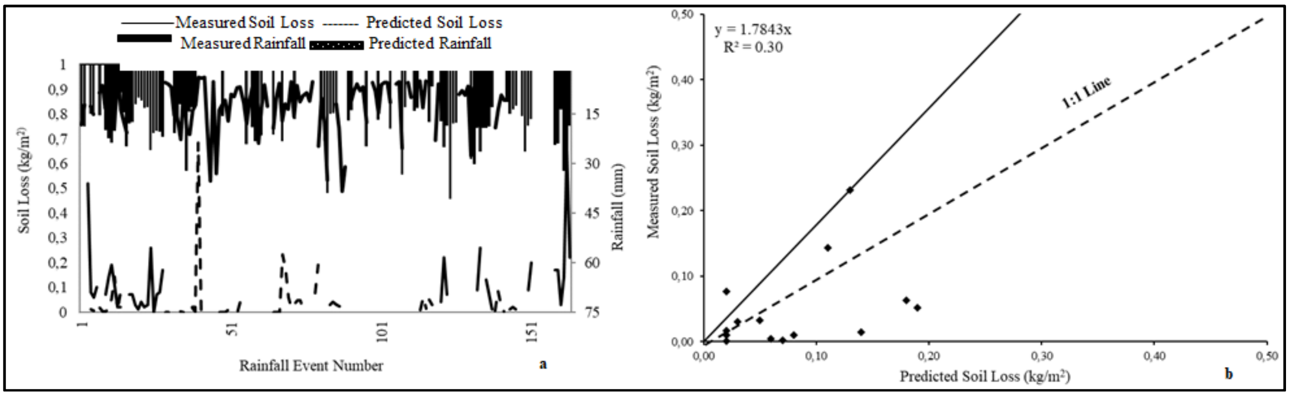

Figure 5. Graphical representation of the relationship between observed and predicted soil loss in K Plot

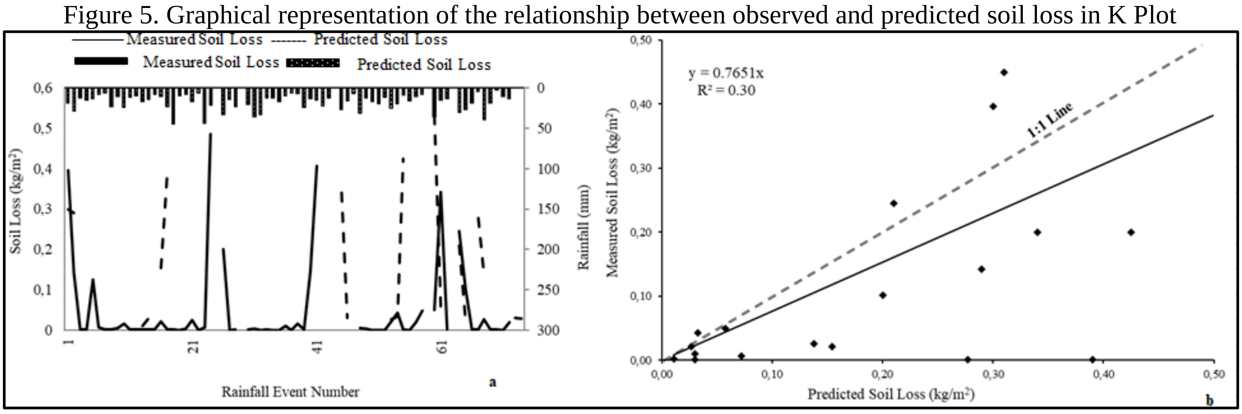

Figure 6. Graphical representation of the relationship between observed and predicted soil loss in P Plot

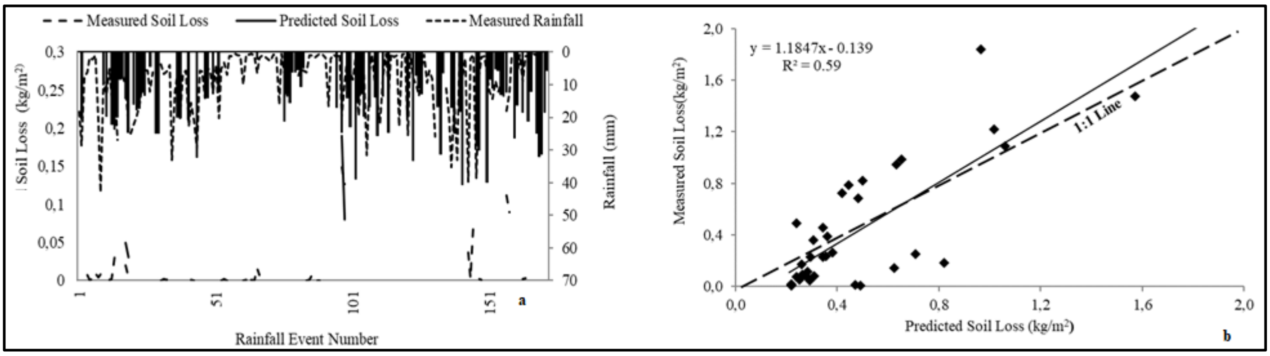

Figure 7. Graphical representation of the relationship between observed and predicted soil loss in C Plot

Table 2. Statistics of event-based soil loss data

Statistical Description	SOIL LOSS					
	Plot K		Plot P		Plot C	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
Average soil loss (kgm^{-2})	0.09	0.11	0.11	0.27	012	0.16
Standard D.	0.22	0.12	0.29	0.45	0.21	0.22
Skewness	3.60	2.56	3.44	3.83	2.17	2.63
RMSE	0.26		0.42		0.21	
E_{NS}	0.04		0.37		0.08	
t- calculated	0.52		0.42		0.00	
t-critical (two tailed)	0.06		0.506		0.620	

predicting soil losses resulting from extreme precipitation. The data are distributed slightly above the 1:1 line with an R^2 value of 0.30.

In plot C, 78 soil loss events were observed, and 14 were predicted with a total loss of 0.06 kgm^{-2} for observed and 0.18 kgm^{-2} for predicted (Fig. 7). Data in Figure 5 shows the relationship of this data are distributed above and below the 1:1 line, with an R^2 of 0.59. In a study for comparing soil loss using WEPP and GeoWEPP, Licciardello et al., (2011) found that WEPP predicted soil loss greater than the observed values.

Erosion is a complex process and is affected by a wide range of parameters. These include precipitation, surface runoff, soil texture and structure, land use, terrain slope and soil conservation methods. Therefore, event-based soil losses can be quite high (Elliot & Hall, 1997). In the simulation, WEPP tends to predict greater amount of soil loss than the observed value. Terrain condition is degraded by ploughing parallel to the slope, and heavy precipitation may accelerate soil loss resulting in rill erosion. Areas where winter wheat is cultivated are arid and semi-arid and are also exposed to high air temperatures (Convertini et al., 1996). Throughout the cultivation season of winter wheat, precipitation occurs during May, August and October and may have erosive effects on exposed soil. The lentil fields, are tilled in May and the crop is harvested in July. Alternatively, tobacco is planted in early May and harvested in early July.

During the winter wheat rotation, the soil is tilled during a precipitation period. Increase in precipitation also occurs during the soybean cultivation season (Zhang, 2005; Guo et al., 2015). On the other hand, seasons with heavy precipitation maybe a period of cultivation and crop covered, resulting in less soil loss compared to both the winter wheat and soybean fields. In their study based on the wheat-fallow-maize-maize crop rotation, (Wischmeier & Smith, 1978) found a decrease in soil loss.

With this site, R^2 values calculated from the model results ranging from 0.30– 0.59 for soil loss (Fig. 7). In Nearing (1998), simulation study based on 6014 event-based soil loss data; Nearing found that the model predicted lower values compared to greater observed values, and greater predicted values compared to lower observed values.

Statistical properties of observed and predicted event-based soil loss data are given in Table 3. Very high skewness coefficients for the observed data is the result of variation in soil characteristics. On the other hand, simulated data show a rather near-normal distribution. Because the model algorithm normalizes the data. The relationship between observed and predicted data is significant according to the students't-test (Table 3). The model's best predictions are based on RMSE and E_{NS} values on Plots P and C, prediction correlations are less on Plot K (Zeleke, 1999).

5. CONCLUSION

In this study, surface runoff and soil loss data were collected under three different crop management scenarios at the Middle Black Sea Transitional Zone Agricultural Research Institute. The observed data was compared with the WEPP Hillslope model.

1) The WEPP Hillslope model predicted event-based surface runoff values in Plots K, P and C greater than the observed values. Routinely, the model tended to predict surface runoff values lower than the observed values. This finding suggests that future modelling work in areas with high subsurface flow could be employed to improve the predictive ability of the models.

2) In our study the measured natural erosion plots erosion rates were very low, and the model were employed to predict low values for runoff and soil loss when the values under tolerable soil loss. The model has been found relatively successful estimation in considerably low soil loss conditions.

3) Both results of surface runoff and soil loss simulations reveal that soil tillage and the specific crop variety can be modelled effectively with the WEPP model. In this instance, tobacco and lentils have a decreasing effect on soil loss, while winter wheat rotation promoted soil loss.

4) According to the surface runoff and soil loss estimates of the WEPP hillslope model, the model successfully implemented the climate conditions of Tokat. By building a climate database with the CLIGEN software, crop variety and agricultural practices for the region can be enhanced.

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