Catena 139 (2016) 99–104

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Different effects of sheep manure conditioner on runoff and soil loss components in eroded soil

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ARTICLE INFO

Article history:
Received 2 June 2015
Received in revised form 4 November 2015
Accepted 20 December 2015
Available online 5 January 2016

Keywords:
Eroded plot
Laboratory conditions
Organic amendment
Rainfall intensity

ABSTRACT

Conservation of the soil surface by organic and inorganic amendments or stabilizers is often adopted to reduce runoff and splash erosion. The manure as an organic amendment is a resource which can be utilized for crop production and soil conservation. However, the effect of manure on mitigating soil erosion on eroded soil has not been yet considered. The present study attempted to determine the efficiency of manure with rate of 0.3 kg m^{-2} in changing the splash erosion, runoff, sediment concentration and soil loss under laboratory conditions. The study has been conducted for a sandy-loam soil taken from summer rangeland, the Alborz Mountains, Northern Iran with simulated rainfall intensities of 30, 50, 70 and 90 mm/h and the slope of 30% in three replicates for each treatment. The obtained data from 36 splash cups showed that the manure could reduce the splash erosion in all studied rainfall intensities and also the maximum reduction occurred in rainfall intensity of 30 mm/h. The results also showed that the manure affected differently in changing splash erosion, runoff and soil loss characteristics. The maximum changing for splash erosion, time to runoff, sediment concentration and soil loss was observed in the rainfall intensities of 30, 50, 90 and 90 mm/h, respectively. The results showed that the time to runoff had more effect in rainfall intensity of 50 mm/h with rate of − 115.95%. The maximum reducing runoff coefficient, sediment concentration and soil loss occurred in rainfall intensity of 50, 90 and 90 mm/h with rates of 8.98, 14.65 and 13.14%, respectively.

1. Introduction

Soil erosion is a global problem that can cause environmental pollution of waterways and loss of soil fertility (Fletcher, 2007), detached particles of soil surface, close the soil porosity leading to reduced infiltration and increasing runoff value. Soil erosion leads to hazardous environmental implications at on-site and off-site scales. These processes, reducing topsoil, plant nutrient depletion and declining crop yields are some of the major on-site effects (Gessesse et al., 2015). When the plant cannot be established, organic amendments can be used to quickly protect the soil surface against the erosive forces of rain and runoff (Smets et al., 2008). Therefore, the manure application as one amendment benefits for soil conservation (Pinamonti and Zorzi, 1996), especially in degraded soils and/or in soils susceptible to erosion. Also, it is an important source of nutrients (N and P) and other elements which could reduce further fertilization costs (Martínez et al., 2004). But the manure should be applied at rates that do not adversely affect the environment (Gilley and Eghball, 1998). Soil conservation can impact an important topic in the 21st century because the soil erosion will increase on agricultural lands to feed an ever-growing global population, especially in developing world parts (Mekonnen et al., 2014). The soil erosion rates are accelerated by tillage and low vegetation cover (Cerdà et al., 2009, 2010). Population increase and a growing demand for agricultural products (Zhao et al., 2013). Amendments can control the runoff and soil loss by protecting the soil surface (Sadeghi et al., 2015). To reduce erosion in degraded soils need the techniques development for remediates the degradation effects (Macci et al., 2013).

Application of organic manure for fertilization purpose has been started a long way back. However, limited studies have been documented for soil and water conservation worldwide. Mitchell and Gunther (1976) studied the effect of liquid swine manure studied on runoff and soil erosion in slopes of three and nine percent. The results showed that the manure application caused a decrease in runoff and also the total solid concentration. Giddens and Barnett (1980) used the effects of the application of poultry litter on runoff and soil loss by using a rainfall simulator in the slope of nine percent and the rainfall simulation of 76.2 mm/h. They found that the poultry litter in southeastern United States is effective in reducing runoff and soil loss. Chandra and De (1982) conducted a laboratory study to measure erosion from soils on which cattle manure had been applied. They found that the soil erosion was reduced on soils where manure had been incorporated. Edwards

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http://dx.doi.org/10.1016/j.catena.2015.12.011
0341-8162/

and Daniel (1993) used poultry litter to control runoff by using rainfall simulation and plot scale. No significant difference in runoff was found between the control and poultry litter treatments. Gilley and Eghball (1998) reported the effect of beef cattle manure on runoff and soil loss in Nebraska for slope of five to nine percent and rainfall intensity of 64 mm/h. The results showed that the runoff and erosion from simulated rainfall were not significantly influenced by the single application of manure. Also, Gilley and Risse (2000) studied influences of the manure rate of 1.1 to 4.5 t/ha in the USA and plot scale on runoff and soil loss. The runoff was reduced from 2 to 62%, and soil loss decreased from 15 to 65% compared to non-manured. Gilley et al. (2001) conducted the manure impacts on interrill erosion in plot scale. Interrill erosion was not influenced by applying of manure immediately before rainfall simulation tests to soils on which manure had been applied in previous years. Gossin et al. (2003) checked the effect of the manure on Nebraska for 0.1 ha plot on changing surface runoff and soil erosion. The results showed that the sediment concentration was high but sediment yield was low because runoff value was reduced. Daverede et al. (2004) studied the liquid swine manure in Illinois at Monmouth and plot scale on runoff and soil loss. They found the injected low rate and high rate liquid manure plots had runoff sediment concentrations 34 and 56% less than the chisel plowed plots without manure. Then Gessel et al. (2004) investigated influence of liquid swine manure on runoff and soil loss in Morris, Minnesota. They found that the runoff and soil loss from plots with liquid swine manure was less than that from plots with manure and they also found that the season of application of manure could affect the results. Martínez et al. (2004) studied the cattle manure on the runoff and sediment concentration in Spain at plot scale with the amount of 3 and 5 t/ha and rainfall intensity of 80 mm/h. The runoff decreased but the sediment concentration was higher in treated plots. Ramos and Martínez-Casasnovas (2006) investigated the effect of cattle manure in Spain at field plots on sediment concentration and time to runoff and volume. They showed that the time to runoff and runoff volume increased and decreased, respectively and also sediment concentration in runoff was lower in treated than in untreated soils. Rees et al. (2011) reported that the application of four tons/hectare of poultry manure in northwestern New Brunswick at plot scale with slopes of 8 to 11% could significantly reduce runoff and soil loss. After reviewing previous researches, the results showed that the existing literatures studied the effectiveness of manure on runoff and erosion values but the researches are limited for these amendments on splash erosion and time to runoff. The present study therefore formulated to assess the effects of application of sheep manure (1) time to runoff and volume (2) sediment concentration and (3) sediment yield in plot scale, for a sandy-loam soil taken from summer rangeland in the Alborz Mountains, Northern Iran. The study was taken place under laboratory conditions with simulated rainfall intensities of 30, 50, 70 and 90 mm/h and the slope of 30%.

2. Materials and methods

2.1. Laboratory condition and treatment

The laboratory experiments were conducted using three 6 × 1 m erosion plots with the depth of 0.5 m and the slope of 30% installed in the Faculty of Natural Resources of Tarbiat Modares University (TMU), Iran. In this study, nine splash cups were used for measuring splash erosion (three splash cups in each plot) (Khaledi Darvishan et al., 2014). The time to runoff and runoff volume, sediment concentration and soil loss were also measured from 6 m^2-plot. Each run was conducted using new soil and manure (Gilley and Risse, 2000; Gilley et al., 2001; Gossin et al., 2003). A general view of the componential plots and splash cups has been shown in Fig. 1. The manure with balk density of 0.3 kg m^2 was manually spread (Ramos et al., 2006; Rasoulzadehm and Yaghoubi, 2010) with 3 replications (Nyamangara et al., 2001).

A sandy-loam soil was collected from the top layer of 0–20 cm (Kukal and Sarkar, 2010; Khaledi Darvishan et al., 2014) of summer rangeland, the Alborz Mountains, Northern Iran. The pebbles and plant residues were removed from the soil through passing from 8 mm sieve to obtain maximum similarity with soil natural conditions (Defersha et al., 2011; Khaledi Darvishan et al., 2014).

The mineral pumice grains with total thickness of 15 cm were used as a filter layer at the bottom of the plots in order to simulate natural drainage condition and decreasing plot weight (Defersha et al., 2011; Khaledi Darvishan et al., 2014). Then, the soil was placed on the filter layer and was ultimately compacted by PVC roller filled with cement and sand to achieve the bulk density of 1.376 g cm^{-3} almost equal to that measured for the soil under natural conditions (Romkens et al., 2001; Khaledi Darvishan et al., 2014). The moisture content, pH, EC and organic matter were 29%, 7.95, 75.5 μmohs/cm and 2.167%, respectively.

The rainfall intensities of 30, 50, 70 and 90 mm/h were then selected based on analysis made for data collected from the nearest synoptic station (Kojour) with the return period less than 20 years (Khaledi Darvishan et al., 2014). The samples were measured before (as control

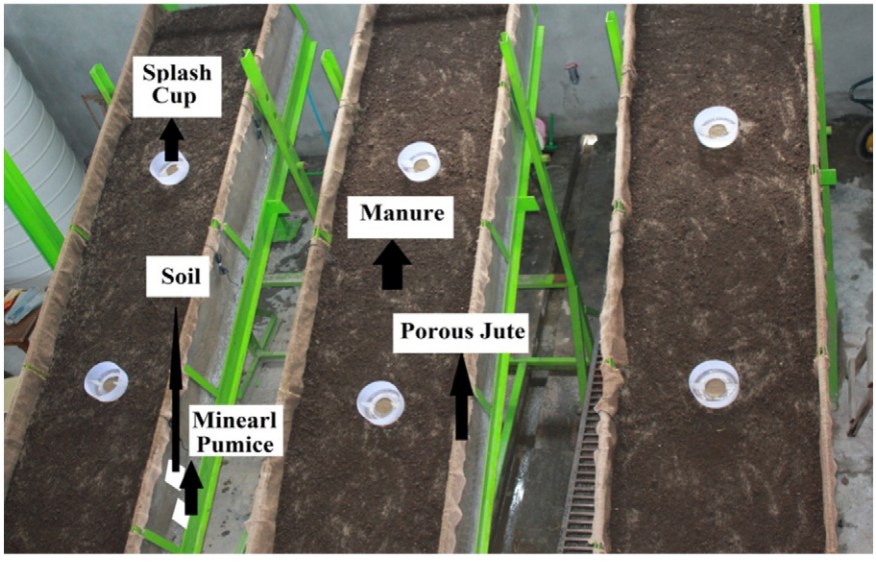

Fig. 1. A View of treated plots with sheep manure under laboratory condition at rainfall simulation and soil erosion laboratory, Tarbiat Modares University, Iran.