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Effects of different tillage practices and cropping systems on soil loss and in - situ water conservation in Clay loam of Assosa, Ethiopia

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Abstract: Soil erosion is a global environmental crisis in the world today that threatens natural environment and also the agriculture where it can be mentioned as more serious in Ethiopia. Thus, site specific soil and water conservation measures study that can easily attain both agricultural and environmental sustainability had been carried out at Assosa. A field experiment was conducted under natural rainfall conditions to investigate the effects of farming systems (soil tillage and cropping systems) on runoff, soil loss on Nitisol of Assosa area, western Ethiopia. Eighteen experimental runoff plots of 8 m long and 3 m wide each were framed with corrugated iron sheets. The experimental design used was randomized complete block design (RCBD) with six treatment in factorial combinations vis-à-vis three cropping systems (sole maize, sole soya bean and intercropping of maize with soya bean), with tillage system (no tillage and convectional tillage), that were replicated three times. The results revealed non-significant variation among the treatments regarding their effect on runoff depth, soil loss, sediment concentration, in situ water conservation. No tillage had reduced sediment concentration per litre of runoff by (3.26 g/L, 3.13 g/L and 4.37 g/L), total runoff volume (by 0.06m3, 0.03m3and 0.06m3per plot and soil loss per hectare by (507 kg/ha, 1300.4 kg/ha and 897.3 kg/ha) as compared to conventional tillage with intercropping, sole maize and sole soya bean cropping systems respectively. Also, No tillage had increased in situ-water retention by 18 mm, 21.3 mm and 14.63 mm per plot as compared to conventional tillage for maize, soya bean and maize-soya bean intercropping systems respectively. Totally, the study ratified the key importance of no tillage for both soil and water conservation than conventional tillage.

Key words: soil loss, runoff, sediment concentrati

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1. INTRODUCTION

Soil erosion is one of the biggest environmental problems that threaten agriculture in Africa and other parts of the world (Eswaran *et al.,* 2001). The problem is becoming increasingly more alarming in developing countries like Ethiopia where majority of the population are dependent on agriculture. According to El-Swaify and Hurni (1996), the Ethiopian highlands with 46% of the total land area and over 95% of the regularly cropped land, constitute one of the most degraded lands in Africa.

The average rate of soil erosion from cultivated land in Ethiopia has been estimated to be 42 tons ha^{-1} yr^{-1} (Hurni, 1990; Nebel and Wright, 1993), which is by far in excess of the mean annual soil loss tolerance value of 5 to 11 tons ha^{-1} which is generally accepted as permissible rate of soil erosion (Montgomery, 2007) though this value can be as low as 2 tons ha^{-1} for particularly sensitive areas where soils are thin or highly erodible (Hudson, 1995). In addition to accelerated soil erosion and the alarming rate of land degradation, the loss of nutrients with sediments and runoff coupled with low external input of chemical fertilizer is the fundamental cause of low productivity in Ethiopia.

Beside soil losses, rainwater loss in the form of runoff is an important production constraint. Loss of rainwater as runoff not only limits the water available for crop production but also forms an erosion hazard (Rao et al., 1998; Nyssen *et al*., 2005). Thus, knowledge of rainfall, runoff, and soil loss, and their relationships as well as variation in time and space are very important for soil and water management such as designing soil and water conservation and water harvesting structures (Sharman *et al*., 2001).

Runoff studies can also produce useful information on the water-yield capabilities of different land uses and help to determine the proportion of rainfall that reaches the rivers as runoff and sediment contributed to water bodies. Keeping other factors constant, runoff and soil loss from a given catchment vary depending on the type of land uses (Singh, 1999; Gebresamuel *et al*., 2010). This is because different land uses have different ground cover and root system which affects runoff generated under such land uses. Very limited studies have been conducted on runoff and soil loss as well as rainfall-runoff- soil loss relationships under different land uses in Ethiopia.

Thus, there is an urgent need to evaluate technologies at hand and introduce the promising ones in order to manage the fragile soil of dry areas in sustainable manner. It is, therefore, important to develop a package of technology for cropping pattern and soil management practices in accordance with rainfall pattern and soil characteristics under local conditions for obtaining an increase in yield and reduction in soil and water losses. It is also necessary to provide data for erosion modeling and simulation to prevent soil physical and chemical degradation. In this study an attempt was made to assess soil losses and the effect of these soil losses on soil physico-chemical properties under different tillage practices with mono-cropping and inter-cropping to understand the relationship between soil erosion and soil physico-chemical properties and generate data for development of soil and moisture conservation techniques.

Therefore, the aim of this study was to examine the effects of different tillage practices and cropping systems on soil and water loss, in situ water conservation and relationship of rainfall with runoff and soil loss focusing on the dominant cereal and oil crop of Assosa, Benishangul gumuz. This may provide farmers and other land users the information on the desirability of a conservation tillage system for sustainable crop yield increases with minimal negative impact on the soil and the environment.

2. MATERIAL AND METHODS

2.1. Description of the Study Area

The study was conducted at the Assosa Agricultural Research Center (ASARC), which is located in Assosa District at Benishangul-Gumuz Regional State (BGRS). The ASARC is located in the western part of Ethiopia from 10º 01' 25'' to 10º 02' 50'' north latitude and from 34º 33' 50'' to 34º 34' 35'' east longitude. The study area covers a total land area of 202.5 ha with geologyof Tarmabe basalt, sometimes porphyritic of the Miocene to Pliocene period (Tefera *et al.* (1996). The Assosa District is characterized by hot to warm moist lowland plain with uni-modal rainfall pattern. The rainy season starts at the early May and lasts at the end of October with maximum rainfall in the months of June, July, and August. The total annual average (2000-2007) rainfall is 1316 mm. The annual mean minimum and mean maximum temperatures of the District for the periods from 2000 to 2008 were 16.75 and 27.92 ^{O}C, respectively. The soil type of the study area was characterized as Nitisol.

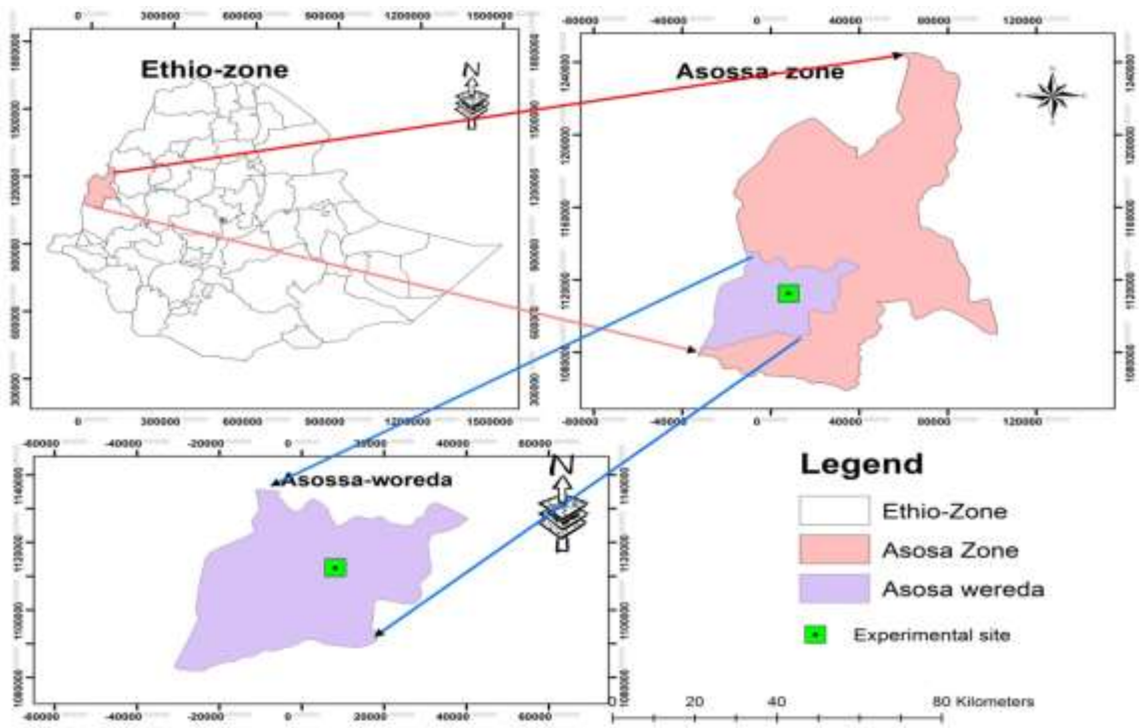
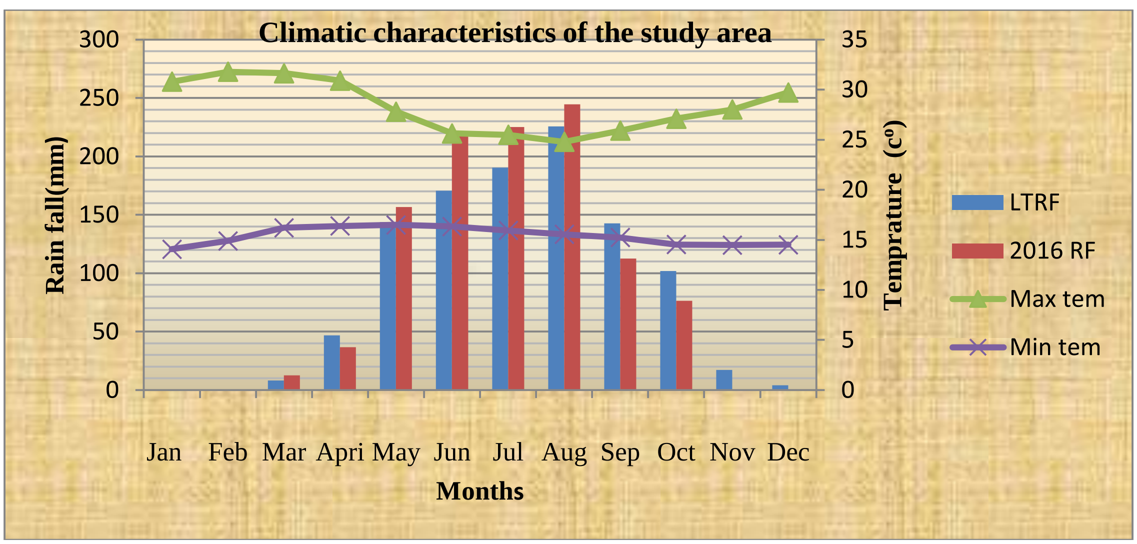


Figure 1: Location map of experimental site



LTRF= Long term rainfall, Max tem= maximum temperature, Min tem= minimum temperature, rf = rain fall

Figure.2: Long term (1983-2016) average rainfall and temperature and one year (2016) rainfall of Assosa Agricultural Research Center (1983 -2016)

2.2. Experimental Set up

The experiment had 6 treatments combinations and three replications with the total experimental plots of 18. The experimental plots were applied to runoff plots of 3m x 8m dimension that was laid out by completely randomized block design (RCBD) in factorial combination. The treatments were:

1. T1: Conventional tillage (the farmers local tillage practice to sow maize) + sole crop (maize)

2. T2: No tillage (tilling the place where to put the seed only, (2.5 t/ha)) + sole crop (maize)

3. T3: Conventional tillage (the farmers local tillage practice for both test crops) + Intercropping (maize +soybean)
4. T4: No tillage (tilling the place where to put the seed only, (2.5 t/ha) + Intercropping (maize +soybean)
5. T5: Conventional tillage (the farmers local tillage practice to sow soya bean was used) + sole soybean)
6. T6: No tillage (tilling the place where to put the seed only, (2.5t/ha)) + sole crop (soybean)

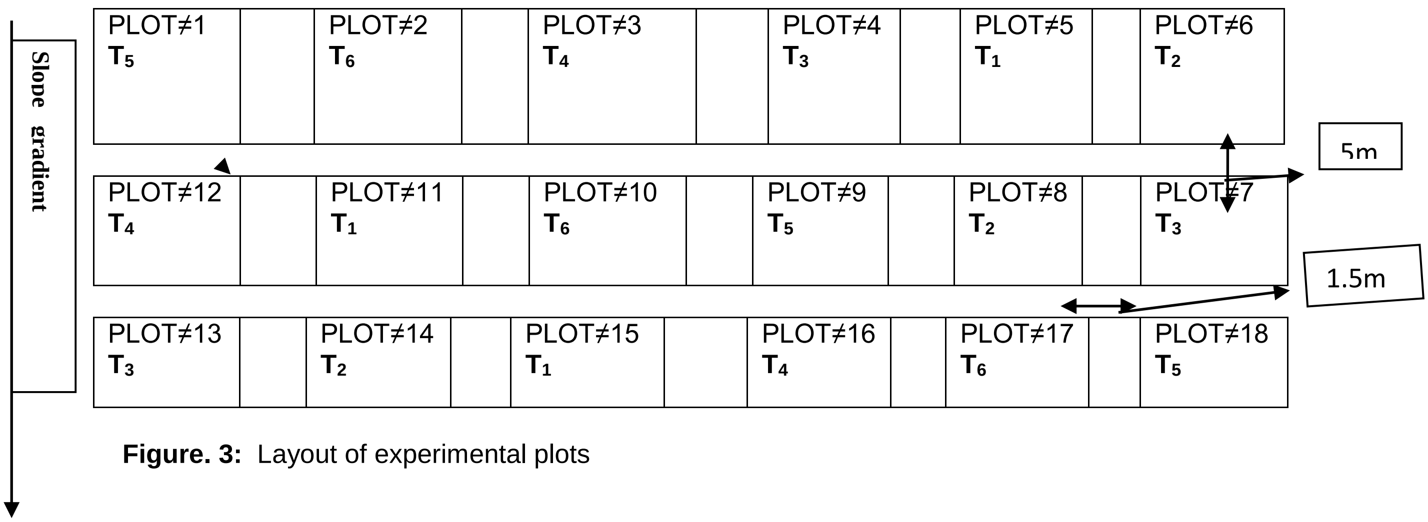


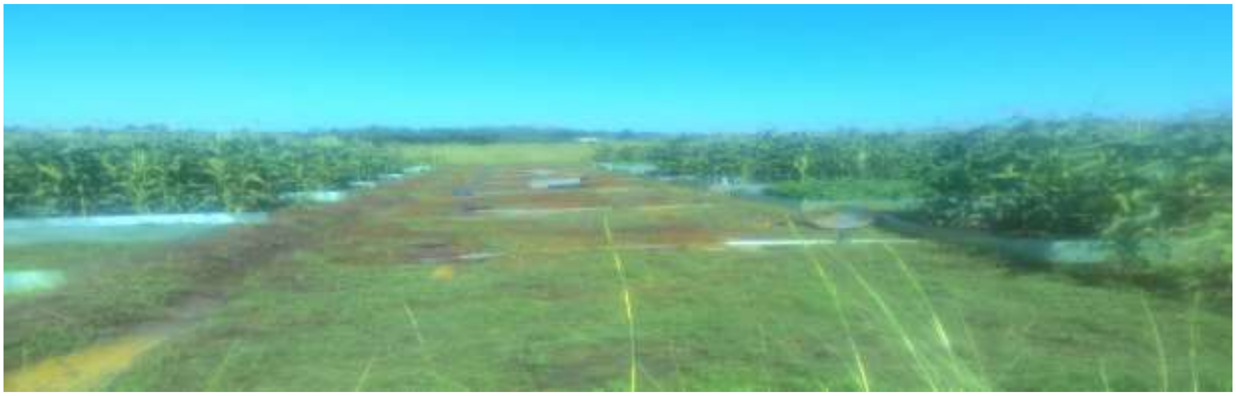
Figure. 3: Layout of experimental plots

2.3. Test plots Arrangement and Management Techniques

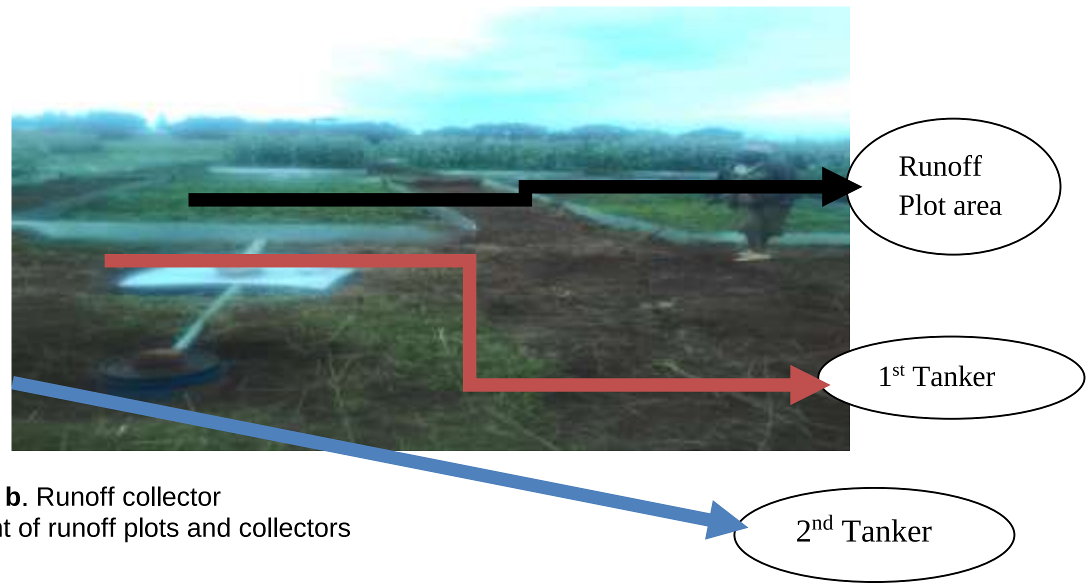
The study was carried out by using RCBD in factorial combination with different surface management practices and cropping system as the experimental factors on 7% slope of land. It had 6 treatment combinations with three replications. There were two tillage practices (no tillage along with 5tonnes of soya bean straw mulch, conventional tillage (the farmers local practice for the test crop) and three cropping system (sole maize, sole soya bean, and intercropping of maize and soya bean). Blanket recommendation of fertilizer of the area was added to both test crops (46 kg/ha P_2O_5&18 kg/ha N for soya bean & 92 kg/ha N & 46 kg/ha P_2O_5 for maize). The study was carried out in hydrologically isolated experimental runoff plots of 3m x 8m.

The inter and intra spacing of maize and soya bean for the area was 75cm x 30cm and 40cm x 5cm respectively. The total rows for sole maize and sole soya bean were 9 and 17 rows respectively, whereas the total rows for intercropping were 9 and 8 rows for maize and soya bean respectively. The total harvestable rows for sole maize and sole soya bean were 7 and 10 rows, whereas, 7 and 7 rows for intercropping of maize and soya bean respectively. The total number of plants in sole maize and sole soya bean were 72 and 1020 plants and in intercropping the number of maize and soya bean were 72 and 480.

The tillage operation used was oxen plow (Maresha) for conventional tillage practice of all cropping systems to a depth of 15 cm (triple passes) for maize and 12 cm (double passes) for soya bean, whereas pickaxe was used for all no tillage treatments at sowing for maize to a depth of 10 cm and hoe for soya bean to a depth of 7 cm. The tillage frequency used for soya bean and maize were two and three times as the farmer's local practice of the area for conventional tillage. Hand hoeing was used for weeding for all treatments.



a. Overview of runoff plots



b. Runoff collector

Figure 4. Establishment of runoff plots and collectors

The test plots had a dimension of 3m wide and 8m long each with the spacing of 1.5m between plots and 5m between replications with the total dimension 25.5m width and 39m long. The plots were bounded by corrugated iron sheets on three sides that were inserted 15 cm into the ground with 15 cm high above the surface and provided with the tank at the fourth and lower side for the collection of runoff and sediments. Runoff and soil loss were collected in two tanks at the lower end of the plot through an inlet tube of 50 mm plastic pipe diameter. The first tank (A) accommodate most of the sediment and small runoff coming from the plot where as the second tank (B) collected possible over-flow from the first tank. To determine the total runoff, the water volume collected in the first tanks and the second tanker (multiplying by three) during the runoff - emptying period was directly measured (SCRP, 2000).

The duration of a collecting tank-emptying period depends on the amount of rainfall and runoff. The SCRP test plot tanks were emptied and soil loss and runoff were recorded if: recent rainfall exceeds 12.5 mm, or runoff is higher than 2.4 mm (indicated by a water level of 25 cm in the tanks). If either of these preconditions is not fulfilled, tank emptying was not performed even if there was runoff (Gete, 2000). Sometimes in the night time, rainstorms could not be separately recorded if there was another rainstorm the next morning. Thus, one recording of runoff might incorporate several rainstorms, a so called emptying period, which is the shortest common time span for recording and analysis. One period encompassed at least one storm, and during the rainy seasons often a couple of storms. One emptying period equaled one record in the database. The accuracy of plot runoff values, as the result of a range of systematic and random data errors, parameter estimation errors, and model errors, was investigated by Herwege and Ostrowski (1997). For single emptying period and annual data, the accuracy of runoff ranged from 2 to 5% and 0.1%, respectively.

Meteorological parameters like precipitation, maximum and minimum temperature were collected from the meteorological station of Assosa Agricultural Research Center which was found in the vicinity of the experimental site. Precipitation is much more important than the other metrological parameters because rainfall has a direct relation with runoff and sediment generation from the experimental plots.

2.4. Runoff and Sediment Loss

Total volume of daily runoff from each plot was measured in the collecting tanks after each rainstorm event. The runoff depth was calculated by dividing the total runoff volume collected in a tank by the plot area. The contents of the tanks were vigorously stirred with a wooden stick to ensure a uniform distribution of sediment throughout the depth of water in the collecting tank. Immediately after stirring, 1L (one litre) capacity graduated jar were immersed to a substantial depth beneath the surface of water in the collecting tank and 1L sample of water-sediment mixture was taken in pre-washed 1L bottles from each collecting tank.

Whenever overflow occurred from the collecting tank, the volume of runoff in the second collecting tank was multiplied by a factor of three to obtain the total volume of overflow from the first tank drilled at the same height assuming equal out flow from the first height and one from the three was allowed to enter the second tanker. The runoff samples were taken to soil laboratory and transferred to beakers and allowed to stand for 72 hr until the sediments completely settled (Tang *et al.,* 1993). The clear water was then carefully decanted and the weight of wet sediment per litre of runoff was measured, air dried and kept for further physicochemical analysis except that 2 to 5g of wet sediments was oven dried at 105°C for 24 hr for the determination of moisture correction factor (mcf). Dry sediment concentration per litre of runoff was determined as:

$$Sc = Mw / Mcf \quad (1)$$

where, Sc is the Sediment concentration (g/L); Mw is the mass of wet sediment (g/L); Mcf is the moisture correction factor given as:

$$Mcf = (100 + Mc)/100 \quad (2)$$

where, Mc is the moisture content of sediment (%). The product of the sediment concentration and the total runoff per plot per day was used to determine the daily sediment loss as:

$$SL = (Sc*Ro) / 1000 \quad (3)$$

where, SL is the daily sediment loss (kg/ ha); Sc is the sediment concentration (g/L) and Ro is the daily runoff (L/ha). Finally, the daily sediment losses were summed up to give seasonal soil loss values.

2.5 In-situ water conservation

The total depth of rainwater that was retained in-situ under each of the treatments was determined on the basis of runoff producing rainfall and runoff depth as:

$$Wc = RF - Ro \quad (4)$$

Where, WC= depth of water that was retained in the soil in-situ (mm)
RF= rainfall depth (mm)
Ro= runoff depth (mm)
Finally, the daily values of retained rainwater will be summed up to get seasonal values

2.6. Data analysis

All measured parameter were subjected to statistics' version 8 and treatment means was compared using the least significant difference at the 5% probability level (LSD0.05) where the variance ratio for treatment effects shows significance. A simple correlation and regression analysis was employed to test the relationship between rainfall and runoff, rainfall and sediment loss, runoff and nutrient loss, and soil and associated nutrient loss using Pearson correlation coefficient and Microsoft excel 2007.

3. RESULT AND DISCUSSION

3.1. Sediment Concentration, Runoff Volume, Soil Loss, and In-situ Water Conservation

Analysis of variance revealed that both cropping systems and tillage practices had shown non-significant difference for Sediment Concentration, Runoff Volume, In-situ Water Conservation and significant for soil loss ($p<0.05$) with LSD means of comparison. Even though, there was no significant difference among treatments, the highest values of sediment concentration and soil loss for both conventional and no tillage treatments with the descending order for sole maize, sole soya bean, and intercropping cropping systems, whereas the vice versa for in situ water conservation, showing the more effectiveness of no tillage with intercropping than other treatments for both soil and water conservation. Here the study in detail reveals the effect of cropping system on both soil loss and runoff reduction showing the special effect of tillage practice for all the above parameters.

Table 1. Interaction effect of tillage and cropping systems on Sediment concentration, Runoff volume, Soil loss, and In-situ Water Conservation

Treatments	Sc (g/L/plot)	Ro(m3/plot)	SL (Kg/ha)	In-Wc (mm/plot)
Conventional tillage with maize (T1)	19.26	0.27	2404.7[a]	164.67
Conventional tillage with soya bean (T5)	18.43	0.28	1775.3[b]	167.00
Conventional tillage with intercropping (T3)	18.2	0.27	1354.7[c]	173.67
Minimum tillage with maize (T2)	16	0.24	1104.3[cd]	182.67
Minimum tillage with soya bean (T6)	15.3	0.22	878.0[d]	188
Minimum tillage with intercropping (T4)	13.83	0.21	847.7[d]	188.3
Lsd (0.05)	ns	ns	327.41	ns
Cv (%)	6.24	10.47	12.91	3.25

Sc: sediment concentration, Ro: runoff volume, Sl: soil loss, IN-wc; in situ water conservation

3.3.1 Sediment concentration

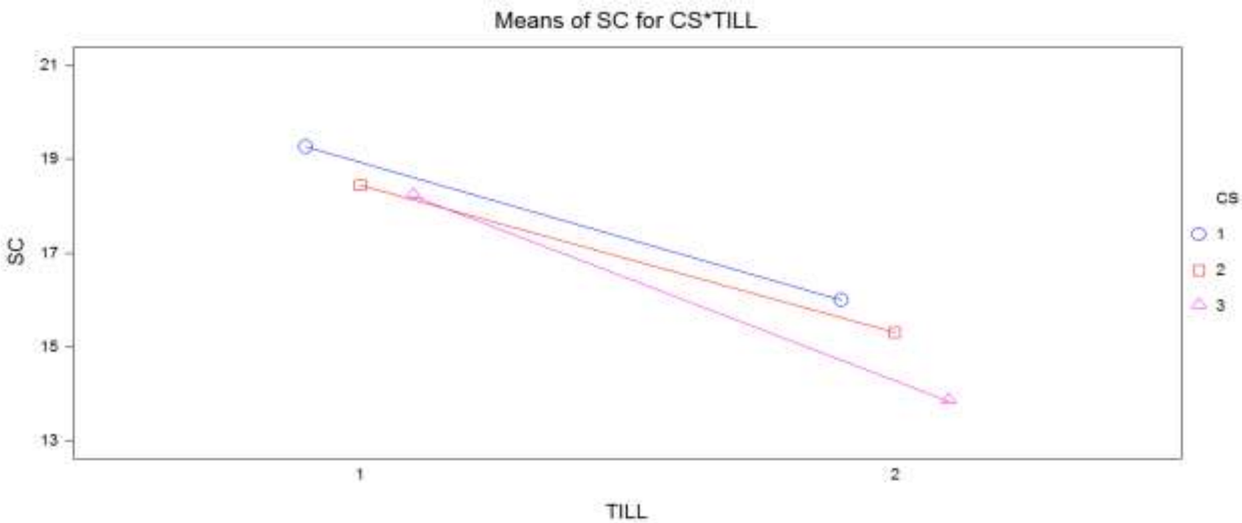
The analysis of variance revealed non-significant variation due to the interaction effect of tillage and cropping systems on sediment concentration and significant variation due to independent effect of the factors. Independent effect of tillage and cropping systems resulted in significant variation ($p<0.0001$) as mentioned on (Table 2) showing less sediment concentration for no tillage as compared to conventional tillage. No tillage had reduced the sediment concentration by 19.23% (3.59 g/L) as compared to conventional tillage. This study also revealed the impact of cropping system on sediment concentration showing less sediment concentration for intercropping as followed by soya bean and maize. Intercropping had also reduced sediment concentration by 9.15% (1.63 g/L) and 5% (0.77g/L) in relative to sole maize and soya bean respectively (Table 2).

Table 2: Independent effect of tillage types and cropping systems on sediment concentration

Factors of variation	Parameter
	Sediment concentration (g/L)
Tillage types	
No tillage	15.04 [b]
Conventional tillage	18.63 [a]
LSD (0.05)	1.104
Cropping systems	
Sole maize	17.63 [a]
Sole soya bean	16.86[ab]
Intercropping	16.017[b]
LSD (0.05)	1.35

Interaction effect of the factors showed non-significant variations among treatments and showing the great importance of no tillage with intercropping in reducing the amount of sediments in runoff due to its canopy cover, mulch and tillage with its high sediment filtering capacity. Even though there is no significant difference among treatments statistically, no tillage with mulch had reduced the sediment concentration per litre of runoff by 16.92% (3.13 g/L), 16.98% (4.37 g/L) and 24.01% (3.36 g/L) as compared to conventional tillage for intercropping, maize and soya bean cropping systems respectively (Table 1). The more the canopy cover and

residues, the less sediment load in runoff generated from agricultural land hence more time was given for the runoff to infiltrate and the sediment to be retained.
Under intercropped and mulched land, runoff velocity decrease then only the clear water flow out from the land. Thus as the result reveals, increasing the frequency of tillage is the main cause for increasing the amount of sediment in runoff. The reason behind this is that the more the land is tilled, the more fine is the seed bed which makes it more susceptible for water erosion. This study in lines with Blanco and Lal, 2008 and Gebresamuel et *al*., 2010, who ratified the ability of surface cover to neutralizes the impact and erosive energies of raindrops and resulting to slow down runoff velocity, thereby filter soil particles in runoff.



Sc: sediment concentration, cs: cropping system, Till: Tillage, 1 CS- Sole maize, 2 CS- Sole soya bean, 3CS- intercropping & 1 TILL- convectional tillage, 2 TILL-no tillage

Figure 4: Mean of sediment concentration in g/L for interaction of cropping system and tillage practice

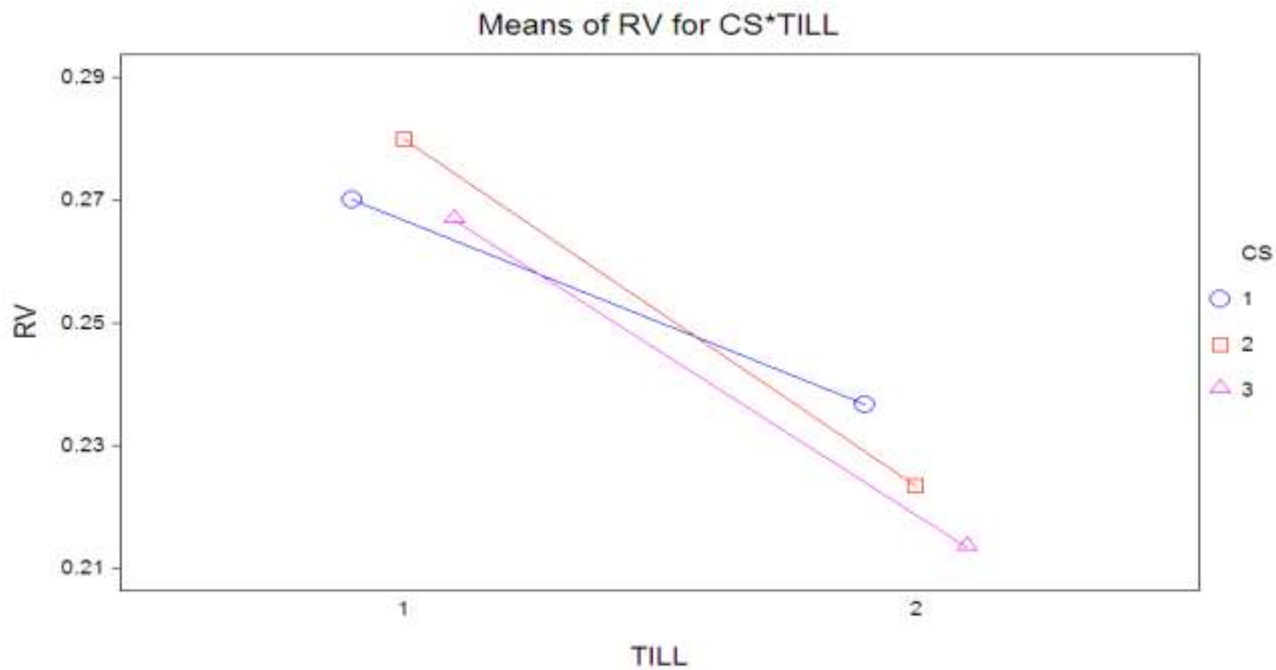
3.3.2 Runoff volume

The analysis of variance revealed non-significant variation due to the interaction effect of tillage and cropping systems on runoff volume and significant variation due to tillage practices. Independent effect of tillage resulted in significant variation ($p<0.0001$) as mentioned on (Table 3) showing less runoff volume for no tillage as compared to conventional tillage. No tillage had reduced runoff volume by 15.2 % (0.04m^3) as compared to conventional tillage whereas, cropping systems didn't show significant variation on runoff volume but showing the more advantage of intercropping of reducing runoff volume by 5.54 % (0.013m^3)and 4.87 % (0.0016m^3)than sole maize and soya bean (Table 3).

Table 3. Independent effect of tillage types and cropping systems on runoff volume (m^3)

Factors of variation	**Parameter**
	Run off volume (m^3)
Tillage types	
No tillage	0.23^b
Conventional tillage	0.27^a
LSD (0.05)	0.027
Cropping systems	
Sole maize	0.2533
Sole soya bean	0.2517
Intercropping	0.24
LSD (0.05)	

Interaction effect of tillage and cropping system didn't show significant variation among treatments. No tillage with mulch decreased the total runoff volume by 12.33% (0.06m^3) , 20.25% (0.03m^3) and 20.02% (0.06m^3) as compared to conventional tillage treatments for maize, soya bean and maize-soya bean intercropping systems respectively (Table 1). As the result shows, effect of tillage and residue management on soil hydraulic conductivity, infiltration is generally higher in zero tillage with residue retention as compared to conventional tillage due to the direct and indirect effect of residue cover on water infiltration. In addition, the residues left on the topsoil with zero tillage and crop retention act as a succession of barriers, reducing the runoff velocity and giving the water more time to infiltrate and then reduce the runoff volume. The corollary of the higher infiltration with residue and canopy cover is a concomitant reduction in runoff which inlines the study (Rao *et al.* 1998, Rhoton *et al.* 2002, Silburn and Glanville 2002).



RV: runoff volume, cs: cropping system, 1 CS- Sole maize, 2 CS- Sole soyabean, 3CS- intercropping & 1 TILL- convectional tillage e, 2 TILL-no tillage

Figure 5: Mean of Runoff volume in m^3 for interaction of cropping system and tillage practice

3.3.3 Soil loss

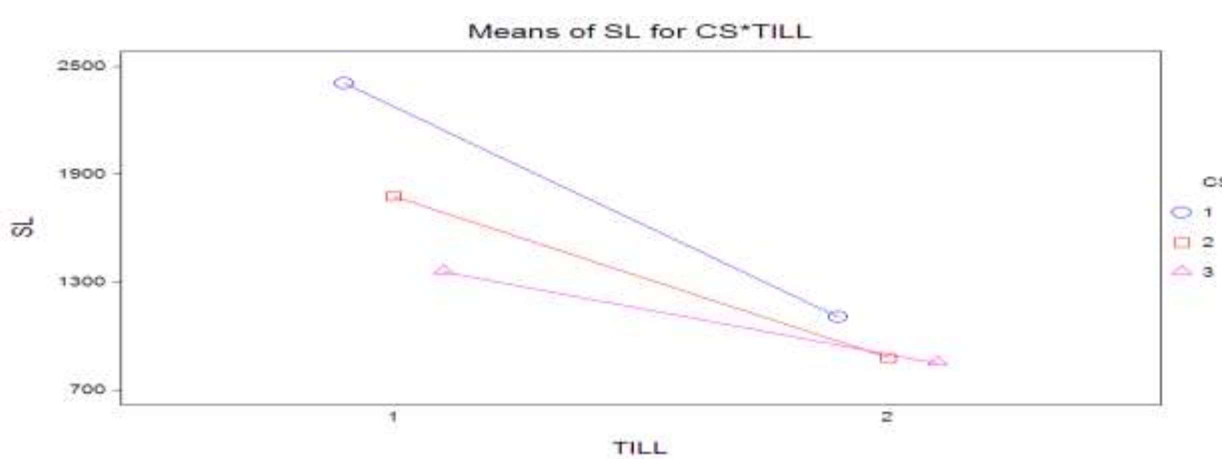
The analysis of variance revealed that the amount of soil loss from each treatment varied significantly for both interaction and independent effect ($p<0.0001$). Independent effect of tillage and cropping systems resulted in significant variation showing less soil loss for no tillage as compared to conventional tillage. No tillage had reduced the soil loss by 51.1 % (901 kg/ha) as compared to conventional tillage. This study also revealed the impact of cropping system on soil loss showing less soil loss for intercropping as followed by soya bean and maize (Table 11). Intercropping had also reduced soil loss by 37.23% (653.3 kg/ha) and 17% (225.5kg/ha) as compared to sole maize and soya bean respectively (Table 4).

Table 4. Independent effect of tillage types and cropping systems on soil loss (Kg/ha)

Factors of variation	Parameter
	Soil loss (Kg/ha)
Tillage types	
No tillage	943.3[b]
Conventional tillage	1844.9[a]
LSD (0.05)	189.03
Cropping systems	
Sole maize	1754.5[a]
Sole soya bean	1326.7[b]
Intercropping	1101.2 [b]
LSD (0.05)	231.52

Interaction effect of the factors had also showed significant variations ($p<0.0001$) among treatments and showing the great importance of no tillage with intercropping in reducing the amount of soil lost in runoff due to its canopy cover, mulch and tillage with its high sediment filtering capacity. No tillage with mulch treatments had reduced the soil loss by 54.13% (1300.4 kg/ha), 50.54% (897.3 kg/ha) and 37.42% (507 kg/ha) as compared to conventional tillage for maize, soya bean and maize-soya bean intercropping respectively (Table 1). The residues left on zero tillage and crop canopy on the topsoil with zero tillage act as a succession of barriers, and intercepts rainfall and releases it more slowly afterwards then reduce the runoff velocity which plays vital role for reduction of soil loss by settling of soil aggregates. Due to its mulch cover under zero tillage, the soil aggregates were left stable under zero tillage than conventional tillage and then less the soil loss. which coincides with the study of Carter 1992a,Chan *et al*. 2002, Filho *et al*. 2002, Hernanz *et al.* 2002., Pinheiro *et al*. 2004, Li *et al*. 2007,Govaerts *et al*. 2007c, 200, who ratified the more stability of soil aggregates under zero tillage with residue retention as compared to conventional tillage .

As the result shows, intercropping with zero tillage had reduced a lot of soil loss than other treatments due to its canopy cover and mulch which in lines with the study of Elwell 1981, who demonstrated an exponential decrease in soil loss with increasing percentage of interception of rainfall energy by increasing canopy cover. Also, Khisa *et al.* (2002), recorded the highest (3.30 t ha^{-1}) and the lowest (0.35 t ha^{-1}) soil losses from 0.0% and 43.20% crop cover, respectively under maize-mucuna pruriens inter-crop as compared to the pure stand of maize.



SL: soil loss, CS: cropping system, 1 CS- Sole maize, 2 CS- Sole soya bean , 3CS- intercropping & 1 TILL- convectional tillage, 2 TILL-no tillage

Figure 6: Mean of Soil loss in Kg/ha for interaction of cropping system and tillage practice

3.3.4 In-situ water conservation

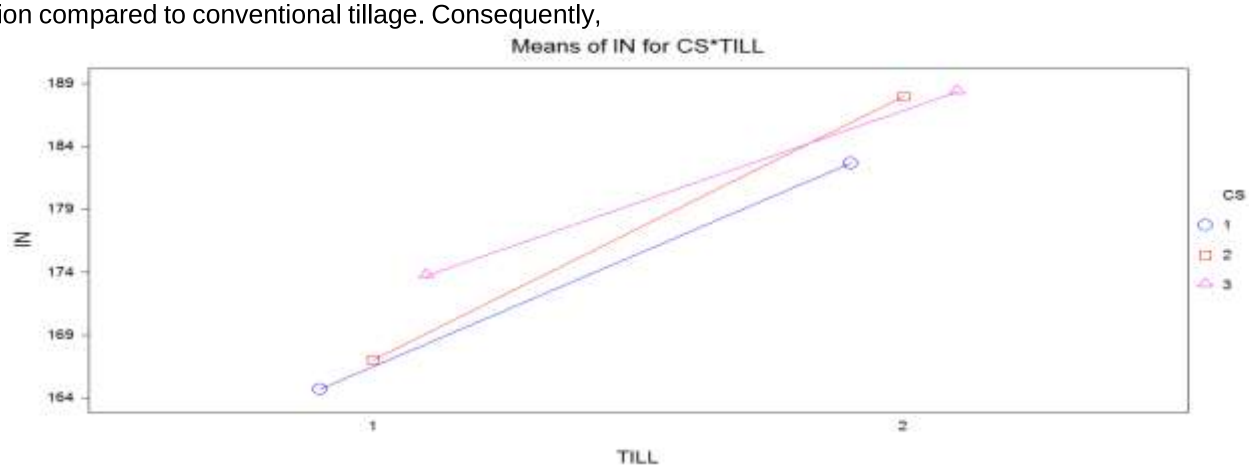
The analysis of variance revealed non-significant variation due to the interaction effect of tillage and cropping systems on in-situ water conservation and significant variation due to tillage practices. Independent effect of tillage resulted in significant variation (p<0.0001) showing high in-situ water conservation for no tillage as compared to conventional tillage. Tillage had a great impact on the amount of in-situ water conservation generated from each treatment. No tillage had increased in-situ water conservation by 9.6% (17.8mm) as compared to conventional tillage whereas, cropping systems didn't show significant variation on in-situ water conservation but showing the more advantage of intercropping of reducing in-situ water conservation by 2% (7.33mm) and 4.04 % (3.5mm) than sole maize and soya bean (Table 5).

Table 5. Independent effect of tillage types and cropping systems on in-situ water conservation (mm)

Factors of variation	Parameter
	In –situ water conservation (mm)
Tillage types	
No tillage	186.33[a]
Conventional tillage	168.44[b]
LSD (0.05)	6.06
Cropping systems	
Sole maize	173.67
Sole soya bean	177.5
Intercropping	181
LSD (0.05)	

Interaction effect of the factors had showed non-significant variation among treatments. The in situ-water retained under conventional tillage was declined by 9.83% (18mm), 11.3% (21mm) and 7.76% (14.63mm) as compared to no tillage with mulch treatments for maize, soya bean and maize-soya bean intercropping respectively (Table 1). The result obtained showed higher amount of retained water under zero tillage with residue management than conventional tillage.

Zero tillage with residue retention can increase infiltration, reduce runoff and evaporation by reducing the sun radiation compared to conventional tillage. Consequently, soil moisture is conserved and more water is available for crops. The amount of energy the soil surface receives is influenced by canopy and residue cover. The study coincides with the study of Kargas, Kerkides, and Poulovassilis (2012) observed that untilled plots retain more water than tilled plot. Sauer *et al*. 1996 , Blevins *et al.* 1971, Papendick *et al.* 1973 who also reported that the presence of residue on the surface reduced soil water evaporation by 34 to 50% and tillage disturbance of the soil surface increased soil water evaporation compared to untilled areas.



IN-in situ water conservation (mm), cs: cropping system 1 CS- Sole maize, 2 CS- Sole soya bean, 3CS- intercropping & 1 TILL- convectional tillage, 2 TILL-no tillage

Figure 7: Mean of in situ-water conservation in (mm) for interaction of cropping system and tillage practice

3.2. Rainfall – Runoff –Soil Loss Relationships

Coefficient of correlation (r) and determination (r^2) for daily rainfall, runoff and soil loss values of the experiment for each treatment during the study period (July to the end of September 2016).

Out of the 47 rainfall events that occurred during the experimental period (considered as rainfall event when rainfall was ≥ 1 mm, a limit set by the East African Meteorological Department), 8 of them generated runoff and soil loss. It has been observed that the heavy storms do not necessarily coincide with higher amounts of runoff or sediment loss. For example, rainfall with magnitude of 10.3 mm that occurred on September 4, 2016 yielded more runoff and soil loss under most of the treatments than did 53.8 mm rainfall that occurred on August 10, 2016.

This result suggests that rainfall – runoff relationship is a complex, and dynamic, which is affected by many and often inter-related physical factors. The most important cause of such non linearity in runoff and soil loss response to rainfall is represented by the effect of antecedent moisture content (AMC), surface cover, infiltration capacity and surface storage.

The result indicates that, the same amount of rainfall generates varying amounts of runoff and soil loss under different surface management practices. The interception of rainfall was less on plots treated by conventional tillage under maize crop. This plot gave higher runoff and consequently, more soil loss than no tillage treatments followed by conventional tillage and soya bean. This shows the impacts of canopy cover and frequency of tillage on runoff and soil loss reduction respectively. As the result reveals, plots under the same tillage but different crop cover vary on their effect on runoff and soil loss generation. It is obvious that soya bean has dense canopy cover than maize and helps to reduce the beating action of rainfall, detachment as well as transport of soil particles and losses of soil which coincide with Gŏmez *et al.* 2009, who reported that cover crops reduced runoff (64.4%), soil loss (97.7%), and sediment concentration in runoff (89%).

The degree of correlation between rainfall-runoff, rainfall-soil loss, runoff- soil loss, runoff-sediment concentration and soil loss-sediment concentration is shown in (Table 6). Under all treatments, soil losses were positively and significantly correlated with rainfall event basis except for no tillage with intercropping. Soil loss was highly and positively correlated with runoff and sediment concentration for all treatments. The correlation coefficient (r) value ranges from 0.91 to 0.95 for runoff with soil loss, 0.75 to 0.85 for runoff with sediment concentration and 0.83 to 0.93 for sediment concentration with soil loss were the values ranges in highly correlated as rated by Field (2006) as low (r ≤ +0.3), medium (+0.3 < r > +0.5) and high (r ≥ +0.5), showing unit increases of runoff increase the soil loss and sediment concentration for all treatments (Table 13). Also, the sediment concentration increment will increase the soil loss as the study reveals. The significant correlation between rainfall and soil loss is in line with the reports of Zenebe *et.al* (2011).

Table 6: Pearson correlation coefficient for runoff and soil loss for response to rainfall

Treatments	n	RF-R0	RF-SL	RO-SL	RO-SC	SL-SC
Conventional tillage with maize (T1)	8	0.88**	0.82*	0.91**	0.81*	0.93**
Conventional tillage with soya.(T5)	8	0.88**	0.84**	0.95**	0.85**	0.91**
Conventional tillage with intercropping (T3)	8	0.86**	0.79*	0.93**	0.81*	0.93**
No tillage with maize (T2)	8	0.86*	0.74*	0.95**	0.75*	0.84**
No tillage with soya .(T6)	8	0.77**	0.62*	0.94**	0.78*	0.83*
No tillage with intercr (T4)	8	0.73*	0.59ns	0.94**	0.82*	0.88**

n= number of events Ro=run off Sl= Soil loss, Sc= Sediment concentration Rf= rain fall

*** highly significant at p<0.01,* significant at p<0.05 and ns= non-significant*

The coefficient of determination (r^2) between rainfall-runoff and rainfall-soil loss under different surface management practices. These relationships were analyzed for the different treatments to assess the effect of farming systems on runoff and erosion. The regression analysis showed that relationships between daily rainfall and runoff had coefficient of determination (R^2) ranging from 0.014 (1.4%) for no tillage with intercropping to 0.383 (38.3%) for conventional tillage with soya bean. The relationship between soil loss and runoff ranges from 0.537 (53.7%) for conventional tillage with intercropping to 0.78 (78%) for no tillage with maize. The positive correlation of runoff volume with soil loss in this study, in line with the report of Teklu 1997, Mulugeta 1998, Sonnoveld *et.al* 1999, Tesgera, 2005.

The results of the experiment further demonstrated that annual soil loss was mainly governed by few erosive storms. This could be explained by the largest erosive storm (37.3 mm) that occurred on September19, 2016, which accounted for 34.52, 22.67, 16.84, 29.23, 36.32, and 20.96 % of the seasonal soil loss from no tillage with intercropping, conventional with soya bean, conventional with intercropping, no tillage with maize, no tillage with soya bean and conventional tillage with maize, respectively. This agrees with the findings of Morgan *et al.* (1986) who reported that over a period of 1973-79 in Mid-Bedfordshire, England, 80 % of the erosion occurred in 13 storms, the greatest soil loss comprising 21 percent of the erosion resulting from a storm of 57.2 mm. Similarly, Hudson (1981) reported that only two storm events accounted for 50 percent of the annual soil loss and that, in one year, 75% of the erosion took place in ten minutes in Zimbabwe.

4. CONCLUSION

Soil tillage is probably as old as settled agriculture which plays an important role in the dynamic processes governing soil degradation. It had been therefore an integral part of traditional and/or conventional agriculture. The impacts of tillage on soil degradation and hence agricultural sustainability are more important now than ever before.

Therefore, it is essential that appropriate land management practices be implemented to reduce soil loss to tolerable levels. Designing realistic and acceptable conservation techniques and identifying promising approaches for intervention require among other factors, a rigorous understanding of the process, extent and rate of resource degradation.

No tillage had reduced the sediment concentration per litre of runoff by 3.26 g/L, 3.13 g/L and 4.37g/L per plot under intercropping of maize with soya bean, sole maize and sole soya bean cropping systems respectively as compared to conventional tillage. No tillage had reduced the total runoff volume by 0.06m^3, 0.03m^{3}and 0.06m^3 per plot under intercropping of maize with soya bean, sole maize and sole soya bean cropping systems respectively as compared to conventional tillage. No tillage treatments further showed the relative effectiveness of tillage practices in increasing the amount of rain water intake and reducing runoff.

No tillage had reduced the soil loss by 507 kg/ha, 1300.4 kg/ha and 897.3 kg/ha under intercropping of maize with soya bean, sole maize and sole soya bean cropping systems respectively as compared to conventional tillage. Inversely, no tillage had increased in-situ water conservation by 18 mm, 21.3 mm and 14.63 mm per plot under intercropping of maize with soya bean, sole maize and sole soya bean cropping systems respectively as compared to conventional tillage.

Therefore, the results of this study showed the effect of tillage and cropping system on run off, and soil loss. As the result revealed, no tillage with cropping systems plays vital role on reducing soil degradation by reducing sediment concentration, run off, and soil loss and consequently land degradation.

5. REFERENCEs

Blanco, H. and R. Lal, 2008. Principles of Soil Conservation and Management. Springer Science + Business Media B.V. 617pp.

Chen, S. Y., X. Y. Zhang, D. Pei, H. Y. Sun and S. L. Chen, 2007. Effects of straw mulching on soil temperature, evaporation and yield of winter wheat: field experiments on the North China Plain. *Annals of Applied Biology*, 150(3):261-268.

El-Swaify, S. A. and Hurni, H. 1996. Transboundary effects of soil erosion and conservation in the Nile basin. Land Husbandry 1(1&2): 6-21.Erosion in the Uluguru Mountains,Tanzania. *Soil Tillage Research* 81:97–108

Eswaran H, Lal R and Reich, P. F. 2001. Land degradation: An overview. In: Response to Land Degradation, Bridges EM, I.D. Hannam, L.R. Oldeman, F.W.T. Penning deVries, J. S. Scherr and S. Sombatpanit (eds). *Science Publisher, Inc*.: Enfield, NH; 20–35.

Gebresamuel, G, Singh, BR and Dick, O. 2010.Land-use changes and their impacts on soil degradation and surface runoff of two catchments of Northern Ethiopia.*Acta Agriculturae Scandinavica,* Section B- Plant Soil Science 60(3):211-226.

Gete Zeleke, 2000.Landscape dynamics and soil erosion process modelling in North western Ethiopia highlands. *Institute of Geography, University of Berne, Switzerland*

Gòmez, J. A., M. G. Guzmán, J. V. Giráldez and E. Fereres, 2009.The influence of cover crops and tillage on water and sediment yield, and on nutrient, and organic matter losses in an olive orchard on a sandy loam soil.*Soil & Tillage Research,* 106: 137–144.

Herweg K**,** Ludi E 1999. The performance of selected soil and water conservation measures-case studies from Ethiopia and Eritrea. Catena, 36(1):99-114

Hudson, N. W., 1981. Soil Conservation, 2nd ed. Batsford, London.

Kargas, G., Kerkides, P., &Poulovassilis,A. 2012. Infiltration of rain water in semi-arid areas under three land surface treatments. *Soil and Tillage Research,* 120, 15–24.

Khisa, P., Gachene, C.K.K., Karanja N.K. and Mureithi, J.G. 2002. The effect of post-harvest cover on soil erosion in a maize-legume based cropping systems in Gatanga, Kenya. *Journal of Agriculture in Tropics and Subtropics* 103(1): 17-28.

Li, L.L., Huang, G.B., &Zhang,R.Z. 2005.Effects of conservation tillage on soil water regimes in rain fed areas. *Acta Ecologica Sinica*, 25(9), 2326–2332.

Montgomery, D. R., 2007. Soil erosion and agricultural sustainability. Proceedings of the National Academy of Sciences 104, 13268–13272.

Morgan,R. P. C., 2005. Soil Erosion and Conservation (3rd ed.). Blackwell Science Ltd., 304pp. Mulugeta T., 1998. Soil conservation on cultivated land in Mayber area, South wello zone, Ethiopia. *Soil conservation research program*, Research Report 16.

Nebel, B. J. and Wright, R. T. 1993. Environmental Science. Prentice Hall, New Jersey.

Rao, K.P.C., Steenhuis, T.S., Cogle, A.L., Srinivasan, S.T., Yule, D.F., and Smith, G.D. 1998. Rainfall infiltration and runoff from an Alfisol in semi-arid tropical India.I.No-tillsystems.*SoilTill.Res.* 48:51-59.

Rhoton, F.E.2000. Influence of time on soil response to no-till practices. *Soil Science Society of America Journal*, 64, 700–709.

Silburn, D.M., Freebairn, D.M., &Rattray, D.J.2007.Tillage and the environment in sub-tropical Australia Tradeoffs and challenges.*Soil and Tillage Research*, 97,306 317.

Singh, G., S. P. Bharadwaj and B. P. Singh, 1999.Effect of row cropping of maize and soybean on erosion losses.*Indian J. Soil Conservation*.**7** (2): 13-16.

Sonneveld, B, Keyzer, M. and Alberson.P, 1999. Anon parametric analysis of qualitative data for erosion modeling: a case study for Ethiopia. A paper presented at the conference of ISCO, Lafayette, US, 24-28 May 1999.

Teklu E. 1999. Effects of land preparation on runoff and soil loss on a vertisoil at Ginchi (Ethiopia).*Ethiopian Journal of Natural Resource Volume* 1(1):1-5

Tesgera D. 2005. Modeling Rainfsll, runoff, and soil loss under different land preparation methods in vertisoil of Gimbichu woreda,Oromia Region. Msc theisis, *Haramaya University*.Haramaya.

Tefera, M., Cherenet, T. and Haro, W. 1996.Explanation of the geological map of Ethiopia *2nd ed.Ethiopian Institute of Geological Surveys.* Addis Ababa, Ethiopia.

Zenebe A. and Nigussie H. 2011. Runoff, soil and their interrelationship under different land uses in central highland of Ethiopia. Holeta Agricultural Research Center, *Ethiopian Institute of Agricultural Research*, P. O. Box 2003, Addis Ababa, Ethiopia