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Research Article

Land management and crop cover effect on soil erosion in the humid lowlands of Beles River Sub-Basin, North-Western Ethiopia

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Abstract

Soil erosion is the most devastating environmental crisis in Ethiopia where the loss of soil from cultivated land is almost seven times the tolerable limit; specifically, Nitisol is very susceptible to erosion. To investigate the response of land management and cropping practices on soil loss, a field experiment was conducted under natural environment on Nitisol of Pawe area. Nine treatments combining two tillage methods (zero and conventional), four crop covers (continuous maize, continuous soya bean, rotated maize, and maize soya bean intercrop), and continuous bare fallow as control were laid out in a randomized complete block design (RCBD) with three replications. The result showed that land management and crop cover significantly affect soil loss. Cultivation of crops without soil disturbance with full residue retention reduced soil loss by 6%, 36%, 36%, and 44% under soya bean, rotated maize, maize soya bean intercropping, and maize, respectively. Similarly, maize crop reduces soil loss by 34% under zero tillage management. Compared with conventionally managed maize crops, sediment concentration was also reduced by 14%, 17%, and 31%, maize with zero tillage, rotated maize with zero tillage, and maize soya bean intercropping with zero tillage, respectively. Except for zero-tilled maize soya bean intercropping and rotated maize, the seasonal soil loss was above the tolerable soil loss level of Ethiopia (2-10 t ha^{-1}). This indicates there is a need for other management practices like physical and agronomic soil conservation methods to lower soil loss rates below the tolerable limit. Generally, zero tillage with greater crop cover is an appropriate approach to reduce soil loss by improving soil hydrological properties without negatively affecting grain yield. To understand and quantify the long-term impact of tillage and crop cover on soil health and productivity in Ethiopia long-term study is needed as this study was based on one-year data from four years of permanent plots.

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Introduction

Globally, land degradation is one of the bottlenecks of agricultural production which is a source of raw materials for industries, especially in developing nations like Ethiopia (Dagnew, 2007) where soil erosion is a series problem. According to Borrelli et al. (2017), the global annual average soil erosion shows an increase of 2.5% (35.9 billion t year^{-1}), which is driven by spatial changes in land use. Thus, soil erosion from cropland accounts for up to 17 billion t year^{-1} in which the conversion of forests to cropland is responsible for about a 52% increase in soil loss (Borrelli et al., 2017). They predicted that the highest average soil erosion rate was in South America (3.53 Mg ha$^{−1}$ year$^{−1}$) followed by Africa (3.51 Mg ha$^{−1}$ year$^{−1}$ and Asia (3.47 Mg ha$^{−1}$ year$^{−1}$). Soil degradation in Ethiopia is a deep-rooted fact. The causes of land degradation are due to ill-functional land management or human development practices that are not sustainable over a long period which is substantiated in different regions in the country (Nyssen et al., 2008). The country's average annual rate of soil loss is estimated to be 12 t ha$^{−1}$ year$^{−1,}$ and it can even be extremely high and severe (300 t ha$^{−1}$ year$^{−1}$) on steep slopes and in places where the vegetation cover is low (Abera, 2003) and local erosion over 400 t ha$^{−1}$ year$^{−1}$ (Mitiku et al., 2006). The estimated total soil loss of Ethiopia was 2 billion m^3 of fertile topsoil per annum; this designates that out of 60 million hectares of agriculturally productive land 27 million, 14 million, and 2 million hectares are significantly eroded, seriously eroded, and reached out of production, respectively (Bewket, 2002; Bobe, 2004). Thus, soil erosion is estimated to cost the country around 1 billion US$ per year (Sonneveld, 2002), which accounts for between 2% and 3% of the national agricultural GDP (MoARD and World Bank, 2007). A study in 2014 reported about 44 billion ETB is required to conserve the cultivated land by investing in SWC structures (Hurni et al., 2015).

Almost all cultivated lands in North-Western Ethiopia are susceptible to accelerated soil erosion (Symeonakis and Drake, 2004), and annual soil loss from cultivated lands has been reported to reach up to 300 t ha^{-1} year^{-1} (Mitiku et al., 2006). Soil erosion from cropland in the study area is a symptom of land misuse in that ecological environment. According to Surur (2010), the important problem of land degradation is due to inappropriate farming practices, deforestation, high rainfall, population pressure, continuous cultivation, over exploitation of soil fertility, overgrazing, and total clearing of surface cover. Hence, inappropriate techniques in agriculture lead to reduced infiltration, increased surface runoff and evaporation, accelerated erosion, drying up of rivers, increased flooding frequency, and rapid silting up of reservoirs (Bewket, 2002; Nyssen et al., 2008; Tilahun et al., 2013). The primary cause of land degradation in the region is accelerated soil erosion by water (Berry, 2003; Hurni et al., 2010) and leads changed relationship between environmental and biophysical factors which occur as a result of human interventions (Holden and Shiferawl, 2004; Gebremichael et al., 2005; Jemberu et al., 2017). Thus, soil loss from cultivated land should be mitigated by improving conservation practices and cropping patterns to fulfill the projected food and fiber needs of the growing population without worsening water quality issues.

A regional review by Haregeweyn et al. (2016) indicates that the major bottlenecks of soil erosion study in Ethiopia are the availability and reliability of soil erosion data and heterogeneity of environmental factors combined with a lack of adaptable methods, field observations, and participatory research. From various soil and water conservation measures conservation tillage is mostly used practice to reduce soil loss and improve the soil properties hence creating favorable conditions for plant growth (Pundlik and Tathod, 2019). Conservation agriculture was promoted in Ethiopia by Sasakwa Global 2000 mainly with minimum and zero tillage integrated with herbicides on teff and wheat at Debrezeyit and Gojjam (Melesse and Birhanu, 2014).

Scholars in Ethiopia reported that compared with conventional tillage, minimum tillage with residue increases soil loss. Zero tillage also increased soil loss by 9.7 times more than conventional plots (Woyessa and Bennie, 2004), by 10%, and increased up to 45% with residue retention (Adimassu et al., 2019) than conventional tillage. Application of minimum tillage in Tigray showed a reduction of soil loss ranging from 12% to 17% (Haregeweyn et al., 2016). Sufficient crop residue integrated with minimum tillage reduced soil loss by 27% (Erkossa et al., 2005), while stubble mulch reduced soil loss by 78.3% (Kurothe et al., 2014). Generally, the national level estimation of soil loss is inconsistent and tentative (Haregeweyn et al., 2016). A review of conservation tillage in the Ethiopian highlands indicates that the effect of tillage on soil loss was both spatially and temporally inconsistent (Asmamaw, 2014). Thus, almost all tillage research in Ethiopia was conducted in the humid highlands and dry areas of the region, and little was reported with runoff plot studies.

Regardless of the crop cover managed with a conventional tillage system, cereal-legume intercropping is a better management system in reducing soil loss than mono cropping of cereal and legume where legume crops were more effective in reducing soil loss than cereals (Singh et al., 2014; Lima et al., 2018). Thus, soil loss was significantly reduced by soya bean than maize (Ma et al., 2016). Relative to the bare plot, plots covered with soya bean reduced soil loss more than maize (31% and 55%, 24% and 47%, respectively which indicates a lower soil loss ratio under soya bean (Ma et al., 2016). Generally, as the soil cover increases, the loss of soil is reduced (Dechen et al., 2015).

In addition to the above arguments, most of the studies were done either on highlands or moisture deficit areas. This calls for simultaneous quantification of the effect of these land management practices i.e., tillage and crop pattern on soil loss in humid lowlands of Ethiopia where no adequate studies were undertaken. Similarly, expansion of crop land and biological degradation is, therefore, the specific objective of this study is to quantify the effect of land management and crop pattern on soil erosion.

Methods

Description of the study area

The experiment was conducted at Pawe district, which is located at a distance of about 565 km from Addis

Ababa in North-Western direction in Metekel zone, Benishangul-Gumuz Regional State, Ethiopia. As indicated on Figure 1 it is geographically located from 11°18´40´´to 11º19´29´´ latitude and from 36º24´26´´ to 36º25´27´´ longitude. The elevation of the district ranges from 1000 to 1200 meters above sea level (masl) with slightly undulating from hill-tops towards 'Beles' river, which is the economic growth corridor of Ethiopia (MOFED, 2007). The mean annual rainfall, annual minimum, and maximum temperatures of the district are 1608.78 mm, 16.7 and 32.6 ºC, respectively (Figure 2).

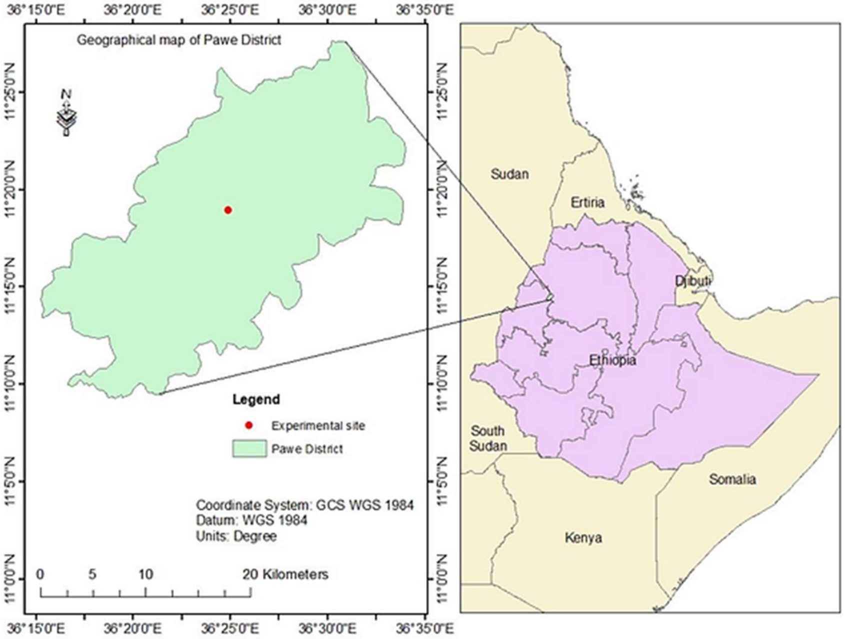

Figure 1. Geographical map of Pawe District.

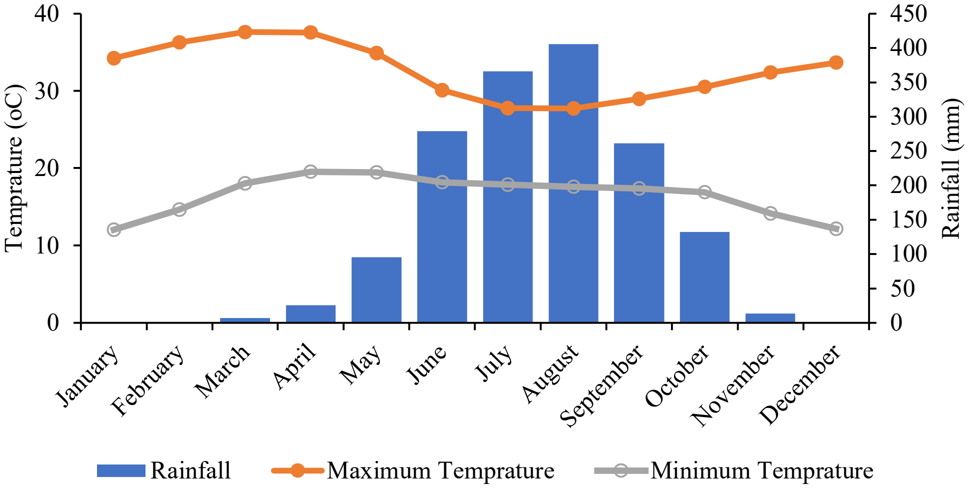

Figure 2. Thirty years (1987-2017) mean monthly rainfall, the minimum and maximum temperature recorded at Pawe meteorological stations.

The maximum temperature of the area rises up to 42 ºC. The area is characterized as a uni-modal rainfall pattern that extends from May to October, with high rainfall in August. The climate of the area is characterized by warm sub-humid low lands. According to Barnes (2017), by the end of the 21th century, global warming tends to slightly increase rainfall over the basin. Grain production is the majority of the farming system in the study area. Cereals and legume crops are the major crop production system in the district in which maize, sorghum, finger millet, rice, soybean, haricot bean, sesame, and groundnut are the major crops grown in the area. To improve soil fertility farmers practice crop rotation of cereal with a legume. Among all crop types, Sorghum (*Sorghum bicolor* L. Moench), maize (*Zea mays*), sesame (*Sesamum indicum*), soya bean (*Glycine max*), and groundnut (*Arachis hypogaea*) are the most common crop species cultivated in the study area.

Experimental setup

A field experiment was conducted on permanent runoff plots established for conservation agriculture at Pawe research site. The current research takes advantage of a four years old permanent plots managed with different tillage and cropping pattern practices. This was because the significant effect of conservation agriculture on crop yield was observed after three years of implementation (Araya et al., 2011). Similarly, the rate of infiltration that water enters the soil was affected by tillage system after 11 months of operation (Ward et al., 2015).

Runoff plot setup

A total of twenty-seven runoff plots having 9.75 m by 6 m dimensions were established at Pawe research site. All plots were laid out at a slope of 5%. Each plot border was enclosed by corrugated iron sheets. The corrugated iron sheets were installed 25 cm above and 25 cm below the ground surface to prevent inflow and lateral flow of runoff, respectively. Besides, it was supported by heaping soil around the iron sheet and compacting the soil surface in between plots to minimize lateral flow. Daily rainfall was recorded from meteorological stations located within the experimental site of Pawe Agricultural Research Center.

Multi-slot divisors are used to sample runoff samples. The runoff collectors were fitted to the lower end of the plot to receive eroded soil and runoff generated from the plot. The second runoff collector which was attached to the first collector using a slotting divisor receives overflowed runoff from the first tank. Nine slotting divisors and second runoff collector tanks having a capacity to store one-ninth of the runoff were decided using the long-term daily rainfall data. The capacity of slotting divisors to discharge runoff was calibrated using the volumetric method at regular intervals during the measurement period. Runoff collectors, which were provided at the lower end of each plot, were buried and painted with antirust. The collectors were closed to avoid entrainment of direct rainfall, evaporation, and animal drinking, thereby minimizing over and underestimation of runoff.

Treatment setup

The experiment was conducted on permanent plots at the age of four from the start of implementation. The experiment consists of a factorial combination of two levels of tillage method (conventional and zero tillage) and four crop cover types (maize, soya bean, maize soya bean intercrop, and rotated maize). The experiment was arranged using a randomized complete block design. To compare the response of the treatments to hydrology and soil loss tilled bare plot, which was kept bare throughout the year, was incorporated. A total of twenty-seven experimental runoff plots (9 treatments replicated three times) having 9.75 m x 6 m dimensions were established within the experimental site of Pawe Agricultural Research Center to measure runoff and sediment loss (Thierfelder et al., 2012; Adimassu et al., 2019). Each replication of treatments was supplied with runoff collectors. The spacing between plots was 1m while replication was 4m apart where water collectors are placed.

Treatments

1. Bare plot as control
2. Maize with Conventional Tillage
3. Maize with Zero Tillage
4. Intercropping of maize and soya bean with Conventional Tillage
5. Intercropping of maize and soya bean with Zero Tillage
6. Rotation of maize and soya bean with Conventional Tillage
7. Rotation of maize and soya bean with Zero Tillage
8. Soya bean with Zero Tillage
9. Soya bean with Conventional Tillage

Description of treatments

- ✓ Bare: the plot was kept bare (tilled fallow) over the years
- ✓ Conventional tillage (CT) for both maize and soya bean. A local tillage practice, where local farmers practiced in the study area, where they do at least two times tillage by oxen plough and remove the residues
- ✓ Zero tillage: no-tillage, no burning and total residues retained as mulch year-round
- ✓ Intercropping maize with soya bean: maize was used as the main crop keeping an appropriate spacing, while soya bean was sown in between the rows of maize.
- ✓ Rotated maize: maize was cultivated on plots where previously cultivated with soya bean.

Agronomic practices

Maize (BH 545 variety) and soya bean (TGX variety) crops were used to test the effect of land management and crop cover on soil loss. The inter and intra row spacing of maize and soya bean crop were 75 cm by 30 cm and 60 cm by 5cm, respectively. For all treatment plots except the bare plot received a blanket recommendation of DAP (100 kg ha^{-1}) and Urea (100 kg ha^{-1}) fertilizer for maize. Whereas 100 kg ha^{-1} DAP was applied for soya bean. Oxen plough was used to till conventional plots with two tillage frequencies. These conventional plots were leveled using a rake to avoid waterlogging. Crops under zero-tillage plots were sown by opening holes to place the seeds via hoe, which is also used for agronomic management. Weeds under conventional tillage and after crop emergency in zero tilled plots were managed using labor. Glyphosate (roundup) was sprayed under zero tilled plots prior to the emergency of the crop.

Data collection and measurement

Soil loss measurement

Runoff samples for sediment analysis were collected after taking all measurements. One-liter runoff samples from each collector tank / were taken separately. Finally, all tanks were emptied and cleaned daily, but whenever the runoff volume collected in the tank is high enough and judged to cause overtopping it was emptied and cleaned before evening or within half days. Then the sample was allowed to settle through the decantation method, and sediment other than decantation was filtered by FILTER-LAB filter paper of 185mm diameter having 1-3 µm porosity. Thus, after decantation and filtration, the soil samples were oven-dried at 105 ºC for roughly 24 hours to determine the amount of sediment lost along with runoff as described by Adimassu et al. (2014). The total sediment loss due to land management and crop cover was then estimated using runoff and sediment concentration of each plot.

The sediment concentration and the total runoff per plot area per rainy day were used to determine the daily sediment concentration (Equation 1).

$$\mathrm{Sc} = \frac{\mathrm{O_{dSwt}}}{\mathrm{RSV}} - - - - - - - - - - - - - - - - \ (1)$$

where:

Sc = Sediment concentration ($\mathrm{g\ L^{-1}}$)
$\mathrm{O_{dswt}}$ = Oven-dried weight of sediment (g)
RSV = Runoff sample volume (L)

The total sediment in a given volume of runoff was calculated using Equation 2:

$$\mathrm{S} = \mathrm{R} * \frac{\mathrm{Sc}}{1000} - - - - - - - - - - - - - - - - (2)$$

where:

S = sediment loss ($\mathrm{kg\ ha^{-1}}$)
R = daily runoff ($\mathrm{L\ ha^{-1}}$)
Sc = sediment concentration of runoff ($\mathrm{g\ L^{-1}}$)
1000 = a factor to convert gm to kg

Method of data analysis

The collected data were managed with Microsoft Excel and subjected to analysis of Variance (ANOVA) using SAS statistical package with PROC GLM procedure to compare the soil loss effect of different land management and crop cover. Mean separation was compared with list significance difference (LSD) at 5% level of rejection. Percent deviations (D in %) from the control plot or conventional tillage (CT) was calculated based on (Araya et al., 2012) (Equation 3).

$$\frac{\text{Targeted treatment} - \text{Control treatment}}{\text{Control treatment}} \mathrm{x}100 - -(3)$$

where, the parameters are measured data i.e., soil loss obtained in zero tillage treatments while CT represents measured value in the conventional tillage treatment.

Whereas, the response ratio (RR) or relative values was calculated as measured data in target treatment divided by control treatment (Equation 4).

$$\mathrm{RR} = \frac{\text{Targeted treatment}}{\text{Control treatment}} - - - - - - - - - (4)$$

Results and Discussion

Soil loss

The effect of tillage management and crop cover practices on the loss of soil was highly significant (p<0.05) (Table 1). The highest soil loss (39.48 Mg $\mathrm{ha^{-1}}$) was recorded from the bare plot which is inferred by no surface cover for dissipating raindrop energy. From plots where the treatments were applied, the highest quantity of soil (23.91 Mg $\mathrm{ha^{-1}}$) was lost from plots of conventionally tilled continuous sole maize cultivation and tailed by continuously tilled sole soya bean cultivation practice.

The lowest soil loss (9.8 Mg/ha) was obtained on plots managed with maize soya bean intercropping practice with zero tillage management which is below the tolerable limit of soil loss. The loss of soil under maize soya bean intercropping managed with zero tillage practice was not statistically different when compared with soil lost under maize with crop rotation and continuously cultivated sole maize, and conventionally tilled maize soya bean intercropping practice. Even though maize soya bean intercropping under zero tillage did not show a statistically significant difference in soil loss, it reduced soil loss by 5.5 Mg $\mathrm{ha^{-1}}$. A combination of zero tillage and intercropping can reduce soil loss by 144% relative to the conventionally tilled sole maize practice. This implies that zero tillage with intercropping is effective in reducing the erodibility of soils.

Continuously tilled and untilled cultivation of soya bean reduced soil loss by 6.6% and 11.9%, respectively as compared with conventionally tilled sole maize cultivation. Whereas cultivation of maize soya bean intercropping, rotated maize and sole maize all managed with zero tillage were effective in reducing soil loss by 59%, 54.4%, and 43.9%, respectively. This figure was increased to 75.2%, 72.4%, and 66%, respectively when compared with the loss of soil from bare plot. Compared to conventional tillage, zero tillage reduced soil loss under all cropping patterns by 6%, 36%, 36%, and 44% for sole soya bean, rotated maize, maize soya bean intercrop and sole maize, respectively. Thus, on average zero tillage with full residue retention reduced soil loss by 30% as compared with conventional tillage management. This indicates that conventional tillage with continuous sole crop production enhances soil erosion. This is due to the absence of residue cover particularly early in the growing season, loosening the soil by tillage, smaller organic carbon and consequently aggravating the erodibility of soil. Greater sediment concentration with runoff volume under conventionally tilled continuous crop cultivation systems was also the other root cause for greater soil loss. Generally, soil erosion can be affected by crop cover and tillage practice due to its effect on infiltration rate and porosity. Similarly, with similar tillage management cultivation crop affect soil erosion. Under zero tillage practice maize crop cultivation reduced soil loss by 36% while it aggravated soil erosion by 7% when managed with conventional tillage due to the better ground cover by soya bean under the conventional tillage system. This result is in line with other studies in other geographic areas. Zero tillage was an effective management strategy in reducing runoff and soil loss than conventional practice (Dembele, 2015; Bogunovic et al., 2018; Adimassu et al., 2019). Soil loss from zero tillage was up to 8.7 times (Truman et al., 2003), up to 84% (Deuschle et al., 2019), lower than conventional practice. Therefore, crop residue removal enhances the production of more water runoff, soil loss and nutrient leach. The research was done on the wheat cultivation system under clay loam soil of Vernon, Texas reported that loss of soil from conventional tillage was 2.8 times greater than zero tillage (DeLaune and Sij, 2012).

Table 1. Effect of land management and crop pattern on soil loss.

Treatments	Soil loss Mg ha^{-1}	RR against bare	RR against CTM
Bare	39.48 ^{a}	1	1.65
Maize with Conventional tillage (CTM)	23.91 ^{b}	0.61	1
Soya bean with conventional tillage	22.34 ^{bc}	0.57	0.93
Soya bean with zero tillage	21.07 ^{bcd}	0.53	0.88
Rotated maize with conventional tillage	17.00 ^{cde}	0.43	0.71
Maize soya bean intercropping with conventional tillage	15.30 ^{def}	0.39	0.64
Maize with zero tillage	13.42 ^{ef}	0.34	0.56
Rotated maize with zero tillage	10.90 ^{f}	0.28	0.46
Maize soya bean intercropping with zero tillage	9.80 ^{f}	0.25	0.41
CV (%)	18.16		
LSD$_{0.05}$	6.05		

Note: LSD = least significant, CV = coefficient of variation; RR = response ratio.

Studies in the central highlands of Ethiopia reported that zero tillage reduced soil loss ranging from 23% to 32% (Adimassu et al., 2014) relative to conventional plots. Sufficient crop residue (30%) in the Tigray region of Ethiopia significantly reduced soil loss by up to 46% compared to conventional tillage (Araya et al., 2012). According to Erkossa et al. (2005), integration of minimum tillage with mulch reduced soil loss by 27% relative to conventional tillage. Studies from May Zeg-zeg catchment of northern highland reported that soil loss from conventional tillage was more than double of the conservation system; 35.4 t ha^{-1} year^{-1} and 14.4 t ha^{-1} year^{-1}, respectively (Lanckriet et al., 2012). For cropping practices managed under zero tillage, the highest soil loss (21.07 t ha^{-1}) was from sole soya bean followed by sole maize (13.42 t ha^{-1}) and rotated maize (10.9 t ha^{-1}) while the lowest soil loss record (9.8 t ha^{-1}) was under maize soya bean intercropping practice. Similarly, in the case of conventional tillage, the lowest (15.3 t ha^{-1}) and the highest (23.91 t ha^{-1}) soil loss were measured from intercropping and sole maize, which is significantly different from each other. Studies at Bako, Ethiopian highland reported that maize-haricot bean intercropping reduces soil loss by 79% against conventionally tilled sole maize (Degefa et al., 2016). Soil loss from zero tilled plots was 9.7 times greater than conventional plots (Woyessa and Bennie, 2004).

Sediment concentration

The concentration of sediment from the sampled runoff was statistically different ($p<0.0001$) (Table 2). The highest sediment concentration (5.9 g L^{-1}) was found on a bare plot followed by zero tilled continuous sole soya bean (3.58 g L^{-1}). This was inferred by the complete removal of any cover that minimizes the erosive power of rainfall and loosened by tillage to aggravate soil erosion. Whereas the lowest sediment concentration (1.92 g L^{-1}) was observed on zero tilled maize soya bean intercropping. Crop cover managed with zero and conventional tillage reduced sediment concentration ranged from 39% to 67% relative to bare land in increasing order of maize with zero tillage (39%), rotated maize with conventional tillage (48%), soya bean with conventional tillage (51%), maize soya bean intercropping with conventional tillage (51%), maize with conventional tillage (53%), maize with zero tillage (60%), rotated maize with zero tillage (61%), and maize soya bean intercropping with zero tillage (67%) due to the roughness created by tillage system and crop covers which dissipate runoff velocity and allows the sediment to be settled. Compared with maize cultivation managed with conventional tillage, maize-based cultivation systems which were managed using zero tillage reduced sediment concentration, i.e., maize soya bean intercropping (31%), rotated maize with zero tillage (17%), and maize with zero tillage

(14%). Whereas conventionally managed maize soya bean intercropping, soya bean, and rotated maize increase sediment concentration by 4%, 5%, and 12%, respectively. Similarly, soya bean with zero tillage (29%) and bare land (113%) generates higher sediment concentration relative to conventionally managed maize cultivated fields. Sediment concentration was also affected by land management systems as maize-based cultivation managed with zero tillage reduced sediment concentration in decreasing order of maize soya bean intercropping (34%), rotated maize (26%) and sole maize (14%), while the reverse is true for sole soya bean cultivation system where soya bean with zero tillage increase the concentration of sediment by 23% as compared with its conventional management. Meanwhile, crop type also affects sediment concentration. Thus, maize cultivation reduced the concentration of sediment by 34% and 5% under zero tillage and conventional tillage management system, respectively. This infers as the growth of maize is faster in covering the soil, which reduces the entrainment of soil particles to be displaced.

Table 2. Effect of land management and crop pattern on sediment concentration.

Treatments	Sediment Concentration (g L^{-1})	% Red. against bare	% Red. against CTM
Bare	5.90 ^{a}	0	113
Soya bean with zero tillage	3.58 ^{b}	39	29
Rotated maize with conventional tillage	3.09 ^{bc}	48	12
Soya bean with conventional tillage	2.92 ^{bcd}	51	5
Maize soya bean intercropping with conventional tillage	2.89 ^{bcd}	51	4
Maize with Conventional tillage (CTM)	2.77 ^{bcd}	53	0
Maize with zero tillage	2.38 ^{cd}	60	-14
Rotated maize with zero tillage	2.30 ^{cd}	61	-17
Maize soya bean intercropping with zero tillage	1.92 ^{d}	67	-31
CV (%)	19.30		
$LSD_{0.05}$	1.03		

Note: LSD = least significant, CV = coefficient of variation, % Red. = percent reduction.

The presence of residue covers, as well as crop cover, minimizes the erodibility of soil by improving soil organic matter, infiltration, and porosity. This implies erosion can be prevented by any factor which diminishes raindrop power and hinders the transport of soil (Araya et al., 2011). A research report from the northern Iran of Alborz mountains indicates that straw mulch reduced sediment concentration by 45.6%, and 8.98% over control and manure, respectively (Sadeghi et al., 2015). Generally, the trend of sediment concentration follows the statistical difference trend of soil loss. Conventional tillage yields a greater sediment concentration than the no-tillage system (Kurothe et al., 2014).

Conclusion

Soil management is a critical issue in the world as degradation adversely affects the fertility of soil due to the interlinked behavior of soil properties. Land degradation results in loss of nutrients, and reduce water infiltration, thereby lower available water stored in the soil hence directly affecting productivity. To lower soil loss from cultivated fields to a tolerable level, appropriate land management methods need to be strategically designed without negatively affecting productivity. Appropriate soil management strategies such as conservation tillage and crop cover having maximum cover have the capacity to reduce the degradation rate of the soil by reducing runoff generation. A field experiment under the natural environment was undertaken during the cropping season (June – November) of 2018 on Nitisol of Pawe Agricultural Research Center research station to study the response of land management to sediment loss.

Conventional tillage with no residue increases soil loss. Generally, practicing zero tillage with higher crop cover enhances regulating ecosystem services by reducing the loss of soil. Minimum tillage, in combination with cropping systems, is found to enhance soil health conditions and improve productivity. It is thus advisable to extend these conservation agriculture practices into the development action at scale through developing appropriate packages and extension guides. Since the study was undertaken in the fourth year of implementation, it does not indicate the long-term effect of tillage and cropping patterns on soil loss. Therefore, to figure out the long-term impact of tillage and cropping patterns in Ethiopia a long-term study is needed by strategically establishing monitoring plots.

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