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Effects of Selected Physical Soil and Water Conservation Structures on Wheat Crop Yield: The Case of Lemo District in Central Ethiopia

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Abstract

The soil loss in Ethiopia in general and particularly in Central Ethiopia has becoming critical to be considered as burning issue in relation to crop production. In Central Ethiopia, the need for physical soil and water conservation is high and farmers are constructing both soil bund and fanya juu on their farms. With this fact the pragmatic approach based research was conducted to investigate the effects of soil bund and fanya juu bund on crop (wheat) yield of the farmers. Randomized complete block design (RCBD) three position (lower, middle and upper) with seven levels of replication and the wheat crop as a test were used for this investigation. Data on plant height, 1000 seed weight, number of seed per spike, grain yield and day to 50% spiking were taken in consideration and of data collected. Considering the seven levels of replication treated plots of fanya juu bund showed 50.9% and treated plots of soil bund showed 43.2% greater yield than the control plots. Correlation analysis result showed significant correlation with most of the agronomic characteristics on level soil bund and fanya juu bund whereas showed insignificant correlation with control plot. The soil bund and fanya juu bund improved the yield of wheat crop in the study area. It appears important to suggest that further study should be conducted under different agro-ecological zones to attain more comprehensive results.

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Introduction

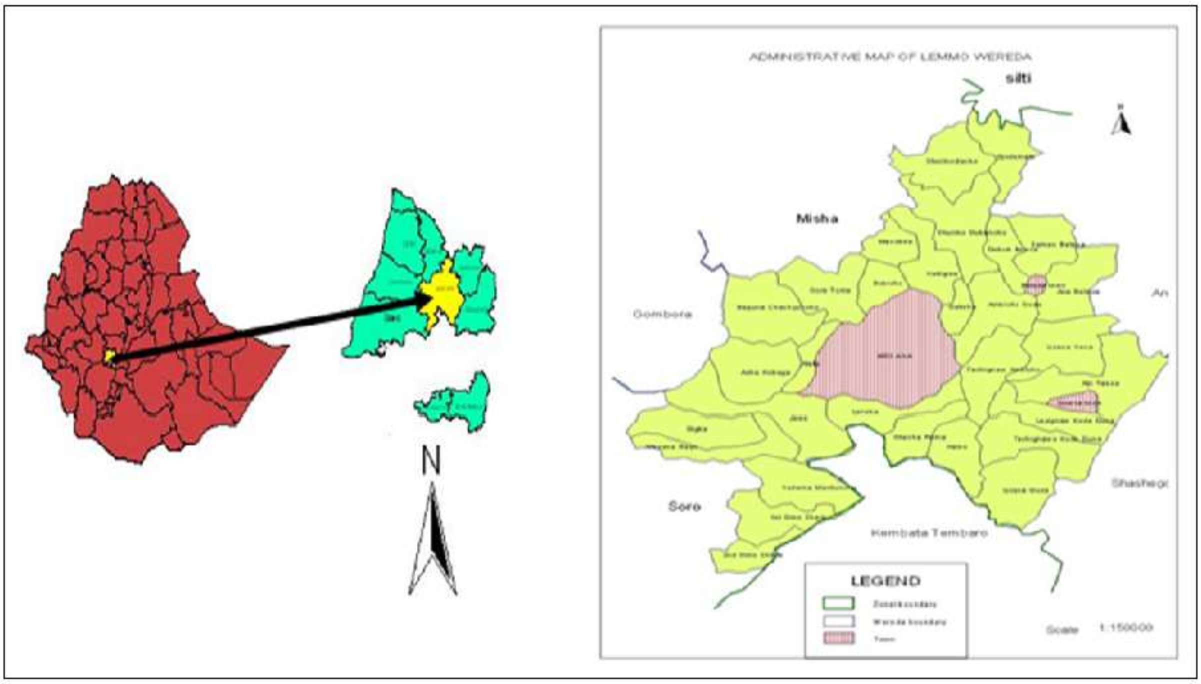
Recent estimate indicate annual soil loss in Ethiopia is between 1.5 and 3 billion tons (Bogale *et al*., 2020) of this about 50% occurs in cropland where soil loss has been reported to be very high (296 tons/ha/year) on a 16% slope with *teff* crop (*Eragrostis abasinica*) on nitisols (Tilahun, and Belay, 2019 and Hailu, 2019). The Ethiopian High Land Reclamation Study (EHRS) estimated that about 50% of the high lands are already significantly eroded of which about 14 million hectares are severely eroded. In Ethiopia two millions hectares have reached a stage of irreversible destruction and cannot sustain cropping in the future (Mushir and Kedru, 2012).

The effects of soil degradation can be described as: Flood hazard, decreases in productivity of the land as well as production per unit area and the regulatory capacity of the mountains is drastically reduced and the overall effect is frequent drought, famine, and related disasters (Wolka *et al*., 2013; Adimassu *et al*., 2017). Ethiopia has a long history of following traditional conservation methods. These are numerous examples of certain parts of the country where these techniques can be seen. For example, stone terracing in Konso, Gomugoffa, random bench terraces in North Shoa and Hararge, contour bench terraces and tied ridges in Konso, drainage furrows of North-East Shoa, and sod rotation, trash bunds, trash heap composting and fallowing. To date, these techniques have not been evaluated nor has there been any attempt to improve them or popularize them (Subhatu *et al*., 2017; Lal, 2020). The scientific conservation programme is a recent phenomenon. A start was made in early 1970s. But serious attempts on a large scale were delayed until the early 1970s, when assistance of the WFP and UNDP/FAO become available. The Ethiopian high lands saw probably the most extensive soil conservation activity in 1970s and 1980s (Melaku *et al*., 2018). Between 1980 and 1990, about 2.3 million ha of land was covered by hill side terraces for a forestation of steep slope; about 1 million hectare was planted with different tree seedlings (Lakew, 2018; Guadie *et al*., 2020). One of these high land areas of Ethiopia is Hadiya zone Lemmo district where these soil conservation practices by government programme is carried out. According to AaNRDD (Agriculture and Natural Resource Development Department) (2017) in Hadiya zone 15000 hectares was covered by soil and water conservation structures in between 2006 to 2012. Even if so much amount of land was covered by soil and water conservation structures their benefit by the farmers was not known and the effects brought by soil and fanya juu bund on yield of crops are not yet investigated. Hence this research conducted to investigate the effectiveness of soil bund and fanya juu bund on wheat crop yield in comparison with unprotected land, where no physical soil and water conservation measures are taken.

Materials and methods

Description of the Study Area

This study was conducted in Lemo District in the Hadiya zone, Central Ethiopia. Geographically the study area is located in 07°41'N Latitude and 037°31'E Longitude. Topography of the study area is rugged high land and hilly areas with range of slope from 2-35 percent. Generally the terrain is mountainous, undulating and broken type that is very much prone to soil erosion. As stated by Dunn *et al.* (2016) land-use planning the soil types or the distribution of soil units in study area is sand sandy loam, loam and clay. As it has been indicated above, the most widely distributed or that covers large area is loam. They are distinguished by high amount of clay and these soils are high fertile and probably well-drained. The District is found in '*Woina Dega*' agro-climatic zone with altitudinal range of 1950-2400 meter above sea level. It has a temperature range of 15-18°C and an average rainfall is 1150mm. In the study area there are a number of rivers and seasonal streams that drain to the area. They supply water for both drinking and sanitation purposes. The interventions of human being have influenced the natural vegetation in the study area greatly. Farmers are already adapted to planting of some tree species in the District, to meet the demands for wood need. This is actually dominated by different types of *Eucalyptus* species (AaNRDD, 2017).



(Source: Survey result)

Fig.1. Location of Lemo District in Hadiya zone, Central Ethiopia.

The District has a population of 207,469, of which 103,576 are male and 103,893 female. The dominant land-use types in the District are sedentary mixed farming, whereby the cultivated land accounts for 89% of the total land area. This in turn indicates that there is great pressure on land. The area practices complete integration of trees, crop and animal production that is similar to (Singh *et al.*, 2013).

Research experimental design

The type of the study governs the choice of the study design. In this study, the pragmatic (matter of-factual) world outlook or rational approach was suitable since it is factual-world practice-oriented and problem-centered (Creswell and Clark, 2011). In this study a mixed methods design that is, a mix of quantitative and qualitative approach were employed for collection of data and data analysis. This study adopted the pragmatic philosophic approach (Creswell, 2009. The experiment was done on farmers' field using level soil bund, fanya juu bund and control plot as treatment and wheat as a test crop. Neither farm yard manure nor mineral fertilizer was applied in all the treatments during experimentation. The experiment was laid out in randomized complete block design (RCBD) with 63 observations per variable that is 7 replications, 3 treatments, 3 positions and plot size of 378m^2 (Fig. 2). Throughout the crop season, all the experimental plots were observed closely and seen that there was serious control of disease and pest incidence noticed on the plant and not considered to be a factor in affecting growth or yield of the crop. When the crop in the experiment plot was ready for harvest it was harvested and collected from each of the plot separately using a new sack. After threshing the grain from each plot were weighed and the value was extrapolated for the total crop yield per hectare basis. Days to 50% spiking and plant height were recorded on the same day when 50% of the plant in the plot reaches the respective phonological stage. Plant height of wheat crop was measured in cm from the three position one farmer plot 72 plants which are randomly taken from each plot 10 days before harvesting. At harvest time spikes were taken manually and thousand grains were counted and weighed from the bulk of shelled grain at moisture content 12% level and expressed in grams. Seed moisture was determined in Van, (2013) seed quality testing by oven dry method rather than the quick method in order to avoid errors during reading of the meter which was less precise than the results determined with the air-oven method (Munkholm *et al*., 2013). In this method the wheat was grinded by grinding machine and after grinding a sample of 4gm was taken and put in the oven of 133°C for two hours after two hours it was taken from the oven and placed in the desiccators for cooling and after ten minutes it was measured to obtain the weight and calculate for the moisture.

Data collection

For each experimental plot all parameters (grain yield (kg/ha, days to 50% spiking and maturity, plants height in (cm) and thousand grain weight (kg) crop yield was collected using an appropriate sampling technique. When the crop in the experiment plot was ready for harvest, it was harvested and collected by sacks from each plot separately in order to avoid grain loss during threshing. The grain was weighed and recorded as grain yield in kg per hectare. Days to 50% spiking and maturity of wheat was recorded when fifty percent of the plant in a plot reach the respective phonological stage. Plant height of wheat is measured in cm from twenty four plants from each position (upper, middle and lower) sampled randomly from left, right and center of each plot one week before harvesting. Thousand grain weights was measured after sampling from the bulk of shelled grain moisture content of 12% level for all samples and expressed in grams.

Data analysis

The data collected for different parameters regarding crop yield were analyzed statistically using analysis of variance for 7 replications of RCBD was computed using the SAS to show if there was significant difference among the treatment means for the different parameters. Least significance difference was used to separate means from each other among the replications using 5% probability level. Pearson correlation coefficient was used to show the relationship and significance of the recorded yield of wheat.

Results and discussion

Impacts of Soil and Water Conservation Structures on Wheat Yield

From each treated conservation structure and untreated plots, plant height in centimeter (cm), number of seed per spike, 1000 seed weight in gram (gm), day to 50% spiking and grain yield in quintal per hectare were recorded during the growth period and harvest time from plant samples taken from the plots. The data on wheat yield and agronomic characteristics as affected by different soil and water conservation treatment at seven replications is shown in Table 1. The soil and water conservation structures displayed a statistically significant effect ($P \leq 0.05$) on wheat plant height, number of seed per spike, days to 50% spiking and grain yield.

Table 1. Wheat yield versus treatments.

Replications/replications	Yield increment qt/ha in (%) over the control plot		
	Control plot	Soil bund	Fanya juu bund
North Ballesa sample one (R_1)	14.71	4.74	10.08
North Ballesa sample two (R_2)	22.99	13.06	2.8
Ana-Ballesa sample three (R_3)	20.14	4.67	13.5
Ana-Ballesa sample four (R_4)	19.43	2.67	4.21
Ana-Ballesa sample five (R_5)	15.86	8.43	10.19
Amibicho sample six (R_6)	13.07	13.94	12.36
Ambicho sample seven (R_7)	17.15	5.95	10.17
Mean	17.6	7.64	9.04

(Source: Survey result).

In order to display the different effects of the soil and water conservation structures on agronomic characteristics and yield a comparison of the averages of the seven replications were made on wheat crop. The relative average mean of 9.04 quintal/hectare (55%) was recorded on fanya juu bund and 7.64 quintal/hectare (45%) increment were recorded on soil bund and the highest mean yield increments due to conservation structures was recorded on Ambicho-six with soil bund (13.94 quintal/hectare), and Ana-Ballesa three fanya juu bund (13.5 quintal/hectare) over the control plots (Table 1). But in the overall mean increment the highest percent increment was recorded on fanya juu bund (Table 1).

Table 2. Wheat yield and yield parameters.

Treatments	Number of seed per spike		Plant height in cm		1000 seed weight (gm)		Grain yield in Quintal/hectare	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Soil bund	31.19a	8.76*	95a	10*	40a	7*	26.39a	7.96*
Fanya juu bund	30.81a	8.38*	97b	12*	42a	9*	27.82a	9.39*
Control	22.43b	-	85c	-	33b	-	18.43	-
CV (%)	16.05		5.31		11.2		15.9	
LSD (0.05)	2.82		3.08		2.66		2.4	

CV =Coefficient of variance LSD= least significant difference means significantly different at ($P \leq 0.05$) (Source: Survey result).

This high yield increment may be due to organic matter and nutrient availability on treated plots relative to the control plot. This finding was in agreement with Adgo *et al.* (2013) and Lampurlanés *et al.* (2016) which showed that bean yield was increased because of fanya juu bund. Study by Bazongo *et al.* (2015) also estimated that on the average field protected by bunds have higher sorghum yield than the control plots. The same is true for the study of Assefa *et al.* (2020) which indicated that, estimated yields of wheat and faba bean grown on soil accumulation and soil erosion segments of terraces and on un-terraced (up slope) areas in the Tembien (same plots as used by Amare *et al.* (2013) that indicated yields were higher than non-terraced fields.

Table 3. Wheat yield on seven replications of the experimental plot.

Conservation Measures	Wheat grain yield quintal/hectare on seven replications							
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	Means
Level soil bund	19.45	40.05	24.81	22.1	24.29	31.01	23.1	26.4
Fanya juu bund bund	24.79	27.79	33.64	23.64	26.05	29.43	27.32	27.52
Control	14.71	26.99	20.14	19.43	15.86	17.07	17.15	18.76
Means	19.68	32.28	26.2	21.72	22.07	25.84	22.52	

*R_1 to R_7 = Replications one to seven (Source: Survey result).

The possible reason of yield decrease on the control plot is due to less amount of organic matter, nitrogen, phosphorous, organic carbon, which is decreased and washed away because of water erosion (Table 2 and 7). Similar to the study of Taye *et al.*, (2013) found a yield increment of 7.43% in fields treated with soil bunds compared with untreated plot. A significantly higher ($P \leq 0.05$) plant height, 1000 seed weight of wheat, number of seed per spike was observed in both soil bund and fanya juu bund compared to control plots (Table 2). Both soil bund and fanya juu bund produced a significantly higher ($P \leq 0.05$) yield than the untreated plot. However, no significant differences ($P \leq 0.05$) were observed between soil bund and fanya juu bund in terms of number of seeds per spike, grain yield and 1000 seed weight. Considering the mean yield on the seven replications wheat produced under the influence of soil bund was 26.39 quintal/hectare which is greater by 43.2 % than the control plot and fanya juu bund 27.82 quintal/hectare that is (50.9%) higher than the control plot (Table 2). The average wheat yield obtained in fanya juu bund was higher than the soil bund and control plot followed by the soil bund. At the same time fanya juu bund treated plots had gained an increase in plant height and 1000 seed weight of wheat which is 12cm (14.1%), 9gm (27.3%) over the untreated plots respectively.

Table 3. Average wheat yield as measured on conservation structure.

Treatments	Plant height in (cm)	Number of seeds per spike	1000 seed weight in (gm)	Days to 50% spiking	Grain yield in quintal/hectare
Level soil bund	95	31	39.63	66.6	26.39
Fanya juu bund bund	97	31	42	67.4	27.82
Control	85	22	32.55	70.85	18.43

(Source: Survey result).

It is difficult to formulate a one-to-one, cause and effect relationship between crop yields on the one hand and soil erosion and erosion induced soil degradation on the other (Teshome *et al.*, 2013). Under field condition it will be difficult to relate crop yield to any individual factor which is an integrated response of many parameters. According to Sörlin and Wormbs (2018), the vast quantity of our soil washed away every year contains 92,172 and 300 tons of phosphorus, Potassium, Nitrogen, Calcium and Magnesium as computed from the average analysis of 389 samples of surface soil collected throughout the United State. As shown in Table 3 the highest (40.05 quintal/hectare) and the lowest (14.71 quintal/hectare) grain yield of wheat was recorded on the soil bund treated plot at North Ballesa-two and on control plot North Ballesa-one respectively.

On considering the average of all conservation measures on all replications the highest (32.28 quintal/hectare) grain yield was obtained at North Ballesa-two and the lowest (19.68 quintal/hectare) is recorded at North Ballesa-one (Table 3). In general, all the average grain yield and agronomic characteristics displayed the lowest record in the control plot in all seven replications.

Table 5. Correlation between wheat yield and different conservation structures.

Soil/crop characteristic	Soil bund	Fanya juu bund	Control
Number of seed/spike	-.466	-.925**	-.453
1000 seed weight	.577	.683*	-.280
Plant height	.419	-.464	-.348

N.B **Correlation is significant at (P≤0.01). *Correlation is significant at (P≤0.05). (Source: Survey result).

The 1000-seed weight in soil bund and fanya juu bund was significantly higher (P≤0.05) than the control plot. There is no significant difference between soil bund and fanya juu bund treated plots. The mean 1000-seed weight of wheat grown under soil bund and fanya juu bund treated plots were 7 gm (21.2%) and 9 gm (27.3%) higher respectively than the control plot. This implies that 1000-seed weight is one of the important components of wheat yield.

Among the seven replications the highest average 1000-seed weight was recorded (42.11gm) at North-Ballesa-three and the smallest (33.46gm) was at Ana-Ballesa-five. Statistically significant difference (P≤0.05) was also observed on 1000-seed weight (Table 2). The lowest average 1000 seed weight observed in Ana-Ballesa-five was due to low value recorded on control plot. This implies also low level of organic matter and nutrients on the location. A statistically significant difference (P≤0.05) was also observed on the number of seeds per spike between soil bund, fanya juu bund and the control plot (Table 2). The mean difference of number of seeds per spike on soil bund was (8.76) and on fanya juu bund (8.38) higher than the control plot (Table 2). There was no significant difference between soil bund and fanya juu bund. The average1000 seed weight recorded on soil bund and fanya juu bund was (21.75%) and (29.03%) greater than the control plot respectively. The mean highest number of seeds per spike among replications was 35 recorded at North-Ballesa-two and the lowest 22 at Ana-Ballesa-five. A greater degradation of physical and chemical properties on the control plot greatly affected the wheat yield and agronomic characteristics. This may be due to increased erosion and erodibility on the control plot may be because of the reduction of organic matter. Plot studies at Hilton experimental sites, Ball and Munkholm (2015) showed that small reduction in soil organic matter content markedly increased erodibility and erosion. The same findings by the study of (Donjadee and Tingsanchali, 2016; Lakew *et al.*, 2019).

Table 4. Correlation between wheat yield, and soil chemical properties.

Soil/crop characteristic	Soil bund	fanya juu bund	Control
Total nitrogen	-.501	-.662	.403
Organic matter	.305	.596	.159
Organic carbon	.433	.594	.152
CEC	-.568	-.282	-.213

(Source: Survey result)

As shown in Table 4 the average value of days to 50% spiking for soil bund was 66.6 and fanya juu bund was 67.4 whereas for control plot was 70.85. This show those days to 50% spiking was delayed on control plot; because of nutrient deficiency on the control plot due to erosion by water. Similar observations stated plants grow slowly when nitrogen is deficient; they also appear spindly, stunted and pale when compared with healthy plants. The pale green color of nitrogen-deficient plants results from a shortage of chlorophyll because chlorophyll is needed for carbohydrate production by photosynthesis (Taye *et al.*, 2013; Dimtsu *et al.*, 2018). A tentative identification of a phosphorus deficiency made on the basis of such symptoms as stunting, delayed maturity, dark green coloration, and purple spots or streaks were observed. Among the seven replications, the highest (107cm) and the smallest plant height (81cm) was observed at Ana-Ballesa-three and Amibicho-six, respectively. This is due to different physical and chemical properties of soil in the replications and lack of conservation structures on the control plot. As shown in (Table 4) the smallest plant height is observed on control plot (85cm). This may be due to lower content of nutrients on the control plot which is similar to study by (Sharma *et al.*, 2018) and Adgo *et al.* (2013) observed a decrease in plant height with loss of nitrogen, phosphorus, and potassium and soil organic matter by erosion which is usually followed by reduction in soil pH. Soils may be deficient in organic matter leading to shortage of nitrogen, phosphorus and potassium. These deficiencies retarded plant growth, cause poor color and affect the eminence of crop productivity.

Table 7. Correlation between wheat yield and soil physical characteristics.

Soil/crop characteristic	soil bund	fanya juu bund	Control
Bulk density	-.482	-.449	-.397
Total porosity	.575	-.806*	.389
water holding capacity	.715*	.486	.340
Clay	-.728*	-.748*	.182
Sand	.723*	.546	-.327

N.B. *Correlation is significant at ($p \leq 0.05$) (Source: Survey result).

Correlation of Wheat Yield and Soil Properties

Correlation analysis was used to describe the strength and direction of the linear relationship and to show the properties most affected by erosion and the quantity of the detail predominant relationship among the agronomic characteristics of the wheat crop and the soil and water conservation structures on the one hand and the soil physico-chemical proprieties and yield on the other. Table 5 and 6 show the correlation between wheat yield and some of the agronomic characteristics and soil physico-chemical properties with the soil and water conservation structures which Pearson's correlation (r) ranges in between -1 to 1. This value indicates the strength of the relationship between variables. Study by scholars Nyangena and Köhlin (2009) and Demelash and Stahr (2010) had suggested the following guide line of interpreting Pearson's correlation (r). The negative sign according to the guide line applies only to the direction of the relationship not the strength.

As indicated in the Table 5, wheat yield showed positive and significant correlation values with 1000seed weight on soil bund (r=0.577), fanya juu bund (r=0.683*) whereas it showed negative and small correlation with control plot (r=-0.280). wheat yield correlated negatively on all treated and untreated plots with number of seeds per spike and showed significant and large correlation on fanya juu bund treated plot (r=-0.925**) (P≤0.01) whereas plant height showed positive and medium correlation on soil bund (r=0.419) and negative correlation on fanya juu bund and control plot (r= -0.464) and (r = -0.348) respectively.

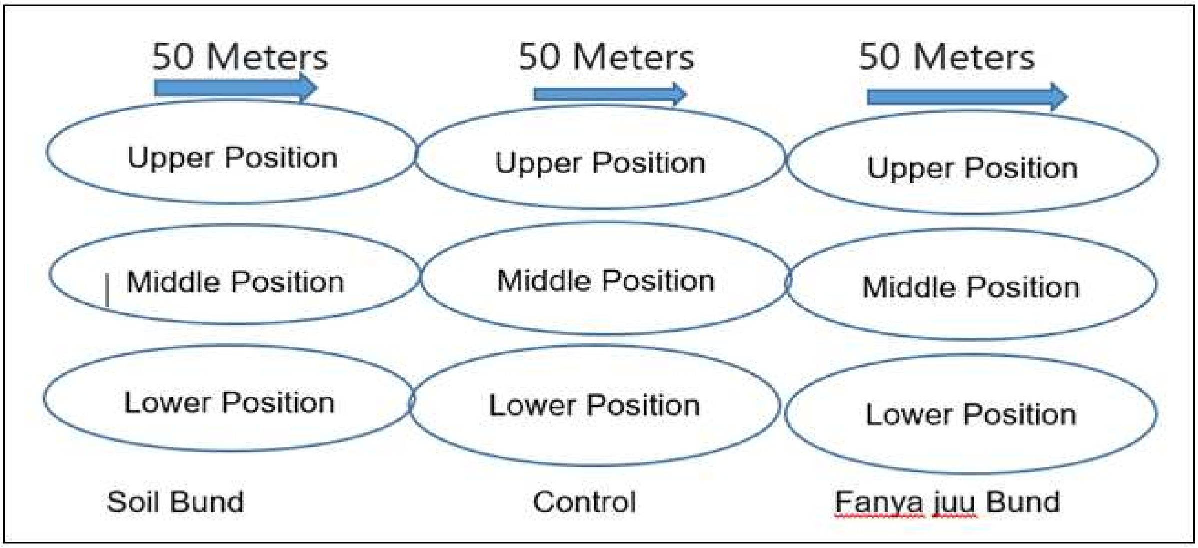


Fig. 2. Experimental layout of plots.

Organic carbon and organic matter showed a medium relationship on soil bund whereas, total nitrogen and cation exchange capacity showed large relationship. On the other hand, total nitrogen, organic carbon, organic matter and cation exchange capacity showed large relationship on fanya juu bund whereas the relationship on untreated plot was small and insignificant. Organic matter loss not only results in reduced water holding capacity and soil degradation but also the loss of plant nutrients which are used to increase yield. This was confirmed by the study results of Yaekob *et al.* (2020) and Adimassu *et al.* (2017) which states that, the major problem to the farm associated with soil erosion come from loss of nutrients and reduced water holding capacity, accounting 50 to 70% of productivity loss. Zhao *et al.* (2019) also showed that the effects of erosion from slight to severe on organic matter soil phosphorus level, and plant available water reduces their content from 3% to1.9%, 31kg/acre to 20kg/acre and 7.4% to 3.6% respectively which in-turn affects productivity of the land.

Among the soil physical properties clay, sand and total porosity have a large correlation because they have the value greater than 0.5 and -0.5. This was due to soil erosion which changes the texture of the plough layer by washing away the organic fine textured and fertile soil and exposing the sand particles in the lower horizons. Clay has got a negative and significant correlation with wheat yield (r= -0.728* and r= -0.748*) with soil bund and fanya juu bund whereas it has a positive and insignificant correlation with control plot (r=0.182) which is showing a small correlation (Table 7). Sand has a positive and significant correlation with soil bund (r=0.723*) and a positive correlation (r=0.546) with fanya juu bund, negative and insignificant correlation with control plot.

A small and insignificant correlation on the control plot was due to erosion problem which has taken the finer topsoil from untreated plot and left behind the coarser soil that reduces the organic matter content and plant nutrient casing yield reduction on the control plot. Total porosity has got a positive and large correlation with wheat yield on soil bund (Table 7). It has negative, significant and large correlation on fanya juu bund, whereas, it has got a positive and medium correlation on the control plot. The other texture related soil physical property such as bulk density has got a negative and large correlation on soil bund and fanya juu bund. It has also got a negative and medium correlation with control plot. Available water holding capacity showed a positive; large and medium correlation with wheat yield on soil bund and fanya juu bund respectively and a positive and medium correlation on the control plot. Available water showed significant correlation with soil bund. This was due to clay content and structural arrangement of the soil. It varies also with soil treatment because the size and distribution of pores in the top soil reflects surface exposure, normal seasonal wetting and drying and management. Lal (2020) and Rashid *et al.* (2016) studied the water content of soil samples found that the available soil water of well-structured soil was one third twice as large as that in poorly structured or degraded soil. Lakew *et al.* (2019) and Kumar *et al.* (2020) confirmed that significant differences in porosity and water holding capacity occurs only when exposed soil material are intensively cultivated and the soil are structurally degraded.

Conclusion

The use of crop management practices like mulching, and leaving crop residues on the field to control soil erosion was difficult in the study area, because of the absence of crop cover when it is most needed, as they are mainly used for animal feed. Consequently mechanical conservation measures are of great importance. Much of the present efforts of conservation are based on the building of cut-offs and in construction of soil bunds and fanya juu bund. Soil conservation treated plots in the area showed significant difference ($P \leq 0.05$) on wheat plant height, number of seed per spike, days to 50% spiking and grain yield. The relative average mean of 55% was recorded on the fanya juu bund and 45% increment was recorded on soil bund.

Soil bund and fanya juu bund which are widely used in the area showed an increment in crop yield. Soil erosion affects crop production primarily because it affects (a) soil nutrients (b) the soil water holding capacity (c) bulk density (d) soil tiles (e) infiltration of the soil and others. These facts were shown on the study area on the control plots. The overall results of this study indicated that soil and water conservation structures increased crop yield which may be because of improved soil properties.

Recommendations

Soil and water conservation measures should have to be exercised on cultivated land where there is soil erosion problem. Raising yield per hectare and improving the quantity of product will increasingly difficult without a steady use of soil and water conservation technologies by the farmers. Hence the government should encourage the respective offices to extend soil and water conservation technologies to be used by all farmers of the area in order to achieve the goal intended in agricultural crops.

A greater work should have to be done to increase farmers' source of information and technical assistance that will help those increases their awareness and recognizes soil erosion as a problem on their own farm. The "mass media," especially farm magazines, should be used in greater amounts for the dissemination of conservation information in the farmers training center, day of farmers' demonstration and by written leaflets. The role soil and water conservation should be clarified, as common goals among the stakeholders should be firmly established, and a team work approach of public and private organizations at the local level should be emphasized. Obstacles to soil and water conservation should be identified at the local level and dealt with as part of the program implementation process.

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References

Aa NRDD. (Agriculture and Natural Resources Development Department). 2017. Five Years Development Report.

Adgo E, Teshome A, Mati B. 2013. Impacts of long-term soil and water conservation on agricultural productivity: The case of Anjenie watershed, Ethiopia. Agricultural Water Management **117,** 55-61 p.
http://dx.doi.org/10.1016/j.agwat.2012.10.026

Adimassu Z, Langan S, Johnston R, Mekuria W, Amede T. 2017. Impacts of soil and water conservation practices on crop yield, run-off, soil loss and nutrient loss in Ethiopia: review and synthesis. Environmental management **59(1),** 87-101.
http://dx.doi.org/10.1007/s00267-016-0776-1

Amare T, Terefe A, Selassie YG, Yitaferu B, Wolfgramm B, Hurni H. 2013. Soil properties and crop yields along the terraces and toposequece of Anjeni Watershed, Central Highlands of Ethiopia. Journal of Agricultural Science **5(2),** 134 p.
http://dx.doi.org/10.5539/jas.v5n2p134

Assefa T, Jha M, Reyes M, Worqlul AW, Doro L, Tilahun S. 2020. Conservation agriculture with drip irrigation: Effects on soil quality and crop yield in sub-Saharan Africa. Journal of Soil and Water Conservation **75(2),** 209-217 p.
http://dx.doi.org/10.2489/jswc.75.2.209

Ball BC, Munkholm LJ. eds. 2015. Visual Soil Evaluation: Realizing potential crop production with minimum environmental impact. CABI.

Bazongo P, Traore K, Traore O, Yelemou B, Sanon KB, Kabore S, Hien V, Nacro BH. 2015. Influence of Jatropha hedges on the yield of a sorghum crop (Sorghum vulgare) in the western region of Burkina Faso: case of Torokoro locality. International Journal of Biological and Chemical Sciences ***9*****(6),** 2595-2607 p.

Bogale M, Regassa A, Tilahun A. 2020. Inter-structural Space Effect of Fanya juu and Soil Bund Soil and Water Conservation Structures on Selected Soil Properties: In the Case of Habru District, North Ethiopia.
http://dx.doi.org/10.7176/JEES/10-3-01

Creswell JW. 2009. Editorial: Mapping the field of mixed methods research. Journal of Mixed Methods Research **3(2),** 95-108 p.
https://journals.sagepub.com/doi/10.1177/1558689808330883

Creswell JW, Clark VP. 2011. Designing and conducting mixed methods research. Retrieved on July, *25*, 2014 p.

Demelash M, Stahr K. 2010. Assessment of integrated soil and water conservation measures on key soil properties in South Gonder, North-Western Highlands of Ethiopia. Journal of Soil Science and Environmental Management **1(7),** 164-176. p

Dimtsu GY, Kifle M, Darcha G. 2018. Effect of soil and water conservation on rehabilitation of degraded lands and crop productivity in Maego watershed, North Ethiopia. Journal of Degraded and Mining Lands Management **5(3),** 1191 p.
http://dx.doi.org/10.15243/jdmlm.2018.053.1191

Donjadee S, Tingsanchali T. 2016. Soil and water conservation on steep slopes by mulching using rice straw and vetiver grass clippings. Agriculture and Natural Resources **50(1),** 75-79 p.
http://dx.doi.org/10.1016/j.anres.2015.03.001

Dunn BW, Dunn TS, Orchard BA. 2016. Nitrogen rate and timing effects on growth and yield of drill-sown rice. Crop and pasture Science **67(11),** 1149-1157 p. https://doi.org/10.1071/CP16331

Guadie M, Molla E, Mekonnen M, Cerdà A. 2020. Effects of Soil Bund and Stone-Faced Soil Bund on Soil Physicochemical Properties and Crop Yield under Rain-Fed Conditions of Northwest Ethiopia. Land **9(1),** 13 p. https://doi.org/10.3390/land9010013

Hailu L. 2019. Effects of Soil and Water Conservation on Selected Soil Physicochemical Properties and Its Implication on Soil Productivity in Ethiopia. A Review. https://doi.org/10.7176/JEES

Lakew W, Baartman J, Flesken L, Selassie Y, Ritsema C. 2019. Measuring and modelling the impacts of soil and water conservation measures on soil erosion and sediment yield in North-Western Ethiopian highlands. Authorea Preprints.

Kumar S, Singh DR, Singh A, Singh NP, Jha GK. 2020. Does Adoption of Soil and Water Conservation Practice Enhance Productivity and Reduce Risk Exposure? Empirical Evidence from Semi-Arid Tropics (SAT), India. Sustainability **12(17),** 6965 p. https://doi.org/10.3390/su12176965

Lal R. 2020. Soil organic matter content and crop yield. Journal of Soil and Water Conservation, **75(2),** pp.27A-32A. https://doi.org/10.2489/jswc.75.2.27A

Lampurlanés J, Plaza-Bonilla D, Álvaro-Fuentes J, Cantero-Martínez C. 2016. Long-term analysis of soil water conservation and crop yield under different tillage systems in Mediterranean rainfed conditions. Field Crops Research **189,** 59-67 p. http://dx.doi.org/10.1016/j.fcr.2016.02.010

Melaku ND, Renschler CS, Flagler J, Bayu W, Klik A. 2018. Integrated impact assessment of soil and water conservation structures on runoff and sediment yield through measurements and modeling in the Northern Ethiopian highlands. Catena **169,** 140-150 p. https://doi.org/10.1016/j.catena.2018.05.035

Munkholm LJ, Heck RJ, Deen B. 2013. Long-term rotation and tillage effects on soil structure and crop yield. Soil and Tillage Research **127,** 85-91 p. https://doiorg.subzero.lib.uoguelph.ca/10.1016/j.still.2012.02.007

Mushir A, Kedru S. 2012. Soil and water conservation management through indigenous and traditional practices in Ethiopia: A case study. Ethiopian Journal of Environmental Studies and Management **5(4),** 343-355 p. http://dx.doi.org/10.4314/ejesm.v5i4.3

Nyangena W, Köhlin G. 2009. Estimating returns to soil and water conservation investments-an application to crop yield in Kenya.

Rashid M, Alvi S, Kausar R, Akram MI. 2016. The effectiveness of soil and water conservation terrace structures for improvement of crops and soil productivity in rainfed terraced system. Pakistan Journal of Agricultural Sciences **53(1).** https://doi.org/10.21162/PAKJAS/16.1502.

Sharma KL, Reddy KS, Chary GR, Indoria AK, Srinivas K, Chandrika DS, Lal M, Prabhakar M, Prathiba G, Thakur P, Vasavi M. 2018. Effect of surface residue management under minimum tillage on crop yield and soil quality indices after 6 years in sorghum (Sorghum bicolor (L.) Moench)-cowpea (Vigna unguiculata) system in rainfed Alfisols. Indian Journal of Dryland Agricultural Research and Development **33(1),** 64-74 p.

Singh G, Singh B, Rathore TS. 2013. Effects of agroforestry land use on microclimate modification and productivity in dry areas. Indian Journal of Agroforestry **15(2),** pp.68-78.

Sörlin S, Wormbs N. 2018. Environing technologies: A theory of making environment. History and Technology **34(2),** 101-125 p. https://doi.org/10.1080/07341512.2018.1548066

Subhatu A, Lemann T, Hurni K, Portner B, Kassawmar T, Zeleke G, Hurni H. 2017. Deposition of eroded soil on terraced croplands in Minchet catchment, Ethiopian Highlands. International soil and water conservation research **5(3),** 212-220 p. https://doi.org/10.1016/j.iswcr.2017.05.008

Taye G, Poesen J, Wesemael BV, Vanmaercke M, Teka D, Deckers J, Goosse T, Maetens W, Nyssen J, Hallet V Haregeweyn N. 2013. Effects of land use, slope gradient, and soil and water conservation structures on runoff and soil loss in semi-arid Northern Ethiopia. Physical Geography **34(3),** 236-259 p.

Teshome A, Rolker, D, de Graaff J. 2013. Financial viability of soil and water conservation technologies in northwestern Ethiopian highlands. Applied Geography **37,** 139-149. https://doi.org/10.1016/j.apgeog.2012.11.007

Tilahun A, Belay F. 2019. Conservation and production impacts of soil and water conservation practices under different socio-economic and biophysical setting: a review. Journal of Degraded and Mining Lands Management **6(2),** 1653 p. https://doi.org/10.15243/jdmlm.2019.062.1653

Van Jaarsveld E. 2013. Waterwise gardening in South Africa and Namibia. Penguin Random House South Africa.

Wolka K, Moges A, Yimer F. 2013. Farmers' perception of the effects of soil and water conservation structures on crop production: The case of Bokole watershed, Southern Ethiopia. African journal of environmental science and technology **7(11),** 990-1000. https://doi.org/10.5897/AJEST2013.1529

Yaekob T, Tamene L, Gebrehiwot SG, Demissie SS, Adimassu Z, Woldearegay K, Mekonnen K, Amede T, Abera W, Recha JW, Solomon D. 2020. Assessing the impacts of different land uses and soil and water conservation interventions on runoff and sediment yield at different scales in the central highlands of Ethiopia. Renewable Agriculture and Food Systems, 1-15 p. https://doi.org/10.1017/S1742170520000010

Zhao J, Yang Z, Govers G. 2019. Soil and water conservation measures reduce soil and water losses in China but not down to background levels: Evidence from erosion plot data. *Geoderma* **337,** 729-741 p. https://doi.org/10.1016/j.geoderma.2018.10.023