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Effects of Level Soil Bund and Ages of Bund on Teff Productivity and Soil Properties: At, Nejo District, Oromia Region, Ethiopia

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Abstract

Land degradation can be considered in terms of the loss of actual or potential productivity or utility as a result of natural or human factors; it is the decline in land quality or reduction in its productivity. It causes running down of soil organic matter and available water for crop growth. Consequently, implementation of soil and water conservation especially level soil bund is supposed to alleviate the impacts of soil erosion and increase agricultural land production and crop productivity. Based on that the effects of level soil bund was evaluated by conducting on-farm study during the cropping season of 2019 in Eba wakeyo kebele, Nejo District, Western Wollega of Oromia Regional State with the objective of evaluating level soil bund on teff productivity and soil properties. The study involves two factor: level soil bund (with and without) was a main plot and the ages of level soil bund was taken as the sub-plots. The treatment (T1=with bund of six year splited in to 7, T=with bund of 4 year splited in to 7, T3=with bund of 2 year splited in to 7 and T4=without splited in to 7) with randomized complete block design. The data was analyzed using general linear model procedures and to separate difference between mean LSD (5%) was used. The level soil bund increased the mean value of soil moisture contents at 0-30 cm and 0-60 cm soil depth, the teff (Eragrostis tef) grain yield increased by 22.85% when compared with controlled block and the teff biomass increased by 24.32%. As the wall, it is concluded that level soil bund improves soil fertility, soil moisture status and teff (Eragrostis tef) grain yield and yield components.

Keywords: Land degradation; Level soil bund; Soil erosion; Soil properties and teff productivity

Introduction

Background and Justification

Natural resource degradation and land degradation in particular has negative impact on the economy of developing countries including Ethiopia. This is because; the country heavily depends on their natural resource for food self-sufficient, food security and economic development. Soil erosion and nutrient depletion are the most important forms of land degradation in Ethiopia [1]. Erratic and erosive rainfalls, steep terrain, deforestation, inappropriate land use, land fragmentation, overgrazing and weak management practices are among the factors that cause land degradation in the country [2].

Soil erosions are the serious problem in Ethiopia since agriculture is the major source of livelihood in the country. The average annual rate of soil loss in the country is estimated to be 12 tons/hectare/year, and it can be even higher (300 tons/hectare/year) on steep slopes and in places where the vegetation cover is low [3]. Agricultural activities change the soil chemical, physical, and biological properties, and play the major role for soil degradation mainly due to soil fertility decline because of lack of nutrient inputs [4].

The sorting action of erosion removes large proportions of the clay and humus from soil, leaving behind the less productive coarse sand, gravel, and in some case even stones, impairing the quality of the remaining topsoil. The removal of this organic matter affects soil properties including texture, structure, nutrient availability and biological activity and makes soil more susceptible to further erosion as its aggregates becomes less stable thus, negatively affecting crop production.

Soil and water conservation measures such as soil bunds and stone bunds are adaptation options to mitigate the problems caused by soil erosion and its consequences. Since 2000, government and nongovernment organizations such as sustainable land management programme have been

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promoting agricultural production through the implementation of biological and physical soil and water conservation measures in the degraded of Nejo district. Especially, Construction of level soil bunds has been the major activities that preformed on the croplands. But the long-term effects of those interventions on production have not been investigated. This study assessed the effects of Level Soil Bund (LSB) on teff productivity and selected soil physico- chemical properties.

Statement of the problem

Soil deterioration and low water quality due to erosion and surface runoff have become severe problems worldwide. Soil erosion is the main driver of land degradation in Ethiopia. In the study area it is a serious problem due to continues cultivation of crops, over grazing, limitations of soil and water conservation practice, termite, poor soil infiltration capacity and high volumes of runoff. This leads to change on a soil properties and reduction of crop land productivity. Based on those phenomena, the lives of local peoples in the study area was under deterioration. Even if the agricultural extensions try to introduce soil and water conservation practices like level soil bund in the area, the spreading out of the structures was poor. Consequently, it is important to conduct a research to assess how level soil bund is effective to improve soil properties and enhance crop productivity in the study area.

Objective of the study

General objective: To evaluate the effects of level soil bund on crop productivity and soil properties.

The specific objectives are

I. To evaluate the effect of level soil bund to improve teff crop yield and yield components.

II. To assess the effects of level soil bund soil selected chemical properties.

III. To assess the impacts of level soil bund on selected soil physical properties.

Materials and Methods

Description of the study site

The study was conducted at Nejo district Eba wakeyo kebele which is located in western Wollega zone of the Oromia Regional State at the latitude of 9°5'N and longitude of 35°45'E in western Ethiopia. The site has an elevation of 1735 meters above sea. Nejo, is found at about 498 km west of Addis Ababa.

Treatments and experimental design

For study, Eba wakeyo kebele was selected. For experimental work 28 farmers' plots a quarter of a hectare each, was selected whereas 7 plot with level soil bund of six years, 7 plots level soil bunds of four years, 7 plots of two years and 7 plots was without level soil bund and the experimental protocol was 4 treatments which can be conducted as follows:

1. Pure stand crop on a plot without soil bund of six years (T1).
2. Pure stand crop on a plot with soil bund of 4 years (T2).
3. Pure stand crop on a plot with soil bund of 2years (T2).
4. Pure stand crop on a plot with soil bund (T3).

Soil sampling and analysis

Monitoring soil chemical properties and physical properties: Composite soil samples was collected for homogeneity of soil from all plots at 0-30 cm and 0-60 cm using Auger and the selected chemical properties including texture by Bouyoucos hydrometer method (Day, 1965), organic carbon using Walkely and Black method (Neilsan and Sommers, 1917), and total nitrogen using Kjeldahl digestion and distillation method (Bremner and Mulvaney, 1982), available phosphorous (Olsen and Dean (1965), Soil pH was determined at soil: water suspension ratio of 1:2 using a conventional glass electrode pH meter (Jackson,1973) at Bedele Soil Research Center of Oromia Agricultural Research Institute (OARI). Texture: texture determination was carried out using the hydrometer method (Day, 1965).

Agronomic data collection

Biomass: was calculated at harvesting stage by measuring the total biomass using spring balance from three randomly selected samples using a 1 m x 1 m quadrant at each plot. Grain yield: Grain yield from 1 m x 1 m per plot was measured using electronic balance and then adjusted to 12.5% moisture and converted to hectare basis after oven drying the samples as follows (African journals of plant science).

Where; FW=Field Weight harvested from sample plot; AMC=Actual Moisture Content; RDW=Recommended Dry Weight (Given)=87.5; 0.8=Shelling % (Given). Then the yield per plot is converted into yield per hectare (tones ha^{-1}).

Data analysis

The collected data from both crop and grazing land were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedures in SAS version 9.2.3 (SAS Institute, 2002). Means that were significantly affected by the treatments were separated using the Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Soil physical properties

Soil moisture contents: Soil moisture content was affected by soil and water conservation practices. As data presented in (Figure 1) the level soil bund significantly influence the soil moisture content of the study area. Consequently, the higher mean value of soil moisture content of plots with level soil bund of six years were 37% at 30-60 cm and 33 % at 0-30 cm soil depth. On the 4 years, the mean value of soil moisture content were 35.4 % at 30-60 cm and 31.53% at 0-30 cm soil depth in the plots with level soil bund while 30.75 % at 0-30 cm and 34.5 % at 0-60 cm soil depth in the plots without level soil bund. As the present study level soil bund improves soil moisture content, which is a key factor to improve land production. Also ages of the

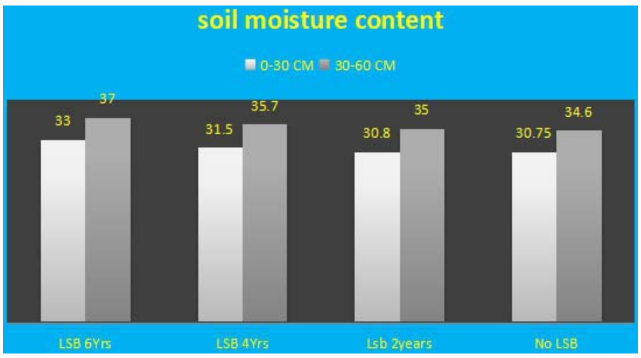

Figure 1: Soil moisture content affected by level soil bund at 0-30 and 30-60 cm.

Table 1: Mean value of on selected soil physical properties affected by soil bund.

Treatment	BD (g cm^{-3})	Sand (%)	Clay (%)	Silt (%)	Textural class
With LSB 6Y	0.91	27.28	32.72	36	Clay loam
With LSB 4Y	1.01	29.5	34.72	32.5	Clay loam
With LSB 2Y	1.07	33.48	34.79	32	Clay loam
Without LSB	1.10	45.12	36.88	30	Sandy clay
LSD (5%)					
CV%	4.32	4.68	5.96	9.57	-

Table 2: Mean value of on selected soil chemical properties affected by soil bund.

Treatment	TN (%)	AvP (ppm)	PH(1:2H$_2$O)	OC (%)	CEC(meq/100g)
With LSB 6Y	0.25	7.13	5	3.64	23.62
With LSB 4Y	0.24	6.69	4.5	3.5	21.85
With LSB 2Y	0.21	6.33	4.17	3.12	20.46
Without LSB	0.19	5	4	2.22	22.48
CV%		10.93	9.83	11.43	

bund and soil moisture content have positive relationships. As the ages the bund increases the soil moisture content also increases.

Soil bulk density and texture: Soil bulk density (BD) (g cm^{-3}) was affected by soil conservation practices. It ranges from 0.91 g cm^{-3} (level soil bund of six years) to 1.10 g cm^{-3} (plots without level soil bund) (Table 1). The lower mean BD value under six years level sol bund measures might be the subsequent effects of reduced soil loss and crop residue through erosion; and addition of organic matter from plants. Similar results were reported by [5-8] who indicated lower mean soil BD value in conserved farms than non-treated cultivated lands. Data regarding particle size distribution revealed dominantly loam clay textural class which implying that SWC practices (management) alter the soil texture classes.

Soil chemical properties

Soil (pH): The mean soil pH value was significantly affected by the use of level soil bund at (P<0.05). Also the ages of level soil bund have effects on soil pH value. In general , the higher mean pH value (5) obtained from the plots of level soil bund of six year while ph value (4.5) and (4.17) obtained from the plots with level soil buds of four and two years respectively. In addition to the lower mean pH value (4) was obtained from the plots without level soil bund (Table.2).

Total nitrogen (TN): Total nitrogen (TN) contents were significantly different at (P<0.05) among the conservation practices and ages of soil bund (Table 2). The higher mean values of TN (0.25) observed in the plots of level soil bund of six year. The plots of four year and two years gives the mean values of TN (0.24 and 0.21) respectively. While the lower mean value (0.19) obtained from the plots of without level soil bund. The result was match with the finding of [9] that reported as the farmlands with physical SWC measures have high TN as compared to the non-conserved.

Available phosphorus (AvP): Available Phosphorous (AP) was significantly different at (P<0.05) among the plots of conservation and blocks and ages of soil bund (Table 2). The mean values of available phosphorus of the soils sampled from the level soil bund plots were higher than that of non-conserved plots. The higher mean value (7.13 ppm) and the lower mean value (5 ppm) of AvP were observed under the plots of with and without level soil bund, respectively. Also, the ages of bund has an effects on the mean values of available phosphorus since the high value (7.13 ppm) observed on the plots level soil bund of six years While, the plots of two years so gives the lower value (6.33).

Catin exchange capacity (CEC): Catin Exchange Capacity (CEC) was the use of bund and ages of bund. So that, higher mean value of CEC (23.62 meq/100g) and the lower mean value of CEC (18.76. meq/100g) were observed under the plots of with and without level soil bund, respectively (Table 2). The CEC of a soil is strongly affected by the amount and type of clay, and amount of OM present in the soil Curtis and Courson (1981) [10] and Soils with CEC less than 16meq/100g are considered not to be fertile.

Organic carbon: The values of soil organic carbon in the study area was significantly (p<0.05) affected by use of level soil bund as a result of the practice of physical soil. As the result numerically the higher mean value of OC 3.64 % and the lower value OC 2.22 % recorded in the plots of with level bund of six year and without level soil bund respectively. The ages of the bund also significantly affects the mean value of OC % since higher OC% value obtained from the plots of level soil bund and lower value obtained from the plots of two years level soil bund among the treated plots (Table 2).

Effects of level soil bund on yield and yield components of teff

Days to panicle emergence: Days to panicle emergence were not significantly (P<0.01) affected by the soil management practice. In the plots of level soil bund of six years the days to panicle emergency were prolonged about 48 after sowing followed by 46 days under the plots of without level soil bunds. In the other hand the ages of the bund has an impact on the days of panicle emergency since the plots of six years prolonged about 48 days while the plots of 4 year and two year are 45.7 and 43 days respectively.

Days to maturity: The practice and ages of Soil and water conservation significantly affects days of physiological maturity and harvesting maturity of teff at (p<0.05) as presented in (Table 3) as a result of soil moisture increased by level soil bund. The maximum day to reach maturity was 103 days from level soil bunds of six year, while the minimum 94.6 days was recorded from the plots without level soil bund respectively. The ages of the bund has an also similar effect since the maturity dates of the plots of six year prolong for about 103 days while the plots of four years and 2 years prolonged 100.85 and 97.42 days respectively.

In the present study, Plants in the control treatment matured at the earliest, while plants in the level soil bund showed delayed maturity. The result reported by [11] that indicates the maturity days of crops and physiological maturity increase with increases in soil moisture content have a similarity with finding. Level soil bund reduces surface runoff, soil loss, retain water that enhances crop growth and increase the yield by extending maturity. Therefore, level

Table 3: Mean values of days to panicle emergence and days to maturity.

Treatment	Days to panicle emergence	Days to maturity
With LSB 6 years	37	102.37
With LSB 4 years	35.4	100.85
With LSB 2 years	39.85	97.42
Without	38.71	94.57
CV(%)	12.04	4.51

Means within the same column or row followed by the same letter are not significantly different at 95 % confidence limit. NS= Not Significantly.

Table 4: Mean of on plant height, tiller per plant biomass and teff grain yield.

Treatment (cm)	plant height (number)	Tiller (kgha^{-1})	Biomass (kgha^{-1})	Grain yield
With LSB 6 years	63	2.71	111.57	12.21
With LSB 4 years	60.14	2.57	97.57	10.28
With LSB 2years	52	2.1	106.42	10.21
No LSB	47.14	1.71	84.57	9.42
CV(%)	9.86	23.65	12.63	16.59

Means within the same column or row followed by the same letter are not significantly different at 95 % confidence limit. NS=Not Significantly.

soil bund have been accepted and introduced to reduce soil loss by creating barrier against surface runoff and reducing slope length and gradient in the long-term.

Plant height: The analysis of variance showed that plant height was affected significantly (P<0.01) by the conservation practices and ages of level soil bund. The mean plant height generally increased with the increase in the ages of level soil bund of (Table 4). Thus, the highest plants height was observed on the plots of level soil bunds of six years (63 cm) and on the plots of four and two years of level soil bund the mean pant height were (60.14 cm) and (52 cm) respectively. The lowest plant was observed on the plots of without level soil bund (47.14). The plausible reason could be associated with the effect of SWC practices on increasing soil moisture availability in the course of increased infiltration and protecting washing away of crucial soil nutrients as it was observed in soil analysis result (Table 2). The reduced constraint of water and nutrients allowed luxurious vegetative growth of crops grown on plots with soil bunds, while those grown without soil bund switched to early senescence and maturity due to the possible terminal moisture stress [12-14].

Number of effective tillers: Statistical analyses of variance showed that there were significant differences between plots of level soil bund and controlled on the number of tillers per plants. The Mean tiller numbers were also increased as the ages of the bund was increases (p<0.05) as shown in (Table 4). The higher mean value of tiller numbers per plants observed on the plots of with LSB of six years was (2.71) while the plot without LSB was (1.71). Also the ages of LS has have an impacts on the tiller per plants since the plots of four years (2.57) and the plots of 2 years LSB was (2.1). The result was supported by the outcome that point toward the tiller formation increases with increasing age of SWC practices [15].

Grain yields: The use and ages of level soil bund significantly affects biomass of teff at (P<0.05). The mean high value of grain yield obtained from the plots of level soil bund was (12.21kg ha^{-1}) whereas a controlled plot gives low teff grain yields (9.42 kg ha^{-1}). As the age of the bund increases the grain yield also increases (Table 4). The higher grain yield from the plot of level soil bund may be attributed to the soil moisture preserved by the structure and the sediment deposited on the farm plot. Similar finding was made by the previous work of Admasu et al., (2014) [4] reported as the improvement in yield and yield components due to soil bund is related to the enhanced water availability during the grain filling stage Table 4.

The use of level soil bund significant affects the grain yield of teff as a result of sufficient soil moisture gained under level soil bund.

Biomass: The analysis of variance indicates that the use and ages of level soil bund significantly (P≤0.05) affects the total above ground dry biomass of teff. The higher mean value of dry biomass (111.71 kg ha^{-1}) was obtained from the plots of level soil bund while the lower mean value (94 kg ha^{-1}) recorded from the plots of without level soil bunds (Table 4).

The result was similar with the findings of Solomon (2015) [7] that reported as the above ground biomass of maize was affected by water conservation technique.

Conclusion

It is concluded that level soil bund practices have positive impacts on soil fertility and crop productivity of cultivated lands. Especially, the use of level soil bund in a relatively high rainfall area of western Wollega has improved crop growth and yield. Also the effects of level soil bund on soil chemical characteristics were significant on few most parameters. The use of soil bund increased soil moisture content during the growing period, and resulted in extended growing period. This increased the number of days to flowering and maturity, which contributed to the increased yield and biomass. As a result, the grain yield was higher when soil bund was used as compared to when not, even when the total above ground biomass was lower. The ages of the level soil bund enhanced crop growth, yield and yield components since high crop yield obtained from the plots of level soil bund of six years.

Thus, this study recommends the use of level soil bund practices to increase production and productivity of the land. Yet, further studies on other crops yield performance and cost effectiveness of SWC practices are suggested. Furthermore, identification of best grass/ plant type that can stabilize the bund and provide added benefits to farmers should be investigated.

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