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# Participatory evaluation and demonstration of grass strips and tied ridge as soil and water conservation measures for rehabilitation of degraded farmlands in Dollo Schem, Kamba District, South Ethiopia

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## Abstract

Soil erosion, a result of land deterioration, is the main environmental issue. This study was demonstrated grass strips and tied ridge as soil and water Conservation measures for rehabilitation of degraded farmlands in Dollo Schem, Kamba district, and South Ethiopia. Six (6) adjacent trials farmers were participated directly on the demonstration. The study result shows that there was significant difference ($P < 0.05$) between treatments. When compared to sole maize, grass strip with maize, tied ridge with Maize (Zea Mays L.) and integrated grass strip with tied ridge were produced higher grain yields and also it has 33.14% of yield advantage over sole maize. The study result also indicates that, biomass result from harvested Elephant grass has an improvement with each harvesting cycle. Based on the result this study concluded Elephant grass strip with tied ridge has an effect on maintaining soil moisture, trials farmers have benefited economically having access to more feed for their animals by cut and carry arrangement. Accordingly the farmer's first preference was implementing grass strip on their farm land by evaluating it with different criteria's. Based on the results, the study advice planting Maize while incorporating biological soil amendments and used tied ridge to improve yields. The investigation must be completed for more than one year in the future. Because the effect of grass strip and tied ridge is observed after some years of grass stabilize.

**Keywords:** Grass strips; Tied ridge; Rehabilitation; Soil moisture; Perception

## 1. Introduction

Land degradation is the permanent decline in the land capacity to produce yields useful to local livelihoods [1]. About 24% of the world's land has been affected by land degradation and more than 1.5 billion people live in those degraded land areas [2]. In Ethiopia, soil productivity has been declining as a result of soil erosion, nutrient depletion, and organic matter depletion [3]. According to [4], the degradation causes environmental impacts and major economic losses from decreased agricultural production and from off-site effects on infrastructure and water quality by sedimentation processes. The increased poverty is associated with shortage of food which is attributed to the declining of soil fertility and crop yield [5]. In addition to accelerated soil erosion and the alarming rate of land degradation, the losses of water as runoff and periodic drought during the cropping season on degraded lands are problems of rain-fed crop production [6 and 7]. Deficit of soil water in semi-arid areas is also attributed to low infiltration rates (due to surface sealing and crusting and low organic matter content) and subsequent high runoff rates [8]. The conservation of soil moisture in semi-arid areas requires appropriate tillage practices that not only improve rain infiltration but also conserves adequate soil moisture for plant growth [9].

Conservation tillage practices such as tied ridging, sub soiling and ripping have the potential of soil moisture retention. The practices also mitigate impact of intra-seasonal dry spells that often result in low productivity and crop failure [10].

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According to [11], conservation tillage has positive effects on soil productivity such as enhancing infiltration and soil moisture storage. The better adoption of physical soil and water conservation technologies, integrating with biological SWC is very important. Biological grasses are effective in filtering run-off.

Tie-ridging as in-situ water harvesting technique improved 46% grain yield of sorghum as compared to the farmer's practices in the dry areas of Ethiopia [12]. The effectiveness of tide ridge cultivation particularly on Maize was verified at silte and Arbaminch zuriya, which contributed 30-45% productivity change [13 and 14]. The effect of tie-ridging on soil water content and crop yield differs from season to season and from location to location. This is due to tied ridging effect on the crop is depending on climatic data, soil characteristics, slope, and crop. However; the integrated effect of both grass strips and tide ridge cultivation on rehabilitating degraded farmlands are not well demonstrated and documented on major crop types. Therefore, the present study was carried out to evaluate and demonstrate Elephant grass strip and tide-ridge as SWC measures in rehabilitating degraded farmlands in Dollo sachem.

## 2. Materials and Methods

### 2.1. Study Area Description

The study was conducted in Dollo Schem, Kamba District, Gamo Zone, South Ethiopia Regional State, of Ethiopia. Geographically, it's located between 11$^0$ 27' 0" and 11$^0$ 23'0"N and 03$^0$ 60'15"and 36$^0$ 26'0"E with an altitude range 1115-1219 meter above sea level (Figure 1).

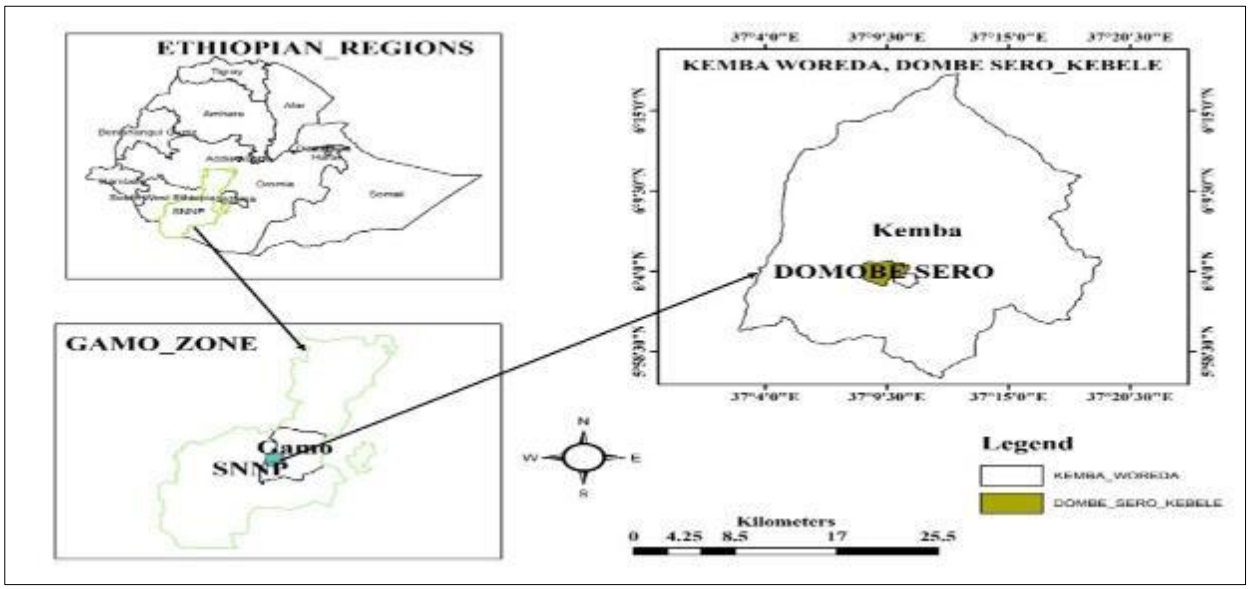



**Figure 1** Location map of the study area

### 2.2. Topography and agro-climatic condation

The minimum and maximum annual rainfall of the study area is 900mm-1500 mm respectively. It has unimodal rainfall distribution pattern, with mean minimum and maximum annually temperature ranging from 28$^0$c to 38$^0$c, respectively. The topography of the study is characterized as slightly undulating from hill-tops towards rivers with its slope ranges from 3% to 8%. Most of the farmlands are relatively gentle and flat with an average slope of 5 % (Figure 2).

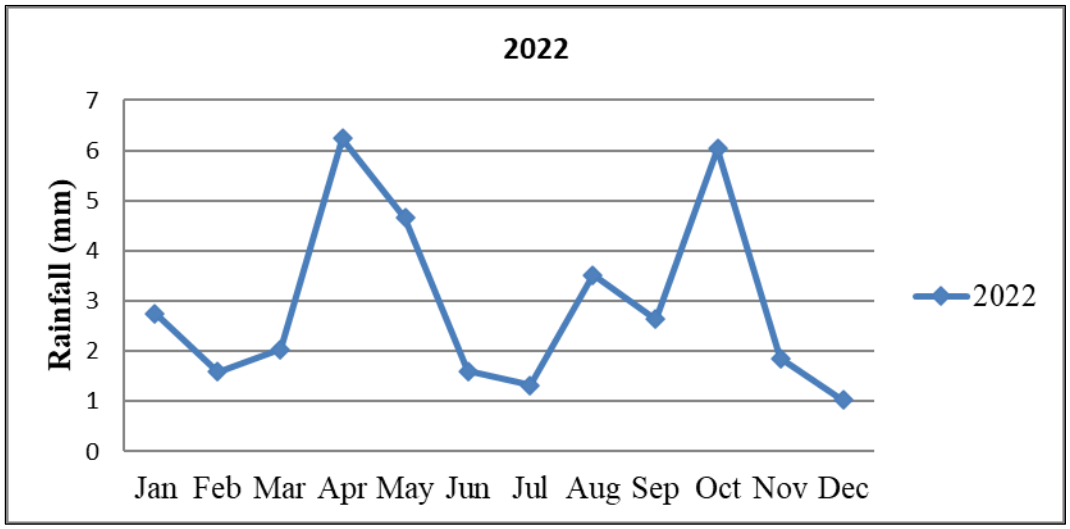



**Figure 2** Rainfall data

### 2.3. Site and Farmers Selection

The demonstrative research was conducted in purposively selected Dollo irrigation schemes and the selection of sites was based on severity of soil erosion which highly affects the irrigation scheme within the watershed and IFAD project target area. Six (6) adjacent trials farmers was selected, from the members of farmers research and extension group (FREG) in the Dollo schem in order to participate on the demonstration. The trial farmers were selected due to access to demonstration farmland with slope measuring 5 to 10% and existence of adjacent farmland ownership. Field observation through transect walk was conducted prior to demonstration particularly on the problem of soil erosion, availability and potential of selected grass stabilizers, potential crop types grown in the area with participating FREG. Then, common consensus was reached with the farmers on severity of soil erosion and interventions required. Finally, the study was demonstrated on the selected farmlands of trial farmers.

### 2.4. Study Design

The research was conducted by compering four treatments such as, (1), Elephant grass with tide-ridge cultivation, (2), Elephant grass strip only (3), tie-ridge only and (4), free plot without grass strips and tide-ridge cultivation was compared. As a test crop Maize (Zea Mays L.) BH546 with a spacing of 40cm*80cm was used between plant and rows respectively. The plot size of the experimental area was used 20m x 31m, and spacing between plots was one meter. The treatments were laid on randomized complete block design (RCBD) with 6 farmers replications. The recommended NPSB and urea fertilizer was used. Urea was applied two times 1/3 at planting and 2/3 at knee height.

### 2.5. Land Preparation

The selected trial farmers prepare their farmlands as part of their usual land preparation and all the necessary inputs such as seed, fertilizers and grasses was provided from Arba Minch Agricultural Research Center.

### 2.6. Planting Grass

Contour line was marked first using water level in the farmlands. The Elephant grass strips was planted along the contour following the contour line. Grass strips planted without physical conservation structures and were integrated with tide-ridging technologies. The number of strips per plot was decided depending on the farm size. One meter grass strip width was established per plot. The grass was planted in 30cm between split and 50cm between rows at staggered position. Totally, 3 rows of grass per strip were established prior to planting the test crop.

### 2.7. Construction of Tied-ridges

The practices are ideal for the areas of limited soil moisture and recommended for all soil types. Between the rows of maize, appropriate furrow was prepared after three weeks of crop germination. The furrow was tide at 5m with 30 cm depth before the on-set of rainfall to control the flow of water within the furrow and the tied height was periodically maintained.

### 2.8. Data Collection

The collected data for the trials was soil moisture content, grass strips biomass, Maize yield, agronomic data and farmer's preference.

### 2.9. Grass Biomass

The treated grass strip plot was, 1m*1m quadrant laid along the strips to monitor the biomass production and create an observation. The grass was cut down at 20 cm height from the surface. The evaluation of regrowth rate at monthly basis then harvested data was weighted and converted to hectare basis. The green biomass yield harvest Elephant grass was carried out after three month of plantings, while the other harvesting frequency was done at a 20 day interval.

### 2.10. Determine Soil Moisture Content

Representative soil samples was collected from different parts of the plot from 0-30 cm soil depth at three period intervals (initial, development and harvest stage) to evaluate the amount of soil water during dry periods. The weight of wet soil samples was measured and put in an oven at $105^0$ c for 24 hours, and then the dry samples was measured. The volume of soil water stored in each treatment was calculated by multiplying bulk density and percent of soil moisture contents.

$$\mathbf{SMC}=\frac{\boldsymbol{Ww}-\boldsymbol{Wd}}{\boldsymbol{Wd}}*\mathbf{100}$$

Where: SMC = Soil moisture content dry base (%), Ww = Weight of the wet soil (gm), Wd= Weight of the dry soil (gm).

### 2.11. Crop Data

Plant height was measured in (m) as the height from ground level to the base of the tassel by taking ten randomly selected plants per plot using measuring stick. Cob length was measured (in cm) from base level to the tip along the length of the cob from ten randomly selected cobs per plot with ruler and the average was recorded. Above ground, biomass was determined after harvesting the crop. Grain yield $ha^{-1}$ was obtained from the central four rows of maize, and then the yield was measured after the seeds are picked and shelled by hand. The grain yield was adjusted to 12.5% moisture level and then converted to $t/ha^{-1}$ bases and calculated as follows:

$$\text{Adjusted Grain Yield(kg/ha)} = \frac{Actual\ Grain\ Yield * 100 - M}{100 - \text{D}}$$

Where Where= M, is the measured moisture content in grain and D is the designated moisture content (12.5%).

### 2.12. Capacity Building

**Figure 3** Picture taken during community training

Training was given to trail farmers, head of woreda agricultural and natural resource management office, experts and IFAD focal persons, kebele development agents in Dollo scheme sites. Basically, the training was focused on the effect of Elephant grasses with tied ridge on reducing soil erosion, moisture increments and rehabilitation of degraded farm land. The practices were presented using understandable descriptions in the local language and confirmed by the participants. The advantages and disadvantages of integrated moisture conservation methods were identified from the

perspective of the local communities. The rating of each practice or intervention as excellent, very good, good and not good.

### 2.13. Farmer's Perceptions

The perception of farmer's demonstration, knowledge, attitude and skills on degraded land management were collected using focus group discussion. FREG was visit the trail farmer's field at different crop growth stages (at planting, development stage and harvest) to identify the key gap, promote the trail farmers in field management and draw the success of the technology. Farmers were asked to prioritize the grass strip and tide ridge by giving scours based on each criteria, excellent, very good, good, not good (1,2,3and 4) respectively.

### 2.14. Data analysis

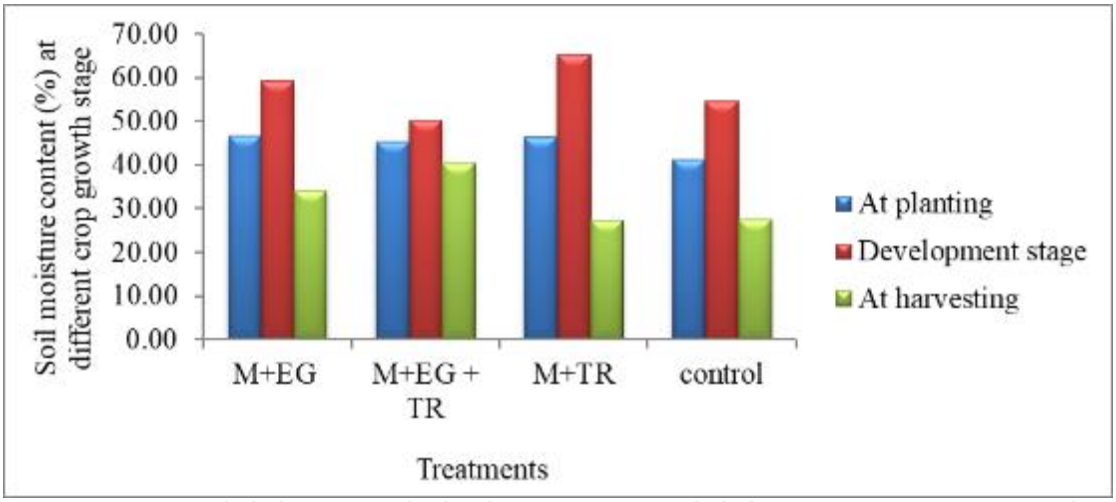
Analysis of variance (ANOVA) and least significant difference (LSD) was used to compare the treatment means at a 5% significance level.

## 3. Results and Discussion

### 3.1. Effect of Elephant Grass Strip and Tide-ridge on Soil Moisture Content

The findings showed that soil moisture content had an impact on maize grain production (Figure 3). Throughout the growing season, the soil moisture accumulation in the Elephant grass with tied ridging plots was significantly higher than that of the farmer's practice. High levels moisture content of vegetative growth were the result of planting grass and tied ridge growing in different seasonal ways. Moreover, the analysis result showed that, higher soil moisture (65.3%) was observed in the development stage of crop growth. Only tied ridging and farmer practices during harvesting time (27.36% and 27.66%) showed decreased moisture content. In degraded farmlands, integrated tied ridge and Elephant grass provide more effective moisture conservation. This showed that the installation of tied ridges and the planting of Elephant grass improved other hydrological processes like percolation and enhanced soil moisture storage by increasing soil aggregation. Preserving soil moisture is crucial for regulating a variety of atmospheric, ecological, hydrological, and pedagogical processes, especially in the scheme's water-limited environments. Similarly a study by [15], found that the root systems of Elephant grass strips reduce surface runoff, evaporation, erosion, and soil microenvironment modification in order to conserve moisture.

### 3.2. Soil Moisture Content on Different Crop Growth Stage




Note: M + EG + TR:- Maize with elephant grass with tide-ridge; M + EG:- Maize with elephant grass strip; M + TR:- Maize with tie-ridge

**Figure 3** Soil moisture content in different crop grouth stage

Results from statistical analysis, showed that significant variation in the amount of soil moisture was observed when maize reached different growth stages. The study reveals, higher soil moisture content at planting, development, and harvesting stage, tied ridging with Elephant grass produced the maximum moisture content (45.26%, 50.11%, and 40.42%), respectively. This is explained by the increased availability of water. The soil capacity to retain moisture is one of the key factors influencing plant productivity and growth. It also affects how quickly soil substrates break down.

### 3.3. Elephant Grass Strip on Fresh Grass Biomass

The average fresh biomass of Elephant grass was harvested in (Figure 4) blow shows. Only one Elephant grass strip recorded 4 kg/m2, and the average above-ground biomass of Elephant grass strips with tide ridge was 5.5 kg/m2. The trend of biomass coverage of Elephant grass with tide ridge indicates increments. Statically Elephant grass produced the greatest fresh weight biomass statistics because of their rapid growth rate. Elephant grass biomass harvesting results show that the trial farmers have profited financially from this as well as by having extra feed available for their animals through the cut and carry system. Elephant grass is used as a year-round livestock fodder. Elephant grass is also a highly nutritious and high biomass yielding grass that has long been used as a staple feed in tropical climates. In Northwest Ethiopia, Elephant grass is being utilized for revenue production, animal feed, and biological soil conservation [16].

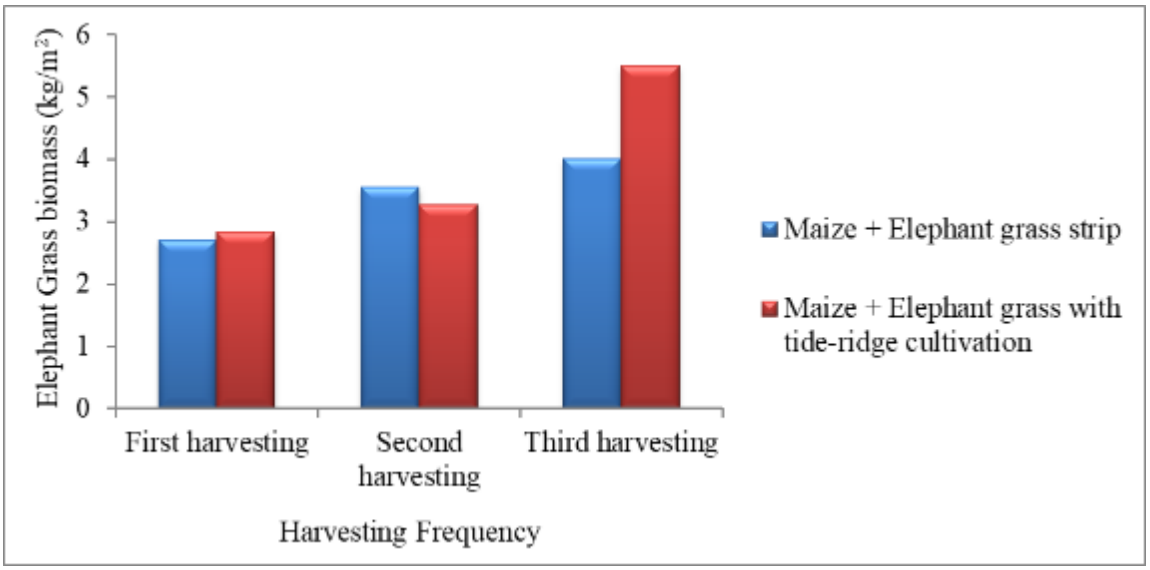



**Figure 4** Elephant grass biomass

**Figure 4** Elephant grass strips biomass

### 3.4. Grain Yield and Yield Components of Maize

The study results shows that, there was non-significant difference between yield and yield components of maize in terms of cob length, plant height, and grain yield parameters, there was no significant difference ($p>0.05$) between the treatments. However, there was a significant difference ($p< 0.05$) in cob length and biomass between maize with Elephant grass and maize without a grass strip and tide ridge. This result shows that the effect of grass strip and tide ridge is observed after some years of grass stabilize. This result is consistent with the findings different papers, which stated that 79.3% of the farmers surveyed felt that the yield had increased after two years. The biomass output increased as a result of tie-ridging management done correctly. Elephant grass plantings with maize had the maximum biomass production (2.35 tons/ha), while farmer practices had the lowest biomass yield (1.58 tons/ha).

**Table 1** Yield and yield components of maize

| Treatments | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Cob number | Cob length (m) | Plant height (m) | Biomass (ton/ha) | Grain yield (ton/ha) | TSW (kg) |
| M + EG | 1.55 | 0.23[a] | 2.47 | 2.35[a] | 1.81 | 0.34 |
| M+EG+TR | 1.55 | 0.24[a] | 2.4 | 2.19[a] | 2.05 | 0.34 |
| M+ TR | 1.4 | 0.24[a] | 2.42 | 1.69[b] | 1.83 | 0.36 |
| Control | 1.55 | 0.22[b] | 2.38 | 1.58[b] | 1.67 | 0.35 |
| LSD | Ns | 0.02 | Ns | 0.47 | Ns | Ns |
| CV (%) | 16.23 | 4.49 | 6.68 | 15.14 | 21.88 | 13.84 |

Note: M + EG + TR:- Maize with elephant grass with tide-ridge; M + EG:- Maize with elephant grass strip; M + TR:- Maize with tie-ridge, LSD- list significant difference, CV- coefficient variation, NS-non-significant difference, TSW -thousand seed weight

### 3.5. Farmers Perceptions towards Grass Stripe for Soil and Water Conservation

As the result shows in the (Table 2), where farmers' opinions of Elephant grass with tide ridge were highly rated when evaluated using a pre-made check list. As a result, all participants (100%) recognized significant benefits of integrated tied ridge with elephant grass, including increased land production, drought tolerance, and moisture incrimination. According to the conversation with farmers, Elephant grass is fast growing, eases to establish, resistant to drought, conserves moisture, and is harvested more frequently. They contend that the majority of soil and water conservation initiatives, especially those implemented through campaigns, failed because farmers were not aware of the benefits of these measures, especially when it came to agricultural land. Therefore, it is crucial to carry out these kinds of demonstration efforts in order to alter farmers' unfavorable perceptions of integrated soil and water conservation. Additionally, they intend to keep up these conservation buildings and grasslands for future demonstration and scaling up to include more district participants.

**Table 2** Farmer perception of Elephant grass and tide ridge

| No | Criteria for comparison | Preference ranking | | | |
|---|---|---|---|---|---|
| | | Elephant grass strips | Tide-ridge | Integrated Elephant grass stripe with tide-ridge | Control |
| 1 | Moisture increment | 3 | 2 | 1 | 4 |
| 2 | Drought resistance | 2 | 3 | 1 | 4 |
| 3 | Yield increment | 2 | 3 | 1 | 4 |
| 4 | Based on multi-purpose | 2 | 3 | 1 | 4 |

Note: 1 is excellent, 2 is very good, 3 is good, 4 is not good

### 3.6. Training

Training on the importance of technology (moisture conservation, soil conservation, land saving, increase production and productivity of both land and livestock), construction of tide-ridge, planting of grass strip spacing, and others were covered for farmers, district experts, and development agents (DAs). All FREG members, DAs, and district experts were given training sessions and field trips by farmers to raise awareness of the value of integrated soil water conservation practices in reducing soil erosion, increasing soil moisture, enhancing soil fertility and productivity, and serving as a supplement to livestock feed. Between 2015 and 2016, a total of 32 farmers four FREG, six DAs, and four experts was participated in training (Table 3).

**Table 3** Number of participant during the training

| No | Participant | Male | Female | Total |
|---|---|---|---|---|
| 1 | Farmers | 25 | 7 | 32 |
| 2 | DAs | 4 | 2 | 6 |
| 3 | District expert | 3 | 1 | 4 |
| | Total | 32 | 10 | 42 |

## 4. Conclusion and Recommendations

The study result concluded that there was significant difference between the treatments. When compared to sole maize, integrated Elephant grass strip with tied ridge and sown Maize produced higher grain yields and also it has yield advantage over sole sown maize. The study result also concluded that, the biomass result from harvested Elephant grass indicates an improvement with each harvesting cycle. The trials farmers have benefited economically by having access to more feed for their animals through cut and carry system. During the study year better moisture content of the soil was recorded in the planting, development and harvesting stage in Integration of tied ridge with Elephant grass than only sowing maize. Based on the results, the study recommended that, planting Maize while incorporating biological soil amendments and water-saving techniques should be improved yields and it needs to escalate to other similar agro ecological area. Further, Further, the study needs to carry out more than Two years due to the effect of grass strip and tied ridge is observed after some years of grass stabilize.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

No conflict of interest is associated with this work.

## References

[1] Scoones, I., & Toulmin, C. (1999). Policies for soil fertility in Africa. A Report prepared for the, Department of International Development, by Institute of Development Studies and International Institute for Environment and Development, DFID, Brighton/ London.

[2] Institute, I. F. P. R. (2013). *2012 Global Food Policy Report*. Intl Food Policy Res Inst.

[3] Hadera, A., & Gebrekidan, H. (2013). Soil acidity characterization and effects of liming and chemical fertilization on dry matter yield and nutrient uptake of wheat (Triticum aestivum L.) on soils of Tsegede District [Doctoral dissertation]. Northern Ethiopia, Haramaya University.

[4] Amsalu Aklilu, Leo S. and Jande G. (2007). Long-term dynamics in land resource use and the driving forces in the Beressa watershed, High Lands of Ethiopia, Environmental Management .83: 448-459.

[5] Eyasu Elias (2002). Farmers' perception of soil fertility change and management. Institute for Sustainable Development, Addis Abeba, Ethiopia.

[6] Tamirie H (1986) Increasing Agricultural Production in Ethiopia through Improved Soil-Water and Crop Management Practices. Towards a Food and Nutrition Strategy for Ethiopia. Proceeding of the National Workshop on Food Strategy for Ethiopia. AUA, pp: 243.

[7] Heluf G, Yohannes U (2002) Soil and water conservation (tied ridge sand planting methods) on cultivated lands: The case of eastern Ethiopian; Soil and Water Management Research Program, Alemaya University, Ethiopia, pp: 154.

[8] Rockstrom J, Barron J, Fox P (2003). Water productivity in rainfed agriculture: Challenges and opportunities for smallholder farmers in drought prone tropical agro ecosystem. CABI, IWMI, Wallingford, UK, Colombo, Sri Lanka.

[9] Cornelis WM, Araya T, Wildermeersch J et al (2013). Building resilience against drought: the soil - water perspective. In: De Boever et al (eds). Desertification and Land degradation: Processes and Mitigation. UNESCO Chair of Eremology, Ghent University, Belgium. pp 1 – 15.

[10] Manyatsi AM, Mhazo N, Mkhatshwa M et al (2011). The effect of different in-situ water conservation tillage methods on growth and development of Taro (Colocasia esculenta L.). Asian Journal of Agricultural Sciences, 3(1): 11 – 18.

[11] FAO (2008). Investing in Sustainable Agricultural Intensification. The Role of Conservation Agriculture. A Framework for Action. Food and Agriculture Organization of the United Nations, Rome.

[12] Abebe. G., Effect of Np fertilizer and moisture conservation on the yield and yield components of Haricot bean (phaseolus vulgaris L.) in the semi-arid zones of the central rift valley in Ethiopia, Adv. Environ. Biol. 3 (2009) 302–307.

[13] Dagnaw A, Bagegnehu B and Abiy G. (2018). On-farm Verification of the Soil Moisture and Yield Response of Tied Ridge on Maize Production in Dry Areas of SNNPR, Ethiopia Journal of Environment and Earth Science Vol.8, No.5, 2018.

[14] Wolde B, Naba W, Gebremichael A (2020) Evaluation of In-situ Moisture Conservation Techniques for Maize Production in Moisture Stress Areas of Mirab Abaya Woreda, Southern, Ethiopia. Adv Crop Sci Tech 8: 442.

[15] Solomon T (2015) On-Farm Verification of the Effects of Selected Soil Moisture Conservation Techniques on Yield and Yield Components of Early Maturing Maize (Zea Mays L.) (Zea Mays L.) Varieties at Bako, Western Ethiopia. International Journal of Advanced Earth Science and Engineering 4(1): 254-264.

[16] Wolka K, Moges A, Yimer F. Farmers‟ perception of the effects of soil and water conservation structures on crop production: The case of Bokole watershed, Southern Ethiopia. Afr J Environ Sci Technol, 2013; 7(11): 990-1000.