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Participatory Demonstration of Grass Strips as Biological Soil and Water Conservation Measures in Kamba Woreda, South Ethiopia

Yenealem Gemi[1], Amare Gojjam[2], Tademe Minase[3], Dagnaw Ademe[4,*], Birhanu Wolde[5]

Abstract

Land degradation due to soil erosion and soil fertility depletion is a significant threat to the agricultural system, limiting food security and sustainable agricultural production. This study demonstrated Desho grass strips as biological soil and water conservation measures in Kamba woreda Gamo zone south Ethiopia. Six (6) nearby trial farmers who took part in the demonstration directly were chosen for the study using the purposive sample technique. Sole maize and integrated Desho grass strip with maize have been demonstrated on the trial farmers land having plot size of 4x12. Focus group discussions with farmers' research extension group members have been carried out to determined farmers' perception on the effect of Desho grass strip. The gathered information was examined using both descriptive and inferential statistics. The study's findings indicate that all metrics showed a significant difference (P < 0.05) between the treatments. When compared to sole maize, integrated grass strip with maize produced higher grain yields. The study revealed integrated grass strip with maize has 33.14% of yield advantage over sole maize. Additionally, the biomass result from harvested desho grass indicates an improvement with each harvesting cycle. Moreover, the result from focus group discussions shows, Desho grass strip has an effect on improving soil moisture, crop productivity, reducing soil erosion, and trials farmers have benefited economically having access to more feed for their animals by cut and carry system. Hence, the farmer's first preference was implementing desho grass strip on their farm land by evaluating it with different criteria's. The study concluded that, integrated Desho grass strips with maize has plays vital role for biological soil and water conservation measures and yield increment. Therefore, planting maize incorporating with biological soil amendments and water-saving techniques to improve maize yields and needs to popularize the investigation in large scale to reach the wider community.

Keywords: Biological, Grass strips, Soil moisture, Perception

INTRODUCTION

Land management practices were emerged as an issue of major international concern. This is not only because of the increasing population pressure on limited land resources, demanding for increased food production, but also by the recognition of the fact that the degradation of natural resources is accelerating in many countries of the world (Fentabil, 2016). Land degradation has been a major global challenge throughout the 20th century and will remain high on the international agenda in the coming century (Bichaye, 2019). notably at risk from poverty and the depletion of natural resources, notably soil erosion, is Sub-Saharan Africa (SSA) (Derej, 2019). Since most people in poorer nations rely on these resources for their livelihoods, the situation is worse there.

***Author for Correspondence**
Dagnaw Ademe
E-mail: dagnawademe04@gmail.com

[1-5]Assistant Professor, South Ethiopia Agricultural Research Institute, Arba Minch Agricultural Research Center, Arba Minch Ethiopia

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Ethiopia is one of the nations most impacted by land degradation, a serious environmental issue throughout sub-Saharan Africa (Abiy, 2008). Ethiopia's agricultural land, particularly in the southern region, has been subject to degradation, endangering the people's ability to survive and their economic well-being (Genene and Abiy, 2014).

Over 80% of Ethiopia's population engages in agricultural activities (CSA, 2008), which are dependent on land resource. About 42 t $ha^{-1}yr^{-1}$ of fertile soil containing essential plant nutrients are lost from cultivated lands of Ethiopia due to poor soil and water conservation practice (Hurni et al., 2008). Unwise soil and land use patterns can have a negatively intense impact on soil fertility (Tolesa et al., 2021). Erosion-induced soil degradation aggravated the problems of low agricultural productivity, food insecurity and rural poverty (Smith, 2010). Lack of soil water is one factor contributing to low yield and crop failure in rain-fed agriculture. This is caused by a combination of low and erratic rainfall and poor utilization of the water that is available. Therefore, controlling soil moisture is essential while attempting to increase agricultural output.

This makes the issue of soil conservation measures as a vital concern for Ethiopia to achieve sustainable development of its agricultural sector (Daniel, 2002).

Since 1970's in collaboration with international partners, Ethiopia has made substantial efforts to introduce soil and water conservation technologies to reduce the risks of soil erosion and associated problems (Wolka, 2014). Problems of soil loss and its fertility, which are the base for agricultural production has motivated experts, planners and researchers to make tremendous efforts in land management practices (Molla et al., 2017). In the country main challenges of soil and water conservation include, focus on initial construction of physical structures (e.g., terraces, bund, etc.), and fail to integrate physical structures with biological practices (Bekele et al., 2018). However, the government has realized the causes and failures in soil and water conservation efforts and give due attention to integrate physical structures with biological practices, encourage community participation, and use desho grass (P. pedicellatum) for sustainable land management (Smith, 2010).

In Ethiopia Desho grass is discovered in 1991 at Chencha District South Ethiopia region and well adopted in different agro-ecology (Leta et al., 2013). In the highlands of Ethiopia, the grass had been used as grass strip to protect croplands from soil erosion and degradations, to rehabilitate degraded land and improve livestock feeding (Yakob et al., 2015). Based on the grass's character and diverse roles it is widely distributed and used for land management with similar agro ecology. Farmer's use of desho grass as grass strip to protect cropland from erosion, rehabilitate degraded land and livestock feeding is uneven among farmers which have been affected by different factors (Wolka, 2014). The effect of different grass strips includes, Desho, elephant, and Guatemala grasses on soil erosion control and crop grain yield has been evaluated and demonstrated in plot basis in different parts of south Ethiopia. However, in the study area, very limited information is available on farmers' use of Desho grass as grass strip and plot-based result should be widely scaled out at watershed level to ensure the watershed sustainability and livelihood of communities. Therefore, the study was aimed to demonstrate the contribution of Desho grass strips as biological soil conservation measures and to assess farmer's perception in Kamba woreda Gamo Zone South Ethiopia.

MATERIALS AND METHODS

Study Area Description

This demonstrative research was conducted in Kamba woreda, Gamo Zone, South Ethiopia in Dollo irrigation scheme. Geographically, the study area located between 5º 58' 30"N - 6º 15' 0" N and 37º 4' 0" E - 37º 20' 30" E. Kamba woreda is home to 155,979 people, comprising 79,273 males and 76,706 women, according to the CSA's 2007 census. 4,702 of them, or 3.02 percent, reside in cities (CSA, 2007).

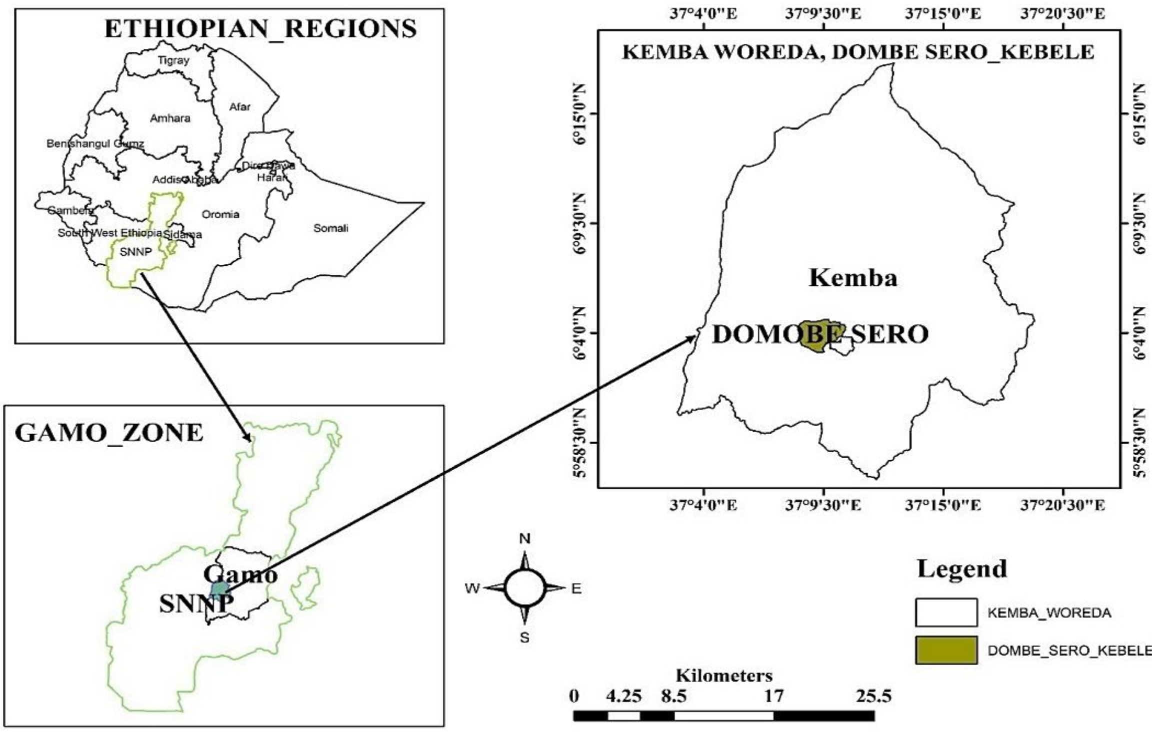

Figure 1. Location of the study area.

As shown in Figure 2 below the area received maximum and minimum monthly rainfall of (5.68 mm and 0.84 mm) in 2022 and (10.11 mm and 0.65 mm) in 2023 respectively. The maximum and minimum monthly rainfall was recorded on october and december respectively.

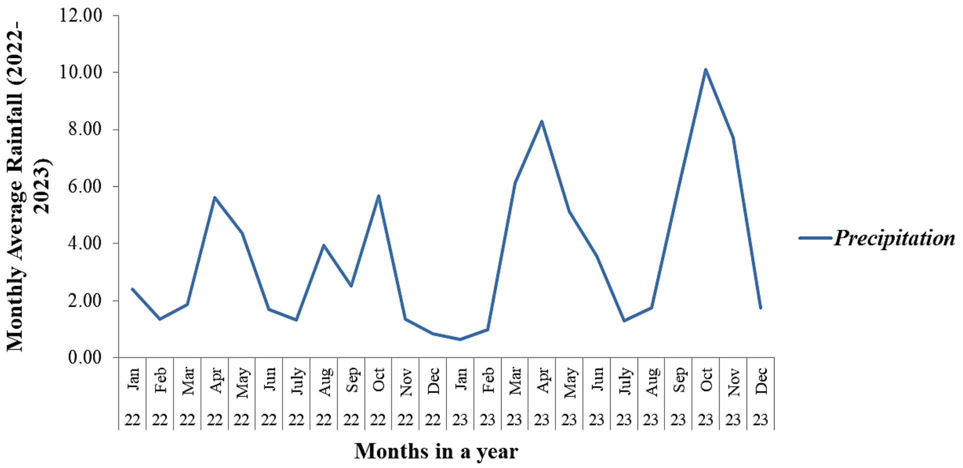

Figure 2. Rainfall distribution from the year 2022 to 2023/Source google earth engine accessed 05/20/2024

Site and Farmer's Selection

The study used purposive sampling technique in Dollo irrigation scheme. Six (6) adjacent trials farmers were selected from members of each farmer research and extension group (FREG) in order to participate directly on the demonstration. The trial farmers were selected due to access to demonstration farmland with slope measuring 5%. While conducting field observation through transect walk 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 and also discussion was held with kebele experts, administers and committee leaders.

Figure 3. (a,b) Taken during site selection.

Capacity building training

A capacity development training is one of the pillars in sustainable development goal thus before conducting demonstration training was given on the effect of biological soil and water conservation on reducing soil erosion, also its potential as fodder source through cuttings (cut and carry system) and their effect on crop productivity involving trial farmers, experts and researchers in Dollo scheme sites. In the training 48 trial farmers (30 men and 18 women), eight (8) experts from woreda and kebele and seven (7) researchers generally a total of 65 individuals were participated in the training.

Figure 4. Taken during training

Research Design and Treatment Setups

The trail farmers prepare their farmlands as part of their usual land preparation and all the necessary inputs such as seed, fertilizers and Desho grasses was provided from Arba Minch agricultural research center. According to the crop calendar in Dollo scheme Maize was sown in between two strips of the Desho grass in collaboration with kebele experts and trial farmers. In this demonstration two treatments maize with desho grass strips and free plot without biological grass was used. Maize variety (BH140), seed rate of maize 25 kg/ha was used. 100 kg/ha NPS Fertilizer as well as one third (1/3) of urea was applied at planting and two third 2/3 of it at knee height. The plot area was 16 m by 8 m. One-meter strip width was established per plot. Spacing of maize was 40 cm*80 cm plant and rows respectively. Desho grass was planted in 10 cm *20 cm split and rows at staggered position respectively.

Data Collection

Grass Biomass Measurement

Grass biomass data was collected by laying a 50 cm by 50 cm quadrant plots along the strips to monitor the biomass production and create an observation. Desho strips were periodically weeded depending on the weed infestation in the area. Thus, desho grasses was cut at 20 cm height from the surface and the same sampling point to evaluate the re growth rate at monthly basis. The harvested data was weighted and convert to hectare basis.

Figure 5. (a–d) Field status of Desho grass strips.

Crop Data

Using a measuring stick, the height of ten randomly chosen plants per plot was measured in centimeters (cm), which is the distance from ground level to the base of the tassel. Using a ruler, the length of five randomly chosen cobs per plot was measured (in centimeters) from base level to the tip, and the average was noted. After the crop was harvested, biomass above ground was measured. Following the manual selection and shelling of the seeds, the grain yield per hectare was assessed from the central four rows of maize. After adjusting the grain yield to a 12.5% moisture content, it was translated to tha-1 bases and computed as follows.

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

where D is the specified moisture percentage (12.5%) and Where= M is the measured moisture content in grain.

Farmer's Perception Data

Based on the demonstrated technologies in the areas, farmers' perception data was collected by active participation of FREG members. The focus group discussions (FGDs) were conducted in the demonstration site to demonstrate Desho grass strip as a biological soil conservation measure and to assess farmer's perception on grass strips. Purposive sampling was used, and respondents were chosen from among the farmers' study group's many community categories, particularly smallholder model farmers from families headed by women and men. Those who took part in the demonstration for two years in a row and those who wanted to participate in the conversation were actually included in the sample. Attending the gatherings were some non-adopters who shared their thoughts on various topics, including growing performance and the many advantages of grass strips.

Analyzing data:
The SPSS statistical software, version 20.0, was utilized to evaluate the gathered data using both descriptive and inferential statistics.

The differences between treatments means was determined using paired T-test. Farmers' perception data was computed using simple descriptive statistics.

RESULT AND DISCUSSION

Yield and Yield Components of Maize

Based on the combined analysis of the two years (from 2022 to 2023) trial result shows that, there was significant difference ($P < 0.05$) in all parameters between the treatments and when compared to sole maize, integrated grass strip with maize produced higher grain yields (Table 1) additionally it has 33.14% of yield advantage over sole maize. The study agrees with the result of (Wudinesh et al., 2023).

Table 1. Combined analysis of biomass and grain yield of maize (2022-2023)

Treatments	Parameters				
	Plant height (m)	*Cob number (#)*	*Cob length(m)*	*Biomass (ton/ha)*	*Grain yield (ton/ha)*
M+GS	*2.50^{a}*	*1.38^{a}*	*0.23^{a}*	*13.62^{a}*	*5.28^{a}*
MO	*2.35^{b}*	*1.13^{b}*	*0.19^{b}*	*11.20^{b}*	*3.53^{b}*
LSD	*0.1*	*0.12*	*8.7*	*1.8*	*0.55*
CV (%)	*1.42*	*5.63*	*2.35*	*8.23*	*7.18*

Note: M+DGS is for Maize with Desho grass strip and MO is for sole Maize as control

Grass Biomass

The biomass result from harvested desho grass indicates an improvement with each harvesting cycle (Figures 6 & 7). The trials farmers have benefited economically from this, as well as from having access to more feed for their animals by cut and carry system. Desho grass is used as a year-round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010) and is mainly grown on small home plots used for livestock fodder and soil conservation practices. Studies also showed that, it is sold for income generation as small business opportunity, mostly for high land Ethiopian farmers (Leta et al., 2013). According to Smith (2010) who reported that desho grass is naturally spreading across the escarpment of the highlands and used for multiple purposes. It has an extensive root system and produces high biomass per unit area (Ramirez et al., 2010). Desho grass is currently used as biological soil conservation, animal fodder and income generation in northwestern Ethiopia (Asmare et al., 2015).

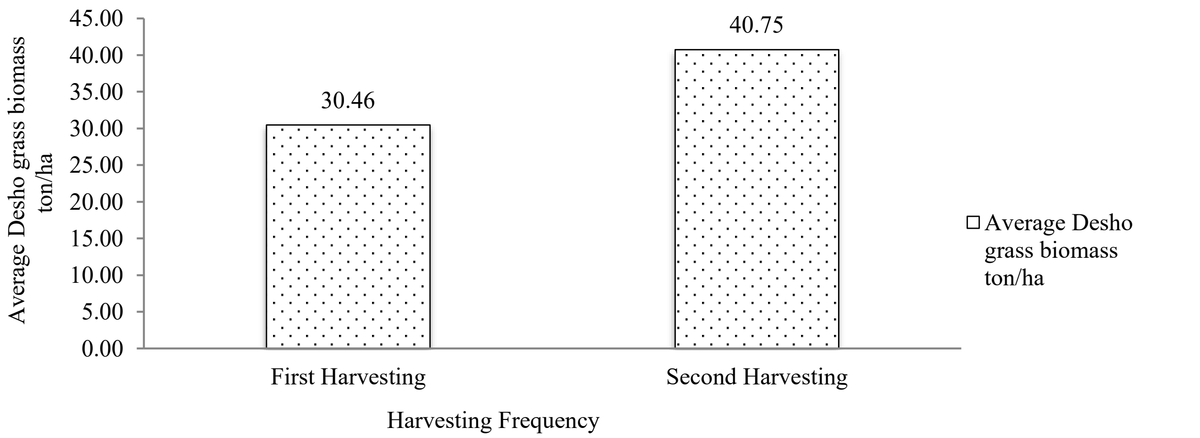

Figure 6. First year (2022) average biomass yield of Desho grass

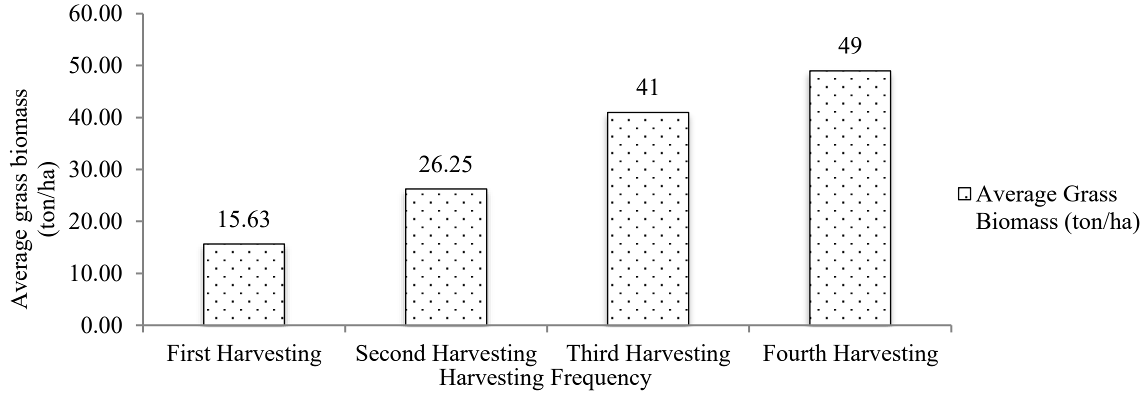

Figure 7. Second year (2023) average biomass yield of Desho grass

Figure 8. Taken during measuring grass biomass.

Effect of Desho Grass Strips on soil moisture

During the second year trial season, better moisture content of the soil was recorded in the development (51.73%)) and harvesting (32.10%) stage respectively in maize with Desho grass strips than sole maize. A study conducted by Umer et al. (2019), was revealed that, the root systems of the Desho grass strips conserve moisture through minimizing erosion, evaporation, surface runoff and modifying soil microenvironment. According to a study by Danano (2007), Desho grass's extensive root system efficiently uses deeper nutrients for development while strengthening the soil's structure and enhancing its ability to conserve water.

In line with this, Djikeng et al. (2014), discovered Desho grass can be grown on small home plots, improves soil cover and fertility, while increasing soil moisture retention and biodiversity.

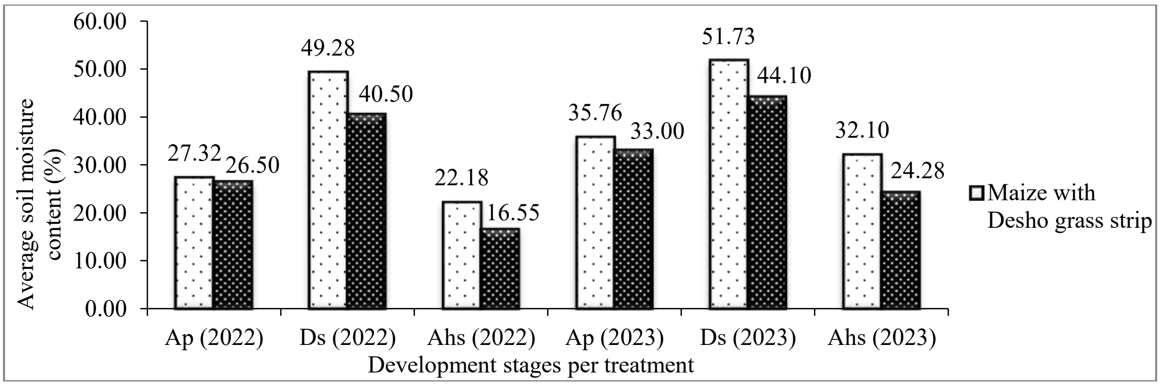

Figure 9. Average soil moisture at different development stage

Note : Ap is for at planting, Ds is for development stage and Ahs is at harvesting stage

Farmer's Perception Towards Desho Grass Strips

Causes and Effects of Soil Erosion Problem Before Intervention

According to the FGD, the study reveals that, before the intervention there was severe soil erosion problem in their farm land as well as they have discussed some of the indicators and causes of soil erosion. Accordingly, poor growth of crops and grasses, absence of fertile top soil, root exposure and reduced soil depth are those indicators of soil erosion and also absence of soil and water conservation measures, restless cultivation and absence of fallowing and free grazing system are the causes of soil erosion in the area. The effects of soil erosion problem as mentioned during the focus group discussion such as loss of vegetation cover and grasses, requirement of high input and management, declining in soil fertility.

Table 2. Farmer's perception on the causes and effects of soil erosion.

Causes	Problem ranking	Effects
Steep slope cultivation	3	Loss of vegetation cover and grasses
Restless cultivation and absence of fallowing	2	Requirement of high input and management
Free grazing system	4	Declining in soil fertility
Absence of soil and water conservation measures	1	Declining productivity of crops over time

Effects of Desho Grass Strip on Farm Land After Intervention

As discussed during focus group discussions, in the study area desho grass strip has an effect on maintaining soil fertility, the farmers have benefited economically having access to more feed for their animals by cut and carry system, reducing soil erosion and improving crop productivity. Hence, the farmers first preference was implementing grass strip on their farm land by evaluating it with different criteria's (Table 3). In line with Asmare et al. (2015), planting Desho grass has directly and indirectly increases the benefit of desho multiplicators. Directly desho grass planting material can be sold from producer to user and by doing so it increases the income of desho multiplicators. The indirect benefit of desho grass can be fed to animals and then increases production and productivity which results the increment in the income through the sale of animals themselves or their out puts.

Table 3. Farmers preference based on evaluation criteria

Selection criteria	Integrating grass strip on farm land	Sowing without grass strip
Maintain soil fertility	2	1
Improves crop production	4	1
Sources of fodder for livestock by cuttings	3	1
Reduction in soil erosion	4	1
Rank	1st	2nd

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

Figure 10. Taken during assessing farmers' perception data

CONCLUSION AND RECOMMENDATION

Based on the results, the study concluded, demonstration of Desho grass strip as biological soil and water conservation measures have plays significant role on grain yield and farmers perception. Comparative to sole maize, integrated grass strip-with maize produced higher grain yields and yield advantage. Additionally, the study determined that, demonstration of Desho grass strip has enhanced moisture content of the soil and economic benefits of the farmers through cut and carry system of the grass. Therefore, the study recommends that, planting maize incorporating with biological soil amendments and water-saving techniques should improve crop yields and needs to popularize the investigation in large scale to reach the wider community.

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Competing Interests

We declare that the authors have no competing interests as defined by this Journal, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

All the authors have made significant contribution for data collection, data analysis and interpretation and the final manuscript preparation.

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