World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 6.129

PERFORMANCE EVALUATION OF BIOLOGICAL SOIL AND WATER CONSERVATION MEASURES AT PHYSICALLY TREATED GULLY SIDE OF TANQUA ABERGELE WATERSHEDS

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Article Received on 14/05/2020 **Article Revised on 04/06/2020** **Article Accepted on 24/06/2020**

ABSTRACT

Gully erosion is the worst form of erosion affecting to the society and environment, primarily caused by surface runoff and dramatically accelerated due to human induced factors. Biological Soil and Water Conservation (BSWC) grasses have a great contribution in protecting soil erosion and gully rehabilitation. The study was initiated with the aim of evaluating the performance and growth rate of selected biological soil and water conservation grasses towards gully rehabilitation and soil loss reduction. The study was conducted at Agbe (Maytsahli sub - watershed) in Tanqua Abergelle districts, which is located in central zone of Tigray regional state. The study area was selected purposively based on the prevalence of soil erosion problem and gully occurrence. Five treatments with three replications were applied using Randomized Complete Block Design (RCBD) with a plot size of 4 m * 6 m. Field observation, interview and measurements were used to collect the data. Height of growth rate, dimension of gully section and volume of soil loss data were analyzed using Statistical package for Social Science (SPSS) and Microsoft-excel softwares. The obtained result of grass height was evaluated four times per year with in three (3) months interval. The analysis result showed that, Giant reed grass had the highest (2.31 m) growth performance followed by elephant grass (1.46 m) as compared with vetiver (0.81 m) and sisal (0.53 m) grases, due to their physiological behavior of each grasses. Due to implementation of BSWC grasses, the depth of the gully was reduced from 1.75 m to 1.51 m and the width of the gully remains constant. The volume of soil loss from the gully section was also reduced from 559 ton/ha/yr to 468 ton/ha/yr. Therefore, the BSWC grasses showed a promising contribution in reducing soil loss from the gully. Therefore, farmers, experts and stakeholders should have to expand and disseminate those technologies to all watersheds in order to stabilize gully and reduce soil loss.

KEYWORDS: Biological grasses, Soil and water conservation, Gully erosion and soil loss.

INTRODUCTION

Land degradation, comprising degradation of the natural vegetation cover, soil erosion, loss of soil fertility and moisture stress is a well-known problem in Ethiopian highlands (Herweg et al, 1996). Land degradation, particularly by water erosion, is an important factor in both the long-term decline and the seasonal reduction in food crop production (FAO, 1986).

Soil erosion is one of the factors that affect the physical and chemical properties of the soil. Erosion devastation has now become so apparent in the world; fertile top soil, good farm land, and grazing are gone and gutted with sheet and gully erosions. Erosion is one of the most agricultural problem in the world (Schwab, etal., 1993). According to the Ethiopian highlands reclamation study, over 14 million hectares (or 27% of the area) of the highlands was estimated to be seriously eroded, and about 15 million hectares were found to be susceptible to erosion. Similarly, studies in Tigray region, northern Ethiopia have indicated that the mean rate of soil erosion varies from 7 t ha^{-1} y^{-1} (Nyssen, 2001) to more than 24 t ha^{-1} y^{-1} (Tamene, 2005) and 80 t ha^{-1} y^{-1} (Tekeste and Paul, 1989).

Being a limited and an irreplaceable resource, soil erosion poses a great danger to agricultural production. Though the magnitude varies with ecological zones owing to variations in the interplay of causative factors, soil erosion persists severely, on agricultural lands in Ethiopia. It continues to pose a formidable threat to both national food security and environmental quality. To curb erosive land degradation requires soil conservation measures that are cheap, replicable and Sustainable.

A biological treated watershed of the world can be considered as if life is there because it best merits biodiversity conservation. The biological biomass conserves soil and water as its sites and eventually makes good access as food for livestock. The crops cultivated, the grass land with full of grass, forest land which is free from any intervention/i.e. enclosure/, a single tree shed could directly or indirectly conserves nature biologically. Therefore, the biological soil and water conservation measures for a watershed are vital for its natural stability and for controlling soil erosion. Different biological soil and water conservation measures are there in today's world. Elephant grass, bamboo grass, salt bush, banna grass, sisal species, eragrostic, populs, pigeon pea, vetiver grass and cactus are among the measures for biological conservation. Hence study is intended to focus on the former two measures to study their effectiveness for biological conservation. These above biological measures for soil and water conservation work by their protective impact on the vegetation impact on the vegetation cover, a dense vegetation cover, prevents splash erosion, reduces the velocity of surface runoff, facilitate accumulation of soil particles and increase surface roughness which reduces runoff and increase infiltration.

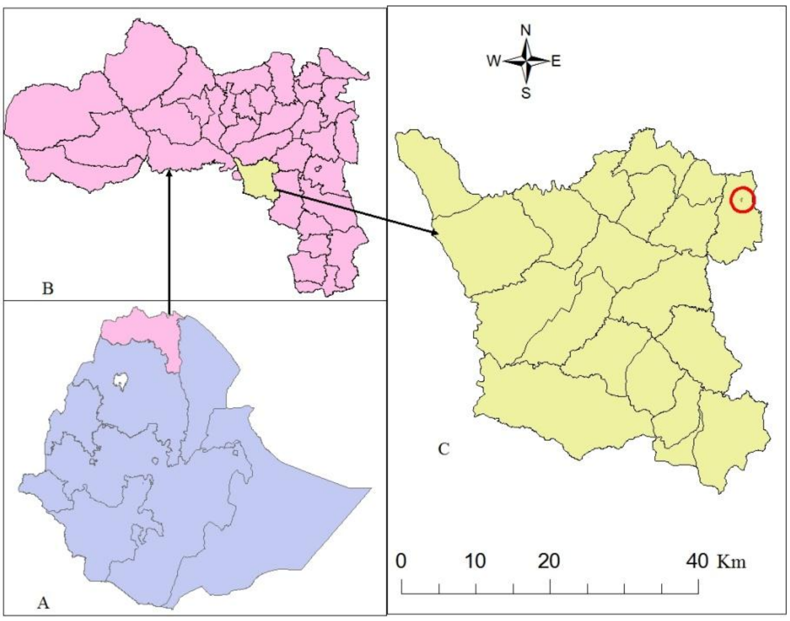
In our mandate area watersheds that area treated by physical soil and water conservation structures are ineffective. The reason may be inappropriate site selection, inappropriate design, the community may have no interest in constructing the structure and these physical structures may not be stabilized by biological measures.

Gullies which are treated by physical conservation measures needs biological measures in order to stabilize the structure. The biological soil and water conservation measures for a watershed are vital for its natural stability and for controlling soil erosion. Elephant grass, bamboo grass, salt bush, bana grass, sisal species, eragrostic, populs, pigeon pea, vetiver grass, and cactus are among the measures for biological conservation. So, the use of biological grasses have offered such prospects in a wide range of climatic environments (World Bank, 1990).

MATERIAL AND METHODS

Study Area Description

The study was conducted at Agbe (Maysele sub - watershed) in Tanqua Abergelle districts, which is located in central zone of Tigray regional state. It is located at 13^0 14' 06'' N latitude and 38^0 58'50'' E longitudes (Figure 1). The agricultural system is mixed farming. It is agro-ecologically characterized as hot warm sub- moist low land (SM1- 4b) below 1500 m.a.s.l. The rainfall of the area is erratic and short duration rainfall events and average annual rainfall varies from 350 – 700 mm. It is mono-modal rainfall event occur mainly during the months of July to August with dry spell from November to April. According the laboratory analysis, the soil type in the area is dominated by leptosols (32%) and cambisols (27%) respectively, and the fertility level is below the critical (unpublished data of ATA).



A= Ethiopia, B = Tigray region and C= Tanqua Abergelle woreda
Fig. 1: Map of the study site.

2.2 Methods of Data Collection and Analysis

2.2.1 Site Selection and Experimental lay out

The study area was selected purposively based on the prevalence of soil erosion problem and gully occurrence. Four types of selected BSWC grasses (Vetiver, Elephant, Sisal and Giant reed grass) were used in the study. Some of the biological soil and water conservation grasses were transplanted (i.e vetiver and elephant grasses) from the nurseries and some of them were collected from the nearest areas (i.e Giant reed grass and sisal grass). The method of propagation is split (vetiver & sisal) and cutting (elephant & Giant reed grass).

A Complete Randomized Block Design (RCBD) was used and the plot size was 4 m * 6 m (24 m^2). The spacing between plots, rows, blocks and grasses were 0.5 m, 0.3 m, 1 m and 0.2 m respectively. The following treatments were used to commence the experiment.

T1: Vetiver grass
T2: Elephant grass
T3: Sisal grass
T4: Giant reed grass
T5: Control

2-3 tillers or cuttings were planted along the contour line in single rows per pit with parallel pattern. The slope of the study area was 12%. The growth rate of the selected grasses which were planted at watersheds were evaluated by conducting a measuring tap. For this case, an evaluation was done four times per year, with in 3 months interval.

In order to calculate the quantity of soil lost by gully, relationships and analysis has been done as follows putted below in (eq 2).

$$Cross\_sectional\ area = \frac{(W1+W2)}{2} * D \quad (1)$$

Where; W1= Averag top width of the gully (m)
W2= Averag bottom width of the gully (m)
D= Averag depth of the gully (m)

$$\text{Volume of soil loss (V) } (m^3) = \sum_{i=1}^{n} Vi \quad (2)$$

Where; Vi = Volume of soil loss in a section gully (i.e cross-sectional area * gully length)

2.3 Method of data collection and Analysis

Data such as grass height, growth rate, slope of the area, gully cross sectional area (length, width and depth) before and after, and rate of soil loss were collected for the two consecutive years. In addition the effectiveness of grasses and its acceptance and mitigation solutions were collected through structured questionnaires.

The collected data were analyzed using descriptive statistical techniques with the help of Statistical Package for Social Science (SPSS) software. In addition, MS-Excel was used to generate tables and graphs.

RESULT AND DISCUSSION

Rainfall distribution

The rainfall pattern of the study area is uni-modal and characterized with a wet season of about two months occurring in July and August in the main rainy season (“Kiremti”) with minor rain events occuring between March and May. The rainfall variability in time is considerably high especially at the beginning and end of the main rainy season. The monthly amount and distribution of the rainfall that causes the runoff at the study area is presented below (Figure 2). The amount of annual rainfall that causes runoff in 2014 and 2015 were 456 and 701 mm respectively. The highest rainfall was observed in 2015 as compared to 2014 rainy season.

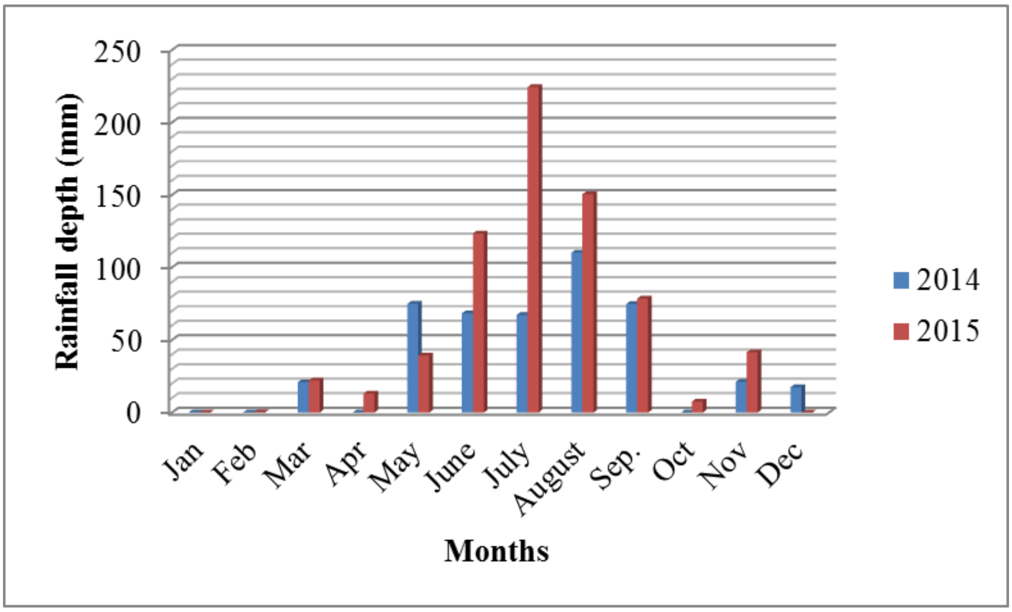


Figure 2: Monthly rainfall distribution at the study area.

Gully depth

According to the gully measurements, the measured gully have U-shape cross sections and its average depth of the gully is 1.51 m. Based on the depth, the gully is classified as medium gully (Thomas, 1997). Meanwhile, the observed gully in the study area was active (actively eroded). The change in depth of the gully is also the basic parameter used to quantify the competence/efficiency of the biological soil and water conservation measures.

Based on this, data of depth of the gully was collected yearly in the rainy season of 2013/14 and 2014/15. The initial average depth of the gully before intervention was

1.75 m and later on reduced to 1.72 m at the end of the first year December, 2014 (after intervention) (Table 1). On the second study year, the biological grasses had brought the change from 1.72 m to 1.51 m. As a result of the intervention of BSWC grasses, the the depth of the gully has reduced from 1.75 m to 1.51 m. Whereas, the top width and bottom width of the gully has almost showed no change and this shows the BSWC grasses had a great contribution in stabilizing the gully from being eroded.

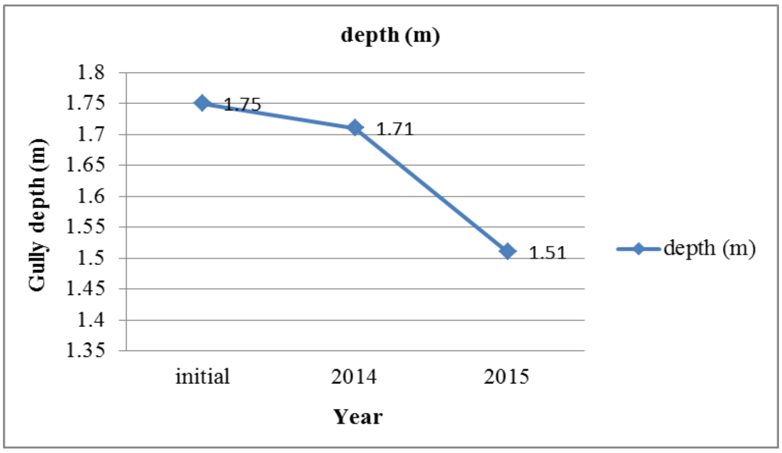


Figure 2: Change of gully depth at different years in the watershed.

Table 1: Average gully depth and its dimension at Mayselele watershed since 2014/15.

year	Dimension of the gully before and after intervention				Aveg. slope
	Length(m)	Width (m)		Depth (m)	%
		Top width	Bottom width		
Initial	180	14.2	4.8	1.75	5
2014	180	14.2	4.8	1.72	5
2015	180	14.2	4.8	1.51	5

Cross-sectional area of the gully

Gully cross-sectional area measurement was done after the gully length is dissected in to sections of the same cross (Stocking and Murnaghan, 2000). Therefore, each gully cross-section was measured for depth, width(s) and length using measuring tape.

The length of the gully was 180 m from head to base with drainage area of 7.2 ha. Bulk density of this gully was 1.3 ton/m^3.

Table 2: Cross sectional area and soil loss in average at Mayselele gully watershed.

Parameter	Initial	2014	2015	Difference
Cross sectional area (m2)	17	16.34	14.34	2.7
Volume of soil loss (m3/yr)	3060	2941.2	2581.2	486
Volume of soil loss per meter equiv. (m3/yr)	0.043	0.041	0.036	0.007
Volume of soil loss to tones per ha. (ton/ha/yr)	559	533	468	91

The initial volume of soil lost from the gully before implementing the biological soil and water conservation grasses was 3060 m^3/yr and later, it was reduced to 2941.2 m^3/yr and 2581.2 m^3/yr at the end of the 2014 and 2015 respectively. As indicated in the above table 2, the introduced technologies reduced the cross sectional area and soil loss of the gully by more than 91 ton/ha/yr and this shows, the soil and water conservation potential of locally available materials for the gully rehabilitation were effective. Similar results were obtained by Obsa et al. (2017), which is the volume of soil loss reduced from 468 ton/ha/yr to 204 ton/ha/yr, due to the application of brush wood (bamboo) with stone check dam on soil and water conservation (gully rehabilitation) in Assosa district at selga watershed.

Growth rate of the selected BSWC grasses

Among the planted BSWC grasses, vetiver and sisal grasses were more drought resistant than the others and can be easily survived withstand to this moisture-stressed area. Whereas elephant and Giant reed grass were more adapted in moist areas and have showed low performance and resistance to drought in the study area.

All grasses showed an increment in their growth rate starting from the plantation season (summer) to the next 3 and 6 months (1^{st} and 2^{nd} quarters). But after the 3^{rd}

quarter (9 months), they reduced their height and started to shrink their leaves, especially elephant and Giant reed grass. The main reason for the reduction of the growth rate of the grasses was occurrence of moisture stress, termites (especially for vetiver grass) and low fertility status of the soil. Even though Vetiver grass is drought resistant grass, it was highly affect by termites at dry spell season.

Giant reed grass showed the highest growth performance (2.31 m height) followed by elephant grass (1.46 m) (Figure 3).

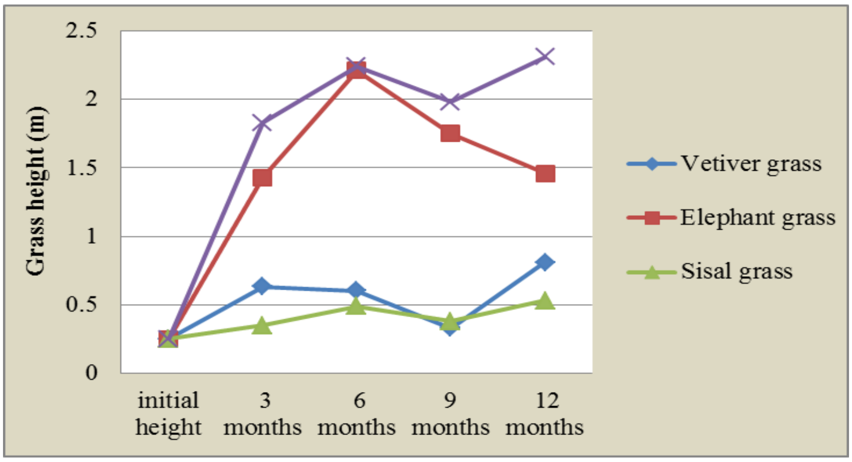


Figure 3: Average growth rate of each biological soil and water conservation grasses.

Effectiveness of the selected grasses on soil loss reduction of the gully

According the experiment and field observation the selected BSWC grasses had a good performance in controlling and reduction of soil that will be lost from the gully. As the result showed, soil loss was reduced from 559 ton/ha/yr (with out intervention) to 468 ton/ha/yr (with intervention of grasses). So, this implies how much they are promising in decreasing soil erosion. Therefore, the effectiveness of the selected BSWC grasses in controlling soil erosion and stabilization of the treated gully in the watershed was promising (Figure 4).

According to the respondents and field observation vetiver and elephant grasses can be used both for stabilization of gully erosion and animal fodder. In addition to their gully rehabilitation purpose, Giant reed grass and sisal grass have an economic value contribution and they are used by the local people in their day to day and livelihood activities. For example, Giant reed grass can be used for construction material, wood works and chair. Similarly sisal grass can be used for house construction and as input for factory for rope making. This shows that farmers have awareness about those selected grasses and this in turn has its own positive implication for the use of those grasses as a technique to reduce soil erosion in treated gully watershed of the study area.

Figure 4: Biological soil and water conservation grasses at Mayselele watershed.

The acceptance of BSWC grasses for stabilization of treated gully by the farmers and its potential on soil and water conservation has also been assessed. All the participants know elephant, sisal and Giant reed grass and their potential for SWC, where as most of them didn't know Vetiver grass and only few of them have slight information. After introduction, all the participants have confirmed/or approved the effectiveness of grasses on stabilization of gully and arresting soil erosion. Finally, almost all of the farmers (100%) are confident that, the problem of soil erosion can be reduced by supplementing the biological soil and water conservation measures with different physical SWC technologies.

CONCLUSION AND RECOMMENDATION

BSWC grasses are very crucial in degraded gully areas, due to water erosion, appropriate SWC techniques such as biological and agronomic were more effective to stabilize and sustain environmental problems.

The result obtained from this study indicated that, The growth rate of the biological grasses was promising and can be planted in areas of similar environment in order to rehabilitate degraded gullies. The study showed that, the conservation potential of BSWC grasses was effective in minimizing and stabilization of gully erosin.

The volume of soil loss from the gully was reduced from 559 ton/ha/yr (without intervention of grasses) to 468 ton/ha/yr (with intervention of BSWC grasses). So, this has given a promising result in reducing soil loss from gully side, which was adaptive and efficient for gully stabilization. Thus, farmers and other stakeholders should have to use and demonstrate those grasses on their area to reduce the soil loss.Because of the erratic rainfall behavior and sever soil erosion of the study area, it is highly recommended that applying BSWC grasses in supplement with physical soil and water conservation measures in the gullies is very important. The systematic use of BSWC grasses (such as vetiver, elephant, giant reed grass and sisal grass) for various purposes provides a valuable and beneficial strategy for soil management and preservation of natural environment particularly, with respect to the maintenance of soil moisture and mitigation of soil erosion in degraded sloppy areas.

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