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Evaluation of *Awir* (*Ipomoea carnea*) for Gully Rehabilitation through Different Propagation Techniques in North Western Zone of Tigray

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Authors' contributions

This work was carried out in collaboration between all authors. Author GD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KA and NB managed the analyses of the study. Author NB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Since the past two decades, watershed management practices such as construction of stone bunds and establishment of exclosures have been widely implemented in the semi-arid low and highlands of northern Ethiopia to curb land degradation by soil erosion. The aim of this study was to identify scientific name and its impact of gully rehabilitation measure in the *Serenta* watershed of the Maitsebri agricultural research center experimental site, northern Ethiopia. Data were collected through semi-structured interviews, transect walks, field observation and field measurements to characterize the species. Scientific name of the species was identified and characterized as *Ipomoea carnea* Jac. by the national herbarium of Addis Ababa University. Based on the average result of the planted cuttings of stem/direct planting, its survival rate at side was greater than

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cuttings planted at top position of the gully; 100% at side and 95.84% at top. And for these cuttings planted by budding/layering, its survival rate at side and top positions are equal; 58.33% at side and 58.33% at top. This study demonstrated the potential of the species to bring remarkable restoration of eroded gully through reinforcement of gabion check dams that could serve as a basis for sustainable planning of future developments of areas experiencing severe land degradation due to water erosion and over grazing.

Keywords: Ipomoea; gully; propagation; Ethiopia.

1. INTRODUCTION

Soil erosion caused by heavy rainfall and surface runoff is a serious problem in agricultural areas. This is more serious on inclined slopes where the soil loss can reduce soil productivity and increase sediment and other pollution loads in receiving waters [1]. Soil erosion often occurs on steep slopes due to improper land use, monoculture and the use of tillage tools that leave the soil bare and pulverize it excessively [2]. After such treatments, the soil can be carried away by heavy rains. This problem affects crop productivity and the incomes of farmers. Soil erosion by runoff is often accepted as an unavoidable phenomenon associated with agriculture on sloping land. However, erosion removes the topsoil which is the part of the soil profile highest in nutrients and organic matter [3]. The annual soil loss of Ethiopia is estimated to be 1.5 billion tons of soils per year [4]. Due to the eroded top soil the productivity of the crop lands decreasing from time to time. One of the most wide spread threats to soil quality in this region is wind and water erosion that impacts the lives of the people in numerous ways. As a result of untreated catchment, poor vegetation covers and severe erosion has been forming gullies in the region. This formation of gullies leads to changing the productive land to marginal/unproductive/ land which in turns impacts the food security of the individual households since the size of land is small due to fragmentation. Using photogrammetric techniques, Shibru et al. cited in [5] to reverse the effect of gully erosion, the government of Tigray region has launched strategies which could improve the natural resources rehabilitation. Among these strategies are catchment treatment, gully reclamation and other soil and water conservation structures. Recently introduced gully reshaping and revegetation efforts are found in various parts of the region with promising results. To be more effective, the physical soil and water structures should be integrated with biological measures such as, grasses, shrubs and trees to reinforce, strengthen and provides complete ground protection [6]. It is with this burning issue in mind that conserving soil and water through physical and biological measures are the current home work for the present generation to increase the productivity of the land for both short and long period of time.

However, very little or no research has been done so far as biological soil and water conservation tool. In addition, its name was not identified and documented scientifically in Tigray in general and in the study area in particular. However, in Western Tigray, Tsegede woreda Zuria Dansha kebele, farmers used the species as small gully rehabilitation. The shrub is also useful for bee forage, fuel wood and planted as a fence for farmland.

Therefore, the objective of the study was to characterize and evaluate *Awir* as biological gully rehabilitation measure by determining the adaptability of environmental variables and morphological growth characteristics of different propagation techniques.

2. MATERIALS AND METHODS

2.1 Study Area Description

The experiment was conducted at Medhani Alem *kebele* (the smallest political administration units in Ethiopia) Tselemti Woreda, North Western Tigray (Fig. 1). It is categorized as lowland and geographically located at 38008' longitude and 13 005' latitude with an altitude of 1350 m.a.s.l. Sorghum, maize, millet and *Tef* (*Eragrostis tef*) are the major crops. Vegetations such as onion, tomato, potato, pepper, carrot, garlic and groundnut grow in the study site. The area is also rich in *Boswellia papyrifera*, *Zizphus spina - Christ*, *Biospyros mespliformis*, *Cordia africana* and *Adansonia digitata* are the main vegetation types found in the area that serves as a source of income and utilizes for different purposes. Mai Tsebri is located 380 km from the regional city Mekelle. The altitudinal range of the woreda falls

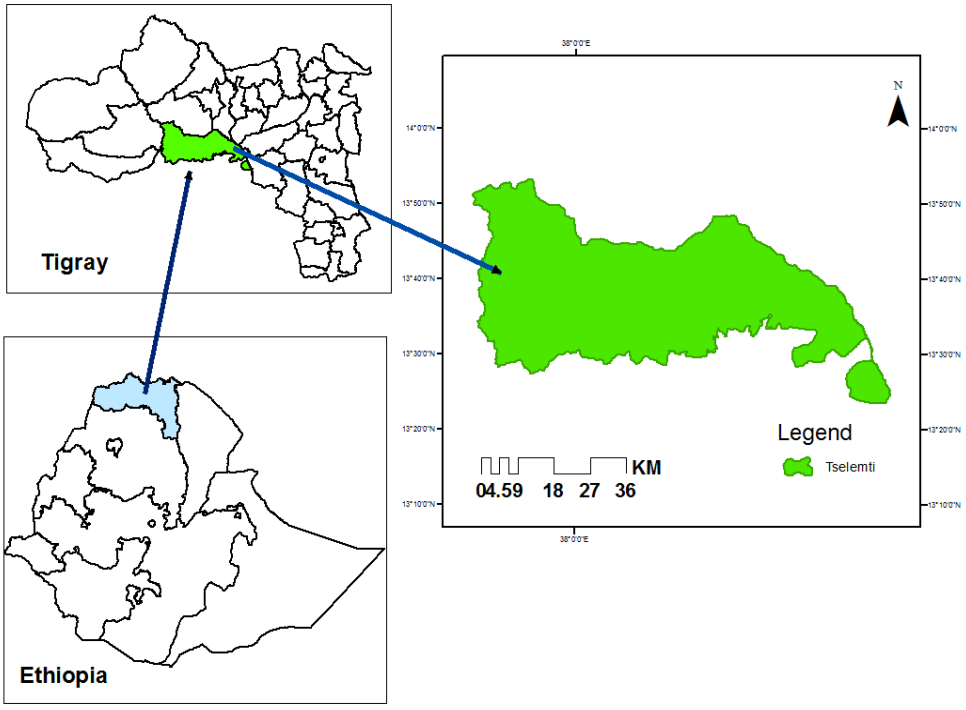

Fig. 1. Location map of the study area

between 800 and 2872 m.a.s.l. The land form is characterized as flat plain plateau, hills, mountains, gorge (valley) and some immediate break of slope.

The agro-climatic condition of the area is hot to dry semiarid lowland plains dictated by a very hot temperature. The maximum temperature ranges from 35.6°C in May to 36.4°C in April, while the minimum temperature is ranging from 15.7°C in December to 21.8°C in May (Tigray National Meteorological Agency (TNMA 2014)) (Fig. 2). The dry season occur between November to March whereas, the rainy season occurs between June to September, which follows a unimodal rainfall pattern.

Agriculture is the main livelihood of the community in the study area. It is known for its mixed farming system, where the rural people depend on crop and livestock production and in addition with agroforestry practices for their living.

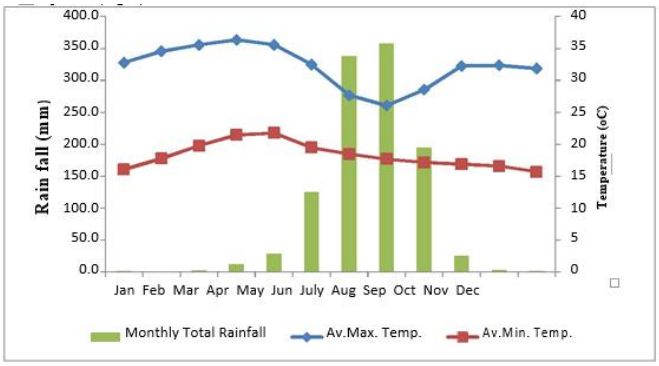

Fig. 2. Six-year rainfall and temperature of the study area
(Source: TNMA, 2014)

2.2 Identification of *Awir* and Source of Cuttings

It is a shrub species, which is found in western zone of Tigray. Traditionally local communities of the area have been planting *Awir* on their homesteads to protect their lands from erosion. Literatures were reviewed to identify and understand its agro-ecological distributions, management requirements and scientific nomenclature, but information was not found about the history of the species. In contrast, these areas have been covered with *Awir* resources that have not provide multi- service functions to the local communities in particular and the region in general. So, to utilize and manage the species properly as biological soil and water conservation and other socio-economic importance, its local and scientific name should be known and registered. Hence, sample was taken to the national herbarium of Addis Ababa University for identification and characterization. The study was conducted through analysis of secondary data and supported using a participatory reconnaissance survey by employing different participatory tools, such as personal observation, transect walks, group discussions and focused group interviews. A total of thirty key informants and development agents were interviewed to know the main uses, area converges and distribution of the species.

Awir growing localities, namely Zuria Dansha and Baeker were selected for cutting collection based on agro-ecology similarity, representativeness, accessibility and distance from the experimental site. This was done through consultation of local people and agricultural expertise by employing different tools of participatory reconnaissance survey. And then branch cuttings were collected from altitudinal range 1000 to 1350 m.a.s.l to minimize variations among sites and cuttings. Local communities were well recognized about the merits and demerits of the species. Branch cuttings were taken from shrubs that look healthy at least phenotypically with a size range of 3 cm–5 cm in DBH and 2m–4 m in height. Then cuttings were collected, loaded and transported with a great care to ovoid damages and scrapes to the planting site. As soon as arrived at the planting site, cuttings were trimmed to the required size using a sharp axe and planted in the prepared pits to protect cuttings against desiccation.

2.3 Experimental Design and Treatments

2.3.1 Site (gully) selection

The establishment of protective vegetation in a gully is usually much more difficult if run off is not handled through the channel at the same time the plants are being planted. Therefor gullies that are treated with mechanical measures was selected for the satisfactory flood control and revegetation (Fig. 3). Our gulley assessment finding revealed that the dimensions of the gullies were about two meters depth and 8 m width leading to sever farm land deterioration [7].

2.4 Planting Techniques and Managements

Many different types of control measures for handling different kinds of erosion problems have been done over the last decades, even though effective conservation practices have not yet been developed for all numerous problems and combination of problems relating to the contrasting agricultural lands and practices. The question is now, how and when *Awir* can be planted to achieve the required objectives? So the study is designed to answer these questions. Two propagation techniques (stem, layering) and planting position on the gully was used to investigate which type of planting technique and position is appropriate for successful revegetation.

Cuttings of the species was collected from Kafta Humera where *Awir* found naturally exist. At each study experiment a total of 120 cuttings (stem and layering) was considered at side and top position of the gully. The cutting length of stem (1.5 m) and layering (60 cm) with a common branch girth was used in this experiment. There were 4 branch cuttings planted in double rows at spacing of 1m between plants and blocks when stem and layering propagation techniques used. The plot size was used 5 m by 4 m. Each branch cutting was planted in a pit that has 30-45 cm depth and a cross-sectional area of 900 cm2 (Personal communication to local farmers) in July, 2010. It was placed within the fine soil of the pit and slanting lower cut will remain horizontal by keeping the cutting in an oblique position. Revegetation of gully is the plantation of the reshaped gully sides and bottom with biological species so that it reduces run off and control erosion and make the land productive [6]. Gully revegetation implies reaching a dense vegetation cover over the entire gully surface,

Fig. 3. Active gully with free grazing problem of the experimental site

Fig. 4. Gabion check dam construction and planted branch cuttings by direct and layering on reshaped gully

Source: Photo taken by Girmay D. in 21/07/2010

i.e. both sides and bottom by planting Awir species. But for successful revegetation, three conditions and steps are important: Exclude the cattle throughout the year, use cut and carry and reshape the gully sides. Reshaping can be done either by cutting the edges or shaping the slope in to series of small steps or micro benches every 0.75-1 m distance (Fig. 4).

2.5 Data Collection

To evaluate its growth rate 30% samples were taken at the month of 1, 2, 3, 6 & 12 from the total cuttings planted and then data on total shoot number, sample shoot length, total leaf number and sample leaf length and survival rate of the cuttings were collected periodically.

2.6 Data Analysis

Descriptive analysis such as mean of data was conducted on survival rates and planting methods on different growth response of morphological characteristics of planted branch cuttings and supported by photo evidences to show the effect of the species on sediment deposition and gully rehabilitation of the experiment.

3. RESULTS AND DISCUSSION

3.1 Uses and Characterization of *Awir*

It is an exotic shrub species, originally came from Sudan. Local communities of the area have been used to protect their lands from erosion and live fence by planting on their homestead lands. The socioeconomic analysis reveals that the species has two local names; *Awir* and *Serka-abeba* (meaning flowering all year round). Scientific name of the species was identified and characterized as *Ipomoea carnea* Jac. by the national herbarium of Addis Ababa University. Key informants mentioned that, the main function of *Awir* is protecting land from erosion, live fence, enhance soil fertility, honey bee flora and can be used as shade for wild life if planted at protected areas (Fig. 5). Overall, we found a robust indication of positive effects of *Awir* on economic conditions of the households of the study area by protecting the small land from soil erosion. This is in line with the findings of Gebramlak et al. [8] who found that lowland bamboo positively affected the income of rural households in Serako, Tigray, Ethiopia. In respondent's point of view, it is important to scale up this as alternative

technology at areas that have gully and grazing problems. The species does not need much management but if we plant at farm lands, pruning will be important to decrease its holding area coverage. It has the ability to tolerate moisture stress and grow at poor soil fertility and water logging areas.

3.2 Propagation Techniques and its Effect on Gully Reclamation

After cuttings were planted, it started to give new shoots and leaves within 5-7 days. Based on the collected data for stem/Budd planting at both side and top positions of the gully, the average result of planted cuttings characteristics are presented in Table 1.

Based on the average result of the planted cuttings of stem/direct planting, its survival rate at side was greater than cuttings planted at top position of the gully; 100% at side and 95.84% at top position of the gully. And for these cuttings planted by budding/layering, its survival rate at side and top positions are equal. (58.33% at side and 58.33% at top). For budding propagation method of Awir, the survival percent is decreasing due to huge flooding (side) and water logging (top) effect. This study is in line with the findings of Reubens et al. [6] who reported that Mortality rate for Dodonaea tree seedlings planted at gully flour was especially high during the summer rains. Hence, when we see almost all the morphological growth characteristics of planted cuttings in stem/direct planting, promising result has shown than cuttings planted by budding/layering propagation method. Different and relevant stakeholders such as individual farmers, extension workers, researchers, the media and other concerned individuals and professionals were invited to visit the observation trial at different occasions. All the visitors and/or the respondents gave their views on the newly vegetative propagation technology and underlined to scaling up for other similar areas that have gully problems.

In addition to the measured plant characteristics, it was also observed how *Awir* cuttings planted were capable to re-sprout. In line to this finding many studies conclude trees or shrubs that have good re-sprout behavior is good in rehabilitation of degraded gullies [4,6].

Honey bee flora

Irrigation site is protected from flood damage

Gully in homesteads are protected by *Awir*

Fig. 5. The different use of *Awir* by the local communities

Source: Photo taken by Girmay D. in 21/01/2011

Fig. 6. Showing by arrow large tree on the upper catchment to see the effect of the biological species on gully rehabilitation over time

Source: Photo taken by Girmay D. in 21/07/2011

A study conducted by Gebreegziabher [9] in Ethiopia revealed that runoff volume is significantly ($P < 0.05$) reduced due to permanent bed planting system as compared to the *Terwah*[1] system and conventional ploughing. This demonstrates that not only biological soil and water conservation practices but also ploughing techniques can reduce runoff and soil erosion.

[1] *Terwah ploughing: The same tillage operations as described for the traditional system were applied but additionally contour furrows were made at 1.5–2m interval after the third superficial ploughing.*

Table 1. Descriptive analysis of branch cuttings

S. No	Planting method	Shoot number	Sample shoot length	Sample leaf length	Sample crown diameter	Survival rate
1	Stem	18.17	207.78cm	22.45cm	2.92m	97.92%
2	Bud	6.83	160.11cm	22.00 cm	1.47m	58.33

4. CONCLUSION AND RECOMMENDATION

The results suggest that *Ipomoea carnea* Jac., were the most suitable for biological soil and water conservation in active gully rehabilitation where free grazing is the main problem. The study concludes that farmers should select the species due to high performance to adapt to the harsh environmental conditions, easily established, locally available and a lower cost that bring better gully rehabilitation and environmental conservation. The role of the species in sediment trap performance and ecological effect should be studied.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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