Evaluation of Different Water Harvesting Techniques in Improving the Survival Rate of Tree Seedlings in Drought Affected Woredas of the Waghimira Zone, Amhara Region

Samson Bekele
Sekota Dryland Agricultural Research Center, P.O.Box 62, Sekota, Ethiopia

Abstract

Moisture stress is the major limiting factor which highly reduces the survival rate of tree seedlings in semi-arid areas in the region. One of the approaches to overcoming such problems in semi-arid areas is use of different water harvesting structures. In this experiment, four water-harvesting techniques arranged in RCBD with three replications were used in three sites. The treatments were half-moon micro-basin (HM), eyebrow basin (EB), water collection trenches (TR), and a control i.e., normal pit (NP). Most adaptable and multi-purpose tree species (Schinus molle) for the area were planted in July 2003. Grasses, shrubs and tree species were regenerated throughout the experimental period. As a result, HM and EB gave significant results ($P \leq 0.05$) to root collar diameter (RCD) of the trees as compared to the control. On the other hand, a significant result was obtained in tree height ($P \leq 0.05$) for EB as compared to the control.

Survival rate of trees were also taken as the critical indicator for efficiency of the water harvesting structures (WHS). The trench structure gave the higher survival rate percentage, whereas eyebrow and half moon ranked second and third, respectively. From easiness of the construction and from farmers perspective HM was outsmarted over the other moisture conservation structures.

Keywords: Moisture stress, water harvesting, half moon, eyebrow, trench, micro-basin

Introduction

Water stress is the major limiting factor which highly reduces the survival rate of tree seedlings in semi-arid areas in the Amhara Region. The rain fall in Wag Hmira Zone is low in amount and erratic in nature (Hershfield, 1961). Occasionally, high intensity rain produces high runoff and less soil water storage. This excess runoff could have been temporarily stored by creating artificial micro water storage basins around tree seedlings. The harvested water will be used for the tree seedlings, which suffer from moisture stress during most part of the year, mainly due to dry spells.

One of the recent approaches to overcome such problems in semi-arid areas is the use of different water harvesting structures. This includes the methods able to increase water availability to plants such as rainfall multiplier systems and micro runoff storage mechanisms (Volli Carucci, 1996). In Ethiopia, there is limited information and experience on the potentials of water harvesting techniques and its possible uses. In most cases tree seedlings are planted without any water harvesting methods or without using the common half-moon (micro-basin). Despite the structures are used in some places, in most cases they are not constructed carefully following their appropriate designs. The intention of this experiment, therefore, was to evaluate efficiency of the different water harvesting techniques that can store rainfall and runoff water to increase survival rate of tree seedlings in semi-arid areas.

Materials and Methods

Description of the Study Area

The study areas, North Wollo zone and Waghimera zone, are found between $11^0 18^{'}$ and $13^0 16^{'}$ North of latitude and $38^0 20^{'}$ to $40^0 05^{'}$ east longitude in North-eastern part of the Amhara Regional State. North Wollo and Waghimra zones cover an area of 309,432 ha.

The North-eastern part of the Amhara region has a bimodal rainfall; there is a short rain or *belg* in periods of February to May with main rains or *meher* falling in June to September. The Western part of North Wollo and Waghimra zones as a whole is uni-modal rainfall zones where crops are cultivated in *meher* or *kiremt*.

Mean annual rainfall varies from 600 mm to 1300 mm with eastern part of North Wollo receiving the most rainfall and North-eastern part of North Wollo and Waghimra receiving the least. The mean annual temperature in both zones generally ranges from 8 ^oC to 21 ^oC. The poor soil and vegetation cover is the descriptive nature of the study area.

The two zones constitute three major ecological zones: highland (*dega*), midland (*weinadega*), and lowland (*kolla*) which constitutes 12.3, 44.2, and 43.5 and 4.6, 29.2, 66.2 percent of the total area of North Wollo and Waghimra Zones respectively (DHV Consultants, 2001; SERA, 2001).

Sites on hillsides (45-61% slope) where their soils are not too rocky and void of soils were selected in Lalibela. Four water-harvesting techniques arranged in RCBD with three replications and adjacent abandoned lands were used for each site. The treatments were half-moon (micro-basin), eyebrow basin, water collection trenches, and a control. The construction techniques described by Volli Carucci (2000) were adopted for this study. The dimensions of the area for one treatment were 18 by 24m^2 and the area between treatments was 2 meter square. The total area for one replication was 24 by78m^2 including the space between treatments. The most adaptable and multi-purpose tree species (Schinus molle) for the area was planted in July 2003. Each site was fenced with locally available material and was guarded to avoid uncontrolled factors. Baseline data of the site was collected at initial stage of the experiment supported by photographes and video recordings. Experimental data were also collected every three months starting from establishment.

Layout and design:
Slope gradient: 45-61%.
Size of one block was 24 by78m^2.
Area between the blocks: 3m
Size of each treatment (plot size): 18 by24m^2
Area between treatments: 2m^2
The treatments were replicated into three and these include:

- Half moon (micro-basin)
- Eyebrow basin
- Water collection trenches
- Control

Data to be collected were:

- Base line data:
    - Available grass and tree/bush species
    - Surface topography
    - Photograph and video documentation

- Survival rate of tree seedlings
- Height
- Root collar diameter
- Type and density of undergrowth vegetation

- Tree and grass biomass around the seedling
- Regenerated tree or bush species

Results and discussions

As shown on Figure 1 and Table 1, RCD was found significantly increased *($P \leq 0.05$)* for the half moon in the 30th month.

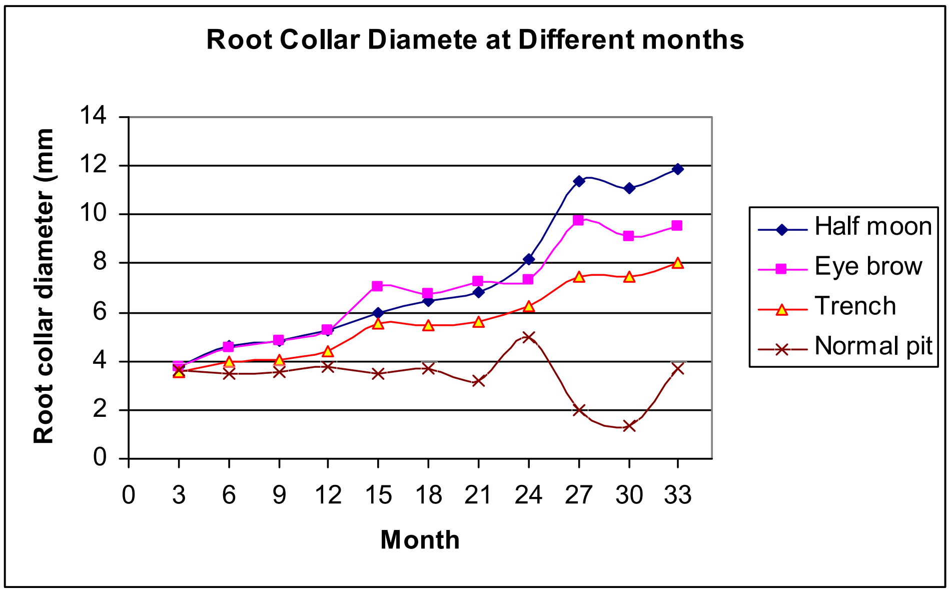

Figure 1: Mean root collar diameter (RCD) for the trees grown in the individual water harvesting structures

When comparing the performance of structure by height of tree seedling growth, similar to the performance indicated above for RCD, half moon, eyebrow and trench were found to be ranked in their order of importance (Figure 2 and Table 2). Almost the increment in heights of the trees is uniform or steady for the period covered in all the three structures. However, both height and RCD were exceptionally found to be higher for the period between 30-33 months. This might be due to high percentages of survival rates were recorded in these months.

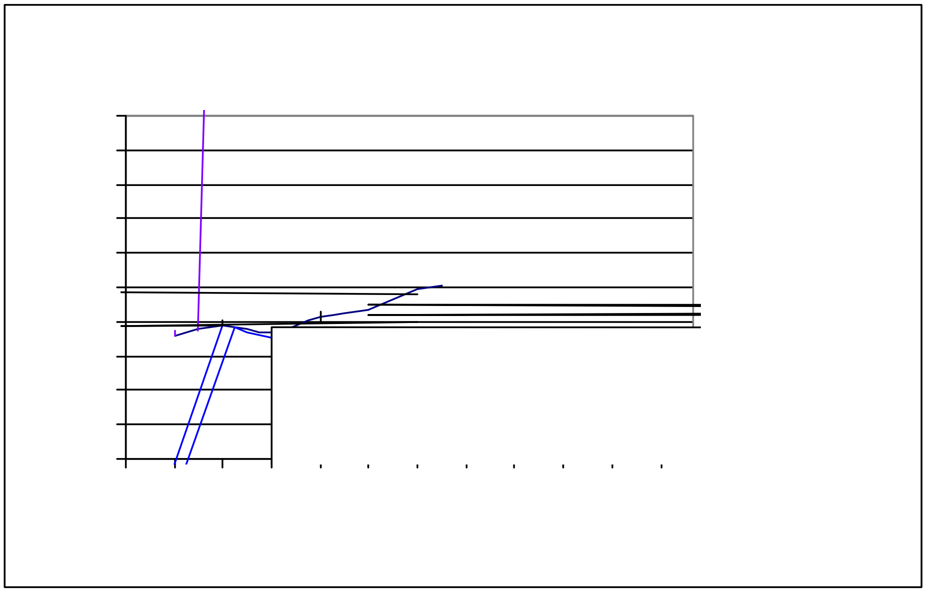

Figure 2: Mean heights of the trees (cm) along the individual water harvesting structures

Survival rate of trees were also taken as the critical indicator for efficiency of the water harvesting structures (WHS). And as shown on Figure 3 and Table 3, the trench structure gave the higher survival rate percentage, whereas eyebrow and half moon ranked second and third, respectively. Survival rate of the tree seedling were found to be decreased at a rate for the period between the 9th and12th months, which were the driest time of the year in the area. However during the rainy season of July to October (12 to 15 months) the dead trees were able to regenerate and the survival rates were found to be improved.

Figure 3: Mean survival rates of trees along the individual water harvesting structures

Table 1. Mean root collar diameter (RCD) in three months interval along the individual water harvesting structures

Treat-ments	RCD (Root Collar Diameter)										
	3	6	9	12	15	18	21	24	27	30	33
HM(1)	3.76	4.61	4.81	5.26	5.96	6.44	6.79	8.15	11.38	11.05	11.84
EB(2)	3.76	4.51	4.84	5.28	7.04	6.76	7.23	7.32	9.76	9.09	9.50
NP(3)	3.60	3.45	3.57	3.78	3.48	3.68	3.16	4.94	2.00	1.33	3.66
TR(4)	3.53	3.96	4.06	4.42	5.57	5.45	5.64	6.28	7.48	7.49	8.06
Mean	3.66	4.13	4.32	4.69	5.51	5.58	5.71	6.67	7.65	7.24	8.26
CV	8.62	14.69	13.24	16.84	14.15	11.59	27.58	11.23	29.66	23.46	32.06
LSD	0.63	1.21	1.14	1.57	1.55	1.29	3.14	1.49	4.54	3.39	5.29

Table 2. Mean heights of trees in three months interval along the individual water harvesting structures

Treat-ments					Height						
	3	6	9	12	15	18	21	24	27	30	33

Table 3. Mean survival of trees in three months interval along the individual water harvesting structures

Treat-ments	Survival Rate										
	3	6	9	12	15	18	21	24	27	30	33
HM(1)	94.44	87.63	78.75	49.58	54.16	55.55	42.36	36.52	35.69	35.00	35.83
EB(2)	97.22	92.91	82.36	45.27	55.54	55.55	36.66	30.55	31.38	32.08	31.25
NP(3)	95.83	86.25	61.25	13.47	18.05	17.77	9.44	5.97	4.02	4.02	3.75
TR(4)	93.05	94.16	75.00	52.08	53.32	56.38	47.63	43.19	41.52	41.25	41.52
Mean	95.13	90.24	74.34	40.10	45.27	46.31	34.02	29.06	28.15	28.09	28.09
CV	5.46	6.36	9.45	22.48	26.05	23.13	31.95	37.18	36.84	36.12	39.65
LSD	10.38	11.46	14.04	18.01	23.56	21.40	21.72	21.59	20.72	20.27	**22.25**

From the appendix tables below (Appendix Table 2- 5) grasses, shrubs and tree species were regenerated throughout the experimental period. Some of shrub species were *Keshelo*, *Mentesie*, *Ensosula*, *Doret*, etc. and some of the tree species were Acacia lahi and Dodonea angostifolia. After each rainy season the grass was cut and distributed for the society with their bylaws by cut and carry system.

Conclusion and Recommendation

In conclusion, Half-Moon and Eyebrow were found to be significantly different in root collar diameter (RCD) as compared to the control, whereas the water trench (TR) structure showed no difference from the control. Regarding height of trees, it was only Eyebrow structure that significantly different from the control structure. Generally, all the treatment structures (HM, EB, and TR) were found to be significantly different from the control in most of the measured variables, whereas there was little or no difference among the treatments. So rather than trying to grow trees and shrubs with out any moisture conservation structures, it is by far better practicing moisture conservation structures for a better survival and growth of trees and shrubs in the drought areas.

References

Hershfield, D.N. 1961. Rainfall Frequency Atlas of the United States. U.S. Weather Bureau Tech. Paper 40, May. Washington, D.C.

Volli Carucci. 1996. Possible soil and water conservation measures for Ethiopian arid and semi-arid lands.

Volli Carucci. 2000. Guidelines on water harvesting and soil conservation for moisture deficit areas in Ethiopia, Manual for trainers, unpublished.