Open Access Library Journal
2018, Volume 5, e4431
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Adoption and Effect of Vetiver Grass (*Vetiveria zizanioides*) on soil Erosion in Somodo Watershed, South-Western Ethiopia

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How to cite this paper: Tesfaye, G., Debebe, Y. and Yakob, T. (2018) Adoption and Effect of Vetiver Grass (*Vetiveria zizanioides*) on soil Erosion in Somodo Watershed, South-Western Ethiopia. *Open Access Library Journal*, **5**: e4431.
https://doi.org/10.4236/oalib.1104431

Received: February 22, 2018
Accepted: May 18, 2018
Published: May 21, 2018

Abstract

Soil erosion is an important cause of land degradation and consequent to soil fertility which reduces land productivity and production. This problem aggravates in developing countries like Ethiopia. To minimize this challenge, soil and water conservation with proper design is the first choice. The aim of this study was to assess the adoption and effect of Vetiver grass on soil erosion in Somodo watershed. Community mobilization was used to implement Vetiver grass on farm lands as bund stabilization and grass strip. Accordingly, more than 45 km (20%) of the watershed was covered by Vetiver grass on soil bund as bund stabilizing measure. The hedge was fully established within two years and formed averagely 36 cm raised terrace. The result of the study showed that within two years period about 36 cm soil was accumulated above the hedgerow. From mean annual soil deposition and average bulk density of the watershed, the mean annual soil loss was recorded 20.88 ton ha^{-1}·$year^{-1}$ in the absence of Vetiver hedge row as erosion barrier. In addition, field slope was reduced on average by 2.5% due to soil accumulated above Vetiver hedgerow. And phosphorus availability was found higher on the above hedgerow than below the hedge row while, exchangeable acidity was found less above the hedgerow than below the Vetiver hedgerow in the watershed which implies soil fertility improvement. The study recommends Vetiver hedgerow as an immediate mitigation measure for soil erosion on hill slopes and farm lands which can be implemented through community mobilization. Further study on how the Vetiver hedgerow improves phosphorus availability and decreases exchangeable acidity is also highly recommended.

Subject Areas

Environmental Sciences, Natural Geography

Keywords

Vetiver Grass, Hedge Row, Soil Erosion

1. Introduction

Soil degradation can be described as a reduction of resource potential by a combination of processes, such as soil erosion by water and wind, acting on the land and bringing about deterioration of the physical, chemical, and biological properties of soil [1]. Land degradation is a major environmental problem in Ethiopia and it is manifested mainly in the form of soil erosion, gully formation, soil fertility loss, and crop yield reduction.

In the Ethiopian highlands case, the decline of soil fertility and severe soil erosion is due to water outflow on steep and fragile land that have been under intensive farming [2]. Researches assessed an actual rate of erosion exceeding the regenerating rate, which is 12 ton/ha/year. In 1986, estimations of the erosion damage were as followed: regarding the highlands, 50% were significantly eroded, of which 25% were seriously one and 4% of those were impossible to regenerate [3].

Soil conservation strategy is one of the most prevention methods of soil being eroded from land surface. These mechanisms reduce soil acidity, salinization, chemically altered by over use and other chemical soil contaminations to retain the fertility of soil. In Ethiopia, the agricultural sector creates employment for about 84% of the population and it accounts for 45% - 50% of the GDP of the country and makes the largest input to raw materials for agro-industries and food security. The cost of loss of soil and essential nutrients due to unsustainable management in Ethiopia is estimated to be about $139 million annually [4]. He stressed that this cost is about 3% - 4% of the agricultural GDP but where 85% of the rapidly growing population depends on agriculture; even this small percentage is critical.

Smallholder farms are pre-dominant and account for more than 90% of agricultural production and cover over 95% of the total areas under cultivation [5] [6]. However, most of their products go for their own use as they retain about 80% of their products for their own consumption [7]. Cognizant of these problems, soil and water conservation technologies were implemented in many parts of the country for the last 30 years. These conservation mechanisms were introduced mainly in some degraded and food deficit parts of the country. Thus, fanyaju and level soil bund are mainly practiced in the area [8]. However, biological conservation measures are ignored for a long period of time in the country. But, in most parts of the world, biological conservation measures have been practicing [9]. In Ethiopia, these biological conservation measures was started during 1980's when revising the soil and water conservation strategies, it included both physical and biological conservation methods.

Runoff is made to move more gently down the slope over the soil surface and

as it does, it is intercepted and spread out by the Vetiver strip. In using the Vetiver as a green structure, the farmer does not need any mathematical formulae or engineering designs for its establishment in the field. Even in situations where steep slope limits the use of engineering structures and erosion continues uncontrolled, the green structure can be used without any constraint. To the farmer, this means food crops can be effectively grown on very steep slopes with a reasonable level of erosion control. Studies on the use of Vetiver grass buffer strips for soil and water conservation are still in their infancy in Nigeria [10]. Field measurements such as erosion plots, bounded runoff plot, erosion pin, splash boards (splash erosion measurement), sequential surveys using aerial photography and recording stations (sediment yield and discharge) are major methods of soil erosion measurement by field measurement and experiments [11].

In the watershed, there is no information on the rate of soil erosion and biological mitigation measures to overcome the problem. In addition, there is no information on the effectiveness of Vetiver hedge row used as grass strip or as bund stabilizer in the study area. Because of these, the study was initiated with the objective of evaluating the effects of Vetiver hedge on soil erosion through erosion pin measurement and slope change in Somodo watershed.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Somodo watershed, which is found at the upper part of Abay (Nile) river basin, Oromia regional state in the South West part of Ethiopia. It is located about 20 km from Jimma town and about 369 kilometers to the South West of Addis Ababa, Capital City of the country. The watershed covers about 400 ha with a total of 300 households and found in between 7˚46'00" - 7˚47'00"N latitude and 36˚47'00" - 36˚48'00"E longitude. The altitude of the watershed varies in the ranges of 1900 to 2075 m.a.s.l. The average annual rainfall of the area is about 1523 mm with the mean temperature of 18.9˚C ranging from 13.0˚C and 24.8˚C (**Figure 1**).

2.2. Method of Data Collection

Awareness and training for stakeholders, local farmers, woreda/district experts and development agents were given in different time on the use of Vetiver grass and how to plant it for soil erosion before intervention. Vetiver grass nursery site was established at Jimma Agricultural research center and distributed for the farmers in the watershed to be planted as a grass strip on gentle slope farm lands and grazing lands, and as stabilizing agent for physical soil and water conservation structures, soil bund, implemented by community mobilization. During the study about 45 km Vetiver hedgerow was planted as a grass strip and 95 km was planted on soil bunds to stabilize the structure. This Vetiver was planted as a single hedgerow and double hedgerows. Above and below hedgerow erosion pins

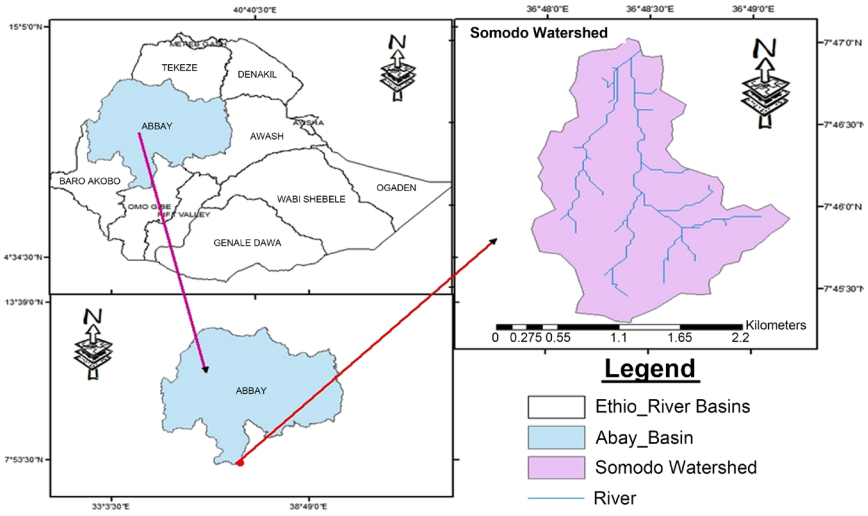

Figure 1. Study area map.

were planted to measure the amount of soil deposited or removed at both above and below the hedgerows.

To evaluate its effect on some soil properties and nutrient contents soil samples were taken from four location in the watershed above the hedgerow and below the hedgerow; and these samples were analyzed in Jimma agricultural research center soil and plant tissue laboratory for phosphorus availability, bulk density and exchangeable acidity separately before and after Vetiver intervention. Furthermore, the slope or gradient changes of farm lands at four locations were also measured by the help of clinometers before and after intervention.

These locations were selected purposively, one from the upper part of the watershed and two from the middle of the watershed. The rest one was from the bottom of the watershed near to the outlet. Mean annual soil loss of the watershed was determined through erosion pin measurement, which is applied through multiplication of pin height and bulk density.

3. Results and Discussions

3.1. Effect of Vetiver Hedge on Soil Erosion

The mean soil deposited from all, four, locations above the Vetiver hedgerow within two years was found to be 36 cm. The maximum soil deposition was observed at location 2 and 3, at the middle of the watershed, and minimum at 1 and 4 locations, which were found at the upper and lower part of the watershed respectively. This result implies that in the absence of Vetiver hedgerows on average about 36 cm soil can be removed or eroded within two years period of time in the watershed and the inverse can occur if Vetiver hedge row is implemented.

As shown in Table 1. The bulk density ranges from 1.11 to 1.20 with a mean value of 1.16. It is clear that if 36 cm soil is deposited within two years due to Vetiver hedge about 18 cm soil can be saved by Vetiver hedge in one year. This

Table 1. Vetiver hedge row effect on soil erosion and bulk density.

Location	Depth of soil accumulated above the hedge (cm)	Bulk density (gm·cm^{-3})
1	33	1.11
2	45	1.17
3	35	1.16
4	33	1.20
Mean	36	1.16

also mean that in the absence of Vetiver hedge on slope farm lands similarly about 18 cm of soil depth can be eroded from the watershed according to this study. Using average soil eroded in one year in the absence of Vetiver which is 18 cm and average bulk density of 1.16 gm·cm^{-3} mean annual soil loss was resulted 20.88 ton ha^{-1}·year^{-1} by multiplying mean soil depth and mean soil bulk density.

This result is in agreement with the findings of some researchers on soil erosion rate in different parts of the country. [12] has found mean annual soil loss ranging from 7 - 243 ton ha^{-1}·year^{-1} for a catchment in the Blue Nile basin while [13] found the annual soil loss of Ethiopia highlands ranges from 16 - 300 ton ha^{-1}·year^{-1} from pasture ranges and cultivated fields. And [14] came up with the result of soil erosion range of 2.60 - 116.94 ton ha^{-1}·year^{-1} in the Eastern part of Ethiopia.

Soil moisture content on the Vetiver plots was higher than on the control by a mean of 25.6% at 40 cm depth and 50.1% at 20 cm depth [15]. The higher moisture content under Vetiver strip management is the result of reduced run-off velocity and enhanced water infiltration during the rains. [16] came out with the result Vetiver grass (*Vetiveria nemoralis*) has great potential for reducing runoff and soil loss by about 38.7 - 68.6.

The Vetiver strips delayed incipient runoff and reduced peak runoff rate and steady erosion rate. The land slope affected soil loss but did not have a significant effect on runoff. A narrow Vetiver hedge interval slightly reduced runoff and soil loss more than a wider one. The soil loss equation obtained in this study revealed that runoff has a higher effect on soil loss.

3.2. Effect of Vetiver Hedge on Slope

The hedge was planted on a field with a slope of 13%, 17% and 18% and after two years of intervention the slopes of these fields were reduced to 11%, 14% and 16% due to the accumulated soil above the hedge. These hedges were currently growing to terrace and field slope length was also reduced. The field length is divided into different segments with the Vetiver hedgerows and as a result field slope was reduced from 16.25% to 13.75% on average, which is about 2.5% slope change due to Vetiver hedge intervention.

Due to the reduction of slope gradient and slope length soil erosion problem

in the watershed was also reduced as some farmers stated. This is because the hedgerows reduce the velocity of running water detaching and transporting soil particles (Table 2).

3.3. Effect of Vetiver Hedge on Soil Nutrient

According to local farmer discussants, soil fertility and productivity around the area is being increased after they had started to implement and adopt Vetiver grass as a protective measure for soil erosion. As indicated in Figure 2 nutrient availability of the above hedge row is higher than below the hedge row. This indicates that, mineral contents in the soil were increasing after this Vetiver grass planted in the watershed. Therefore, the production and productivity of the area was increased.

The other interesting finding of this study was exchangeable acidity improvement which showed increment above the hedgerow was less than below the Vetiver hedgerow in all locations across the watershed. The reason is that, nutrients that were going to be eroded by water erosion were protecting above the Vetiver hedgerow. [17] reported soil bulk density, CEC, Organic Matter, Total Nitrogen, Available Phosphorous, and Potassium contents, were significantly higher for soil with Vetiver than for without Vetiver grass soil at Anno agro industry farm, Gobu Sayo District, Oromiya region, Ethiopia. They concluded that the use of Vetiver grass as a soil conservation practice improved soil fertility and land productivity. Their finding was also in agreement with the finding of this study.

4. Summary and Recommendation

This study revealed that, the implementation of soil and water conservation practices in the watershed has many advantages regarding ecosystem and sustaining farmers' livelihood. The result of this study shows that, Vetiver grass plantation and soil bund construction in the area are significantly affected the soil physico-chemical properties as well as the production and productivity at large. In addition to this, Vetiver grass hedge row as bund stabilization on slope farm lands can minimize soil erosion by 20.88 ton ha^{-1}·$year^{-1}$ and reduce land slope by 13.75 percent in two years. Accordingly, soil fertility can be improved and ecosystem of the watershed is conserved through implementation of Vetiver

Table 2. Effect of Vetiver hedge row on slope.

Location	Slope change (%)	
	Before intervention	After intervention
1	17	14
2	17	14
3	13	11
4	18	16
Mean	16.25	13.75

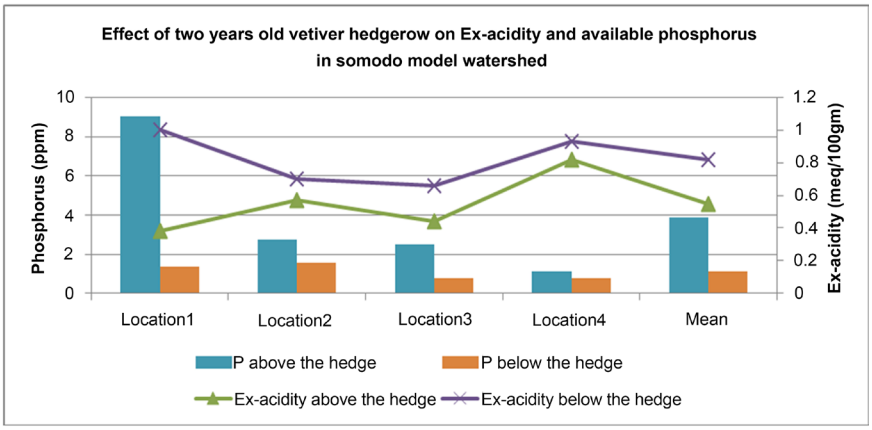

Figure 2. Effect of two years vetiver hedgerow on ex-acidity and available phosphorus in Somodo watershed.

hedge row in the watershed.

The study can recommend Vetiver hedge row to reduce sever erosion, increase soil fertility, reduce land slope length and steepness, and can serve as watershed ecosystem conservation if it is implemented properly through community participatory approach.

Acknowledgements

My great appreciation goes to Jimma Agricultural Research Center Soil and Plant Tissue Laboratory for their active participation in soil sample analysis and Ethiopian Institute of Agricultural Research for supporting this research financially.

References

[1] Maitima, J. and Olson, M. (2001) Guide to Field Methods for Comparative Site Analysis for the Land Use Change, Impacts and Dynamics (LUCID) Project. Working Paper Series Number 15. *International Livestock Research Institute*, Nairobi, Kenya.

[2] Amsalu, A. and De Graaff, J. (2006) Determinants of Adoption and Continued Use of Stone Terraces for Soil and Water Conservation in an Ethiopian Highland Watershed. *Ecological Economics*, **61**, 294-302. https://doi.org/10.1016/j.ecolecon.2006.01.014

[3] FAO (1986) Ethiopian Highlands Reclamation Study, in Final Report (Volume I and II), Annual Report, Food and Agriculture Organization of the United Nations (FAO), Rome.

[4] Berry, L. (2009) Land Degradation in Ethiopia: Its Extent and Impact. Global Mechanism and World Bank.

[5] Tiruneh, A., Tesfaye, T., Wilfred, M. and Hugo, V. (2001) Gender Differentials in Agricultural Production and Decision-Making among Smallholders in Ada'a, Lume and Gimbichu Woredas of the Central Highlands of Ethiopia. International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO), 62 p.

[6] MoFED (2010) The Federal Democratic Republic of Ethiopia, Growth and Trans-

formation Plan (GTP) 2010/11-2014/15, Draft. Addis Ababa.

[7] Clemente R.S., Tingsanchali, T. and Chinnarasri, C. (2009) Effects of Vertical Hedge Interval of Vetiver Grass on Erosion on Steep Agricultural Lands.

[8] Belay, T. (1992) Farmers' Perception of Erosion Hazard and Attitudes towards Soil Conservation in Gunono Wolayita Southern Ethiopia. *Journal of Ethiopian Development Research*, **14**, 31-58.

[9] Evette, A., Labonne, S., Rey, F., Liebault, F., Jancke, O. and Girel, J. (2009) History of Green Structure Technique for Erosion Control in Rivers in Western Europe. *Environmental Management*, **43**, 972-984. https://doi.org/10.1007/s00267-009-9275-y

[10] Babalola, O., Oshunsanya, S.O. and Are, K. (2007) Effects of Vetiver Grass (*Vetivera nigritana*) Strips, Vetiver Grass Mulch and an Organomineral Fertilizer on Soil, Water and Nutrient Losses and Maize (*Zea mays*, L.) Yields. *Soil and Tillage Research*, **96**, 6-18. https://doi.org/10.1016/j.still.2007.02.008

[11] Morgan, R.P.C. (2005) Soil Erosion and Conservation. 3rd Edition, National Soil Resource Institute, Cranfield University.

[12] Bewket, W. and Teferi, E. (2009) Assessment of Soil Erosion Hazard and Prioritization for Treatment at the Watershed Level: Case Study in the Chemoga Watershed, Blue Nile Basin, Ethiopia. *Land Degradation & Development*, **20**, 609-622. https://doi.org/10.1002/ldr.944

[13] Hawando, T. (1995) The Survey of the Soil and Water Resources of Ethiopia. UNU/Toko.

[14] Bobe, B. (2004) Evaluation of Soil Erosion in the Harerge Region of Ethiopia Using Soil Loss Models, Rainfall Simulation and Traits. Doctoral Thesis. University of Pretoria.

[15] Babalola, O., Oshunsaya, S. and Are, K. (2003) Continuous Cultivation of Maize under Vetiver Grass (*Vetiveria nigritana*) Strip Management: Runoff, Soil Loss, Nutrient Loss and Crop Yields. *Journal of Sustainable Agriculture.* (In Press)

[16] Donjadee, R., Clemente, S., Tingsanchali, T. and Chinnarasri, C. (2010) Effects of Vertical Hedge Interval of Vetiver Grass on Erosion on Steep Agricultural Lands. *Land Degradation & Development*, **21**, 219-227. https://doi.org/10.1002/ldr.900

[17] Gesesse, A., Balemi, T., Natarajan, P. and Amha, Y. (2013) Effect of Vetiver Grass Headges in Maintaining Soil Fertility and Productivity at Anno Agro Industry Farm, Gobu Sayo District, Oromiya Region, Ethiopia. *Journal of Science and Sustainable Development* (*JSSD*), **1**, 37-49.