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# Effect of Vetiver Grass Headges in Maintaining Soil Fertility and Productivity at Anno Agro Industry Farm, Gobu Sayo District, Oromiya Region, Ethiopia

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## Abstract

Inappropriate farming system and utilization of natural resources are among the major causes for the current land degradation in Ethiopia. To control soil erosion cheap, replicable and sustainable conservation measures need to be implemented. The use of vetiver grass (*Vetiveria zizanioides* L.) makes a better option for soil erosion and sediment control and nutrient trapping in a wide range of environments. This study was undertaken to investigate the effects of using vetiver grass in improving soil fertility and productivity through nutrient trapping. The study was conducted at Anno agro-industry where vetivar grass was being used for soil conservation purpose for more than one and half decade. Sample top soils (0-30 cm) from with and without vetiver grass adjacent area were collected in six replicates and important soil parameters such as bulk density, moisture content, CEC, soil organic matter, total nitrogen, available phosphorous and available potassium were determined. The study also involved growing maize crop for two months in plastic pots filled with soil sample from with and without vetiver to compare their productivity. Plant growth parameters such as days to emergence, plant height, leaf length, leaf numbers per plant, root and shoot dry and fresh weights and root to shoot ratio were used to evaluate the difference in the productivity of with and without vetiver grass soil. 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. The results revealed that the use of vetiver grass as a soil conservation practice improved soil fertility and productivity.

*Key Words:* Soil Fertility, Soil Productivity, Vetiver Grass

# Introduction

Soil fertility and productivity is declining in many parts of Sub-Saharan Africa (SSA). Soil erosion and severe run-off further depleted the existing soil nutrient reserves. As a result, the levels of soil organic matter are declining as land is subjected to overuse. The pressure of intense human activity and improper farming and management practices posed serious threats to the sustainability of natural resources and maintenance of ecological balance (Mebrahtu, 2009). Excessive soil erosion and consequently the high rate of sedimentation in water bodies and the rapid decline in soil fertility and productivity has become serious concern of today. Especially, maintenance of soil fertility and organic matter content has become a major issue for agricultural research and development in Sub-Saharan Africa (Corbeels *et al.*, 2000).

To reverse the currently observed trend of soil fertility decline, there is an urgent need for adopting economically viable soil conservation techniques. There are diverse approaches to restore degraded lands including the use of structural and biological measures. Soil and water conservation measures usually practiced are site specific and require accurate engineering and design that require regular maintenance (Troung and Loch, 2004). Most of the evidences also suggested that constructed structures reduce soil losses, but do not reduce runoff significantly and in some cases have negative impacts on soil moisture (Grimshaw, 1993). The use of vetiver grass as a soil conservation measure is however, suitable not only for maintaining soil fertility but also improving crop yields (Troung & Loch, 2004). The use of vetiver grass is very simple, practical and inexpensive. It is an effective means of soil and water conservation, sediment control, land stabilization and rehabilitation (Truong & Pinner, 2008). Vetiver grass form a hedge when planted in a single row which is very effective in slowing and spreading runoff water, reducing soil erosion, conserving soil moisture and trapping sediment on the site. Although any hedges can result in the same conservation effect, vetiver grass is the most efficient, due to its extraordinary and unique morphological and physiological properties (Truong, 2008). The extremely deep and massively thick root system of vetiver grass binds the soil, and at the same time makes it very difficult for it to be dislodged under high velocity water flows. The very deep and fast growing root system also makes vetiver grass very drought tolerant and highly suitable for steep slope stabilization.

Soil erosion is a serious problem in Anno Agro Industry Farm (AAIF) due to intense rain storms, steep slopes and high volumes of runoff. Accelerated soil erosion from development and agricultural activities has also further degraded the farmland. Thus, reducing soil erosion and improving the soil fertility status has long been a priority for AAIF investors and development organizations engaged in soil conservation activities in the area. Conventional approaches to check soil erosion often involving the construction of terraces are quite expensive and also further limit the space available for crops. Some of the constructed terraces on sloppy areas were also easily destroyed by strong runoff because of poor engineering design. In contrast, vetiver grass is relatively a low-cost erosion and sediment control technology, making it a promising alternative to conventional terraces. As a result, the AAIF investors started planting vetiver grass in 1995 for soil conservation purpose (Kumsa & Gobena, 2009). However, the contribution of using vetiver was not yet investigated and documented in the study area. This study was therefore, designed to evaluate the effect of using vetiver grass in improving soil fertility and productivity through nutrient trapping so that the study will provide vital information to different stakeholders enabling them to use vetiver grass for nutrient trapping, soil erosion prevention and improvement of soil fertility.

# Materials and Methods

## Description of the study area

The study area (Anno Agro Industry Farm (AAIF)) was located in Gobu Sayo district, of East Wollega Zone, Oromia region, Ethiopia. The district is 265 km away west of Addis Ababa. The district is located between 9.50 $^{0}$N and 36 .6 $^{0}$E. The altitude of AAIF is between 1700 and 1900 m.a.s.l (kumsa & Gobena, 2009). The district has an average annual rainfall of 1070 mm to 1657 mm with a unimodal rain distribution. The annual temperature of the area ranges between 13 $^{0}$C to 27 $^{0}$C. Soils of the study area are characterized as clay loam and loam type and visually reddish in color.

## Soil sampling and sample preparation

Representative top soil (0-30 cm) samples were separately collected from with and without vetiver farmland in six replication using Auger in a zigzag manner for all parameters. Each soil sample was thoroughly homogenized and air dried except for bulk density and passed through 2 mm sieve before laboratory analyses except for samples of organic matter which were sieved through a 0.5 mm sieve. The remaining air dried soil samples were used for the greenhouse experiment to assess soil productivity.

## Determination of soil parameters

Bulk density (BD) was determined by Veihmeyer and Hendrickson (1948) procedure. Moisture content was determined by initially weighing the soil samples and drying the soil samples at 105°C for 24 hours, and weighing them again according to (Sertsu and Bekele, 2000). Soil organic matter content was determined by dichromate oxidation following to Walkley & Black (1934). Total nitrogen (TN) was analyzed by Kjeldahl method according to Bremner & Mulvaney (1982). Available phosphorus (AP) was determined according to Olsen *et al* (1954). Exchangeable Potassium (EK) was extracted by sodium acetate method and measured by flame photometer accrding to Sertsu and Bekele (2000). Cation exchange capacity (CEC) was determined by ammonium acetate extraction method according to Schollenberger and Simon, (1945).

## Soil productivity assessment

Three kg soil sample taken from with and without vetiver farmland that was thoroughly homogenized was filled into five liter pots. The pots were then arranged in Completely Randomized Block Design with four replications. Maize crop (variety B-660) was grown in pots filled with soils obtained from with and without vetiver grass farmlands in greenhouse for two month. The plants were watered every day. Plant parameters such as days to emergence, plant height, leaf numbers per plants, shoots fresh and dry weights, roots fresh and dry weights, and root to shoot ratio were recorded at harvesting.

## Data Analysis

The data was analyzed using SAS statistical Software Version 9.2. Means separation was done according to Tukey test at a significance level $\alpha = 0.05$.

# Results and Discussion

## Effect of vetiver grass on soil bulk density and soil moisture content

Bulk density (BD) of the soil significantly differed between with and without vetiver grass treatments ($P < 0.001$). The bulk density was higher for the without vetiver grass soil (1.39 gm/cm$^3$) than for the with vetiver grass soil (1.29 gm/cm$^3$) (Fig.1). The difference in the bulk density of the with and without vetiver grass soil might be related to difference in soil organic matter content (Fig.2). Our present finding is in close conformity with that of Okon and Babalola (2005) who also reported that the bulk density of the soil from vetiver grass planted farmland was lower than that of non vetiver grass planted farmland. Similarly, the moisture content of soil varied between with vetiver and without vetiver grass farmland ($P < 0.001$). The moisture content for soil taken from vetiver grass farmland was 7.25% while that of the non vetiver farmland was 6.8% (Fig. 1). The higher moisture content of soil from vetiver grass farmland might be due to the fact that the vetiver grass hedges slowed down the runoff water allowing more time for water to infiltrate; the hedge reducing soil erosion and conserving soil moisture on site. The higher moisture content under vetiver strip management was therefore, the result of reduced water velocity and enhanced infiltration during rains since the vetiver strips intercept runoff. Additionally, the higher organic matter content of the soil from vetiver grass farmland (Fig.2) had also contributed to its enhanced soil moisture content. In line with the present finding, Pothinam (2006) also reported that vetiver grass conserves soil and water due to its extensive root systems that penetrate and bind soil particles tightly preventing soil erosion and maintains soil moisture content.

## Effect of vetiver grass on Cation exchange capacity and organic matter content

Results showed that cation exchangeable capacity (CEC) significantly differed between with vetiver and without vetiver treatments ($P < 0.001$). The CEC of with and without vetiver grass soils were 36.96 meq/100 gm and 27.48 meq/100 gm, respectively. The higher CEC of the soil from vetiver grass might be due to the higher organic matter content of the soil which is in line with reports of Camberato (2001) who also reported that soil with high organic matter and clay contents had higher CEC and a decline in the organic matter content substantially decreased the CEC. Result also showed that the percentage soil organic matter (OM) content significantly differed between with vetiver soil and without vetiver soil ($P<0.001$). The organic matter content of soil taken from the farmlands with and without vetiver grass were 4.3 % and 2.7 %, respectively. The higher organic matter content in soil obtained from the with vetiver grass farmlands probably originated from the litter inputs of the above and below ground biomass of vetiver grass used for the soil conservation purpose. Additionally, the higher organic matter content of soil taken from with vetiver grass farmland could also probably be related to the top soil loss checked by the vetiver grass; since the sediments protected by the vetiver grass from loss contain organic matter. According to the soil organic matter rating the vetiver grass farmland and non vetiver grass farmland had high and low soil organic matter content, respectively. In agreement with this result, Materechera (2010) reported that the use of vetiver grass as a soil conservation measure increased the soil organic matter in the surface soil and also improved soil physical and biological properties.

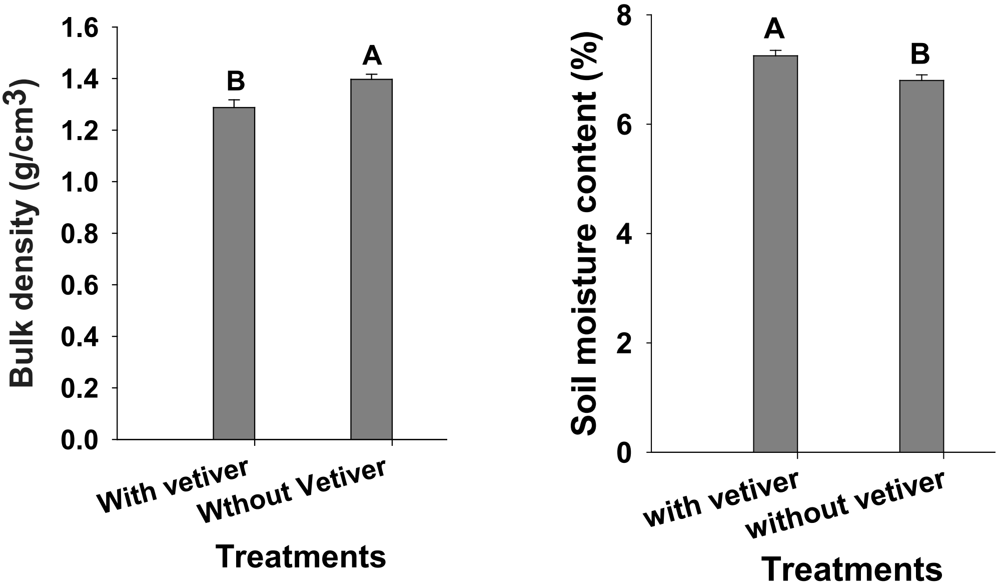


Figure. 1: Effect of vetiver grass on soil bulk density (left) and soil moisture content (right)
*(Bars followed by different letters are significantly different from each other at α = 0.05 according to Tukey test)*

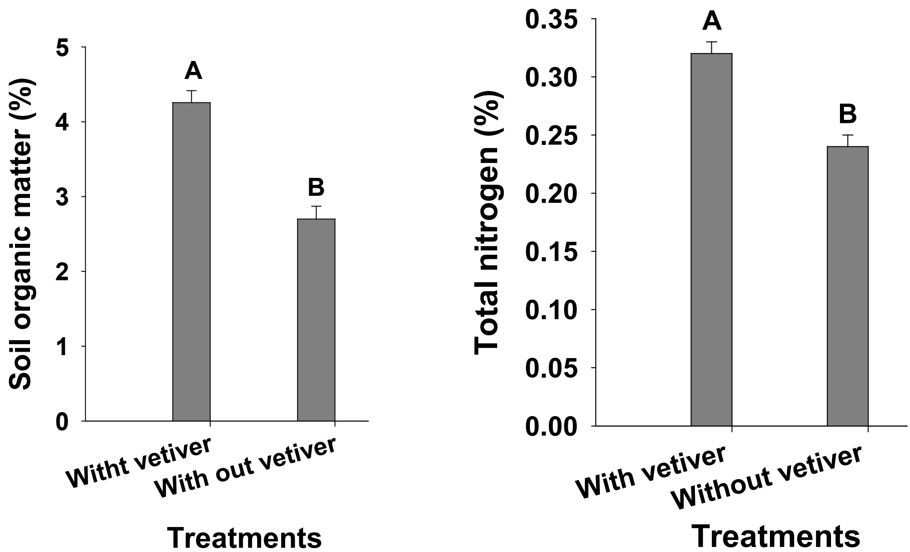


Figure 2: Effect of vetiver grass on soil organic matter (left) and soil total nitrogen (right) contents *(Bars followed by different letters are significantly different from each other at α = 0.05 according to Tukey test)*

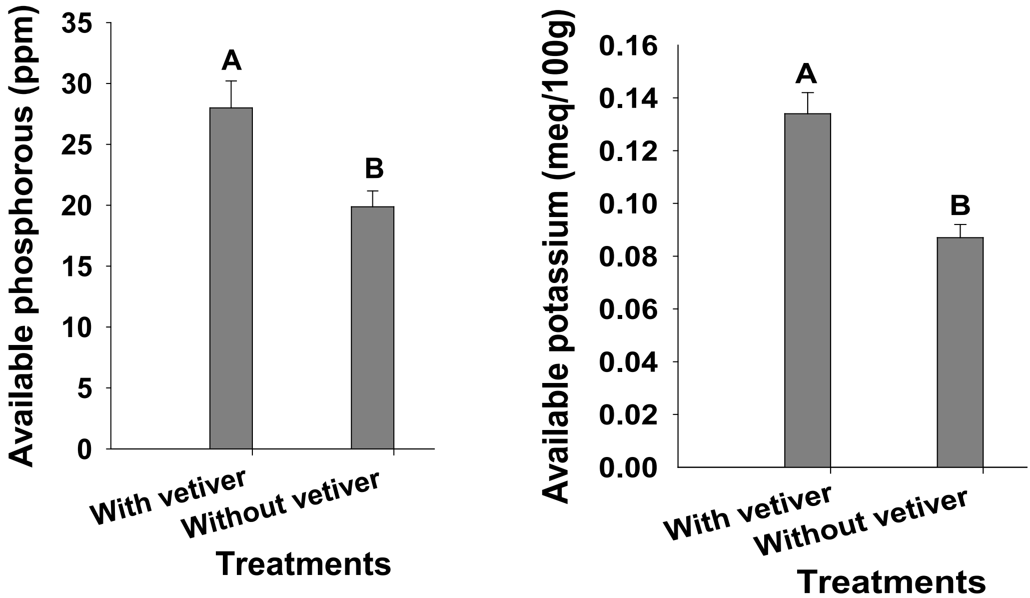


Figure 3: Effect of vetiver grass on soil available phosphorus (left) and potassium (right) contents *(Bars followed by different letters are significantly different from each other at α = 0.05 according to Tukey test)*

## Effect of vetiver grass on total nitrogen, available phosphorus and potassium contents

Results showed that total nitrogen (TN) significantly differed between with and without vetiver soils (P<0.002). The total nitrogen content for soil taken from the farmland with and without vetiver grass were 0.32 % and 0.24 %, respectively. The low total nitrogen content in soil taken from without vetiver grass farmland could be attributed to the lower SOM content, unchecked top soil erosion and reduced soil microbial activity since organic matter is the major source of total nitrogen (Mujale, 2003). Available soil phosphorus also significantly differed between with vetiver and without vetiver treatments (P<0.003). The higher available phosphorous (Fig. 3) in soil from with vetiver farmland might either be related to low soil erosion due to reduced runoff by the vetiver grass or to the higher organic matter content of the soil resulting in mineralization of organic phosphorus to available form. Wieder-holt and Johnson (2005) reported substantial phosphorus loss through runoff water which is in line with our present finding. Likewise, the available potassium also significantly differed between with vetiver and without vetiver treatments (P=0.021). The available potassium for soils from the farmland with and without vetiver grass was 0.134 meq/100g and 0.087 meq/100g, respectively (Fig. 3). The higher available potassium could be related to the higher CEC of the soil from with vetiver farmland since under higher CEC more potassium ions are held to the soil.

## Assessment of Soil Productivity

### Effect of vetiver grass on days to emergence, plant height and leaf number per plant

Results showed that days to emergence significantly differed between with and without vetiver grass soils ($P < 0.001$). Mean values of days to emergence of maize crop grown in soil taken from with vetiver grass farmland was 5.56 days whereas it was 6.25 days for the without vetiver grass soil. The difference in days to emergence might be associated with difference in the extent of soil compaction between the two. Soil from without vetiver grass farmland was compact (had high bulk density) than soil from vetiver grass farmland (Fig. 1). High bulk density does not allow oxygen movement and oxygen is one of the limiting factors for seed germination. This observation is in line with the observation of Nivedita (1992) who reported decreased seed germination percentage with increasing soil bulk density. The results also showed that the plant height and leaf number of the maize crop grown in soil obtained from the with vetiver grass farmland was significantly higher at $P < 0.0004$ and $P < 0.043$, respectively when compared to the maize crop grown in soil from without vetiver grass farmland (Fig. 4). The shorter plant height and reduced number of leaf per plant in the case of without vetiver grass soil might be related to nutrient stress such as N, P and K. The results of the soil analysis showed that the content of primary nutrients (N, P, K) in soil obtained from without vetiver grass farmland was lower as compared to that of the with vetiver grass farmland (Fig. 2 and 3). Nitrogen and phosphorus deficiency inhibited leaf growth and resulted in stunted plant growth (Eltelib *et al.*, 2006) supporting the present observation. Similarly, Fredeen *et al.* (1989) reported that phosphorus deficiency resulted in the restricted delivery of water to leaves due to poor root hydraulic conductance which in turn limited leaf and plant growth.

### Effect of vetiver grass on shoot fresh and dry weight of maize

The results showed that shoots fresh and dry weight significantly differed between with and without vetiver grass soils ($P < 0 .0173$ and $P < 0.0063$, respectively). The shoot fresh and dry weights of maize crop grown in soil with vetiver grass were significantly higher as compared to that of without vetiver grass (Fig. 5). The lower shoot weights of the maize plant grown in soil taken from without vetiver grass farmland was related to the lower primary nutrient (N, P, K) content in the soil from without vetiver grass farmland. Das and Sen (1981) also reported that shoot weights of Bengal gram was reduced due to nitrogen, phosphorus and potassium deficiencies which supports the present findings.

## Effect of vetiver grass on root fresh and dry weight of maize

The root fresh and dry weights of the maize crop also significantly differed at between with and without vetiver grass soils $P < 0.0005$ and $P < 0.0091$, respectively. The root fresh weights of maize crop grown in soil taken from with and without vetiver grass farmlands were 10.31 gm and 6.53 gm, respectively whereas the mean values of root dry weight of maize crop grown in soil taken from with and without vetiver grass farmland were 3.44 gm and 2.85 gm, respectively (Fig.6). The root weights of the maize crop grown in the soil obtained from with vetiver grass farmland was significantly higher than that the without vetiver grass farmland. The lower root weights for maize grown in case of soil taken from the with vetiver grass farmland might be the influence of soil primary nutrient status and oxygen unavailability in the absence of vetiver grass. Drew and Goss (1973) reported that low availability of oxygen in soil low soil nutrient status reduced normal root development of plant further reducing total root mass which agrees with the present observation.

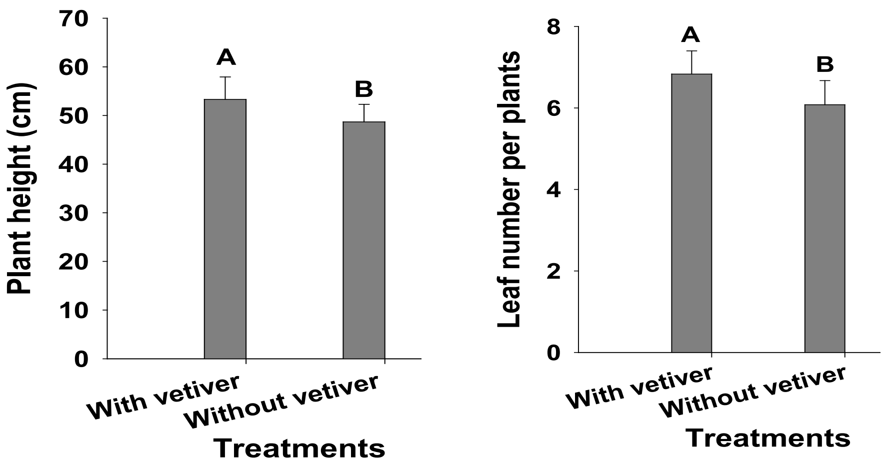


Figure 4: Effect of vetiver grass on plant height (left) and leaf number per plant (right) (Bars followed by different letters are significantly different from each other at α = 0.05 according to Tukey test)

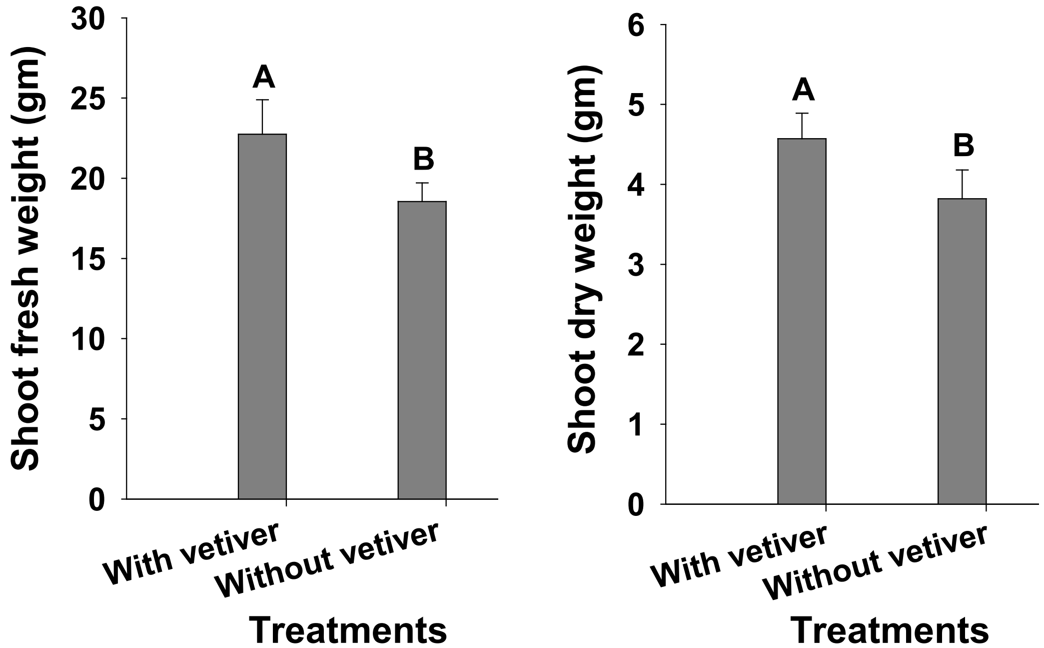


Figure 5: Effect of vetiver grass on shoot fresh (left) and shoot dry (right) weights
(Bars followed by different letters are significantly different from each other at α = 0.05 accordin g to Tukey test)

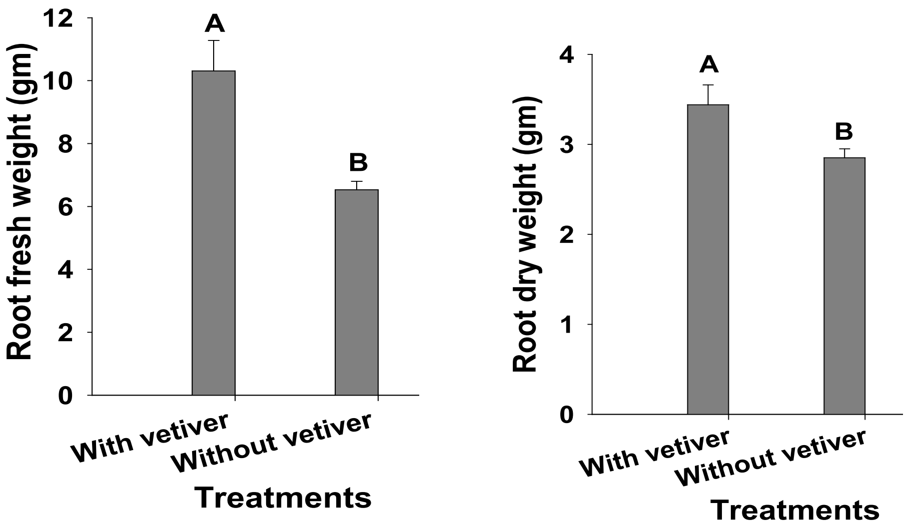


Figure 6: Effect of vetiver grass on root fresh (left) and root dry (right) weight (Bars followed by different letters are significantly different from each other at α = 0.05 according to Tukey test)

### Root to shoot ratio

The root-shoot ratio of the maize crop also significantly differed between with and without vetiver grass treatments ($P < 0.02$). The root-shoot ratio of the maize crop grown in soil taken from with and without vetiver grass farmlands were 0.56 and 0.63, respectively. The root-shoot ratio of the maize crop grown in soil without vetiver grass farmland was significantly higher than that of the maize crop grown in soil taken from with vetiver grass farmland. The increase in root-shoot ratio of maize plant grown in soil from without vetiver grass farmland was due to exposure to stress from primary nutrients since increased root-shoot ratio is one of the plant adaptations to nutrient stress.

## Conclusion

This study showed that vetiver grass has significant impacts on soil conservation and nutrient trapping. The use of vetiver grass improved soil quality through improving CEC, soil moisture content, soil organic matter, total nitrogen, available phosphorus and available potassium contents. This is due to the fact that vetiver grasses form hedges or a living porous barrier, which slows and spreads runoff water and traps sediment. The results obtained from the greenhouse experiments also showed that the productivity of soil (measured in termers of maize crop performance) taken from with vetiver grass farmland was better than the productivity of soil obtained from without vetiver grass farmland.

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