Use of Vetiver Grass for Soil and Water Conservation in Nigeria

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ABSTRACT: Soil erosion persists on agricultural lands in Nigeria. To curb erosive land degradation requires soil conservation measures that are cheap, replicable and sustainable. The use of vetiver grass *(Vetiveria zizanioides*) has offered such prospects in a wide range of climatic environments. Although the grass grows in Nigeria, its potential for soil and water conservation and improved crop yield has not been realized, let alone quantified.

A study was conducted at the Teaching and Research Farm of the University ofOf Ibadan, Nigeria (7^{o}24' N, 3^{o} 54' E) for three growing seasons to assess

(i) the effectiveness of vetiver grass on soil and water loss,
(ii) soil moisture retention and
(iii) crop yields.

Vetiver strips were established on 6% slopes at a surface interval of 20m on erosion plots measuring 40m x 3m each. Plots with and without vetiver strips constituted the treatment and control, respectively. Each was replicated thrice and laid out in a randomized complete block design. Neutron probe access tubes were installed to a depth of 1m at 10m from the upslope end of the plots and 1m behind the first vetiver strip to enable soil weekly moisture measurements at those points using a neutron moisture meter at 10cm depth-intervals down to 80cm depth. The plots, laid bare in the first season to determine the maximum efficiency of the vetiver strips, were sown to cowpea in the second season and maize in the third season when actual runoff and soil loss from each plot were determined using soil and water collecting devices at the end of each plot. In the first season, soil accumulation at the vetiver strips was estimated using calibrated rods.

Results showed that first vetiver strip on the slope accumulated 98% more soil than lower vetiver strips in the first year. Vetiver strips increased cowpea seed and stover yields by 11.1% and 20.6%, respectively and increased soil moisture storage by a range of 1.9% to 50.1% at various soil depths. Maize yield increased by 50%. Soil loss and runoff water were 70% and 130% higher on non-vetiver plots than vetiver plots. Eroded soils on non-vetiver plots were consistently richer in nutrient contents than on vetiver plots. Nitrogen use efficiency was enhanced by about 40%.

Key words: Vetiver, soil loss, runoff, soil moisture, crop yield, nitrogen use efficiency.
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1.0 INTRODUCTION

The detachment of soil particles from the landmass and the transportation of the loosened material to another place, termed soil erosion (Elision, 1946; Hudson, 1965) is perhaps the most fearsome threat confronting mankind today (Babalola, 1993). 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 Nigeria. 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. The use of vetiver grass has offered such prospects in a wide range of climatic environments (World Bank, 1990). Though the grass grows in Nigeria, its potential for soil and water conservation has not been realized (Randev, 1995), let alone quantified. The objectives of the study were, therefore, to assess (i) the effectiveness of vetiver grass as an erosion control measure; (ii) the effect of the grass on soil moisture storage; and (iii) its effect on crop yield.

2 MATERIALS AND METHOD

The study was conducted at the University of Ibadan, Ibadan (7^{o}24'N 3^{o}54'E). Ibadan is characterized by a rainfall average of 1229mm per annum, with a bimodal distribution that peaks in June and September, respectively. There are 175 total wet days. Annual temperature ranges between 21.3°C and 31.2°C. It has a percentage sunshine of between 16% in August to 59% in February and December, respectively, with an average of 44% (FAO, 1990). The soil of the area is Oxic Paleustalf in the class Alfisol, according to the USDA classification and by the local classification, the soil belongs to the Iwo series (Smyth and Montgomery, 1962). Some physio-chemical properties of the soil, which had been under fallow for about three years, are presented in Table 1.

Vetiver strips were established on a 6% slope at a surface interval of 20m on erosion plots measuring 40m x 3m. Plots with and without vetiver strips constituted the treatment and control, respectively. Each was replicated thrice and laid out in a randomized complete block design.

Calibrated rods were installed 0.3m away from the vetiver strips on the upslope side of the strips to measure accretion (soil accumulation) within the immediate upslope environs of the vetiver strips. Access pipes of 5cm diameter were installed to a depth of 1m at 10m and 21m from the upslope end of the plot implying that the access pipes at 21m were 1m behind the first vetiver strip. The access pipes were installed to enable the use of a neutron probe for soil moisture measurements, which were carried out weekly at 10cm intervals down to 80cm depth. Neutron probe calibration carried out by the field method (Babalola, 1978) was used to convert neutron count ratio to volumetric moisture contents.

In the first growing season, all the plots were laid bare without any crop in order to assess the maximum efficiency of the vetiver strips in reducing soil loss. Soil accretion was measured as the height of the exposed portion of the calibrated rods at the time of installation at the onset of the experiment in the first season less the measurement at the end of the rains.

Table 1: Some soil physio-chemical properties in the upper 0-15cm of the soil at the experimental site.

Parameter	Remark
pH (20, 1:1)	6.5
pH (KCL, 1:1)	6.0
% Organic Carbon	1.5
Total nitrogen (g/kg)	5.88
Available phosphorus (mg/kg)	16.48
Exchangeable potassium (Cmol/kg)	5.71
Fine sand (g/kg)	42
Coarse sand (g/kg)	782
Clay (g/kg)	76
Silt (g/kg)	100
Texture	loamy sand
Bulk density (Mg/m^3)	1.53
Porosity	0.42

In the second growing season, the plots were sown to cowpea. Both cowpea seed and stover yields were determined at harvest.

In the third growing season, the soil had become degraded, a situation accentuated by the fact that the soil was left bare in the first season after bush clearance. At this time, soil and water runoff collecting devices were installed at the bottom of each plot by constructing weirs and using calibrated oil drums, 90cm high and 58cm wide. Only one-third of the runoff water was channeled into the runoff collecting devices. Maize was used as a test crop planted at spacings of 90 x 30cm. N-fertilizer at the rate of 100kg N/ha was applied as side-dressing in form of urea. Runoff and soil loss data were collected after every major storm that caused erosion during the tasseling and silking stage of the crop. Volume of runoff was estimated from the height of water in each drum and later converted to mm of water. Soil losses were collected, weighed wet and converted to oven-dry weights.

An aliquot of 100ml of the soil suspension was collected for $N0_3$-N and pH analysis. Soil loss was analysed for the particle size distribution (using the hydrometer method) organic carbon, the total nitrogen, phosphorous and potassium using standard procedures as described by IITA (1982). Nitrogen use efficiency (NUE) was estimated from the equation by Moll et al (1982):

$$NUE\% = \frac{\text{Grain Yield (g)}}{\text{Unit nitrogen supplied (g)}}$$

Maize plant heights on each plot were determined weekly, 4 weeks after planting using a measuring tape.

Statistical analysis was carried out using t-tests. Yield and yield parameters were also separated between top slopes and lower slopes, which were confined by vetiver strips.

3 RESULTS AND DISCUSSION

3.1 Soil Accretion

Mean soil accretion at 0.3m to the vetiver strips was 9.4cm and 0.17cm at the first and second vetiver strips, respectively (Fig.1). Accretion was lower at the second vetiver strip obviously because of a reduced runoff and increased deposition of water and soil between the first and second vetiver strips engendered by runoff interception at the former.

3.2 Soil Moisture

Soil moisture varied with depths. On a comparative basis, soil moisture under vetiver strip management was higher than in the control by a mean range of 25.6% to 1.9% at 40cm and 80cm depths, respectively at 1m before the first strip of vetiver and 50.1% to 7.9% at 20cm and 60cm depths, between the first and second strips, respectively (Table 2). The higher moisture content under vetiver strip management was the result of reduced water velocity and enhanced infiltration during rains since the vetiver strips intercept runoff.

3.3 Cowpea Yield

Cowpea yield and stover yields in vetiver plot were higher than in the control by 11.1% and 20.6%, respectively (Fig.2). This difference was attributed to a reduced soil loss under vetiver, which meant that the soil nutrients were higher under vetiver than in the control. The nitrogen-fixing capacity of the leguminous crop might have reduced the margin of differences in yield due to vetiver strip intervention.

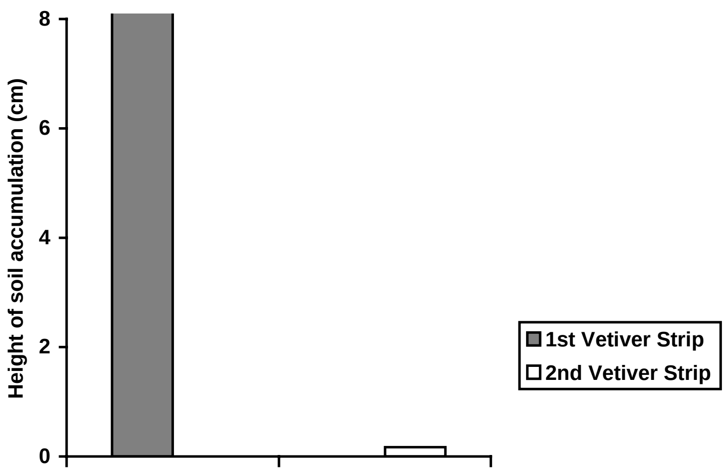


Fig. 1: Soil accumulation as influenced by vetiver strips

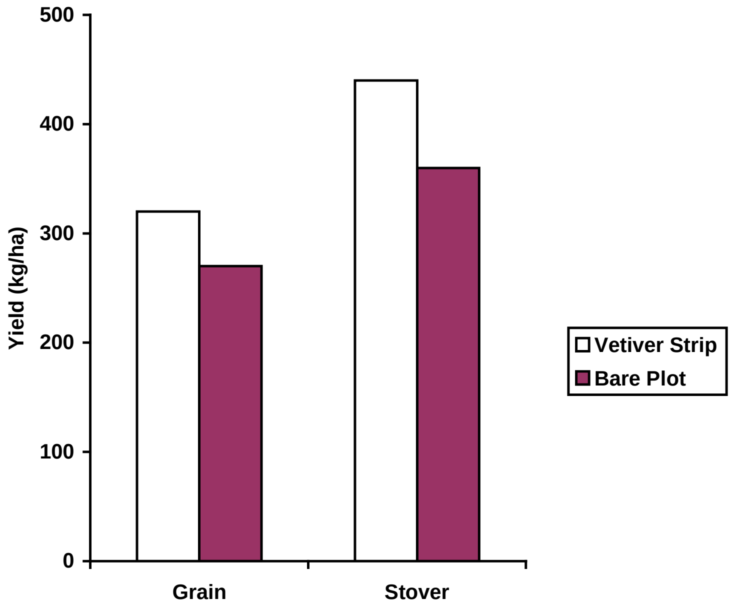


Fig. 2: Effect of vetiver strips on cowpea grain and stover yields

Table 2: Percentage increase in mean soil moisture content on vetiver plots over non-vetiver plots.

Depth (cm)	Before 1st VS*	Between 1st and 2nd VS
10	19.4	25.0
20	5.2	50.1
30	21.5	21.4
40	25.6	21.3
50	14.5	23.2
60	5.8	7.9
80	1.9	8.2

*VS = vetiver strip

3.4 Runoff

For the few rainfall events during which runoff and soil loss were measured before the rains ended; beneficial effect of vetiver strip was clearly evident (Table 3 & Fig.3) even though the average rainfall intensities for the measured storms were lower and not typical of the rainstorms in the area. Mean runoff as a percentage of total rainfall were 6.5% and 0.5% for non-vetiver and vetiver-plots. In other words, runoff was 130% higher under non-vetiver plots than vetiver plots.

Table 3: Mean runoff as influenced by vetiver (V) strips and non-vetiver (NV) plots for three storms on a 40m runoff plot.

	Rainfall events (mm)	Mean runoff (mm) V	NV
	11.40	0.14	2.06
	7.70	0.09	1.19
	39.30	0.07	0.63
Total	**58.40**	**0.30**	**3.88**

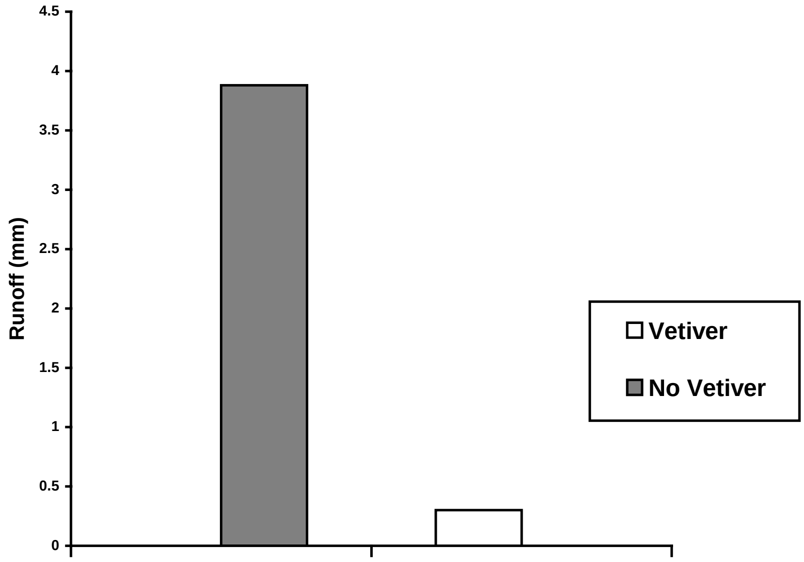


Fig. 3: Runoff as influenced by vetiver strips

3.5 Soil loss

Over the three storms measured, mean soil loss was 70.26kg/ha for no-vetiver plots and 19.95 kg/ha for vetiver-plots (Fig.4).

The mean pH of the runoff water in the vetiver-plot and non-vetiver plots was 7.0 and 6.2 (Table 4). The corresponding $N0_3$ – N values were 0.59 and 0.43 respectively. Although these values were not significantly different, the higher pH and $N0_3$-N values in vetiver plot are attributed to a better nutrient-enriched lower portions of the slope confined by the vetiver strips.

3.6 Nutrient Status

The chemical and physical analyses of the eroded soils (Table 5) show consistently higher nutrient values (organic carbon, % total nitrogen, phosphorus and potassium) in non-vetiver plots than vetiver plots. Similarly, clay and silt contents were higher on soils eroded from non-vetiver plots.

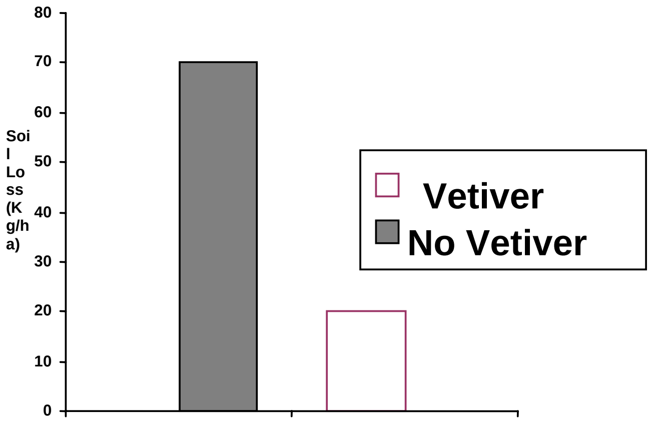


Table 4: $N0_3$-N and pH values of runoff water on vetiver (V) and non-vetiver (NV).

Rainfall (mm)	pH		$N0_3$-N (ppm)	
	V	NV	V	NV
11.40	6.90	6.00	0.97	0.77
7.70	6.90	6.50	0.52	0.31
39.30	7.20	6.20	0.28	0.20
Mean	**7.00**	**6.20**	**0.59**	**0.43**

Table 5: Chemical contents and particle size distribution of the eroded soil as influenced by vetiver strip.

Treatment	Clay (%)	Silt (%)	Sand (%)	pH -	C (%)	Total N (%)	P (ppm)	K (ppm)
Vetiver	3.8	4.0	92.2	7.5	2.13	0.065	5.8	0.24
No-Vetiver	4.6	4.2	91.2	7.5	2.18	0.074	6.2	0.25

3.7 Maize Growth and Yield

Severe degradation of the soil, which occurred in the first year, affected the subsequent crop performance even after the application of 100kg N as urea.

The highest plants were observed on vetiver plots with a mean value of 69cm (Fig.5). The highest plants were observed in the lower portions of the slope confined by vetiver strips. Mean grain yield on the vetiver plots (149.88kg/ha) was about 50 percent higher than on non-vetiver plots

(100.80kg/ha) (Fig.6). Grain yields in the lower slopes of vetiver plots were significantly higher than the yields of the upper slopes.

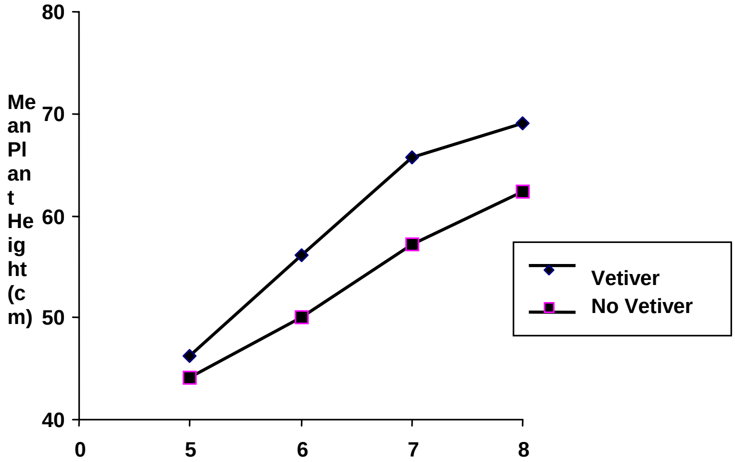
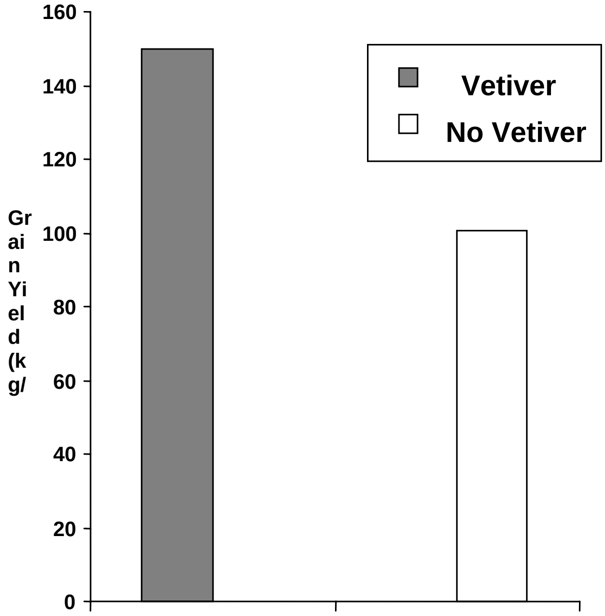


Fig. 5 Mean heights of maize plant as influenced by vetiver strips



3.8 Nitrogen Use Efficiency (NUE)

Nitrogen use efficiency (NUE) calculated as grain yield divided by nitrogen application increased from 7.7% in non-vetiver plots to 12.6% in vetiver plots. The low value of NUE obtained was the result of drought and soil degradation, which affected yield severely.

4 SUMMARY AND CONCLUSION

This work demonstrates the usefulness of vetiver grass as a soil and water conservation measure in the Nigerian environment. Soil physical and chemical conditions were ameliorated behind the vetiver strip for the distance of 20m used as vetiver spacing in this experiment. Thus, crop yields were increased by a range 11 – 26% for cowpea and about 50% for maize under vetiver management. The first vetiver strip on the slope accumulated about 98% more soil than lower vetiver strips. Soil loss and runoff water at the end of 20m runoff plots were 70% and 130% higher respectively in non-vetiver plots than vetiver plots. Eroded soils on non-vetiver plots were consistently richer in nutrient contents than on vetiver plots. Nitrogen use efficiency was enhanced by about 40%.

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6 ACKNOWLEDGEMENT

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