Comparative effects of Vetiver grass prunes, Vetiver hedgerows and Vetiver mulch on Soil quality and Erodibility of a degraded soil

by

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INTRODUCTION

- Vetiver grass system (VS) has become a global household name in soil conservation.

- In Nigeria and most other tropical soils of sub-humid Africa, considerable number of technologies including contour bund, no-till, terracing, alley cropping, agro-forestry, crop rotation and mulching have been deployed for soil conservation measures (Lal, 1976; Aina, 1989; Babalola et al., 2007).

- These studies, however, were confined to measure erosion-induced soil loss and runoff, yield and assessment of only a limited range of soil quality attributes.

- An important challenge for soil quality of eroded lands in the tropics is to identify quantitative parameters and processes that will reflect nutrient deficiencies, erodibility factor, and the overall health status of the soil under vetiver system.

- Thus, the study therefore, was set out to quantify changes in soil quality of an eroded land under composted vetiver grass prunes, vetiver hedgerows and vetiver mulch for the reduction of soil erodibility as well as improving soil quality to achieve sustainable agriculture.

Site Description and Soil

- The research study was conducted on erosion plot at the experimental farm of the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria.
- 7^0 22' N; 3^0 50'E and 160 m above mean sea level.
- The mean annual rainfall is 1382 mm recorded for a period of 10 years (IAR&T, 2010).
- The soil site belongs to Alfisol, classified as Typic Kanhaplustalf according to USDA classification, and locally classified as Iwo series (Smyth and Montgomery, 1962).
- The study site has a uniform slope of 8% and had been under continuous maize (*Zea mays* L.) cultivation for more than 10 years before this study.
- Evidence of erosion impacts on the soil and the site were reflected in low crop yields

Table 1. Physico-chemical properties of the experimental site (0 – 15 cm)

Soil property	Values
Sand (g 100 g^{-1})	78.6
Silt (g 100 g^{-1})	9.0
Clay (g 100 g^{-1})	12.4
Textural class	Sandy Loam
Bulk density (Mg m^{-3})	1.48
Total porosity	0.442
Soil strength at 5 cm depth (kPa)	125
Saturated water content (m^3 m^{-3})	0.430
WSA>0.250 µm (g 100 g^{-1})	49.5
MWD (mm)	0.714
pH (1:1 soil:water suspension)	6.5
SOC (g C kg^{-1} soil)	12.2
Total N (g kg^{-1})	1.21
Available (Bray 1) P (mg kg^{-1})	7.85
Exch. K (cmol kg^{-1})	0.34
Microbial C (mg kg^{-1})	11.4
Microbial N (mg kg^{-1})	0.11

Experimental Setup and Treatments

The trial comprised four treatments:

- Vetiver grass strips (VGS) established at surface intervals of 10 m down the slope;
- Vetiver grass mulch (VGM) imposed at 5 t ha^{-1} (dry matter);
- Vetiver-based compost (Veticompost) applied at 5 t ha^{-1} and
- Control.

- Laid out in a randomized complete block design and replicated thrice (Fig. 1).

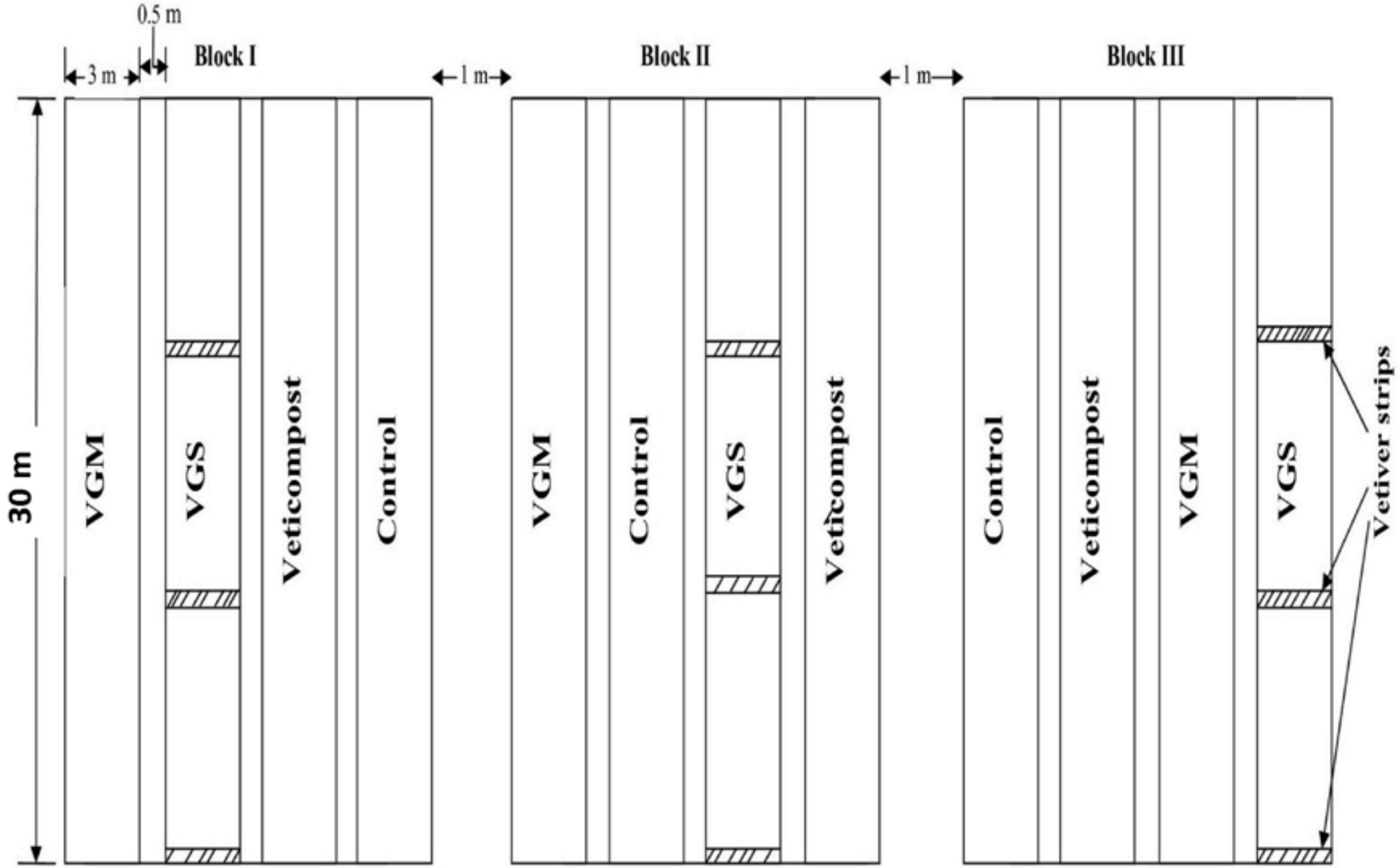
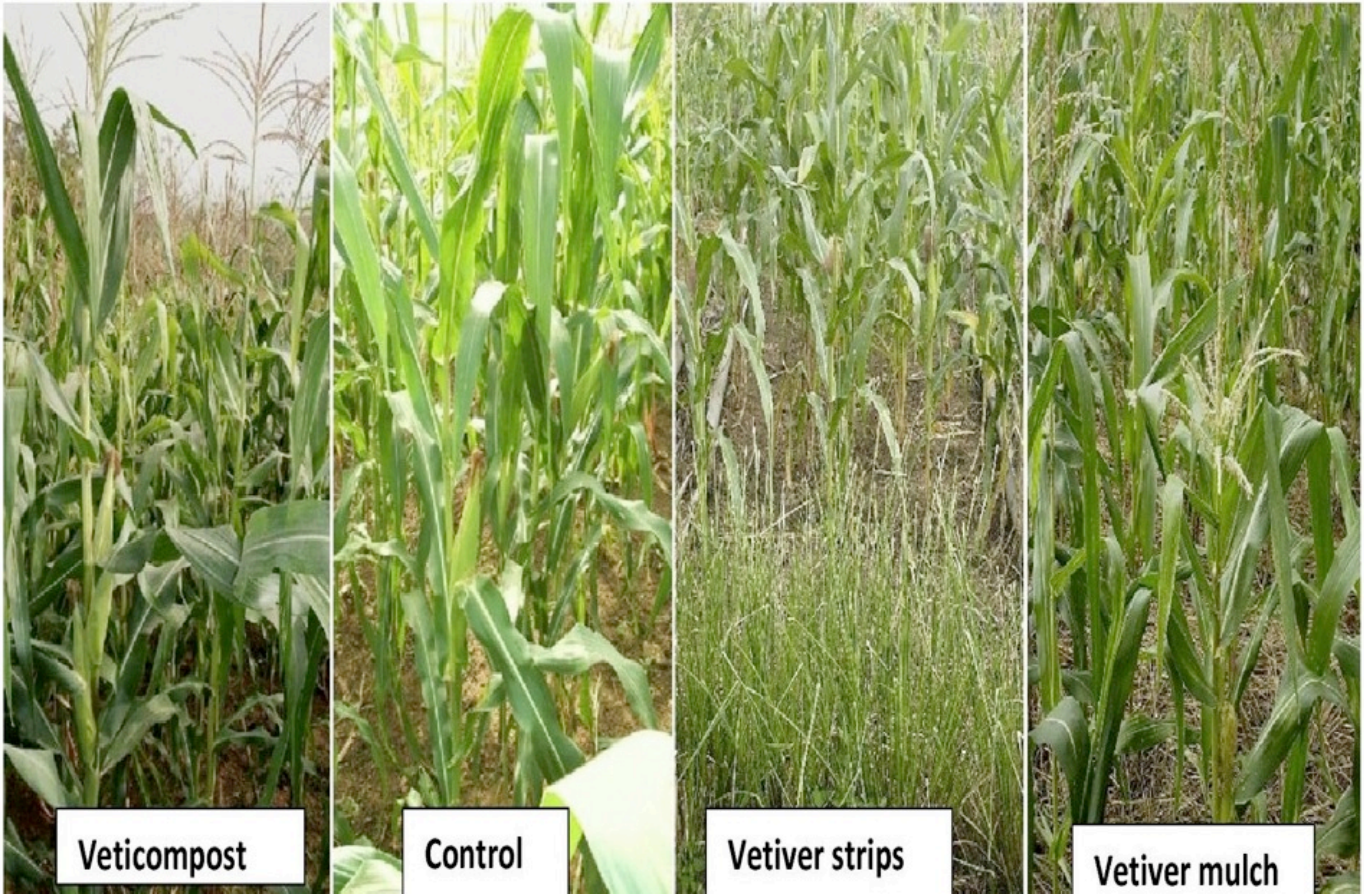


Fig. 1. Experimental layout showing the arrangement of the treatments

Table 2. Proximate analysis of veticompost

Parameter	Value
Nitrogen	6.78%
Phosphorus (P_2O_5)	5.34%
Potassium (K_2O)	1.56%
Org. C	15.44%
C/N	2.28
Mg	0.63%
Na	0.53%
Ca	4.03%
Fe	5915 mg/kg
Cu	30.45 mg/kg
Zn	172.05 mg/kg
Mn	304.00 mg/kg


Veticompost
Control
Vetiver strips
Vetiver mulch

Soil Analyses

- Soil properties were measured for soil quality indicators that are most important factors limiting crop production (Table 3).

- Erodibility factor was computed from the data collected on soil physical properties and organic matter content on the soil surface (0 – 10 cm depth) taking into account silt content (for soil containing less than 70% silt), very fine sand content, and other parameters, according to universal soil loss equation (USLE) (Wischmeier and Smith, 1978).

- Soil physical, biological and chemical quality indicators (Table 3) were determined both in the field and laboratory.

- Assessment of soil quality indicators was done as described in Oluwatosin et al. (2008).

$$SQI = \sum_{i=1}^{n} WS = qt.nav \times wt + qt.nr \times wt + qt.rp \times wt + qt.rd \times wt + qt.be \times wt$$

where SQI = Over all soil quality (s.q) index for crop production
W is the total weighted average of the soil quality factors
S is the relative scores of the factors.
qt.nav = s.q rating for nutrient availability process
qt.nr = s.q rating for nutrient retention process
qt.rp = s.q rating for root penetration
qt.rd = s.q rating for resisting degradation
qt.be = s.q rating for biotic environment
*w*t = relative weight

Table 3: Minimum data set (MDS) used for soil processes and quality indicators relating to crop productivity and their relative weights

Soil processes relating to crop productivity	Relative Weight	Soil quality indicators	Relative Weight
Nutrient availability	0.10	Total Nitrogen	0.25
		pH	0.25
		Avail. P	0.25
		K	0.25
Nutrient retention	0.25	Organic matter	0.35
		ECEC	0.35
		AWC	0.30
Root penetration	0.15	Bulk density	0.30
		Total Porosity	0.20
		Soil strength	0.50
Ability to resist degradation	0.25	Water stable aggregates	0.50
		Soil texture	0.15
		Infiltration capacity	0.35
Soil erodibility	0.15	Organic matter	0.70
		Particle size distribution	0.30
Biotic environment	0.10	Microbial-C	0.35
		Microbial-N	0.35
		Earthworm counts	0.30

RESULTS AND DISCUSSION

Table 4. Chemical quality indicators as affected by vetiver grass strip (VGS), vetiver mulch (VGM) and veticompost

	Total N	Org. C	pH	Av. P	Ca	Mg	K	Na	H+	ECEC	Zn	Mn
Treatments	**g/kg**	**g/kg**	**in H_2O**	**mg kg^{-1}**	**c mol kg^{-1}**						**mg kg^{-1}**	**mg kg^{-1}**
VGS	1.33b	12.10b	6.17ns	7.11a	1.19b	0.89b	0.21ab	0.43ab	0.07ns	2.79b	35.00ns	31.90ns
VGM	**1.97a**	**18.53a**	6.33	**8.44a**	**1.52a**	1.14a	0.24a	0.46a	0.08	**3.44a**	39.73	34.17
Veticompost	**1.90a**	**17.63a**	6.30	**8.52a**	**1.56a**	1.10a	0.26a	0.47a	0.08	**3.46a**	37.37	30.97
Control	1.10b	9.57b	6.03	5.95b	0.79c	0.64c	0.18b	0.38b	0.07	2.06c	33.23	38.90

ns means no significant difference between treatments within a column
Means followed by the different letters in a column are significantly different ($P < 0.05$)

Table 5. Physical and biological quality indicators and erodibility factor as affected by vetiver grass strip (VGS), vetiver mulch (VGM) and Veticompost

Treatments	WSA>250 µm	MWD	Bulk density	Porosity	PR	Microbial C	Microbial N	*K* factor	Soil loss
	(g 100 g^{-1})	(mm)	(Mg m^{-3})	(m^{-3} m^{-3})	(kPa)	(mg kg^{-1})	(mg kg^{-1})	(Mg h MJ^{-1} mm^{-1})	(kg m^{-2})
VGS	59.67ab	0.916ab	1.38a	0.479a	155.5a	14.60bc	0.14bc	0.018bc	**0.028c**
VGM	**73.20a**	**1.112a**	**1.15b**	**0.566b**	**115.0b**	**19.70a**	**0.21a**	**0.013c**	0.040b
Veticompost	**73.23a**	**1.154a**	**1.18b**	**0.553b**	**125.5b**	17.77ab	0.18ab	0.015bc	0.045b
Control	45.70b	0.683b	1.45a	0.452a	165.0a	11.13c	0.10c	0.030a	0.080a

ns means no significant difference between treatments within a column

Means followed by the different letters in a column are significantly different ($P < 0.05$)

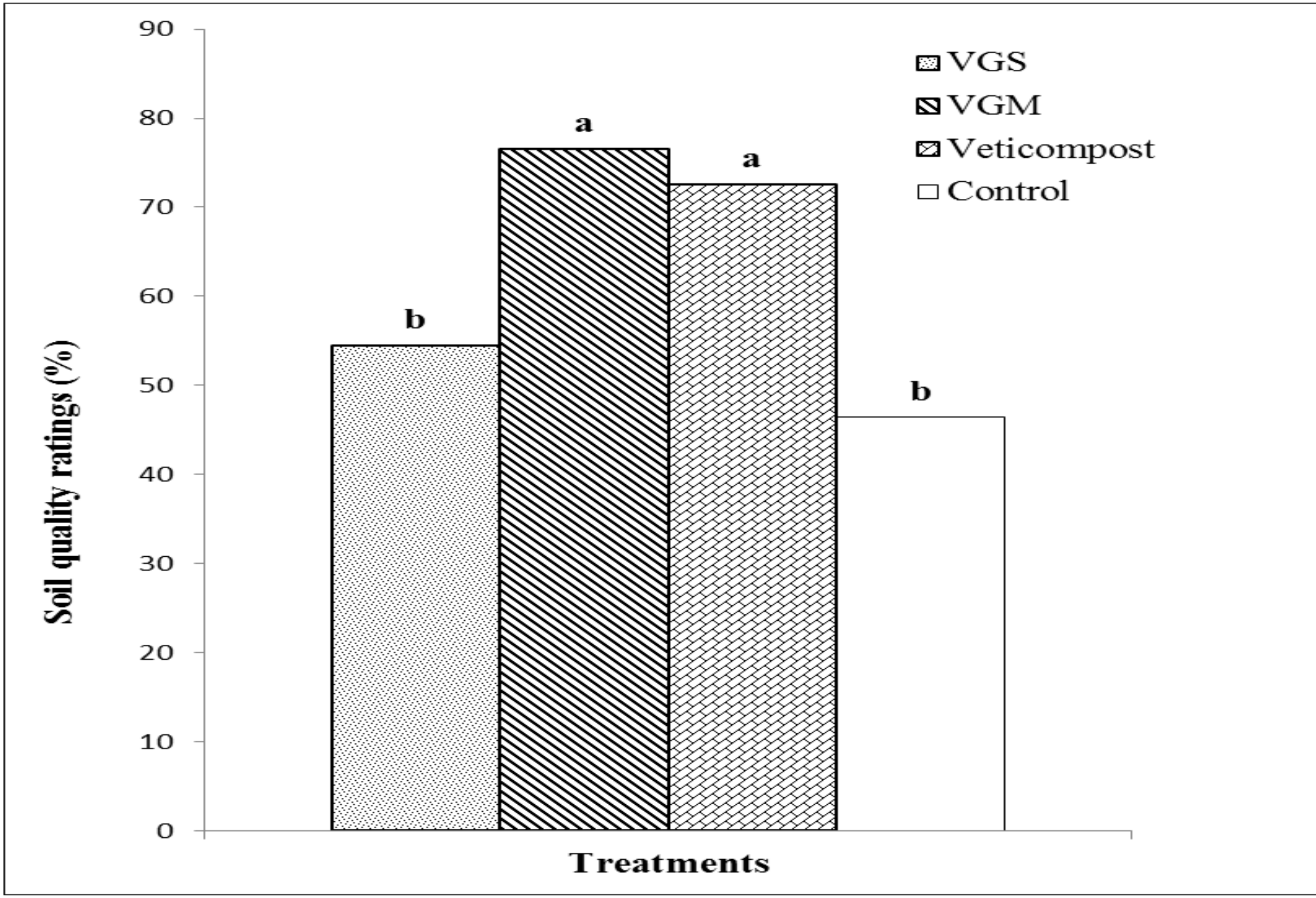


Fig. 2: Soil quality ratings of the soils as influenced by vetiver grass strips, vetiver grass mulch and veticompost.

Treatment means with the same letter do not differ significantly ($P<0.05$).

Table 6: Cumulative plant height, stem girth, stover and grain yields of maize as influenced by vetiver grass strip, vetiver mulch and veticompost between 2009 and 2010.

Treatment	Plant height (cm) Weeks after planting			Stem girth (cm) Weeks after planting			Stover yield t ha^{-1}	Grain yield t ha^{-1}
	4	**6**	**8**	**4**	**6**	**8**		
VGS	55.4ns	177.1ns	211.3ns	1.02ns	1.40bc	2.05b	6.95b	0.91b
VGM	62.6	184.5	216.5	1.07	1.90ab	2.25ab	**7.12ab**	1.05b
Veticompost	68.5	187.3	219.4	1.10	2.00a	2.85a	**7.65a**	**1.57a**
Control	54.6	165.7	203.6	1.01	1.30c	1.90b	6.75b	0.80b

ns means no significant difference between treatments within a column
Means followed by the different letters in a column are significantly different ($P < 0.05$)

CONCLUSIONS

- Vetiver system either as VGS, VGM or veticompost could be a better choice in soil quality build-up as well as reducing soil erodibility in an erosion prone land.

- Although the resistive capacity of VGM and veticompost in trapping sediments was lower (not significant, $P<0.05$) than that of vetiver strips (VGS), application of vetiver mulch and veticompost led to soil quality build-up, and were significantly higher than that of VGS plot.

- The use of vetiver hedgerows alone may not be able to sustain continuous cropping in erosion-induce degraded land unless a nutrient released organic material such as veticompost and vetiver mulch are applied for the build-up of soil organic matter to increase soil fertility as well as overall soil quality.

Thank you!!