COMPARATIVE EFFECTS OF COMPOSTED VETIVER GRASS PRUNES, VETIVER HEDGEROWS AND VETIVER MULCH ON SOIL QUALITY AND ERODIBILITY OF A DEGRADED SOIL.

By

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ABSTRACT

Maintenance of soil quality in an erosion-induce degraded soil has been a major worry in the tropics. To quantify the influence of vetiver grass hedgerows, vetiver mulch and composted vetiver grass prunes (vetiver-compost) on soil quality of an eroded land, an experiment was set up on an Alfisol (Typic Kanhaplustalf) in the Institute of Agricultural Research and Training, Ibadan, Nigeria. The treatments were 3-m wide vetiver hedgerows (VGS) established at 10-m inter-row spacing, vetiver grass mulch (VGM) imposed at 5 t ha^{-1}, composted vetiver grass prunes (veticompost) applied at 5 t ha^{-1} and a control. All quality indicators including physical, chemical and biological indices were collected and analysed between 2008 and 2009. For erosion risk assessment, erodibility factor *K* on each plot was also quantified in accordance with Universal Soil Loss Equation (USLE). Results showed that soil organic matter and associated nutrients play a major role in soil quality variation. VGM plot has the highest quality rating of 76.5% but not significantly different ($P<0.05$) from veticompost plot with 72.5%. These two treatments were however significantly different from the VGS and control plots with 54.5% and 46.4%, respectively. The quality ratings are related to the grain yield of maize. 70% of the grain yield variability was accounted to the soil quality ratings. Although, the soil quality rating of the VGM plot was higher than veticompost, the quality of organic matter and associated nutrients under veticompost enhanced better soil productivity, and thus resulted in greater crop yield than VGM. Properties that determine erodibility such as soil aggregation and shear strength were strongly influenced by vetiver systems while erodibility factor *K* ranged between 0.013 and 0.030 Mg h MJ^{-1} mm^{-1} with the vetiver mulch and control plots having the least and highest erodibility factors, respectively. It is therefore suggested that organic matter addition through application of vetiver mulch and vetiver-compost could be better practices in improving the quality of eroded land as well as reducing the erosive forces that would have broken apart the soil matrix.

Keywords: Soil quality, erodibility, mulch, veticompost, hedgerows

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1 INTRODUCTION

Over-exploitation of soils due to demographic pressure on agricultural land has increased to the point where fallows are rare and farmers have no alternative than to make use of marginal and steep lands for agriculture where nutrient loss is high and the reliance on fertilizer to improve soil fertility is paramount (Are et al., 2011). Among the land degradation processes however, soil erosion has been a major threat to sustainable use of soil and water resources (Lal, 2001). Erosion influences several soil properties, including topsoil depth, soil organic carbon (SOC) content, nutrient status, soil texture and structure, available water holding capacity (AWC) and water transmission characteristics, all culminate in regulating soil quality and determine crop yield (Kaihura et al., 1999).

Doran and Parkin (1994) defined soil quality as the ‘‘capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health’’. It is a manifestation of the inherent and dynamic properties of the soils (Karlen et al., 1997). However, integrated soil quality indices based on a combination of soil properties provide a better indication of soil quality than individual parameters. Karlen et al. (1994) developed a soil quality index (SQI) based on four soil functions, namely the ability of the soil to: (1) accommodate water entry, (2) retain and supply water to plants, (3) resist degradation and (4) support plant growth. Each soil function was explained by a set of indicators that include soil physical, chemical and biological properties, such as soil texture, bulk density, infiltration rate, total C and N content, pH, electric conductivity, microbial biomass, etc. All of the above function-based soil quality assessments were developed for use with temperate soils, whereas soil quality research on tropical soils, particularly in eroded landform of south western Nigeria is limited.

As the need to reduce nutrient loss in an eroded land and improving soil quality are attracting global interest, several soil conservation measures have been put into trial, of which most are not adoptable due to technicalities involved. In Nigeria and most other tropical soils of sub-humid Africa, since smallholder farmers increasingly cultivate steep land, considerable number of technologies including contour bund, no-till, terracing, alley-cropping, agro-forestry, crop rotation and mulching have been deployed, depending on localities (Lal, 1976; Aina, 1989; Babalola et al., 2007), but these studies were confined to measure erosion-induced soil loss and runoff, grain yield and assessment of only a limited range of soil quality attributes.

Vetiver grass system (VS) has become a global household name in soil conservation. However, the conservation-effective measures of vetiver hedgerows, vetiver mulch and composted vetiver prunes for the reduction of soil erodibility as well as improving soil quality of an erosion-induced degraded land requires identification of appropriate vetiver management system to achieve sustainable agriculture. Thus, 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. This study therefore, was set out to quantify changes in soil quality of an eroded land under composted vetiver grass prunes, vetiver hedgerows and mulch of a Typic Kanhaplustalf.

2 MATERIALS AND METHODS

2.1 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 (7^0 22' N; 3^0 50'E and

160 m above mean sea level), Nigeria. The area is characterized by a tropical climate with marked wet and dry seasons. The mean annual rainfall is 1382 mm recorded for a period of 10 years (IAR&T, 2010). Rainfall peaks occur mostly in June and September. Annual temperature ranges from 21.3°C to 31.2°C. There are two cropping seasons: early (March/April – early August) and late (mid-August - October/November) seasons. 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 intervention study.

The soil of the study sites belong to Alfisol, classified as Typic Kanhaplustalf according to USDA classification, and locally classified as Iwo series (Smyth and Montgomery, 1962). The surface soil is sandy loam. Evidence of erosion impacts on the soil and the site were reflected in low crop yields and presence rills in some parts of the land area before this study. Details of the physico-chemical properties of the soil are shown in Table 1.

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

2.2 Experimental Setup and Treatments

The trial comprised four treatments: (i) vetiver grass strips established at surface intervals of 10 m down the slope (VGS), (ii) vetiver grass mulch imposed at 5 t ha^{-1} (dry matter) (VGM), (iii) a vetiver-based compost applied at 5 t ha^{-1} (Veticompost) and (iv) a control, which were laid out in a randomized complete block design and replicated thrice. The proximate analysis of the veticompost is shown in Table 2. The field was initially disc ploughed and harrowed in 2008, and thereafter partitioned into three blocks with each block having four plots. Each plot measured 30 m long and 3 m wide, uniformly lie on 8% slope. Spacing between plots was 0.5 m within each block and 1.0 m between blocks as shown in Fig. 1. Vetiver hedgerows were established immediately after field preparation in May 2008. The roots of the grass slips were pre-treated with cow tea (cow dung slurry), whereas 150 kg ha^{-1} of single superphosphate was applied at planting for faster establishment and tillering. Erosion pins were installed at 0.15 m away from the vetiver hedgerows to evaluate soil in June 2008. Each pin (0.3 m long and 0.005 m thick) was driven vertically into 0.15 m soil depth by hammer, whereas 0.15 m remained outside the soil surface to give a firm stable reference point. For other plots with no vetiver hedgerows, erosions pins were positioned at every 10 m interval down the slope to measure changes in the soil surface level. The erosion pins remained in the same locations throughout the study period.

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

After the vetiver hedgerows had been fully established (between 0.4 m and 0.5 m in width) in April 2009, the plots were cropped with maize (*Zea mays* L. var. SUWAN – 1-SR-Y). In each growing season (early 2009 – late 2010) vetiver mulch and veticompost were imposed each time on selected plots (VGM) 2 to 3 weeks after maize planting. As part of management of the vetiver hedgerows, the grass hedges are pruned every 3 months and used for veticompost making and mulching.

2.3 Soil analyses

Soil physical, chemical and biological properties were measured after harvesting the maize planted on the plots (at 3 months after planting). Soil properties measured were those used for soil quality indicators that are most important factors limiting crop production.

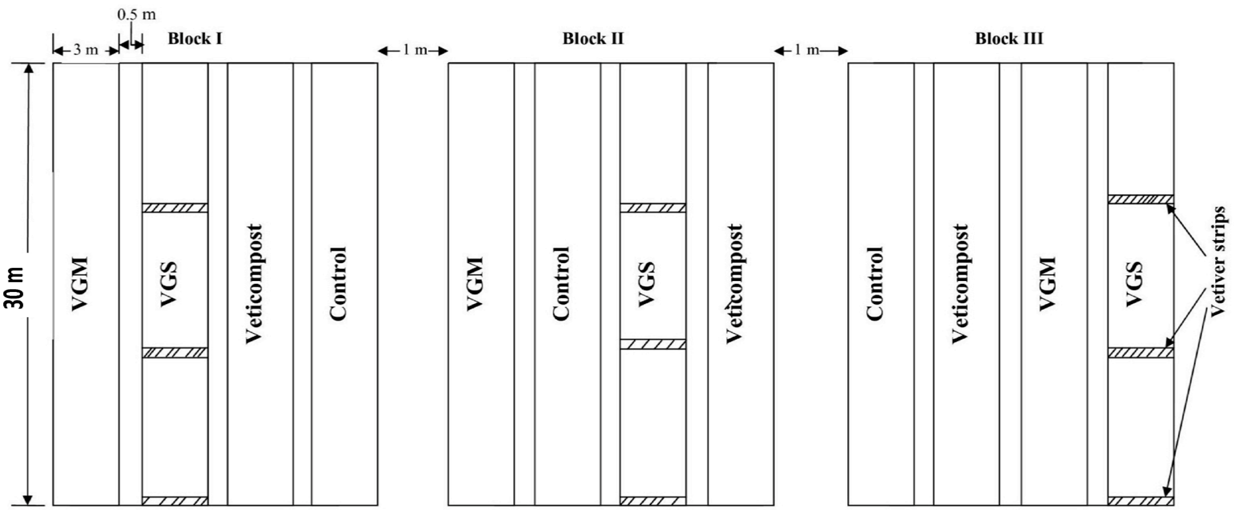

Fig. 1. Experimental layout showing the arrangement of the treatments

2.3.1 Physical properties

An undisturbed soil cores were taken with a cylindrical core sampler (0.05 m – height and inner diameter) from 0 to 0.15 m depths. The soil cores were saturated with water overnight and thereafter weighed at saturation. Water retention characteristics between saturation and 10 kPa matric potential (–100 cm water) were determined by tension plate apparatus; similar to that of Topp and Zebchuk (1979). Pressure was also imposed between 10 and 1500 kPa for the determination of available water capacity (AWC). Bulk density was estimated by dividing the oven-dry mass of the soil by the volume of the soil as described by Grossman and Reinsch (2002). Gravimetric moisture contents (Lowery et al., 1996) at FC and PWP were calculated on dry mass basis. AWC on volume basis was calculated by multiplying the gravimetric moisture content between FC and PWP by the corresponding bulk density, calculated as:

$$\mathbf{AWC = (FC_{\Theta} - PWP_{\Theta})\ \rho_b}$$

where is the gravimetric moisture content (%) and ρ_b is the bulk density at the required depth in Mg m^{-3}.

Pore size distribution and total porosity (TP) were calculated using the water retention data and capillary rise equation as described by Flint and Flint (2002). Macropores (pores >30 µm), taken as drain pores were estimated at 10 kPa matric potential.

Total porosity was estimated as water content at saturation using the following relationship:

$$\mathbf{TP = (M_{SW} - M_{ds})/V_b.}$$

Where M_{SW} is the mass of soil at saturation, M_{ds} is the mass of dry soil at 105^0C and V_b is the volume of the soil. Particle size distribution was carried out on the soils using hydrometer method as described by Gee and Or (2002). Water stable aggregates (WSA) were determined on soil by a modified Kemper and Rosenau wet sieving method described by Nimmo and Perkins (2002). 50 g of air dry soil taken at 0 – 15 cm depth was placed on a set of sieves (5.00, 2.00, 1.00, 0.25 and 0.045 mm) attached to a dipping machine. The set of sieves was cycled through a column of water for 10 min (30 cycles per min, 4.0 cm stroke length). The percentage of WSA as fraction of the total sample was calculated. Mean weight-diameter (MWD), a statistical index of aggregation, was calculated from aggregate size distribution data, after correction had been made for sand fractions by dispersion with sodium hexametaphosphate (HMP). Penetration resistance (PR) was measured using a field penetrometer (Rimik CP20, Agridy Rimik Pty Ltd, Toowoomba, Australia) with a steel cone of 6.3 m^2 (diameter = 1.28 cm, angle = 30^0) inserted into the soil up to 15 cm depth.

Infiltration rates were measured using a double ring infiltrometer (Reynolds et al., 2002). The inner ring (measuring cylinder) is 30 cm long with a diameter of 30 cm while the outer ring (buffer cylinder) has the same length as the inner ring with a diameter of 50 cm. A constant head of 0.10 m water was maintained in the measuring cylinder in the course of measurements. Grass residues were put on the soil in the inner surfaces of the rings prior to water application to minimize surface disturbance when applying water. The amount of water infiltrated was recorded at 1 min for the first 10 min and then every 5 min for 1 h. In each case, steady-state infiltration was attained within the measurement period.

2.3.2 Chemical properties

Total N was determined using kjeldahl method (Bremner and Mulvaney, 1982), available P was determined as described by Bray and Kurtz (1945) and exchangeable bases

(Ca, K, Na, Mg) and Cation exchange capacity (CEC) were quantified as described by Thomas (1982). Soil pH was measured in distilled water (1:2.5 soil:water) using pH meter.

2.3.3 Organic matter, N-mineralization and biological properties

Soil organic C (SOC) was determined by loss-on-ignition as described by Cambardella et al. (2001). SOC mineralization rates were determined by incubating 10 g of the ground samples from the 0 – 15 cm depth at 25 ^{0}C for 28 days. Soil samples were kept at 55% of their field capacity in sealed 1 L jars containing NaOH 0.2 M traps for respired CO_2. Traps were periodically titrated with HCl to determine the C evolved as CO_2 (CO_2 – C). The accumulated CO_2 – C in days 14 and 28 of the incubation (CO_2 – C_{14d} and CO_2 – C_{28d}, respectively) were used for this study. After 28 days of incubation, 2 M KCl extracts (1 g soil:5 ml solution) of the samples were used to determine the amounts of N in the form of ammonium (NH_4–N) and nitrate (NO_3–N) by absorbance measurement (Nelson, 1983). The fraction of organic matter corresponding to particulate organic matter (POM) □53 µm sieve size was isolated by dispersion and sieving of 10 g of air-dried soil, using a method described in Virto et al. (2007).

Soil microbial biomass in the above sieved soil was estimated by the fumigation-extraction (FE) technique (Ross, 1990). In the 0.5 M K_2SO_4 extracts (1 g soil: 4 ml solution), organic-C was determined by dichromate oxidation, and soil microbial biomass-C (µg g^{-1} soil) calculated as:

$$\textbf{Microbial biomass – C} = \Delta\textbf{Organic –C} / k_{EC}$$

using a k_{EC} factor of 0.33 (Ross, 1990) and where ΔOrganic – C is the difference inorganic-C content between the fumigated and the unfumigated sample. A ninhydrin assay for biomass α–amino-N and ammonium-N was used to estimate microbial-N (µg g^{-1} soil) which was calculated as:

$$\textbf{Microbial biomass-N} = \Delta\textbf{Ninhydrin reactive-N} / k_{ninhN}$$

using a k_{ninhN} factor of 0.20 (Joergensen and Brookes, 1990) and where ΔNinhydrin reactive-N is the difference in ninhydrin reactive-N content between the fumigated and the unfumigated sample.

For earthworm activity determination, earthworms were sampled by hand sorting from soils taken with shovel from each plot in the field. Individual worm was weighed (fresh weight basis) immediately after collection.

2.4 Erodibility factor

Soil erodibility, a measure of the susceptibility of soil particles to detachment and transport by rainsplash and overland flow, was measured after two growing seasons of continuous cultivation. Data collected on soil physical properties and organic matter content on the soil surface (0 – 10 cm depth) were used in computing erodibility factor, 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). The mathematical equation is as follows:

$K = (1.292)\,[2.1\text{x}10^{-6}\,M^{1.14}\,(12 – a) + 0.0325\,(b – 2) + 0.025\,(c – 3)]$

Where M = [%Silt + %very fine sand] x [100 – %clay]

where K = soil erodibility factor (Mg h MJ^{-1} mm^{-1})

a = percentage organic matter

b = soil structure index

c = profile permeability class factor

Factor (1.292) is used for the conversion of K-factor from English units to the metric units.

2.5 Growth parameters and the yield of maize

The maize plant heights were measured with measuring tape graduated in centimetre (cm) from the soil surface to the tip of the inner leaves and to the tip of the tassel after tasseling. The mean height of 30 maize stands randomly selected and tagged which spread across each plot was computed as the mean plant height of the maize in a plot. The stem girth was measured using vernier calliper to measure the circumference of the lower ends (about 5 cm above soil surface) of maize plants. The same plant stands for plant height were used for the measurement of stem girth. Both plant height and stem girth were measured at 4, 6 and 8 weeks after planting (WAP).

Precisely, 3 months after planting, the maize was harvested. Maize yield was determined at harvest by taking the weights of maize stovers, dehusked cobs, shelled-grains and air-dried shelled-grains (at 15% moisture content – equivalent to the moisture content of grains sold in market). Harvesting of maize involved cutting of maize stands at soil surface and weighed for the determination of stover yield.

2.6 Assessment of soil quality

The soil quality indicators and their processes were integrated into quality index value (Table 3). All indicators affecting a particular process were grouped together, given scores and relative weights based on importance. The score for each indicator was multiplied by the appropriate weight and summed to provide soil quality rating for each process. The soil quality (s.q.) rating of each process was also multiplied by the appropriate weight, producing a matrix that was summed to provide soil quality index for crop production as described in Oluwatosin et al. (2008):

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

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

2.7 Data analyses

To evaluate the effects of vetiver systems on the soil quality factors, the quality processes were scored while analysis of variance (ANOVA) was performed on the score variables using statistical application software (SAS, 2002). Factors that differed among treatments were separated using Least Significance Difference (P<0.05).

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

2. RESULTS AND DISCUSSION

3.1 Chemical quality indices

Table 3 shows the chemical quality indicators as affected by vetiver strips, vetiver mulch and veticompost. Following the application of 5 Mg ha^{-1} of mulch and veticompost, the concentration of SOC, N, P, ECEC in VGM and veticompost plots were not significantly different (P<0.05), they were however significantly higher than those under VGS and control plots. Although, the chemical quality indicators were better influenced by VGS than the control plot except ECEC, they were however not significantly (P<0.05) higher than the control plot. The manurial capability of vetiver mulch and veticompost on soil was reflected in the higher concentration of C, N and CEC compared with vetiver strip and control. In terms of soil reaction (pH), H^+ and micronutrients did not follow any trend, as there were no significant differences in their mean values (Table 3).

Virtually all the soil quality indices are influenced by the soil organic matter (SOM). A significant reduction in chemical quality indices (SOC, N, P and CEC) of the control plot was as a result of lack of shield that would have kept erosion away or rather reduces its impact on the soil. However, the increase in SOC, total N and CEC following application of VGM and veticompost could be attributed to an increase in belowground biomass production vis-à-vis VGS and control plots. Similar result was reported by Manna et al. (2007).

3.2 Soil physical and biological qualities, soil loss and erodibility factor

The influence of vetiver systems was shown on soil physical quality (Table 5). The size and strength of aggregates as shown by MWD and WSA, respectively, gave a clear indication of the potentials of vetiver systems in re-building soil structural quality after initial degradation by erosion. Although, macroaggregation estimated by WSA□250 μm was poorly formed on VGS plots, the surface soil was however better structured with the WSA□250 µm greater than the control plot by as much as 30.6%. The contribution of organic matter in VGM and veticompost was reflected in the concentration of macroaggregation as VGM and veticompost were significantly higher (*P*<0.01) than the control by 60.1% and 60.2%, respectively. The aggregate size distribution, expressed as MWD (Table 5), followed the same trend as WSA□250 µm. Although the MWD under VGS plot was not significantly higher than the control plot, it was however greater than the control by 34%. The increase in soil macroaggregation under VGM and veticompost was probably the reflection of the SOM content. This is often cited as major cause of improvements in soil tilt and structural quality (Manna, et al., 2007; Mulumba and Lal, 2008). Since the addition of mulch and veticompost means the addition of carbon, it is not surprising that soil microbial activity would be increased. Many research studies have shown that continual addition of compost or mulch usually increases microbial–C and microbial–N, which could lead to positive effect on both soil aggregation and macroporosity (McGill et al., 1986). This of course translates to better soil structure and infiltration. Even then, the variation in aggregate size distribution due to vetiver systems reflected the importance of organic matter in stabilizing soil aggregates.

The response of bulk density and total porosity as soil quality indicators maintain the same trend with WSA and MWD. The imposition of mulch and veticompost reduced the density and increased pore size distribution of the soil. The bulk density and porosity of the soil under both treatments were significantly better (P<0.05) than those under VGS and control plots. The measure of soil strength as described by penetrometer resistance (PR) in Table 5 followed similar trend in bulk density and total porosity. However, the response of soil physical quality indices to the vetiver systems was a reflection of the quality of materials imposed for the control of erosion.

The vetiver systems had significant effect on both soil loss and erodibility factor (*P*<0.05). This is reflected in the values of *K* factor in the 0 – 5 cm soil depth and the soil loss (Table 5). The vegetal cover of vetiver mulch prevented scouring capacity of erosion while contributing to the build-up of soil organic matter after decomposition. This perhaps was responsible for the lower value of *K* factor in the 0 – 5 cm layer VGM plot. Albeit *K* factor in veticompost treated plot is not significantly different from VGS plot, the higher content of organic matter in veticompost perhaps increased the resilient capacity of the surface soil thereby leading to lower K factor (16.7%) than the VGS plot. However, despite having higher *K* factor than both VGM and veticompost, VGS seemed to be more effective than both VGM and veticompost in sediment trapping. This is reflected in the values of soil loss obtained in different plots. Similar results were obtained by Babalola et al. (2007) and Are et al. (2011).

3.3 Soil quality and maize yield

The soil quality as influenced by VGS, VGM and veticompost is shown in Fig. 2. The influence of VGM and veticompost on the overall quality of the soil was not significantly (P<0.05) different but they were significantly higher than both VGS and the control plots. Although the quality of the soil under VGS was not significantly higher than the control plot, the soil quality rating of VGS plot was higher than that of the control plot by 17.5%. The highest soil quality observed in VGM plot might not be unconnected to the greater influence of mulch cover on soil physical and biological properties. However, the deterioration in soil quality indicators on the control plot, especially soil organic matter and its associated nutrients has been cited as a major factor contributing to yield decline under intensive cultivation (Manna et al., 2007; Lal, 1985) and erosion-prone land (Lal, 1995).

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

Treatments	Total N g/kg	Org. C g/kg	pH in H_2O	Av. P mg kg^{-1}	Ca	Mg	K	Na	H+	ECEC	Zn mg kg^{-1}	Mn mg kg^{-1}
					←		c mol 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

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 (g 100 g^{-1})**	**MWD (mm)**	**Bulk density (Mg m^{-3})**	**Porosity (m^{-3} m^{-3})**	**PR (kPa)**	**Microbial C (mg kg^{-1})**	**Microbial N (mg kg^{-1})**	***K* factor (Mg h MJ^{-1} mm^{-1})**	**Soil loss (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 ($P < 0.05$)

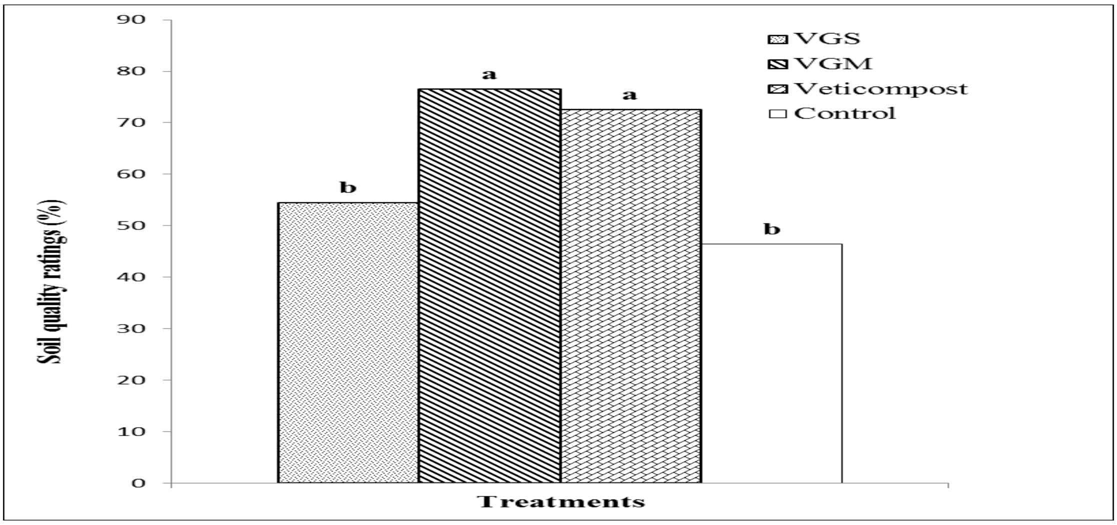

Fig. 2: Soil quality ratings of the soils as influenced by vetiver grass strips, vetiver grass mulch and veticompost. Treatment means with the same letter do not differ significantly (P<0.05).

The growth and grain yield of maize were reflections of the quality of the soils as impacted by the vetiver systems. The cumulative plant heights, girths, stover and grain yields are shown in Table 6. Despite no significant difference in the plant heights in all the weeks, among the treatments, the quality of the soils had influence on the maize height and girth. However, 70% of the grain yield variability (data not shown) was accounted to the soil quality ratings. Plot with veticompost consistently and significantly (P<0.05) has higher grain yield than those with either vetiver buffer strip or mulch. Although, the soil quality rating of the VGM plot was higher than the veticompost, the quality and early release of organic matter and associated nutrients under veticompost enhanced better soil productivity, and thus resulted in greater crop yield than VGM. It is not surprising that the cumulative grain yield on VGS and VGM plots were not significantly higher than the one obtained in the control plot since no soil fertility amendment was added. Even then, the maize grain yield obtained on VGS plot was 13.8% greater than the control while it was 31.3% better on VGM plot than the control. Veticompost plot has higher stover yield at harvest, and was significantly (P<0.05) higher than VGS and the control but not significantly greater than the VGM plot.

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)

4 CONCLUSIONS

Our results suggest that vetiver systems 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. However, 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.

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