Variability in the Physical Properties of an Eroded Cultivated Steep Land Under Farmers' Practice and Vetiver Technology (Bio-Engineering Structure).

***[1]Tangban Eji Ejor & [2]Effiom Essien Oku.**

***[1]Department of Agronomy Faculty of Agriculture and Forestry, Cross River University of Technology, Nigeria.**

[2]Department of Soil Science and Land Resource Management, Faculty of Agriculture, University of Abuja, Nigeria.

***Corresponding Author**

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ABSTRACT

Variability in soil properties is evident in the variability in crop performance in a field and failure of engineering structures. During erosion particles are detached, transported and deposited at different locations down the slope. An experiment was conducted on 20 and 30% slopes within the Cross River University of Technology to assess variability in soil physical properties as induced by water erosion on erosion plots constructed and planted to maize/cassava mixture. No vetiver [farmer's practice] and vetiver grass strips at 5m, 15m and 25m [bioengineering structure] constituted the treatments. Core samples (0 - 15cm) were collected at 5m intervals down the slope in all the treatments for determination of some soil physical properties. Infiltration was measured using double ring infiltrometer. Coefficient of variability (CV%) values ranged from 2 - 4% [bulk density], 2 - 4% [porosity], 16 - 33% [gravimetric moisture], 3 - 8% [void ratio], 16 - 33% [volume wetness], 15 - 32% [degree of saturation], 16 - 37% [water volume ratio], 2 - 7% [air-filled porosity], 16 - 33% [available moisture holding capacity] for the two slopes. Initial infiltration ranged between 1.87 - 2.90cm per minute and 82.63 - 127.80cm after 260 minutes for cumulative infiltration. Coefficient of variability were 19.5% [initial infiltration] 6.18% [cumulative infiltration] for 20 and 30% slopes respectively. CV% values of <15%, 15 - 35% and >35% are considered low, moderate and high respectively. Understanding field variability of soil properties could be a veritable tool for precision soil management to optimize and increase profitability.

Key Words: Erosion, Vetiver, Bioengineering structure and Soil Variability

INTRODUCTION

Soil erosion brings nearly irreversible changes in the physics of the soil (Oku, 2002). The disappearance of the soil leads to the loss in favourable soil structural properties. In the humid forest zone of Nigeria the land is characterized by slopes (steep lands). As a result of poverty, scarcity of arable land and population pressure particularly in this region steep land (marginal soils) otherwise not suitable for farming activities is increasingly being cleared of natural vegetation for farming. As the existing vegetation is being removed for cultivation and the soil surface exposed and made loose by tilling, with the on-set of the rains, raindrops beat the soil causing soil detachment and destruction of the structural properties (Tulu, 2002). The particles are gradually moved and carried from one location to another by run-off water and where the velocity of the run-off reduces it drops heavier particles/sediments carrying along smaller particles down the slope until it empties at the valley bottom. Silt deposition in down streams are becoming more frequent and more severe (Tulu, 2002). As this process continues, the top soil is washed down slope leaving the sub-soil at the crest of the slope. Often, dynamic physical properties like bulk density, hydraulic conductivity, soil mechanical resistance, infiltration e.t.c. area negatively affected. Mean and range in coefficient of variability (CV) have been reported in the literature for selected soil properties sampled from equivalent horizons or depth with landscape mapping units of the same series Upchurch *et al*., (1988). Although these are only guidelines, they serve as useful indices in the absence of on-site data. The CV's for more stable properties range from 5-10%; while for the more dynamic ones, they commonly range from 10-20%, with extreme at 35% Upchurch *et al*., (1988).

To hold back soils on steep land for farming and conserve water by reducing run-off, bio-engineering structures are constructed at intervals along the slope. From (Polster, 1989) works soil bio-engineering systems fit well with ecological restoration and successional reclamation, successful reclamation seeks to reintegrate the disturbed site into the natural successional processes that would help stabilize the soil for minimal variation in the physical properties as caused by erosional agents and serve to re-vegetate the site eventually. Use of vetiver system as a bio-engineering structure is considered a major breakthrough in soil and water conservation technology. The vetiver grass holds back eroding sediments allowing run-off infiltrate into the soil (Oku, 2015). Arising from soil detachment as a result of raindrop impact, transportation of detached sediments by run-off, deposition of the transported sediments at different locations down the slope, it is assumed that there will be variability in the physics of the soil down the slope. Variability in the physics of the soil will cause variability in crop performance and yield as the crops will respond to the differences in the physical qualities. Also, vetiver a bio-engineering structure is meant to break the slope, reduce velocity of run-off, trap down detached and eroding sediments, build up top soil and restore soil favourable physical properties. Accordingly, the objectives of this paper are (a). To measure selected soil physical properties along two steep lands under farmers' practice (no vetiver) and different vetiver strip spacing (bio-engineering) structure and (b). To measure variability of selected soil physical properties along the two steep lands under these treatments.

METHODOLOGY

2.1 Experimental Site:

The experiment was conducted in 2020 on erosion plots constructed in 2005 on two slope regimes within the Teaching and Research farm of Cross River University of Technology, Nigeria (6.8^{o}N, 8.20^{o}E). The plots were under mound cultivation with maize and cassava mixtures. The slopes were 20 and 30% determined using a dummy level. The soil of the experimental site is classified as ultisols, Periaway *et. al.*, (1983). The area is a tropical rain forest. The mean annual rainfall ranges from 2000mm to 2500mm (CRADP, 1992).

2.2 Treatments and Design:

Vetiver strips at 5m, 15m and 25m spacing were used as bioengineering structure and no vetiver (framer's practice) constituted the treatments. Each treatment was replicated three times in a Randomized Complete Block Design (RCBD). The vetiver strips were 3m in length and planted across the slope on the erosion plots (plate 1). The treatments were replicated 3 times each giving a total of twelve (12) erosion plots on each slope, each erosion plot measures 50m long and 3m wide. The erosion plot and treatment were under simple mixed cropping (cassava and maize) using mound tillage system.

2.3 Soil Sampling:

The rigid grid sampling method was used. Core samples were collected (0-15cm) at 5m intervals down the slope on each erosion plot. The core was carefully driven down into the soil with a hammer. A knife was used to dig out the cylindrical core and placed under it, to avoid the soil from the core pouring out. A total of a hundred and twenty (120) composite samples each were collected from the 20% and 30% slopes for analysis.

2.4 Laboratory Practices

2.4.1 Soil bulk density:

This was determined by collecting undisturbed core samples from 1-15cm depth of soil using a cylindrical core. The samples were weighed and oven-dried at 105^{o}c to a constant weight, the mass of oven-dried soil was divided by the total volume of the core ($V_s = \pi r^2 h$ of the cylindrical core) to obtain the bulk density, Blake (1965).

$$BD = \frac{\text{Mass of oven-dried soil (g)}}{\text{Total volume of core sample (cm}^{-3}\text{)}}$$

2.4.2 Total porosity:

Soil porosity was calculated as the total volume not occupied by soil assuming a particle density of 2.65mgm^{-3} Danielson and Sutherland (1986) and Phogat *et. al.* (2015).

$$P = 100(1-B_d/D_p)$$

Where P = porosity

B_d = bulk density

D_p = particle density (D_p estimated to be about 2.65gcm^{-3}

2.4.3 Gravimetric moisture content:

This was also determined mathematically by subtracting the mass of the oven-dried soil from the total sample mass dividing the mass of the oven-dried soil, Phogat *et. al.* (2015) and Hillel (1982).

$$W = (M_t-M_s)/M_s = (M_w/M_s)$$

Where W = gravimetric moisture content

M_t = total mass of sample

M_s = mass of oven-dried sample

M_w = mass of water

2.4.4 Void ratio, *e*

This was also determined mathematically using the formula, Phogat *et. al.* (2015) and Hillel (1982).

$$e = V_f/V_s = (V_f-V_s)/V_s$$

Where: e = void ratio

V_f = volume of water and air

V_s = volume of solid

V_t = total volume.

2.4.5 Volume wetness; Θ

This was also determined mathematically by dividing volume of water by total volume, Phogat *et. al.* (2015) and Hillel (1982).

$$\Theta = V_w/V_t$$

Where Θ = volume wetness

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V_w = volume of water

V_t = total volume.

2.4.6 Degree of saturation; *S*

This was also determined mathematically using the formula, Phogat *et. al.* (2015) and Hillel (1982).

$$S = V_w / (V_t - V_s)$$

Where S = degree of saturation

V_w = volume of water

V_t = total volume

V_s = volume of solid.

2.4.7 Water volume ratio:

This was also determined mathematically using the formula, Phogat *et. al.* (2015) and Hillel (1982).

$$VW = (V_W/V_S)$$

Where VW= water volume ratio

V_W = volume of water

V_S = volume of solid

2.4.8 Air-filled porosity: f_a

This was determined mathematically by subtracting volume of solid from total volume to get volume of air then dividing by total volume. And it is given as

$f_a = V_a/V_s$ Phogat *et. al.* (2015) and Hillel (1982).

Where: f_a = Air-filled porosity

V_a = volume of air

V_s = total volume.

2.4.9 Available moisture holding capacity: (AMHC)

This was done mathematically by multiplying bulk density by the gravimetric moisture content and expressing it as a percentage.

(B_d/W) *100) Phogat *et. al.* (2015) and Hillel (1982).

Where: B_d = Bulk density

W = gravimetric moisture

2.5 Ring Infiltration Measurement:

The double ring infiltrometer was used (plate 2). Infiltration runs were conducted across the erosion plots at the middle of the plots (25m). A total of twenty four infiltrations were ran on the two erosion study sites, (steep land). The rings were hammered uniformly into the soil up to 15cm depth using a piece of wood and hammer. The inner ring (30cm in diameter) was placed at the centre of the outer ring (60cm in diameter). Some pieces of dry leaves and grasses were laid down within the rings to minimize soil disturbance resulting from ponding water into the rings. The outer ring was served as a buffer that prevented horizontal movement of water from the inner ring and ensured vertical movement of water in the inner ring. Measurement of vertical infiltration rates were taken at one minute for thirty minutes and later at two minutes interval after ponding up to equilibrium state, using a graduated ruler placed at the corner of the inner cylinder to record water levels at defined time intervals with a stop watch. The infiltration results were subjected to infiltration models as proposed by Philip (1957) and Kostiakov (1932).

$I = {}^{1}/_{2}\, St + At.$ - - - Philip model

Where

I = Cumulative infiltration

t = time (minutes)

S = Sorptivity

A = adsorptivity or transmissivity

$I = C\, t^{\infty}$ - - -Kostiakov model

Where

I = Cumulative infiltration

t = time (minutes)

c = size of pores

∞ = index of soil stability

2.6 Data Analysis:

Values of soil physical properties along the slope were subjected to fisher classical statistics. Means ($\bar{x}$), standard deviation (SD) and coefficient of variability (CV) of physical properties of the soil along the slopes (20 and 30%) were calculated for each treatment. Also the physical properties and infiltration data and its parameters were subjected to analysis of variance (ANOVA), Gomez and Gomez (1984).

RESULTS AND DISCUSSION

3.1 Variation in Bulk Density (B_d)

Soil bulk density down the 20% slope in all the treatments was least variable. Coefficient of variability (CV) was 2.64, 1.58, 3.01 and 3.69% for the farmers practice, vetiver at 5m, 15m and 25m intervals respectively. Bulk density ranged from 1.41 -1.53, 1.38-1.45, 1.33-1.46 and 1.32 – 1.48m with mean at 1.46, 1.41, 1.41 and 1.40 M_gm^{-3} on the 20% slope for farmers practice, vetiver at 5m, 15m and 25m respectively. Bulk density was highest on the control plot (farmers practice) at almost all points except for the 40-45m sampling point, where it was highest on the 25m interval vetiver pot. Soil bulk density down the 30% slope in all the treatments was also least variable. Coefficient of variability (CV) was 2.34, 2.43, 2.14 and 1.99% for the farmer's practice, vetiver at 5m, 15m and 25m respectively. Bulk density ranged from 1.47-1.57, 1.45 M_gm^{-3} for farmer's practice, at 5m, 15m and 25m intervals respectively. Bulk density was highest throughout in the farmer's practice (control plot) on the 30% slope. The low variability of bulk density had earlier been reported by Wilding (1985). The values of the bulk densities on the two slopes were within acceptable limits (Olaitan and Lombin, 1988, De Geus 1973).

The implication is that plant roots will penetrate the soil with ease and these values show that pore spaces should be adequate for proper plant growth.

3.2 Variation in Total Porosity

Total porosity of the soil along the 20% slope was least variable. The coefficient of variability (CV) was 3.23, 1.89, 3.59 and 4.07% on the 20% slope for farmer's practice, vetiver at 5m, 15m and 25m respectively. Total porosity ranged from 42.77- 46.83, 45.17 - 47.93, 44.50 – 49.70 and 44.30 – 50.07% with mean at 44.78, 46.75, 46.72 and 47.07 on the 20% slope farmer's practice, vetiver at 5m, 15m and 25m respectively. Total porosities of the soil along the 30% slope were all least variable. The coefficient of variability (CV) was 2.99, 3.04, 2.62 and 2.48% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Total porosity in percentage ranged from 40.90 - 45.17, 43.17 – 48.03, 41.27 – 45.43 and 43.00 – 45.40 % for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively.

All values of total porosity were within the range of 0.3-0.6 or 30-60% Hillel (1982) vetiver improved the total porosity on the 15% slope from Kachinskii (1970) classification of soil porosity, soils on the slope are good for agricultural practices. This implies that space for air and water is good from crop production point of consideration.

3.3 Variation in Gravimetric Moisture.

Gravimetric moisture content of the soil along the 20% slope were moderately variable with coefficient of variability (CV's =18.16, 15.85, 24.22 and 28.70%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Gravimetric moisture content of the soil ranged from 0.035-0.0061, 0.025-0.046, 0.027-0.054 and 0.024-0.067 with means at 0.044, 0.038, 0.038 and 0.040 for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively.

Gravimetric moisture content of the along the 30% slope were moderately variable with (CV's = 16.43, 32.29, 33.90 and 16.60%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Gravimetric moisture content ranged from 0.037-0.060, 0.036-0.095, 0.025-0.079 and 0.031-0.055 with means at 0.049, 0.051, 0.048 and 0.046 for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the slope.

3.4 Variation in Void Ratio (*e*).

Values of void ratio (***e***) down the 20% slope were all least variable with (CV's = 5.80, 3.40, 6.40 and 7.57%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Void ratio ranged from 0.740-0.878, 0.824-0.924, 0.821-0.985 and 0.794-1.006 with means at 0.814, 0.882, 0.884 and 0.896 for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Void ratio (***e***) down the 30% slope were also least variable with (CV's = 5.14, 5.85, 4.44 and 4.24%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values of void ratio (***e***) along the 30% slope ranged from 0.695-0.824, 0.759-0.939, 0.705-0.835 and 0.760-0.874 with means at 0.763, 0.816, 0.793 and 0.806 for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the 30% slope. All values of void ratio (***e***) were within acceptable range 0.3-2.0 Hillel (1982). The values were averagely high showing that pore spaces were many to allow for easy plant root penetration.

3.5 Variation in Volume Wetness (Θ).

Volume wetness (Θ) values of the soils down the 20% slope were all moderately variable with (CV's = 17.07, 15.76, 22.79 and 25.10%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the slope. Values ranged from 5.00-8.67, 3.53-6.37, 3.87-7.30 and 3.37-8.67% with means at 6.43, 5.29, 5.29 and 5.58% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values of volume wetness (Θ) of the soil down the 30% slope were also all moderately variable with (CV's = 17.92, 26.24, 33.26 and 17.00%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Volume wetness (Θ) ranged from 5.50-9.17, 5.20-12.23, 3.87-11.47 and 4.57-8.27 with means at 7.46, 7.32, 7.01 and 6.75% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. The values obtained showed that even when the soil looks completely dry, the soil still contains a percentage of moisture which helps some plants with very high absorptive capacity strive during the dry seasons when soil water is held at 15 bar.

3.6 Variation in Degree of Saturation (*s*)

Values of degree of saturation (*s*) of the soil along the 20% slope were both least and moderately variable with (CV's = 14.88, 15.48, 21.84 and 22.24%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the slope. Degree of saturation values ranged 13.00-18.67, 7.57-13.37, 8.37-14.83 and 7.43-17.10% with means at 14.44, 11.33, 11.25, and 11.75% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values of degree of saturation (*s*) of the soil along the 30% slope were all moderately variable with (CV's = 20.41, 21.59, 32.35 and 18.00%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the 30% slope. Degree of saturation (*s*) ranged within 12.63-21.87, 11.50-24.23, 9.13-25.43 and 10.07-19.17% with means at 17.58, 16.25, 15.79 and 15.17% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively.

All values of degree of saturation (*s*) fell within the acceptable limits, Hillel (1983). The low values of degree of saturation show that the soil along the two slopes are well-drained and will support the growth of arable crops with adequate measures of erosion checks put in place.

3.7 Variation in Water Volume Ratio (V_w)

Water volume ratio (V_w) values of the soil down the 20% slope were moderately variable with (CV's = 18.26, 16.06, 24.49 and 28.58%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Water volume ratio (V_w) ranged from 0.092-0.162, 0.067-0.122, 0.082-0.143 and 0.062-0.177 with means at 0.118, 0.099, 0.100 and 0.107 on the 20% slope for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Water volume ratio (V_w) values of the soil down the 30% slope were highly variable for the vetiver at 15m interval treatment and other treatments moderately variable with (CV's = 16.12, 32.09, 36.88, 16.30%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively on the 30% slope. Values of water volume ratio (V_w) ranged from 0.098-0.158, 0.095-0.254, 0.066-0.189 and 0.083-0.145 with means at 0.130, 0.135, 0.124 and 0.122 on the 30% slope for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively.

3.8 Variation in Air-Filled Porosity (f_a)

Air-filled porosity f_a values of the soil along the 20% slope were all least variable with (CV's = 3.19, 2.36, 3.32 and 3.64%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values of air-filled porosity ranged from 36.43 - 40.33, 39.87 - 42.73, 39.50 - 43.83 and 38.70 - 43.77 with means at 38.34, 41.43, 41.43 and 41.50% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values of air-filled porosity of thee soil along the 30% slope were least variable with (CV's = 6.64, 4.02, 5.98 and 4.60%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Air-filled porosity ranged from 32.20-39.33, 35.43-40.07, 32.53-38.93 and 34.83-40.40% with means at 35.67, 37.31, 37.14 and 37.80% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively along the 30% slope.

The values of air-filled porosity gotten show clearly that the soil is well aerated and will support the growth of soil microorganisms in the soil and root growth therefore good for crop production purposes when management practices are also carried out on the two slopes.

3.9 Variation in Available Moisture Holding Capacity, (AMHC)

Available moisture holding capacity of the soil along the 20% slope were moderately variable in all the treatments with (CV's = 16.41, 15.52, 22.83 and 25.04%) for farmer's practice, vetiver at 5m, 15m and 25m intervals along the slope respectively. Available moisture holding capacity of the soil ranged from 5.02-8.65, 3.55-6.40, 3.86-7.29 and 4.10-8.64% with means at 6.46, 5.31, 5.28 and 5.57% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Values available moisture holding capacity of the soil along the 30% slope were also moderately variable with (CV's = 18.13, 26.20, 33.43 and 17.05%) for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. AMHC ranged from 5.35-8.90, 5.22-12.22, 3.71-11.45 and 4.54-8.25% with means at 7.45, 7.32, 7.03 and 6.75% for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. AMHC values obtained shows that the soil along the two slopes is not capable of holding much quantity of water for long, which variably means that the two slopes have well drained soils, for cultivation of crops that do well on well-drained soils, and the soils releases the moisture present in it for plant uptake easily.

3.10 Infiltration

Table 1 and 2 shows initial and cumulative infiltration characteristics of Philip's and Kostiakov's models respectively. Coefficient of correlation (*r*) values were between 0.80 and 0.99 this indicates that the two models fit the data and adequately describes the soil characteristics.

Infiltration of water into the soil under vetiver at 5m, 15m and 25m intervals and farmer's practice (control) treatments did not show any significant difference both for initial infiltration and cumulative infiltration. Infiltration characteristics obtained from the Kostiakov and Philip models (degree of stability α, Sorptivity S, and C, transmisivity) did not show significant difference on both the 20% and 30% slope (Table 1 and 2). Mean values for one minute infiltration were 1.87, 1.87, 1.90 and 2.83 cm on the 20% slope and 2.63, 2.60, 2.63 and 3.90 cm on the 30% slope for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Whereas, mean values for the cumulative infiltration after 260 minutes were 84.80, 83.07, 87.67 and 97.73 cm on the 20% slope and 82.63, 100.57, 127.80 and 84.60 cm on the 30% slope for farmer's practice, vetiver at 5m, 15m and 25m intervals respectively. Initial infiltration was moderately variable on the 20% slope with CV = 19.34% and least variable on the 30% slope with CV= 4.54%, while cumulative infiltration was least on the 20% slope with CV = 6.43% and moderately variable on the 30% slope with CV = 18.28. Values of infiltration characteristics obtained from the Philip's and Kostiakov's infiltration models were both moderately and least variable with {CV's = 34.63, 1.97, 0.101% (Kostiakov) and 38.00, 3.18, 2.89% (Philip) } on the 20% slope and { CV's =7.78, 8.12, 0.20% (Kostiakov) and 8.66, 23.33, 8.03% (Philip) } on the 30% slope for C, α and coefficient of correlation (r) of the Kostiakov's model and S, A and coefficient of correlation (r) of the Philip's model respectively. According to BAI (1979) infiltration rating, infiltration rates were generally rapid on the 20% slope in all the treatments and on the 30% slope, infiltration rate were rapid for farmer's practice, vetiver at 5m, and 25m and very rapid for vetiver at 15m interval with 29.52 cm of water entering the soil per hour.

SUMMARY

Erosion plots were established in 2005 on a 20% and 30% slope within the Cross River University of Technology, Obubra, in Central area of Cross River State. The main objective of was to adapt different vetiver grass strip [5 m, 15 m and 25 m] spacing to a slope with a no vetiver [farmer's practice]. The different vetiver grass strips and no vetiver constitute the treatment. Vetiver strips is a vegetative structure, for soil and water conservation that performs engineering functions (bioengineering). During erosion soil particles are detached, moved and deposited at different locations along the slope. Vetiver grass strip on the other hand slows down the velocity of runoff and trap soil sediments. Arising from the above it is assumed that water erosion will impose variability in the physical properties of the soil down the slope.

The result showed that variability in bulk density, total porosity, void ratio and air-filled porosity down slope were low (CV% = <15%), gravimetric moisture content, volume wetness, degree of saturation, available moisture holding capacity of the soil, water volume ration both slopes showed moderate variability (CV% 15≤35). Only vetiver strip treatment at the 15 m on the 30% slope showed high variability for water volume ratio.

Initial one minute infiltration (cm) and cumulative infiltration of the soil after 260 minutes of constant water ponding were, framer's practices (1.87, 84.80), different vetiver grass strip [VGS] 5 m VGS (1.87, 83.07), 15 m VGS (1.90, 87.67), 25 m VGS (2.83, 97.73) on the 20% slope. Initial infiltration showed moderate variability with treatments whereas variability in cumulative infiltration showed low variability. Sorptivity values of both Kostiakov and Philip infiltration models showed high variability. On the 30% slope initial and cumulative infiltration were, farmer's practice (2.36, 82.63), 5 m VGS (2.60, 100.57), 15 m VGS (2.63, 127.80) and 25m VGS (2.90, 84.60). Initial infiltration showed low variability whereas sorptivity and index of soil stability showed low variability, hydraulic conductivity [A] values showed moderate variability.

CONCLUSION

It can be concluded that vetiver grass strip does not impose variability on the selected soil physical properties. Except water volume ratio all physical properties assessed showed low or moderate variability. This implies the different positions of vetiver strips in the field or slope does not pose different management problem. Uniform management techniques that would ameliorate fertility problems of the soil could be adopted, results of the random sampling for properties within the plot and on a treatment or plot can be generalized for the entire land area under the same treatment.

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TABLES

Table 1: Infiltration and its characteristics on farmer's practice and vetiver plots of the 20% slope

	Initial	Cumulative	Kostiakov model			Philip model		
Vetiver Spacing (M)	1 min. infiltration (cm)	Infiltration (cm/260min)	C	α	*r*	s	A	*r*
FP	1.87	84.80	0.21	0.71	0.990	2.03	0.21	0.920
5	1.87	83.07	0.10	0.73	0.987	1.36	0.22	0.980
15	1.90	87.67	0.21	0.71	0.990	2.00	0.22	0.983
25	2.83	97.73	0.30	0.69	0.990	2.42	0.23	0.990
ẍ	2.12	88.32	0.205	0.710	0.989	1.953	0.220	0.968
SD	0.41	5.68	0.071	0.014	0.001	0.380	0.007	0.028
CV%	19.34	6.43	34.63	1.97	0.101	38.00	3.18	2.89
LSD(P<0.05)	NS	NS	NS	-	-	NS	NS	-

NS=not significant, ẍ= mean, SD= standard deviation, CV= coefficient of variability, FP = farmer's practice-no vetiver, C= sorptivity, α= index of soil stability, r = coefficient of correlation, s= sorptivity of Philip model, A= transmissivity.

Table 2: Infiltration and its characteristics on farmer's practice and vetiver plots of the 30% slope

	Initial	Cumulative	Kostiakov model			Philip model		
Vetiver Spacing (M)	1 min. infiltration (cm)	Infiltration (cm/260min)	C	α	*r*	s	A	*r*
FP	2.63	82.63	0.28	0.66	0.987	1.92	0.20	0.807
5	2.60	100.57	0.27	0.71	0.990	2.31	0.25	0.983
15	2.63	127.80	0.23	0.77	0.990	1.95	0.37	0.990
25	2.90	84.60	0.28	0.62	0.987	1.87	0.24	0.907
ẍ	2.69	98.90	0.27	0.69	0.989	2.01	0.27	0.922
SD	0.122	18.078	0.021	0.056	0.002	0.174	0.063	0.074
CV%	4.54	18.28	7.78	8.12	0.20	8.66	23.33	8.03
LSD(P<0.05)	NS	NS	NS	-	-	NS	NS	-

NS=not significant, ẍ= mean, SD= standard deviation, CV= coefficient of variability, FP = farmer's practice-no vetiver, C= sorptivity, α= index of soil stability, r = coefficient of correlation, s= sorptivity of Philip model, A= transmissivity.

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FIGURES

Plate 1.

Plate 1: Photograph showing the treatments in the field.

Plate 2:

Plate 2: Photograph of infiltration runs in the field.