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Full Length Research Paper

Response of *Solanum lycopersicon* to variation in selected physical soil properties under contrasting watershed management systems

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ABSTRACT

Effective management of watersheds particularly in erosion prone areas of Southeastern Nigeria is critical in sustaining the productivity of their agricultural potentials. The influence of selected soil physical properties of managed and unmanaged watersheds and slope gradients *(I-34.8% gradient, II-29.6% gradient, III-23.8% gradient, and IV-0.52% gradient)* on tomato (*Solanum lycopersicon L)* was studied at three soil depths, namely 0-15, 15-30, and 30-45cm. The experimental design was a 2x4x3 factorial arranged in a Randomized Complete Block Design (RCBD). Data obtained were subjected to Analysis of Variance (ANOVA) and significant differences among treatment means were separated using Fisher's least significant difference (LSD). Results showed significant variations in top soil depth, bulk density, particle size fractions and organic carbon under the two management schemes and four slope gradients. Top soil depths in the managed plots were 9.73, 7.66, 8.35 and 8.21cm in the four slope gradients respectively. The corresponding top soil depths in the four slope gradients of unmanaged plots were 1.93, 1.97, 2.93, 8.21cm respectively. Lowest bulk density (1.47Mg M^{-1}) and highest organic C (1.253%) were obtained at slope III of the managed scheme. Clay content was highest (45%) in slope I of the unmanaged watershed and least in slope IV of the same treatment. Also plant height and number of fruits of tomato were significantly higher in the four slopes of the managed plot than the unmanaged plot. These findings clearly demonstrated the significance of proper design and management of our watersheds for sustainable exploitation and ecological stability.

Key words**:** Watershed, slope gradient, soil depth, physical properties, productivity**.**

INTRODUCTION

Watershed management entails the judicious use of soil, water and vegetation to achieve maximum output and at the same time minimize over-exploitation. Most of the African soils show nutrient deficient problem after only a short period of cultivation because of their nature as well as prevailing environmental conditions (Rafi, 1996). Misuse and mismanagement of soil resources often results in widespread degradation of soil and environment leading to low yield. Afyuni *et al*., (1993) reported that the impact of erosion on soil properties at different landscape positions and terrain characteristics including slope and stream-power indices contribute to massive soil and nutrient loss.

Variation in soils across landscape influences crop productivity and watershed hydrology. Coupled with landscape effects on soils, agricultural management systems also affect soil properties including organic matter content (Cambardella *et al.* 2004). Soil erosion is a major factor in the management of the watershed since it affects many critical properties of the soil.

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Cropping can lead to erosion and leaching of soil nutrients (Chisci and Zanchi, 1981). Eroded soils decreases plant yield through increased bulk density, poorer tilt and reduced organic matter content, nutrient availability and water holding capacity. Soil structure is affected by intensity of land use and this has effect on the distribution of microbial biomass as well as microbial processes within the aggregates (Gupta and Germida, 1988).

Topsoil thickness is a major indicator of soil quality and productivity. The physical, chemical and biological properties of this surface horizon govern the reception, storage and the transfer of water and energy.

Hedgerow farming retains the basic restorative attributes of the bush fallow through nutrient recycling, fertility regeneration and weed suppression; and also combines these with arable cropping so that all processes occur concurrently on the same land, allowing the farmer to crop the land for an extended period. Kang et al. (1991) reported that one vital component of alley cropping is the contour hedgerows which have been proven to be effective in reducing soil erosion and restoring soil fertility. Also this study indicated that hedgerow cropping results in improvements in soil chemical properties and nutrient recycling in addition to providing fodder, stakes and firewood.

Tomato (*Solanum lycopersicon* L.) is an annual crop. It belongs to the genus *lycopersicon (L)* and is in the same family (*Solanaceae*) with pepper and egg plant. The family Solanaceae is composed of 85 genera and 2,300 species (Tindall, 1983). It is widely distributed in the temperate and tropical regions of the world. Tomato fruit is an essential component of human diet for the supply of vitamins, minerals and certain types of hormones precursors in addition to protein and energy (Kallo, 1993). Law-Ogbomo and Egharevba (2009) reported that factors that can result in low yield of tomato include unimproved cultivars commonly grown in the tropics, scanty plants, non-use of fertilizer, organic manures and other improved agricultural inputs in the management of the crops.

The objective of the study is to assess the effect of management on some selected soil physical properties as well as their influence on the growth and productivity of tomato.

MATERIALS AND METHODS

This field study was carried out in Awka, Anambra State, South Eastern Nigeria-an area that lies between latitude 06^0 15' north and longitude 070^0 $4^{'}$ east. The study area was divided into managed and unmanaged watershed. The managed system was characterized with terraces separated by earth bunds and stabilized by permanent trees forming hedgerows which are occasionally pruned to add to the organic content of the soil. The unmanaged system was neither terraced nor ridged and was without any erosion control measure. These two management practices were further sub-divided into three soil depths (0-15, 15-30, 30-45cm) and four slope gradients (Slope1-34.8% gradient, Slope2-29.6% gradient, Slope3-23.8% gradient, and Slope4-0.52% gradient).

A bed of 4x2m was made in each slope of the managed and unmanaged plots. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications.

The tomato plant used as test crop was planted in the nursery and was transplanted into the beds four weeks after germination in bundles of fours at the spacing of 1m apart between the replicates. Final plant heights at maturity were determined from randomly sampled and tagged plants of the replicates. Also matured fruits were harvested at weekly intervals and number of fruits produced recorded.

Soil samples were collected from the two different management plots with the aid of

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auger at the depths of 0-15cm, 15-30cm and 30-45cm. The soil samples were air dried and passed through 2mm sieve and stored in sample bags for analysis.

Particle size analysis was determined by the hydrometer method (Klute, 1986). Organic carbon was determined by the dichromate wet oxidation method as described by Klute (1986) while bulk density was determined using core method as described by Anderson and Ingram (1993). Results were subjected to Analysis of Variance (ANOVA) and significant differences among treatment means were separated using Fisher's least significant difference (LSD).

Results

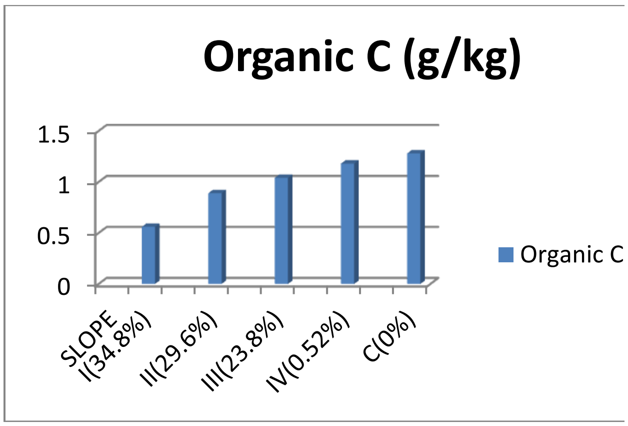


Fig 1: Effect of slope on organic carbon content

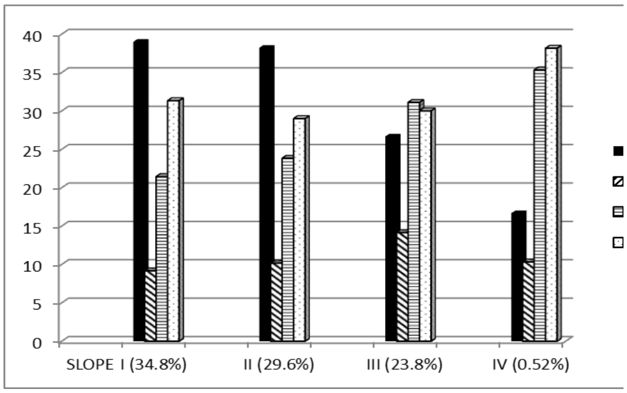


Fig 2: Effect of slope on particle size

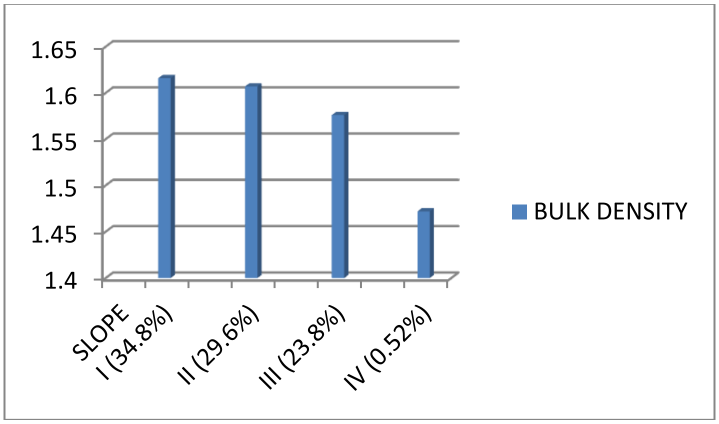


Fig 3: Effect of slope on bulk density

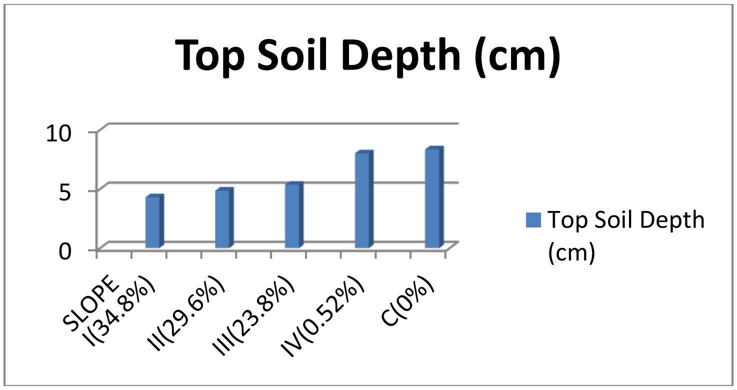
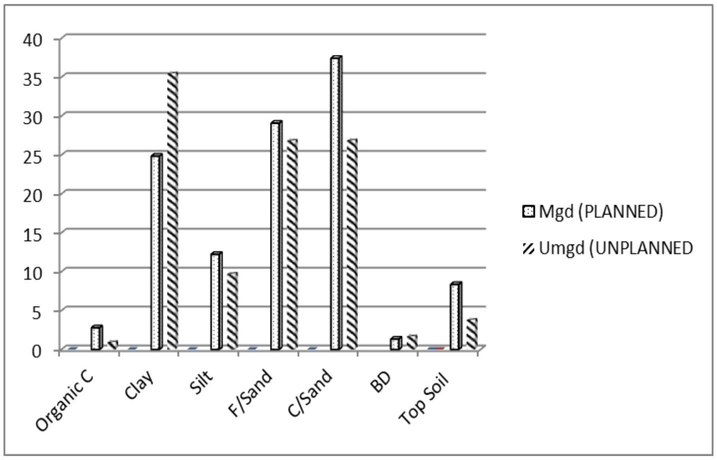


Fig 4: Effect of slope on top soil depth



Mgd= managed plot, umgd= unmanaged plot

Fig 5: Effect of management on organic carbon, particle size, bulk density and top soil depth

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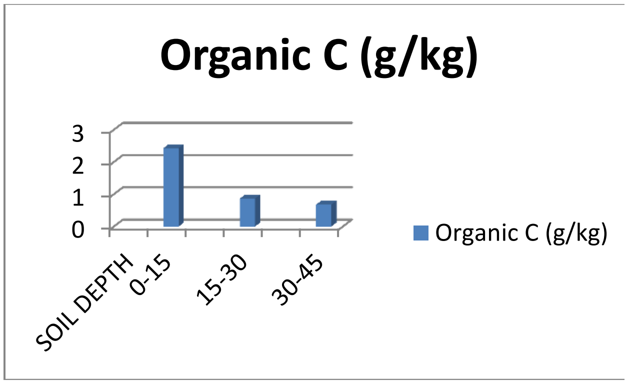


Fig 6: Effect of soil depth on organic carbon content

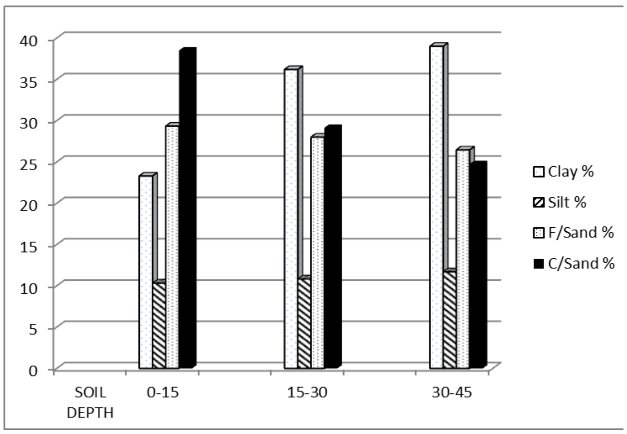
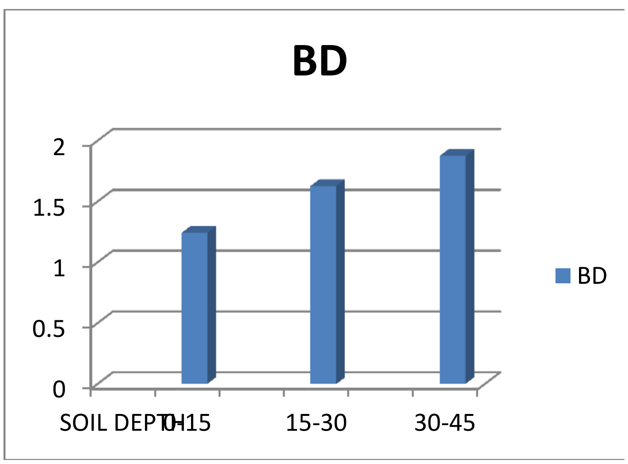
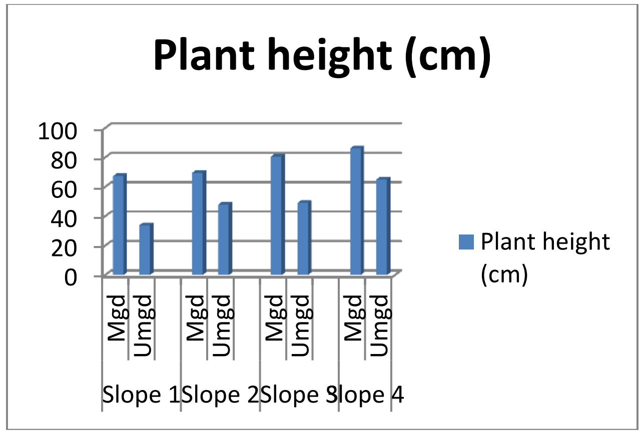


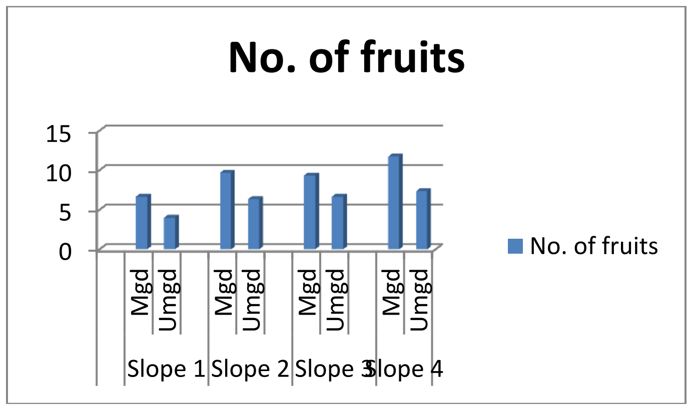
Fig 7: Effect of soil depth on particle size



BD= Bulk density
Fig 8: Effect of soil depth on bulk density



Mgd= managed plot, umgd= unmanaged plot
Fig.9: Effect of management and slope on plant height of tomato



Mgd= managed plot, umgd= unmanaged plot
Fig.10: Effect of management and slope on number of fruits of tomato

DISCUSSION

The influence of slope on the managed (planned) and unmanaged (unplanned) plots of the watershed resulted in increased Organic carbon content down the slopes. From fig.2, percentage fine sand and coarse sand increased down the slope with highest deposits in 0.52% slope gradient (slope IV).

Percentage clay was observed to have decreased down the slope with highest deposits in the upper slopes (34.8% and 29.6%) of the watershed. Erosion and

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flooding emanating from the upper part of the slopes may be responsible for the higher presence of organic carbon content in the lower slopes closer to the stream of the watershed. Increased percentage of clay and silt in the upper slopes may also be attributed to effect of erosion which washed away the top soil of the upper slopes exposing its sub-layer with higher percentage of clay and silt. This agreed with the study by Pruski and Nearing (2002) which indicated that other factors such as land use, result in approximately a 1.7% change in soil erosion for each 1% change in total precipitation under climate change.

Bulk density (fig.3) decreased down the slopes with 0.52% slope (slope IV) recording the lowest bulk density. Also increase in soil depth resulted in increased bulk density (fig 8). This was not the case with top soil depth, which increased down the slope and was highest in the slopes closest to the stream. Erosion which emanates from the upper slopes of the watershed may have carried large amount of humus with nutrients down the slopes depositing them in the lower slopes and often times into the streams of the watershed where large amount of humus and nutrients were lost. Soil nutrient depletion and likely degradation have been considered serious threats to agricultural productivity and have been identified as major causes of decreased crop yields and per capita food production (Henao and Baanante, 2006).

The effect of management (Fig.5) resulted in increased organic carbon content, higher percentage of sand, higher top soil depth (8.35cm) and lower bulk density in managed (planned) watershed than in unmanaged (unplanned) watershed. The increases in organic carbon content and top soil depth with lower bulk density may be ascribed to the decayed plant parts and pruning from the hedgerow trees used in alley across the slopes of the managed (planned) plot as barrier against erosion in the watershed. This finding agreed with the study by Sommerfeldt *et al*. (1988) which reported that organic manure amendments to the soil can improve soil quality by increasing organic matter content, biological activity and aggregation. Also Gonzales and Cooperband (2002) indicated that organic matter provided by pruning from hedgerow species may affect weed population dynamics through the modification of soil physical properties, such as soil water-holding capacity, bulk density, aggregate stability and nutrient content.

Bulk density was lower in managed plot than the unmanaged. This confirmed study by Nnabude and Mbagwu (2001) which reported that Soil organic matter content improves the overall soil quality and reduces the bulk density. Thomas *et al*. (1996) had shown that an increase in organic Carbon content up to around 2.5% in the surface soil of Kentucky silty loam, resulted to a significant reduction in bulk density. Also Oguike and Mbagwu (2009) in a study of organic matter content of the soil under different land use types reported reduction of soil bulk density in a four year fallow system. Hedgerow trees used in the managed (planned) watershed may have prevented erosion from washing away the top soil and nutrients down the slopes.

Higher proportion of percentage silt, fine sand and coarse sand in managed (planned) watershed is an indication of reduction in the speed of erosion occasioned by the presence of the barriers from the earth bounds and hedgerow plants. In the unmanaged watershed, farming activities with unchecked soil erosion and flooding caused major depletion of the topsoil and humus thereby exposing the subsoil which has high clay content and less nutrients. Soil structure is affected by intensive land use and this has effect on the distribution of microbial biomass as well as microbial

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process within the aggregate. Mbagwu and Auerswald (1999) reported that land use influenced structural stability more than intrinsic soil properties and percolation stability of soil increased with increase in organic matter content.

Absence of earth bounds and stabilizing vegetation cover may have exposed the unmanaged (unplanned) to erosion resulting in the depletion of the top soil and exposure of the subsoil with its high clay percentage.

Organic carbon, percentage of sand, silt and clay as well as bulk density were affected by soil depth. Organic carbon content and percentage sand deceased with depth while percentage silt and clay increased depth. This confirmed the study by Cambardella *et al. (*2004) which indicated that coupled with landscape effects on soils, agricultural management systems also affect soil properties including organic matter content.

Data collected from plant heights and number of fruits (Fig.9&10) of tomato showed that there was progressive increase in productivity down the slope of the two management practices. However, managed plots showed significantly higher productivity both in plant heights and number of fruits than the unmanaged plot. These increases recorded in the managed plots may be as a result of higher organic carbon content, top soil depth, lower clay content and reduced bulk density witnessed in the managed plot. These attributes may have been facilitated by the pruning from the hedgerows used in the managed plot. This agreed with Kang and Ghuman (1991) which demonstrated significant positive effects of alley cropping on soil fertility parameters such as organic C levels, total N and extractable P levels over a range of climatic and soil conditions.

Management of watershed has resulted in increased organic carbon content, top soil depth, sand fraction and reduced bulk density in the managed plot of the watershed. Lack of management exposed the unmanaged watershed to invasive action of erosion resulting in increased silt, clay, bulk density and decreased organic carbon content and top soil depth which affected the productivity of the test crop.

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