



**ASSESSMENT OF SOIL PROPERTIES ALONG A TOPOSEQUENCE IN KASHERE, GOMBE STATE,
NORTHERN GUINEA SAVANNA**

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ABSTRACT

A study was conducted along a toposequence at the Teaching and Research Farm, Faculty of Agriculture, Federal University of Kashere, to determine the physical and chemical properties of the soils and their suitability class. Three profile pits (2m x 1.5m x 2m) were dug at upper, middle, and lower slope positions. Soil samples were collected from every slope position. Undisturbed core soil samples were taken for bulk density determination, while disturbed samples were used for analyzing texture, particle density, total porosity, pH, cation exchange capacity (CEC), electrical conductivity (EC), available phosphorus, total nitrogen, organic carbon, and exchangeable bases. Results showed high variability (>35%) in most soil separates except for sand and exchangeable sodium percentage (ESP), which had low variability (<15%), making the textural class predominantly sandy loam. Total porosity, bulk density, and particle density values had low variability (<15%). Bulk density was favorable (less than 1.6g/cm³) for crop production, but total porosity was marginally suitable (below 45%-50%). pH variability was low, while organic matter, total nitrogen, available phosphorus, sodium, and CEC varied marginally. Magnesium, calcium, potassium, EC, and ESP had high variability. Available phosphorus, total nitrogen, organic matter, and CEC were low. The soils were acidic with moderate to high concentrations of exchangeable bases. EC and ESP values indicated non-saline and non-sodic soils. Terrace farming on middle slopes and strategic fertility management, including integrated organic and inorganic fertilizers, are recommended for sustainable agricultural productivity at the Teaching and Research Farm, Federal University of Kashere, Gombe State.

Keywords: Soil chemical properties, soil physical properties, toposequence, terrace

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INTRODUCTION

The productivity of a soil depends on its physical, chemical, and morphological properties. These properties are a result of interaction among soil forming factors and processes [1, 2]. Therefore, it is very important to understand the dynamics and distribution of soil properties, which are decisive factors in assessing land use and management for sustainability [3, 4]. For sustainable utilization and proper management of soils, understanding their properties and their variation is very important [1]. Of the five soil forming factors, topography is reported to significantly affect soil properties by numerous studies. Topography has effect on soil physical and chemical properties and influences the pattern of soil distribution over landscape even when soils are developed from the same parent material [5, 6, 3]. The distribution of clay contents, sand and soil pH on a landscape is affected by the position of the slope in an area. Differences in soil properties due to slope position differ due to degree of deposition and transportation of soil materials [7, 8]. The variation in

soils along topography leads to very shallow and gravelly soils on hills or steep slopes due to the minimal rate of weathering and high removal of soil by erosion, whereas soil on gentle slopes allows ample infiltration of water and develops into deep profiles [9]. Many studies also reported the influence of topography on soil texture, organic carbon (OC) and cation exchange capacity (CEC) in soils of Africa [10, 11]. Some part of the Teaching and Research farm of Federal University of Kashere consists of slopy terrain which is used for crop production. Gombe State including Kashere has insufficient soil data required for providing management practices to attain food security. Previous studies [12, 13, 14] have focused on the assessment of soil properties under varying land uses and management practices and their suitability for crop production. The major factor limiting agricultural productivity is insufficient detailed information on soil properties and quality [15]. Information on the effect of topography on soil properties and quality for crop production in Nigeria is inadequate. However continuous decline in yield is evident in many areas including the study area. The decline in yield could be

attributed to low soil fertility status, improper soil conservation measures and soil quality related issues such as salinity and sodicity. Knowledge of the impact of topography on soil properties and quality and the inherent soil characteristics and their limitations, will help to determine the kind of management practices necessary to prevent problems and overcome them where they are already evident [16,17]. This study would, therefore, provide information which will help to improve potentials of the soil at the Teaching and Research Farm Faculty of Agriculture Federal University of Kashere, Gombe State Nigeria and ultimately enhance its productivity and sustainability.

MATERIALS AND METHODS

Description of the experimental site

The study was conducted at the Teaching and Research Farm Faculty of Agriculture, Federal University of Kashere located in Akko Local Government Area of Gombe State, Nigeria. The study area is situated at the southern part of Gombe metropolis on latitudes 10.2800° North of the equator and longitudes 10.9500° East of Greenwich meridian and 431 metres above sea level. It is in the Sudan Savannah zone of Nigeria, which lies in the Dry Sub-Humid Azare – Gombe Yola Plain of Nigeria [18].

Geology of the study area

The geology of the study area is developed on basement complex rocks with adjoining sedimentary rocks formation [19]. The Gombe Formation is the youngest Cretaceous lithostratigraphic unit in the N-S trending Gongola sub-basin of the Northern Benue Trough [20,21]. It unconformably overlies Fika Shale and is overlain by Palaeocene Keri- Keri Formation [22]. The lithologic units of the Gombe formation are divided into three [23]: basal interbedded unit, middle bedded facie and upper red sandstone facies. The Gombe formation is regarded as Maastrichtian in age [24,25,20].

Climate of the experimental site

The area has a tropical climate as defined by Wladimir Koppen, with distinct wet and dry season [26]. The area records about three to four months of rainfall concentrated in the months of July, August, and September with the average annual rainfall of 951 mm per annum [27]. The mean annual temperature ranged from 30 - 37°C, while March, April and May were observed to be the dry hot months of the year. During the rainy season, the temperature drops considerably due to the cloud cover between July and August as well as during the harmattan periods of November to February [27].

Soil and vegetation cover of the experimental site

The soil of the study area falls within the Leptosols, Cambisols and Luvisols of the Pindiga formation [26]. It is deep, whitish, clay loam and free from concretions and stones. It is well drained, with good moisture holding capacity [28]. The vegetation cover of the study area is characterized by few trees such as shear butter, baobab, mango, locust bean trees, and shrubs with scattered grasses [28].

Land use and human activities

The land use pattern in Kashere varies from residential, educational, commercial, transportation and agricultural [29]. The residential land use represents the largest land use in Kashere. The economic activities of the local community (Kashere) are characterized by mixed farming systems that involve arable crops and livestock subsistence farming [29].

Soil sampling and handling

A profile pit, with dimensions 2m long, 1.5m wide, and 2m deep, was dug on each identified geomorphic surface, viz: upper, middle, and lower slope positions at the study site. Soil samples were collected from the three geomorphic locations. The collected soil samples were then properly labelled in polythene bags and taken to the laboratory for analysis of the parameters below.



Figure 1: One of the dug profile pits

Laboratory analysis

For determining the physicochemical characteristics of the soil, soil was air dried, gently crushed and passed through 2mm sieves; however, samples for organic carbon were ground to pass 0.5mm size sieves. From undisturbed soil samples obtained using core samples and the procedures, the bulk density of the soil was estimated [30]. The particle size distribution was determined according to the procedure outlined by

Bouyoucos [31]. Particle density of the soil samples was determined after the removal of entrapped air in soils using the pycnometer method as described by Blake and Hartge [32]. Total Porosity was computed mathematically using the formula below from bulk and particle density data obtained as described by Anderson and Ingram [33].:

$$Tp = 1 - (Bd/Pb) \times 10$$

Where:

Tp = Total Porosity

Bd = Bulk Density and

Pb = Particle Density

The pH of the soil was measured potentiometrically with a digital pH meter in the supernatant suspension of 1:2.5 soil water solution [34]. In the study by Walkley and Black [35], the wet digestion method was used to determine the soil organic carbon content and percent soil organic matter was obtained by multiplying percent soil organic carbon by a factor of 1.724 [36]. Total nitrogen was determined using the Micro-Kjeldahl digestion, distillation, and titration method as described by Abure [37] by oxidizing the organic matter in concentrated sulfuric acid solution (0.1 NH_2SO_4). Available soils phosphorus was extracted by Mamo *et al.* [38], the method quantified using a spectrophotometer (wavelength of 880 nm) calorimetrically using Vanadomolybdate acid as an indicator. Cation exchange capacity and exchangeable

bases (Ca, Mg, K, and Na) were determined after extracting the soil samples with ammonium acetate (1N, NH_4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were determined using an atomic absorption spectrophotometer, while Na and K were determined using a flame photometer [39]. Cation exchange capacity was thereafter estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution [39]. Exchangeable sodium percentage was computed using the formular:

$$\text{ESP} = \frac{\text{Exchangeable Sodium Ions (Na)}}{\text{Cation Exchange Capacity (CEC)}} \times 100$$

Electrical Conductivity (EC) was determined in a 1:5 soil water extract at 25 °C using a conductivity meter [40].

Suitability class of the soil

The suitability class of the soil was determined based on the quality criteria [40, 60, 61, and 16] provided in Table 8.

Data analysis

The data obtained was subjected to simple descriptive statistics using Mean, Standard Deviation (SD) and Coefficient of Variation (CV) as described by [41].

RESULTS

Table 1: Particle size distribution and textural class of soil across the study area

Locations	%Sand	%Silt	%Clay	Textural Class
US	65.75	13.25	21.00	Sandy Clay Loam
SD	0.24	0.04	0.115	
MS	66.52	16.98	16.50	Sandy Loam
SD	0.08	0.02	0.08	
LS	66.75	17.00	16.25	Sandy Loam
SD	1.67	0.70	0.04	
Mean	66.34	15.74	17.92	Sandy Loam
SD	3.68	5.57	5.71	
CV(%)	5.54	35.37	31.86	

US= upper slope; MS = middle slope; LS = lower slope; SD = Standard Deviation, CV = Coefficient of Variability, where < 15%= least Variable; 15-35% = Moderately Variable; >35% = Highly Variable

Table 2: Physical parameters of soil across the study area

Locations	Bulk Density (gcm ⁻³)	Particle Density (gcm ⁻³)	Porosity (%)
US	1.4700	2.6025	43.51
SD	0.02	0.28	0.11
MS	1.4875	2.6425	43.65
SD	0.01	0.25	1.25
LS	1.5450	2.7350	43.30
SD	0.11	0.21	1.89
Mean	1.5008	2.6600	43.49
SD	0.0939	0.1308	3.94
CV (%)	6.25	4.92	9.06

US= upper slope; MS = middle slope; LS = lower slope; SD = Standard Deviation, CV = Coefficient of Variability, where < 15%= least Variable; 15-35% = Moderately Variable; >35% = Highly Variable

Table 3: Organic carbon, total nitrogen, and available phosphorus status of soil across the study area

Locations	Organic Carbon (g/kg)	Organic Matter (g/kg)	Total Nitrogen (g/kg)	Available Phosphorus (mg/kg)
US	2.9293	3.950	0.6543	4.580
SD	0.05	0.03	0.04	0.04
MS	1.305	2.250	0.511	5.817
SD	0.02	0.05	0.04	0.01
LS	1.998	3.450	0.8722	4.798
SD	0.01	0.38	0.10	0.04
Mean	1.865	3.217	0.6793	5.065
SD	0.868	1.495	0.18	1.313
CV (%)	46.52	46.49	27.08	25.93

US= upper slope; MS = middle slope; LS = lower slope; SD = Standard Deviation, CV = Coefficient of Variability, where < 15%= least Variable; 15-35% = Moderately Variable; >35% = Highly Variable

Table 4: Exchangeable bases and CEC of soils across the study area

Locations	Ca ²⁺ cmol(+)kg ⁻¹	Mg ²⁺ cmol(+)kg ⁻¹	K ⁺ cmol(+)kg ⁻¹	Na ²⁺ cmol(+)kg ⁻¹	CEC cmol(+)Kg ⁻¹
US	2.200	0.900	0.1900	0.0390	1.342
SD	0.13	0.21	0.03	0.01	0.05
MS	1.820	1.230	0.2163	0.04284	1.631
SD	0.09	0.19	0.04	0.03	0.07
LS	1.525	0.606	0.2301	0.04474	1.496
SD	0.11	0.18	0.02	0.01	0.08
Mean	1.848	0.912	0.2121	0.0422	1.490
SD	0.668	0.603	0.0797	0.0298	0.420
CV (%)	36.12	66.13	37.55	23.57	28.18

US= upper slope; MS = middle slope; LS = lower slope; SD = Standard Deviation, CV = Coefficient of Variability, where < 15%= least Variable; 15-35% = Moderately Variable; >35% = Highly Variable

Table 5: Salinity/sodicity indicators of soil across the study area

Locations	pH	EC dSm ⁻¹	ESP (%)
US	6.6150	1.313	2.91
SD	0.20	0.60	0.09
MS	6.422	2.025	2.63
SD	0.19	0.53	0.10
LS	6.485	1.788	2.99
SD	0.18	0.47	0.12
Mean	6.5075	1.708	2.82
SD	0.2812	0.838	0.13
CV (%)	4.32	49.04	4.70

US= upper slope; MS = middle slope; LS = lower slope; SD = Standard Deviation, CV = Coefficient of Variability, where < 15%= least Variable; 15-35% = Moderately Variable; >35% = Highly Variable

Table 6: Fertility rating of soil by [46]and [40]

Parameter	Rating		
	Low	Medium	High
OC (gkg ⁻¹)	<10	10-15	>15
P (mgkg ⁻¹)	<10	10-20	>20
N (gkg ⁻¹)	<1.5	1.5-2	>2
Ca (cmol (+) kg ⁻¹)	<2	2-5	>5
Mg (cmol (+) kg ⁻¹)	<0.3	0.3-1	>1
K (cmol (+) kg ⁻¹)	<0.15	0.15-0.30	>0.30
Na (cmol (+) kg ⁻¹)	<0.1	0.1-0.3	>0.3
CEC (cmol (+) kg ⁻¹)	<6	6-12	>12
%BS (%)	<20	20-60	>60
pH (H ₂ O)	Acidic	Neutral	Alkaline

Table 7: Classification of salt-affected soils

Criteria	Normal	Saline	Sodic	Saline-sodic
EC (dSm ⁻¹)	<4.0	≥4.0	<4.0	≥4.0
ESP (%)	<15	≤15	>15	>15
pH	< 8.0	< 8.5	>8.5	<8.5

Source [59, 40 and 16]

Table 8: Suitability classes of soils

Parameter	Degree of restriction on use		
	None	Moderate	Severe
EC (dS/m)	<0.75	0.75-4.0	>4.0
ESP (%)	<5	5-15	>15
pH	<7.5	7.5-8.5	>8.5

Source: [40, 60, 61, and 16]

DISCUSSION

Soil physical properties:

Particle size distribution and textural class of soils from the study area

The particle size distribution and textural class of the soils is shown in Table 1. The results indicate that the sand, silt, and clay contents ranged from 65.75-66.75%, 13.25-17% and 16.25-21% with corresponding means of 66.34%, 15.74% and 17.92% respectively. The content of all the separates is highly variable (>35%) with locations except for sand which has a low variability (<15%) across the location, thus making the textural class of the locations dominantly sandy loam. The highest percentage of sand was observed in lower slope, this could be attributed to the movement of sand particles caused by wind, gravity, and runoff water. The result agreed with the report of [2] that movement of soil particles by run-off water and gravity affect soil distribution over a landscape. Generally, the study area was dominated by sand; the high percentage of sand may be due to the parent material rich in quartz mineral [42]. The trend of the distribution was in the following order, lower slope, > middle slope > upper slope. This corroborated with earlier reports of high sand content in soils of Gombe by Jimoh and Suleiman [14].

Bulk density

The bulk density (BD) of the soil profiles varied from 1.4700gcm^{-3} - 1.5450gcm^{-3} with corresponding mean of 1.5008gcm^{-3} as shown in Table 2. The bulk density across the locations is least variable (<15%). Bulk density values across the entire location were rated low and were less than 1.60gcm^{-3} and will support root growth and development as opined by Odunze and Kureh [43]. Bulk density increased down the topography and it agrees with the findings of Hu and Lian [6], who also reported higher BD in soils of flat valley positions. The higher BD in the lower slope could be attributed to the higher silt content due to the transportation of fine materials from the upper slope, tramping and continuous cultivation [44].

Particle density

The particle density of soils in the study is shown in Table 2. Values obtained ranged from 2.6025gcm^{-3} - 2.7350gcm^{-3} across the slopes with a corresponding mean of 2.6600gcm^{-3} and it observed to be least variable (<15%) across the locations. The results

indicate that the particle density in the middle and lower slopes is relatively higher than that of the upper slope. This could be attributed to the higher silt content due to the transportation of fine materials from the upper slope [44].

Total porosity

The total porosity values ranged from 43.30 - 43.65% with a corresponding mean of 43.49% across the locations. Porosity values of the middle slope are relatively higher than that of the other locations. This could be attributed to more activities of microorganisms in soils of the middle slope which increase aggregation. Porosity of 45- 50% volume is good for agricultural soils [45]. The porosity values recorded in all locations falls below the ideal porosity value.

Soil chemical properties:

Organic carbon (OC) and organic matter (OM)

The content of organic carbon, total nitrogen, available phosphorus, and organic matter are shown in Table 3. The values for organic carbon ranged from 1.305 - 2.930gkg^{-1} with mean value of 1.865gkg^{-1} across the locations. The values for organic matter ranged from 2.250gkg^{-1} - 3.950gkg^{-1} with mean value of 3.217gkg^{-1} across the locations. Soil OC and OM content for all the locations were rated low across all the slope as their values were lower than 10gkg^{-1} (reference). However, the status of OC and OM in soils of the study were highly variable (>35). The low content of OC and OM could be attributed to the steep slope terrain of the site, which supported the erosion of soils in the surface, resulting in the loss of both organic carbon and organic matter [14]. The low content of OC in the soils could also be due to bush burning, continuous cultivation and overgrazing, which destroy organic materials that would have contributed to soil organic matter [14].

Total nitrogen (TN)

The concentration of total nitrogen (TN) in soils of the study site varied moderately (15 - 35%) across the locations and the values ranged from 0.511 - 0.8722gkg^{-1} (mean = 0.6793gkg^{-1}). The concentration of nitrogen in the study area is also considered to be generally low based on the rating of Esu and Landon [46,40] in Table 6 below. The low value of total nitrogen could be ascribed to the influence of continuous cultivation, crop residue removal, bush burning and low levels of N-fertilizer application

[47]. Hu and Lian as well as Seifu *et al.* [6, 48] reported higher TN in lower slope positions and were attributed to the erosion process that transports organic humus, a major source of nitrogen. Organic carbon in the soils was reported to contribute 95% of the TN content in the soils as also reported by Walworth [49] in a similar study. Similarly, the higher TN value on the lower slope could be attributed to the low temperature conditions, which decreased the volatilization of TN [50]. The low content of TN on the middle slope was attributed to soil erosion, continuous cultivation, plant uptake and volatilization [50].

Available phosphorus (Ap)

The available phosphorous (Ap) status varied moderately (15 - 35%) with locations as shown in Table 3. The Ap on the middle slope recorded the highest value, followed by lower slope. The content of Ap ranged between 4.580 - 5.817 mgkg⁻¹ (mean= 5.065 mgkg⁻¹) across the locations. The available P status of soils of the area is observed to be generally low (<10 mgkg⁻¹) according to the rating by Esu and Landon [46, 40] in Table 6. Similar low values were reported by Ibrahim and Uma, Abba *et al.* [12, 13] in their studies at different locations in Gombe State. The low P value obtained in the study might be due to continuous removal of P through crop harvest without sufficient replenishment.

Exchangeable bases

The data obtained for exchangeable bases of soils in the study area are shown in Table 4. The results obtained, showed that Ca and Na in the soils were rated low; while K and Mg were regarded to be moderate based on the rating presented by Esu and Landon [46, 40] in Table 6. The variability of the exchangeable bases across the locations is observed to be generally high (>35%) except Na which varied marginally (15 - 35%) with locations. The exchangeable bases followed the order $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^{+} > \text{Na}^{+}$ and their distribution in cmol (+) kg⁻¹ in the various locations ranged from 1.525 - 2.200 (mean = 1.848) for Ca; 0.606 - 1.230 (mean = 0.912) for Mg; 0.1990-0.2301 (mean = 0.2121) for K; and 0.0390-0.04474 (mean = 0.0422) for Na. The dominant exchangeable bases in the soils are Ca and Mg. The status of Mg is observed to increase from upper to middle and decreases at lower slope. This collaborated the studies by Abba *et al.* [13] and Jimoh *et al.* [14] who reported the dominance of Ca in soils of Gombe. The predominance of Mg may be due to the presence of Mg bearing parent material. The higher content of exchangeable Mg in the Upper and middle slopes

could be attributed to the low erosion of basic cations due to the stable topography compared to the slope terrain of the lower slope, which favours erosion [12, 3]. The higher K content in the lower slope could be attributed to the transportation and deposition of soluble K⁺ from the upper slope [14]. The low Ca and K obtained in the study might be due to leaching of these ions to lower depths by percolating soil water. The trend of distribution of basic cation in good agricultural soils are in order of $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^{+} > \text{Na}^{+}$ and any change from this trend can cause nutrients imbalance problems for plants [51]. Fortunately, the distribution of basic cations in soils of the study area follow the aforesaid trend.

Cation exchange capacity (CEC)

The results obtained for CEC is also shown in Table 4. CEC varied moderately (15 - 35%) with locations. The data obtained for CEC in cmol (+) kg⁻¹ in the study area ranged from 1.342 - 1.631 (mean = 1.490). The CEC values of soils obtained in the study area were generally low for all the locations, based on the rating by Esu and Landon [46, 40] presented in Table 6. The low CEC values may be attributed to the very low clay and organic matter contents of the soils. Singh *et al.* [52] reported that, soil with high organic matter content is expected to have higher, CEC than the soil with low organic matter. The intensive cultivation and application of acid-forming fertilizers may have reduced the amounts of exchangeable bases, which may be the cause of the lowest mean of CEC.

Salinity/Sodicity Indicators of the Soil:

Soil pH

The soil pH ranged from 6.422 - 6.6150 (mean= 6.5075) (Table 5). The variability of soil pH is regarded to be low (<15%) with locations. The pH could thus be regarded as uniform across the soil profiles. The pH values of soil obtained in upper, middle, and lower slopes were rated neutral. The acidic nature of the soils could be attributed to the removal of basic cations from the surface of the soil to lower depths as observed by Mustapha and Locks, Voncir *et al.* and Kolo *et al.* [53, 54, 55] and or the use of acid-forming fertilizer such as urea for agricultural purposes in the study area to boost yield. The result obtained agrees with earlier reports by Mustapha, Kawu and Voncir *et al.* [56, 16, 57].

Electrical conductivity (EC)

The EC of soil of the study ranged from 1.313 - 2.025 dSm⁻¹ across the soil profiles with the corresponding mean of 1.708 dSm⁻¹ respectively. The variability of EC is observed to be high (>35%). The EC of the soil was medium for all the locations (0.7 – 4dSm⁻¹) signifying a non-saline condition. In terms of degree of restrictions on use the EC values of the soils falls much lower than the acceptable limits described as critical for salinity hazard presented in Table 7. Similar results were obtained by Mustapha, Kawu and Sharu *et al.* [56, 16, 45].

Exchangeable sodium percentage (ESP)

The ESP values obtained ranged from 2.63 – 2.99% for all locations with mean of 2.82% respectively. The ESP of the study area (upper, middle, and lower slope) varied low with location <15%. The percentage of the exchange site occupied by sodium ions is termed exchangeable sodium percentage (ESP). ESP values exceeding 15% can decrease soil permeability and inhibit plant growth. Fortunately, the values recorded in the study area were below the degree of restriction on use (<5) presented in Table 7. Kawu [16] reported similar results for some soils in Gombe states.

Suitability class of the soil

The quality criteria in Table 8 provides the critical limits for EC (dSm⁻¹), ESP (%) and pH respectively for classification of salt affected soils as <4.0, <15 and < 8.0 for normal ≥4.0, ≤15 and < 8.5 for saline, ≥4.0, > 15 and < 8.5 for saline sodic, and < 4.0, > 15 and > 8.5 for sodic soils. Based on these criteria, the soil of the study area could be classified as normal. The soil is thus, free from both salinity and sodicity hazards. The findings of this study agree with the reports of Kawu [16] and Voncir *et al.* [58] who reported that the fadama soil irrigated with surface water in Gombe and Sokoto along perennial surface water bodies were found to be free from both salinity/sodicity hazards.

CONCLUSION

From the results obtained in this study, it can be concluded that the fertility status of the soils is low, and all the chemical parameters evaluated in the study area were influenced by topography except pH which shows low variability across the locations. On the other hand, physical properties evaluated in the study were not significantly influenced by

topography. Furthermore, the soils were found to be non-saline and non-sodic in nature. Terrace farming on steep slope areas (middle slope) rather than on gentle slope sites (upper and lower slope) and conscious strategic fertility management particularly integrated application of organic and inorganic fertilizers are recommended for sustainable agricultural productivity of the Teaching and Research farm of Federal University of Kashere, Gombe State.

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