EVALUATION OF SOIL QUALITY UNDER DATE PALM PLANTATION FOR CLIMATE CHANGE AND FOOD SECURITY IN GOMBE STATE UNIVERSITY, GOMBE NIGERIA

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Abstract

Soil quality and fertility are of fundamental importance in sustainable agricultural production and are increasingly becoming central in policy decisions on food security, environmental management and climate change mitigation. This study aimed at evaluating soil quality under date palm plantation for climate change and food security in Gombe State University, Gombe state, Nigeria. The study area was demarcated into two slope classes; upper and middle slope. The slope classes were subdivided into four classes, five soil samples were taken at the four corners and center of each subclass and bulked to give a composite sample per square. Eight (8) composite samples were collected using a soil auger at a depth of 30 cm and were analyze using standard methods. The result shows that sand dominate the soil fractions. Textural class for upper slope was sandy loam to loamy sand while middle slope was dominated with loamy sand. Silt/clay ratio was above 0.25 indicating that the soils are relatively young with high degree of weathering potential. The soil pH for both slope class ranges from 6.18 - 6.40 were slightly acid and optimal for nutrient uptake by plant roots. Organic carbon (3.5 – 7.2 gkg^{-1}) was low with upper slope recording higher value (7.2 gkg^{-1}), total nitrogen value of 1.05 - 1.75 gkg^{-1} was low to medium, available phosphorus (Ap) value of 10.56 – 51.29 $mgkg^{-1}$ were rated high with the middle slope recording higher value. Soil carbon stock was 22.13 t C/ha and 20.08 t C/ha for upper and middle slope respectively, while percentage soil quality value of 60% and 53% was recorded for upper and middle slope respectively, similar to carbon stock trend. The soils are moderate in quality and have higher potential to sequester more carbon to stabilize gully erosion and support crop production for climate change mitigation and food security.

Key words: *date palm, soil quality, carbon sequestration, climate change.*

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Introduction

Land degradation is a reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation" (WHO, 2005). One of the ways to reduce the impact of land degradation is through Afforestation programs. Forests have been the basis for civilization and supports human life. However, with population growth, forests have been cut down and are gradually decreasing. The decrease in tropical rainforests had already begun in the 1970s when many developing countries began exploiting forests to pursue economic growth. In the world, 80 percent of deforestation is concentrated in three areas: Brazil, Indonesia and Tropical Africa where Nigeria is located. (Jica World, 2016)

Deforestation has led to increase in greenhouse gas such as carbon dioxide emission which results in global warming. In the 1990s, about 20 percent of carbon dioxide emission was due to deforestation. Conversion of natural to agricultural ecosystems causes depletion of the soil organic carbon (SOC) pool by as much as 60 per cent in soils of temperate regions and 75 per cent or more in the cultivated soils of the tropics (Lal, 2004). The depletion is exacerbated when the output of carbon (C) exceeds the input and when soil degradation is severe. Thus, the importance of forest conservation for reducing the emission of greenhouse gases such as carbon dioxide began to be realized. Forest conservation prevents global warming while contributing to maintaining biodiversity and enabling local communities to benefit from the forests. Nevertheless, the effects are somewhat indirect and require much time to be visible. If developing countries can receive economic support for not cutting down trees, this will create direct and short term benefits for forest conservation.

Carbon sequestration implies transferring atmospheric CO_2 into long-lived pools and storing it securely so it is not immediately re-emitted. Thus, soil C sequestration means increasing SOC and soil inorganic carbon stocks through judicious land use and recommended management practices (Lal, 2005). Some of these practices include mulch farming, conservation tillage, agroforestry and diverse cropping systems, cover crops and integrated nutrient management, including the use of manure, compost, biosolids, improved grazing, and forest management. The potential carbon sink capacity of managed ecosystems approximately equals the cumulative historic C loss estimated at 55 to 78 gigatons (Gt) (Lal, 2004). Offsetting fossil-fuel emissions by achievable SOC potential provides multiple biophysical and societal benefits. The soil organic carbon (SOC) pool to 1m depth ranges from 30 tons' ha^{-1} in the arid climates to 800 tons' ha^{-1} in organic soils in cold regions. An increase of 1 ton of soil carbon of degraded cropland soils may increase crop yield by 20 to 40 kg ha^{-1} for wheat, 10 to 20 kg ha^{-1} for maize, and 0.5 to 1 kg ha^{-1} for cowpeas, and could enhance world food security (Lal, 2004). Gombe state is located within Sudan savanna vegetation type which is characterize by few scattered trees and grasses and proximal to Sahara desert is prone to desertification and land degradation due to gully erosion. Mbaya et al (2012) reported that gullies has become one of the greatest environmental disasters facing Gombe town and its fast becoming hazardous for human habitation and the university environment inclusive. The University in 2005 established a date palm plantation so as to conserve the environment through afforestation to reduce the adverse effects of land degradation and desert encroachment, offsetting CO_2 in the atmosphere, increasing the amount of SOC in the soil to reduce gully intensification and campus beautification. This study was conceived so as to assess the quality of the soil after 14 years of establishing the plantation. This study will also assess the potential of the date palm to sequester soil carbon sequestration for climate change and food security.

Materials and Methods

Study Area

This study was conducted in Gombe State University, Gombe town is located between latitudes 10º 15'30" to 10º 17′ 30" N and longitudes 11º 8′ 0" E and 11º10′ 30" E (Figure 1 and 2). It shares common boundary with Akko LGA in the South and West; Yamaltu-Deba to the East and Kwami to the North. It is the capital of Gombe State and occupies an area of about 45km^2 (Ministry of Land and Survey, Gombe, 2008). The climate of Gombe is characterized by a dry season of six months, alternating with a six months rainy season. As in other parts of the Nigerian Savanna, precipitation distribution is mainly triggered by a seasonal shift of the Inter -Tropical Convergence Zone (ITCZ). For the years 1975 to 2014, the mean annual precipitation was 863 mm (Abashiya et al., 2017) and the mean annual temperature was about 32°C whereas relative humidity is highest (94%) in August and dropping to less than 10% during the harmattan period (Balzerek et al., 2003).

The relief of the town ranges between 650 m in the western part to 370 m in the eastern parts. Subsequent dissection and stream incision in the area have carved a landscape consisting of flat topped to conical hills, a granitic residuals and pediment landscape. The stratigraphy consists of the alluvium, the Cretaceous Sedimentary Formations of Kerri Kerri Formation, the siltstone, sand stone and

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ironstone of the Gombe Formation, the shale and limestone of the Pindiga and Yolde Formation, Bima Formation and the basement rocks (Obaje, 1999). The vegetation of the study site was dominated by tree species such of mango, baobab, neem, acacia and palm date.

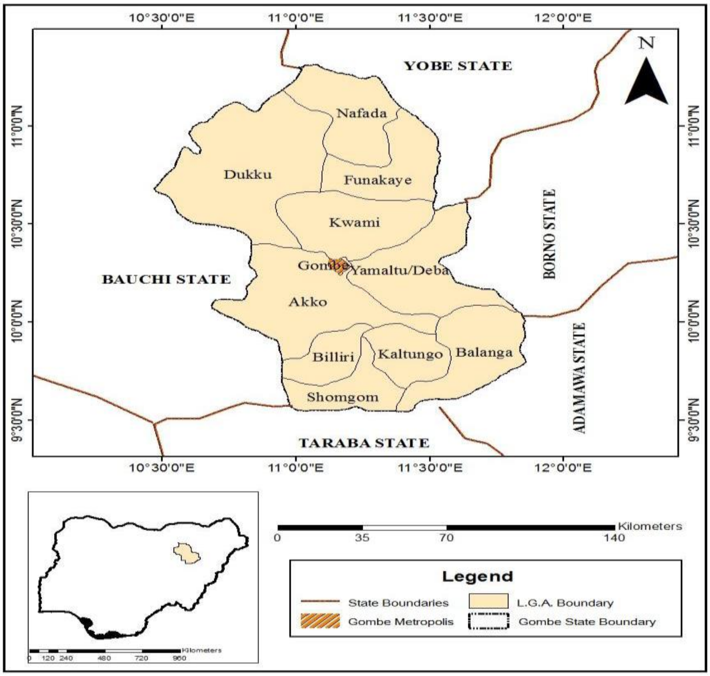

Figure 1
Map of Gombe State showing Gombe Metropolis.

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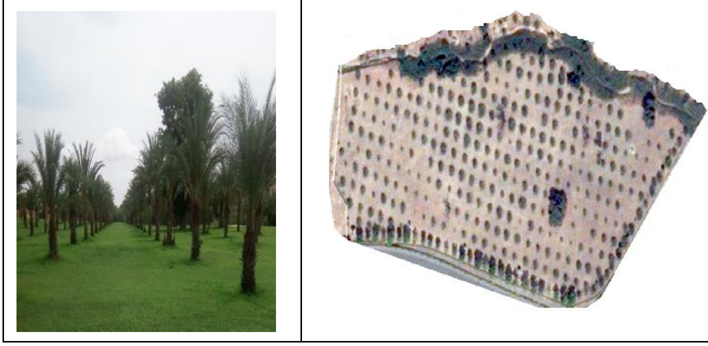

Figure 2
Side and aerial view of the Date Palm Plantation in Gombe State University.

Soil sampling and Laboratory analysis

The Date plantation was established by the University management in 2005 for campus beatification, date palm production and to encourage people within the environment to go into economic tree plantation and to serve as wind break. The entire study area was about 0.04km^2 (3.6 ha) and demarcated into two slope classes; upper and middle slope. The two slope classes were systematically subdivided into four classes each at distance/interval of 0.03km, five soil samples were taken at the four corners and center of each subclass and bulked to give a composite sample per square. Eight (8) composite samples were collected using a soil auger at a depth of 30 cm as based on IPCC guidelines. The composite soil samples from each plot were air dried, crushed lightly, and then passed through a 2mm sieve. The less than 2 mm fractions were used for soil physicochemical analyses. Particle size distribution was determined by the hydrometer method (Gee and Bauder, 1979). Bulk density was determined using the core sampler (Blake and Hartge, 1986). Soil pH was measured in water and (1:2.5 w/v) using glass electrode pH meter (Agbenin, 1995). Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (Nelson and Sommers, 1982). Available Phosphorus was determined using Bray 1 method (IITA, 1979) and Total Nitrogen was determined by the kjeldahl method (Bremner and Malvaney, 1982). Exchangeable bases (calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) in the soil were determined using the ammonium acetate extract. Sodium and K were determined using flame photometer while Ca and Mg was determined using atomic absorption spectrometer. ECEC by total summation of exchangeable bases and acidity. Base saturation was calculated as the sum of total exchangeable bases divided by effective cation exchange capacity (Agbenin, 1995). The soil was analysed at the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria.

Soil Quality Evaluation

Soil quality was evaluated using the Tropical Soil Quality Index (TSQI) described by Arifin *et al.* (2012) to determine soil quality index under the forest tree species. This method is largely suitable for tropical soils as it considered acidic nature of the soil in choosing method of soil analysis. The method uses a scoring of 0 – 2, where soil properties with sufficient amounts receive higher score (2 or 1), while those with low amount receive zero (0). Mineral soil property threshold levels, interpretations, and associated soil index values are listed in (Table 1).
The soil parameter was summed to give a total SQI given as:

$$\text{Total SQI} = \Sigma \text{ individual soil properties index value} \quad [1]$$

$$\text{TSQI \%} = \frac{\text{Total SQI}}{\text{Maximum possible total SQI for properties measured}} \times 100 \quad [2]$$

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Table 1. *Selected soil properies for Tropical Soil Quality Index (TSQI)*

S/N	Parameters	Level	Interpretations	Index
1	Bulk density ($Mg\ m^{-3}$)	> 1.5	Possible adverse effects	0
		≤1.5	Adverse effects unlikely	1
2	Soil acidity	3.01 to 4.0	Strongly acid – only the most acid tolerant plants can grow.	0
		4.01 to 5.5	Moderate acid – growth of acid intolerant plants is affected	1
		5.51 to 7.2	Slightly acid to Near neutral – optimum for many plant species	2
		7.21 to 8.5	Slightly to moderately alkaline – optimum except those prefer acid soils.	1
		> 8.5	Strongly alkaline – preferred by plants adapted to this pH,	0
3	Total carbon (%)	> 5	High excellent buildup of organic C with all associated benefits	2
		1 to 5	Moderate adequate levels	1
		< 1	Low – could indicate a possible loss of organic Carbon.	0
4	Total nitrogen (%)	> 0.5	High – excellent reserve of nitrogen	2
		0.1 to 0.5	Moderate – adequate levels	1
		< 0.1	Low – could indicate loss of organic N	0
5	Available P ($mg\ kg^{-1}$)	> 30	High – excellent reserve of Available P	2
		15 to 30	Moderate – adequate levels for plant growth	1
		< 15	Low – P deficiencies likely	0
6	Exchangeable K ($cmol\ kg^{-1}$)	>1.28	High – excellent reserve of exchangeable K	2
		0.26 to 1.28	Moderate – adequate levels for most plants	1
		< 0.26	Low – possible deficiencies	0
7	Exchangeable Mg ($cmol\ kg^{-1}$)	> 4.17	High – excellent reserve exchangeable Mg	2
		0.42 to 4.17	Moderate – adequate levels for most plants	1
		< 0.42	Low – possible deficiencies	0
8	Exchangeable Ca ($cmol\ kg^{-1}$)	> 5.00	High – excellent reserve, probably calcareous soil	2
		0.51 to 5.00	Moderate – adequate levels for most plants	1
		0.05 to 0.5	Low – possible deficiencies	0
		<0,05	Very low – severe Ca depletion, adverse effects likely	0

Source: Arifin et al, (2012)

Evaluation of Soil Carbon Stock

Soil organic carbon (SOC) stock was using the formula below (equation 3)

$$SOC = (Org.\ C \times d \times Bd \times 10000)/1000\ (t\ C\ ha^{-1}) \qquad [3]$$

where: SOC = Soil Carbon Stock of soil (t C ha^{-1}), Org C = organic carbon content (g kg^{-1}), d = soil depth, Bd = Bulk density at the depth (Mg m^{-3}), 10,000m^2 = 1ha, and 1000 kg = 1 ton.

Results and Discussion

Soil Physical Properties

Table 2 presented data on soil physical and chemical properties. Sand dominates the soil fractions with mean values of 810 gkg^{-1} for upper slope, while middle slope mean value was 805 gkg^{-1}. High sand fraction could be partly attributed to parent material rich in quartz mineral, an essential component in granite (Wilson, 2010) and could also be attributed to the sedimentary origin of the parent materials which produce the soils. This could also be partly due to pedogenic processes involving sorting of soil materials by biological activities, clay migration through eluviation and illuviation, or surface erosion by runoff or their combinations (Malgwi, et al., 2000; Akinbola, 2009).

Furthermore, predominance of sand particles in arid and semiarid climates is not uncommon because many of them were formed from aeolian deposits blown from across several thousands of kilometers (Mortimore, 1989). This confirms the findings of Abba et al., (2016) who also reported high sand content (799 $g{\cdot}kg^{-1}$) in soils of Kanawa forest in Gombe.

Table 2. *Physical and chemical properties of the study area*

S/N	Sand	Silt	Clay	S/C	Textural Class	Bulk Density	pH		OC	TN	SOC
	gkg^{-1}					g/cm^{-3}	H_2O	$CaCl_2$	g/kg		t C ha^{-1}
US1	820	100	800	1.25	Loamy sand	1.35	6.2	5.70	4.7	1.05	18.98
US2	780	120	100	1.20	Sandy loam	1.33	6.4	5.80	6.8	1.75	27.19
US3	780	120	100	1.20	Sandy loam	1.33	6.3	5.80	7.2	1.40	28.73
US4	860	80	600	1.33	Loamy sand	1.35	6.4	5.70	3.8	1.40	15.41
Mean	**810**	**100**	**850**	**1.24**		**1.34**	**6.3**	**5.73**	**5.6**	**1.40**	**22.58**
MS1	840	80	800	1.00	Loamy sand	1.35	6.2	5.70	4.2	1.05	17.00
MS2	800	120	800	1.50	Loamy sand	1.34	6.3	5.50	5.2	1.75	20.95
MS3	840	80	800	1.00	Loamy sand	1.35	6.4	5.90	3.5	1.05	14.22
MS4	740	160	100	1.60	Sandy loam	1.33	6.4	5.90	7.0	1.40	27.96
Mean	**800**	**110**	**850**	**1.27**		**1.34**	**6.3**	**5.74**	**5.0**	**1.31**	**20.03**

US = Upper Slope - **OC** = Organic Carbon - **MS** = Middle Slope - **TN** = Total Nitrogen - **Ap** = Available Phosphorus
S/C = Silt Clay ratio - **SOC** = Soil Organic Carbon - **BD** = Bulk Density

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The mean value of silt was 105 and 110 g·kg^{-1} for upper and middle slope respectively. Clay mean value was both 85 g·kg^{-1} in upper and middle slope respectively. Textural class for upper slope ranged from sandy loam to loamy sand while middle slope was dominated with loamy sand (Table 2).
Silt clay ratio has mean values of 1.25 for upper slope and 1.28 for middle slope. Van Wambeke (1962) reported that "old" parent materials usually have a silt/clay ratio below 0.15 while silt/clay ratios above 0.15 are indicative of "young" parent materials. Asomoa (1973) also reported that young parent materials usually have silt/clay ratio above 0.25. Results of this study show that soil of upper and middle slope have silt/clay ratio above 0.15 and 0.25 indicating that the soils are relatively young with high degree of weathering potential. Lawal et al., (2013) and Jimoh, et al., (2016) also reported silt clay ratio of (> 0.25) on the soils of Sokoto and Kaduna State respectively which indicate that soils of Nigeria Savanna are young soils with high weathering potential. This could be attributed to the average weather condition of the savanna region unlike the weather condition of the forest region of the country which is characterize by high temperature and rainfall which fasten rate of weathering and soil development.

Chemical parameters

The mean pH of soil in water was 6.33 at upper slope and 6.34 at middle slope. In $CaCl_2$ solution, pH was both 5.74 for upper and middle slope (Table 2). The soils were therefore slightly acid at both slope classes and optimal for nutrient uptake by plant roots. Mbaya et al., (2012) reported similar range of pH on soil of Gombe metropolis. The mean values for organic carbon were higher at upper slope (5.6 g·kg^{-1}) than middle slope (5.0 g·kg^{-1}) though rated low. Low organic carbon under the plantation could be attributed to pruning of the palm branches for domestic uses, instead of been allowed to be recycled back into the soils. This confirm the report of Demessie et al. (2012) who reported low soil quality under Eucalyptus to its fast-growing nature that intensively absorb soil nutrients as well as the frequent harvest and transportation of woody material out of the system. The low level of organic C with a high proportion of sand particle will might result to low aggregation, low water retention and poor physical stability of the soil (Salako, 2003) and therefore, low productivity of crops. This has predisposed the soil to erosion which is a common phenomenon in the study area. The value of organic carbon reported under the plantation was lower than 11.79 g·kg^{-1} reported by Abba et al (2016) and (10.3 g·kg^{-1}) reported by Ibrahim and Umar (2012) in soil of Yamaltu Deba, though higher than (4.65 g·kg^{-1}) reported by Mbaya et al., (2012) along gully site in Gombe. Total Nitrogen concentration in the upper slope has a mean value of 1.4 g·kg^{-1} and middle slope mean value of 1.31 g·kg^{-1} and were both rated low to medium, though higher than 1.01 g·kg^{-1} reported by Abba et al (2016) and 1.3 g·kg^{-1} reported by Ibrahim and Umar (2012). The higher value of total nitrogen in this study implies that there is higher rate mineralization of organic carbon. The carbon nitrogen ratio (C/N) is an indication of the extent of decomposition of organic matter and release of nutrient such as nitrogen. Carbon nitrogen ratio of upper slope and middle slope were 4.1 and 3.8 respectively (Table 3).

Table 3. *Chemical properties of the study area*

S/N	C/N	Ap	Ca	Mg	K	Na	Ca/Mg	H+Al	ECEC	BS
		mg/kg	cmol/kg							%
US1	4.48	10.6	2.90	0.30	0.12	0.24	9.60	0.4	**S/N**	90
US2	3.89	22.6	4.77	0.63	0.17	0.26	7.52	0.4	6.23	94
US3	5.14	29.0	3.63	0.46	0.16	0.26	7.89	0.2	4.71	96
US4	2.71	26.0	2.79	0.34	0.13	0.20	8.21	0.2	3.66	95
Mean	**4.06**	**22.1**	**3.52**	**0.43**	**0.15**	**0.24**	**8.12**	**0.30**	**4.64**	**94**
MS1	4.00	20.4	2.25	0.28	0.11	0.21	8.15	0.4	3.24	88
MS2	2.97	13.2	2.97	0.34	0.17	0.26	8.74	0.2	3.94	95
MS3	3.33	51.3	3.44	0.37	0.19	0.17	9.30	0.2	4.37	95
MS4	5.00	17.0	4.56	0.74	0.30	0.22	6.16	0.4	6.22	94
Mean	**3.83**	**25.5**	**3.31**	**0.43**	**0.19**	**0.22**	**7.66**	**0.30**	**4.44**	**93**

Available phosphorus of upper and middle slope mean value was 22.06 mg kg^{-1} and 25.0 mg·kg^{-1} respectively; they were both rated high in available phosphorus. The value of available phosphorus was also higher than those reported by Ibrahim and Umar, (2012) and Abba et al. (2016) in previous studies with in the same location. The higher value of phosphorus in this study could be attributed to high rate mineralization of organic matter which leads to release of phosphorus.

Exchangeable Ca dominated the exchange site. The mean value for upper and middle slope were 3.5 cmol (+) kg^{-1} and 3.26 cmol (+) kg^{-1} respectively as shown in Table 3. The dominancy of calcium among the other bases confirms the reported of Mbaya et al. (2012), Danladi and Ray (2014); Abba et al. (2016) who worked on soils of Gombe, state. The predominance of Ca may be due to calcium bearing parent material in the soil (Nahusenay et al., 2014). Exchangeable Mg rank next with mean value of 0.43 cmol (+) kg^{-1} for both upper and middle slope and was also rated medium. Ca:Mg ratio mean value was 1:8 for both upper and middle slope under the plantation. This ratio was rated high (>5:1), implying that Mg is increasingly become unavailable with increasing Ca contents and P availability may be also reduced. Exchangeable Na mean values varies from 0.24 cmol (+) kg^{-1} to 0.22 cmol (+) kg^{-1} for upper and middle slope. Exchangeable Na was generally

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rated medium (Malgwi, 2007). Exchangeable K mean values varies from 0.15 cmol (+) kg^{-1} to 0.19 cmol (+)kg^{-1} for upper and middle slope. Exchangeable K in the study was rated medium (Malgwi, 2007). Generally, exchangeable bases occurred in the order Ca^{2+}> Mg^{2+}> Na^{+}> K^{+}. This result confirms the report of Mbaya et al. (2012) who also report similar pattern of exchangeable bases in soils of Gombe. The exchangeable bases were medium and sufficient for sustainable crop production. Exchangeable acidity (H^{+}+Al^{3+}) mean values was 0.3 cmol (+) kg^{-1} for both upper and middle slope, and was rated low (<1.0 cmol (+) kg^{-1}). This implies that the soils have little or no acidity problems. Raji and Mohammed (2000) reported similar results and submitted that the contribution of exchange acidity to potential acidity is very low in soils of Nigerian savannas.

ECEC mean value of 4.64 and 4.44 cmol (+) kg^{-1} for upper and middle slope respectively. The value was rated low; though medium rate was recorded in some locations within the slope. The low ECEC level implies that the soils were dominated by low activity clays and sesquioxides (Tan, 2000; Chidowe et al., 2014) and low organic colloidal fractions suggesting the soils would be susceptible to leaching and also predisposing the environment to global warming and climate change effects. Base saturation (BS) mean value range from 94 to 93 % for upper and middle slope respectively. BS (ECEC) was rated higher (>90 %), thus reflecting high corresponding ECEC values. The percentage of sites occupied by ions other than hydrogen is the percent base saturation; however, acid soils may have high cation exchange capacity, but a low % BS, because of high exchangeable hydrogen ions. Soils with a high BS are fertile (Isirimah et al., 2003).

Soil Carbon Stock and Quality based on TSQI under the Date Palm Plantation

Result of the studies reveals that there were differences in quantity of carbon sequestered in the different slope class in the study area. Soil carbon stock over the upper slope ranges from 15.41t C/ha to 27.75t C/ha (mean 22.13t C/ha) while the middle slope values ranges from 14.22t C/ha to 27.96t C/ha (mean 20.08t C/ha) (Table 4). The higher value recorded on the upper slope could be attributed to gentle slope class of the unit which does not support erosion unlike the middle slope. Eight soil parameters were rank from 0 to 2 for soil quality assessment. These include bulk density, pH, total carbon, total nitrogen, available phosphorus, exchangeable potassium, magnesium and calcium. A score of 0 was allocated to parameter with low nutrient rate while 1 to 2 to parameter with optimum nutrient rate (Table 4).

The scores from the slope classes was compare with the ideal soil parameter ranking to make deduction on how much variation are between the ideal score and the score from upper and middle slope. Table 4 Shows that the total score was 15 which is 100% quality, when compare with the soil quality of the slope classes, the values varies from 60% to 53% for upper and middle slope respectively, similar to carbon stock trend. The most severe limitation to soil quality for both slope classes was exchangeable K which was very limited. Total nitrogen, available phosphorus, exchangeable Mg and Ca were moderate limited in the two slope classes; while organic carbon limitation was only recorded in the middle slope. This result is similar to the report of Arinfi et al., (2012) who reported 59.09% as percentage soil quality for Malaysia secondary forest. Generally, the Slope classes were moderate in quality.

Table 4. *Tropical Soil Quality Index (TSQI) score limit*

S/N	Parameters	US Mean Value	MS Mean Value	Full Score	US Score	MS Score
1	Bulk density (Mg m^{-3})	1.34	1.35	1	1	1
2	Soil acidity	6.34	6.34	2	2	2
3	Total carbon (g/kg)	5.50	4.98	2	2	1
4	Total nitrogen (g/kg)	1.4	1.3	2	1	1
5	Available P ($mgkg^{-1}$)	22	25	2	1	1
6	Exchangeable K (cmol kg-^{1})	0.15	0.19	2	0	0
7	Exchangeable Mg (cmol kg$^{-1)}$	0.43	0.43	2	1	1
8	Exchangeable Ca (cmol kg^{-1})	3.52	3.26	2	1	1
	Total Score			15	9	8
	Percentage (%)			100	60	53

Conclusion

The study examined soil quality and soil carbon sequestration under date plantation in Gombe State University, Gombe. Results obtained show that texture of the soils was generally loam sand to sandy loam. The soil pH was moderately acidic, organic matter was low, total nitrogen was low to medium, while available P content of soils was generally high over the study area. The exchangeable cations depict relatively medium values throughout the slope classes. The values of soil ECEC was low and base saturation was high. The soils under the Date palm were moderate in quality with 58-60 % and have high potentials to improve the soils quality for sustainable production, mitigates global warming and climate change, and is therefore advocated for farmers' adoption of agroforestry in the Sudan Savanna zone. The Date Plantation also create microclimate within the University as the temperature is cool than surrounding environment. Appropriate measures to conserve soil and water against flood and/or erosion are advocated to ensure sustainable agricultural productivity and environmental conservation in this agro-

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ecology. Therefore, land use strategies that focus soil organic carbon enrichment and protection of soil organic carbon against further depletion, soil erosion and contribute nitrogen into the soil. Incorporation of farmyard manure and crop residue to increase nutrient retention capacities, improve structural development, improve pH and reduce leaching through management techniques that involve agroforestry systems are advocated for sustainable agricultural production in the Nigerian Savanna. Adequate monitoring of fertility and quality status of plantation should be carried out at regular intervals for sustainable development.

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