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INFLUENCE OF SHELTERBELTS ON SOIL PHYSICOCHEMICAL PROPERTIES IN KAURA NAMODA SEMI-ARID ECOLOGICAL ZONE, NIGERIA

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Abstract

The research was carried out to investigate the influence of shelterbelts on microclimatic factors and soil physicochemical properties in Kaura Namoda semi-arid ecological zone. Electrical conductivity of the soils ranged between 35.30 and 44.25 µS cm^{-1}. Result of soil texture analysis revealed that the soils are predominantly sandy, making the soils to fall into the sandy clay loam classification. Analysis of the physicochemical properties indicated that the concentrations of all the elements at the three locations, except boron were significantly ($p < 0.05$) different from each other. Concentrations of the elements ranged thus: Zn: 0.20-0.30 ppm, Ca: 6.69-9.74 ppm, Fe: 1.78-3.61 ppm, Cu: 0.09-0.25 ppm, B: 1.01-1.17 ppm, Mg: 1.87-5.47 ppm, Mn: 0.19-5.51 ppm, N: 38.00-42.00 mg/kg, K: 30.00-42.00 mg/kg, Na: 23.00-35.00 mg/kg, Cl: 30.20-39.40 mg/L, S: 0.41-0.61 mg/kg, P: 1.21-1.70 mg/kg and OC: 13.26-18.53%. It could be concluded that some of the soil nutrients within the studied areas were slightly below the recommended soil fertility for Northern Nigeria Savanna soil. However, it could be suggested that the presence of the shelterbelts played significant role in keeping the nutrients at the determined concentrations by preventing excessive leaching of soil nutrients due to the harsh weather condition of Kaura Namoda. Based on the findings, it could be recommended that farmers in Kaura Namoda should endeavour to leave behind agricultural wastes on the soils after harvesting as well as boosting the fertility of the soils with both organic and inorganic fertilizers to enhance productivity.

Keywords: Kaura Namoda; Microclimatic factors; Nutrients; Physicochemical properties; Shelterbelts; Soil

Introduction

Shelterbelts consist of rows of planted or naturally regenerated trees that plays an important role in the sustainable development of an agroforestry ecosystem (Rempel *et al*., 2017; Liu *et al*., 2022). It serves the purpose of reducing wind velocity and its impact within farm lands and around buildings (Yuan *et al.,* 2020). Additionally, shelterbelts have been used traditionally over time to reduce soil erosion emanating from wind (Fang 2021; Su *et al.,* 2021). The beneficial effect of shelterbelts on crop yields has been recorded (Smith *et al*., 2021). This is evident as it is effectiveness in reducing wind velocity, increasing relative humidity and suppressing evaporation from open surfaces (Gochez *et al.,* 2020; Weninger *et al.*, 2021). Similarly, planting of shelterbelts around farm lands had greatly improved the physicochemical properties of the soil (Kamal, 2014; Zhuang *et al*., 2017). The resultant effect of this include improved soil organic matter, recycling plant nutrients, improved rain infiltration and provision of habitats for birds and bees, reduction of the occurrences of pests and diseases and reduction of pesticide drift that invariably increases crop yield (Bentrup *et al*., 2019; Gochez *et al.,* 2020; Weninger *et al.,* 2021) .

The effectiveness of shelterbelts is a function of a number of factors, which include; height and type of the trees, length and width of the belt, density as well as the direction and strength of winds (Amichev *et al.,* 2017; Hansen *et al.,* 2020). Interestingly, the age of the trees plays a very important role on the extent and degree of protection. More so, the height of the trees is considered as the most important factor that determine its protective role on the surrounding farmland (Zhu and Song, 2021). Evidently, it has been established that the greater the height of the trees, the greater the protected distance. The protected area is measured in multiples of the height (H) of the shelterbelt.

In arid and semi-arid ecological zones, windbreaks preserve the soil moisture. Findings of Kamal (2014) had shown that soils protected with windbreaks may possess more moisture than unprotected ones. Reduction in the rate of evaporation from the soil is another indirect benefit of windbreaks with its corresponding reduction of wind velocity. This finding corroborated those of an earlier study that documented over 10% yield increase in crop production caused by shelterbelt density (Jiang *et al.*, 2003).

Although, shelterbelts are found at various locations in Kaura Namoda Local Government Area of Zamfara State, studies to assess its full importance to the locality remained unreported. Previous studies conducted in other locations have documented the benefits of shelterbelts to agricultural farmlands which include; control of erosion, wind velocity and desertification which culminated in improved crop yield. However, such studies are yet to be carried out on the shelterbelts in Kaura Namoda. The present study is aimed at investigating the influence of shelterbelts on soil physicochemical properties in Semi-Arid Ecological Zone characterized by hot weather conditions and low rainfall. The study will in no small measure offer useful information to farmers in Kaura Namoda, for full exploitations of the available potentials attributable to shelterbelts.

MATERIALS AND METHODS

Study Area

The study was conducted in some selected shelterbelts within Kaura Namoda Local Government Area, Zamfara State. Three shelterbelts that were selected for this study are situated as follows: Location A: (beside SLT Complex, Federal Polytechnic Kaura Namoda) between latitude 12°38′16″N and longitude 6°35′18″E, location B (Yankaba road, Kaura Namoda) between latitude 12°36′02″N and longitude 6°34′42″E and location C (beside GSS, Kaura Namoda) between latitude 12°36′51″N and longitude 6°35′31″E. Generally, the climate of Zamfara state is characterized by a long dry season (October-April) with a short rainy season (May-September), while the study area in particular (Kaura Namoda) experiences long dry season (October- middle of May) with a short rainy season (middle of May-September) (Shamaki and Abubakar, 2021). The study area experiences harmattan wind, which is usually dry, cold, and dusty blowing between the months of November to early March. The soil of studied area is predominantly sandy. The vegetation of the area falls within the Sudan Savannah vegetation zone characterized by soils that are mostly sandy to loamy in texture with some patches of clayey subsoil. The vegetation of the proposed study area is composed of various species of grasses and legumes, patches of bushes and sparsely distributed indigenous tree species majority of which are thorny tree species (Shamaki and Abubakar, 2021)

Soil Sample Collection

The method described by Mangosongo *et al.*, (2019) was adopted with slight modifications. The soil samples from the sampling plots (within and outside the shelterbelts) were taken. At each shelterbelt, a 25m x 25m within three locations were selected for microclimatic elevation. This was followed by collection of two (0.5kg) composite soil samples in the sampling area. This will be achieved by taking soil samples from the selected sampling areas at a depth of about 0 – 30 cm using a soil auger and then mixed thoroughly in a clean plastic bag labelled and taken to the lab for analysis.

Determination of Soil Physicochemical Properties inside the Shelterbelts

Electrical Conductivity

The electrical conductivity of the soil sample was determined using the method described by Tale and Ingole (2015). This was achieved by preparing a saturated paste of 2 mm sieved soil. This was achieved by adding 120 g of soil sample in 400 mL capacity beaker using deionized water. This was followed by transferring the paste of soil samples in to Cyber scan 500 conductometer and the value was be read out.

Soil Texture (Silk, Clay and Sand)

Soil texture was determined using the pipette method as described by Mangosongo *et al*., (2019) with slight modifications. In this method, the dried, ground soil sample (70 g) was transferred into a 250 ml flask. Distilled water (100 ml) was added followed by 10 ml of 1M NaOAc (sodium acetate) and was centrifuged for 10 minutes at 1500 revolutions per minute (rpm). The supernatant, was decanted while the soil suspension was washed with 50 ml of distilled water. This was followed by further centrifugation and decanting. The pretreated sample from the above analysis was treated with 4 ml of hydrogen peroxide (H_2O_2) and was heated until frothing ceases to remove organic matter.

The sand particles were separated into various sizes by pouring the treated soil on to a 270 mesh (53 µm) sieve and washed with 500 ml of distilled water with gentle stirring. The filtrate (soil suspension) was collected in a 1000 ml cylinder. The filtrate collected in the cylinder was stored for analysis of silt and clay while the residue (sand) on the 270 mesh (53 µm) sieve was collected in a pre-weighed weighing dish, dried at 105^{o}C and was reweighed.

The pipette method described by Mangosongo *et al*., (2019) was adopted to determine the silt (2 - 20 µm) and clay (< 2 µm) fractions of the sample. The silt fraction was evaluated by adding 10 ml of hexametaphosphate solution to the filtrate in 1000 ml cylinder obtained above and made up to the 1000 ml mark with distilled water, followed by covering the cylinder with a stopper with gentle swirling from one end to another for one minute. The filtrate was allowed to settle down for about 4 to 6 minutes at room temperature. Furthermore, 25 ml of the settled filtrate was pipetted from a depth of 10 cm. The pipetted solution was placed in a pre-weighed evaporating dish and dried in an oven at 105^{o}C to constant weight. The weight of the residue was taken as the silt fraction. Determination of clay was done after allowing the filtrate to stand for about 6 to 7 hours and the above procedure was repeated. The weight of the residue was taken as the clay fraction.

The weight of the remaining treated soil sample was determined by adding 10 ml of $CaCl_2$ and 1ml of 1 M HCl to the remaining suspension in the cylinder. This was done to prevent the formation of calcium carbonate, and to cause flocculation of the soil particles. The supernatant was siphoned using pipette after flocculation. This was followed by pouring the soil flocculant into a pre-weighed evaporating dish, dried at 105ºC and re-weighed. The purpose of weighing the treated soil sample was to account for the losses at the various stages of the analysis. The total oven dry weight of the treated sample was used as a base for calculating the size of the soil fractions and was obtained using the equation below. Data was presented as percentage of sand, silt and clay.

$$W_s + W_p + W_r = W_t$$

Where: W_s = Weight of the sand fraction

W_p = Weight of the fractions taken by pipette (silt and clay)

W_r = Weight of the remaining fraction

W_t = Total oven dry weight.

Determination of Soil Organic Carbon

The method described by Mangosongo *et al*., (2019) was adopted with slight modifications. The determination was carried out by carefully weighing out 200 mg air-dry soil sub-sample into 500 ml wide mouth Ertemmeyer flask, followed by addition of 20 ml of 1M $K_2Cr_2O_7$. The suspension was swirled to disperse the soil and the solution followed by rapid addition of 20 ml of concentrated H_2SO_4. The soil-dichromate mixture was shaken gently and was allowed to stand for about 30 minutes, and then, 200 ml of distilled water was added. The resulting solution was titrated against 0.5M $FeSO_4$ using Ophenanthroline indicator and the percentage organic matter was calculated using the formula below:

$$\% \text{ Organic C} = \frac{(K_2Cr_2O_2 - FeSO_4) \text{ x } (0.3) \text{ x f}}{\text{Weight in gram of dry soil}}$$

Where, f = 1.3, a correction factor used to account for carbon that does not oxidize in the procedure.

Determination of Mineral Elements

Total Nitrogen

Total soil nitrogen was determined by using semi-micro Kjeldahl digestion described by Mangosongo *et al*., (2019) followed by colorimetric determination of the resultant ammonium by color reaction (Indo-phenol blue method). In this method, 0.2 g of air-dry soil was weighed into a Kjeldahl flask. To this sample, 0.2 g of copper metal, 0.1 g Selenium (Kjeldahl tablets) and 15 ml of sulphuric acid-salicylate mixture was added. In order to oxidize the organic matter, 2 ml of hydrogen peroxide was added and was heated to boiling point for 5 minutes. In the mixture, 4 g of K_2SO_4 was added and the mixture was digested at 430^{o}C using a thermal Kjeldahl apparatus. The nitrogen present in the sample was converted to ammonium form and the ammonium was determined calorimetrically using a spectrophotometer.

Analysis of Other Mineral Elements

The method of Fatumetuzzehra and Ebru (2010) was adopted to determine the presence of mineral elements such as phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), sulphur (S), iron (Fe), copper (Cu), chlorine (Cl), boron (B), zinc (Zn) and manganese (Mn). Wet digestion method was used following analysis of the digested sample using Flame Atomic Absorption Spectrometry (FAAS) and Electro thermal Atomic Absorption Spectrometry (ETAAS) respectively.

Data Analysis

Data collected for mineral elements analysis were subjected to One-way Analysis of Variance (ANOVA) at 95% confidence level. Significant differences was taken for $p<0.05$. Data generated from the analysis were presented in tables.

3. Results and Discussion

Table 1: Electrical conductivity and soil texture analysis of the shelterbelts

Locations	pH (H_2O)	EC ($\mu S\ cm^{-1}$)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Soil Texture
A: Inside	7.16	42.70	620.00	132.29	247.71	Sandy clay loam
Outside	6.90	44.25	585.71	169.14	245.15	Sandy clay loam
B: Inside	7.12	35.30	605.71	184.00	210.29	Sandy clay loam
Outside	6.85	38.50	574.29	194.00	231.71	Sandy clay loam
C: Inside	7.02	38.60	634.57	171.72	193.71	Sandy loam
Outside	6.81	40.45	574.29	175.14	250.57	Sandy clay loam

pH of the soils inside and outside the shelterbelts at the three Locations were displayed in Table 1 and ranged between 6.81 and 7.16, with the highest value recorded at Location A (7.16 and 6.90), followed by Location B (7.12 and 6.85) and Location C being the least (7.02 and 6.81). The moderately high pH values recorded in the studied area could be attributed to limited rainfall in Kaura Namoda. It has been documented by similar study that limited rainfall could result in higher average pH values (Shehu *et al.*, 2019). These values were within the optimal pH range of 6.5 to 7.5. Within this pH range, most plant nutrients are optimally available to plants, hence, the pH of the soils in the present study would enhance availability of the nutrients necessary for the plant growth and development. Based on the pH values, all the soils analyzed at the three locations are normal or neutral soils. There was no significant difference ($p>0.05$) in the pH value of all the soils analyzed at the three Locations. The present study is in congruence with findings of Jensen and Thomas, (2010).

The electrical conductivity (EC) of the soils analyzed ranged between 35.30 and 44.25 $\mu S\ cm^{-1}$ as shown in Table 1. EC is a measure of the salt content in the soil and an important indicator of soil health. It affects the yield and quality of crops, the nutrients available to the plant as well as the activities of the soil microbes. The highest EC of 44.25 $\mu S\ cm^{-1}$ was obtained in soil from Location A outside while location B inside has the least value. Electrical conductivity is used to estimate the soluble salt concentration in soil and is commonly used as a measure of soil salinity. From the findings of the present study, the electrical conductivity is less than 1 dS/cm, which is consistent with electrical conductivity of normal soil. The result agrees perfectly with the pH values that demonstrated that the soils are normal soils. The results obtained here were higher than those reported by Osakwe and Okolie (2015) but lower than those of Fomenky *et al.,* (2018).

The results of soil texture analysis of the three shelterbelts Locations in the present study were shown in Table 1. The results showed that the soils were predominantly made up of sand particle relative to others. Findings of earlier researchers have reported that Northern Nigerian Savanna soils were developed from aeolian materials and pre-Cambrian basement complex rocks such as granite, schist and sandstone resulting in a large sand fraction in the surface soils of the studied areas (Shehu *et al.,* 2019). The aggressive weather conditions of the studied area could be responsible for the nature of the soil texture as the soil texture of the studied area is mostly sandy clay loam. Correspondingly, the findings of this study is in congruence with those of Malgwi *et al.,* (2000) and Voncir *et al.,* (2008) who independently reported that clay eluviation and wind erosion are additional factors that contribute to large sand content of the surface soils of the Northern Nigerian Savanna.

The zinc values of the soils inside the three Locations are presented in Table 2. Location A had the highest value, followed by Location C while Location B had the least value of 0.30 $\pm$ 0.0252, 0.026 $\pm$ 0.0404 and 0.20 $\pm$ 0.0306 ppm respectively. ANOVA result indicated that the proportion of zinc in the three Locations were significantly different ($p < 0.05$). While a significant difference existed between the values of zinc in Locations A and B, there was no significant difference between the values of zinc in Locations A and C as well as between Locations B and C respectively. It is worthy of note that the values of zinc in all the soils at the three Locations were lower than the critical value of 5.0 mg/kg, according to the ratings of the Nigerian "National Special Programme on Food Security" NSPFS (2005) classification of Nigerian Savanna soils. Zinc is considered as an important micronutrient in the soil responsible for improving crop production.

Table 2: Mineral elements inside the shelterbelt with ANOVA result

ELEMENTS	LOCATION	MEAN $\pm$ SD	ANOVA RESULT	
			F-VALUE	P-VALUE
Zinc (ppm)	A	0.30$\pm$ 0.0252	6.573	0.031*
	B	0.20 $\pm$ 0.0306		
	C	0.26 $\pm$ 0.0404		
Calcium (ppm)	A	5.69 $\pm$ 0.2326	100.996	0.000*
	B	9.74 $\pm$ 0.6250		
	C	5.80 $\pm$ 0.1653		
Iron (ppm)	A	3.61 $\pm$ 0.2552	35.315	0.000*
	B	2.55 $\pm$ 0.3670		
	C	1.78 $\pm$ 0.1100		
Copper (ppm)	A	0.25 $\pm$ 0.0306	34.617	0.001*
	B	0.09 $\pm$ 0.0208		
	C	0.19 $\pm$ 0.0252		
Boron (ppm)	A	1.17 $\pm$ 0.0306	1.227	0.357

	B	1.01 ± 0.2949		
	C	1.33 ± 0.0300		
Magnesium (ppm)	A	1.87 ± 0.1253	240.206	0.000*
	B	5.47 ± 0.3612		
	C	2.08 ± 0.0757		
Manganese (ppm)	A	3.76 ± 0.1604	839.554	0.000*
	B	0.19 ± 0.0322		
	C	5.51 ± 0.2272		
Nitrogen (mg/Kg)	A	42.00 ± 1.0701	26.982	0.001*
	B	40.00 ± 0.2287		
	C	38.00 ± 0.3011		
Potassium (mg/Kg)	A	40.00 ± 0.8578	138.079	0.000*
	B	30.00 ± 0.1442		
	C	42.00 ± 1.3391		

ELEMENTS	**LOCATION**	**MEAN ± SD**	**ANOVA RESULT**	
			F-VALUE	**P-VALUE**
Sodium (mg/Kg)	A	23.00 ± 0.4950	951.595	0.000*
	B	35.00 ± 0.2696		
	C	29.00 ± 0.1249		
Chlorine (mg/L)	A	37.50 ± 0.7966	277.686	0.000*
	B	30.20 ± 0.2359		
	C	39.40 ± 0.2452		
Sulphur (mg/Kg)	A	0.56 ± 0.6409	1672.153	0.000*
	B	0.41 ± 0.1153		
	C	0.61 ± 0.3676		
Phosphorus (mg/Kg)	A	1.21 ± 0.0404	35.902	0.000*
	B	1.70 ± 0.1332		
	C	1.60 ± 0.0252		
Organic Carbon (%)	A	18.53 ± 0.8154	75.034	0.000*
	B	15.21 ± 0.2354		
	C	13.26 ± 0.2352		

Key: * = Significantly different

Calcium concentrations (ppm) (5.69 $\pm$ 0.2326, 9.74 $\pm$ 0.6250 and 5.80 $\pm$ 0.1653) in the soils inside the shelterbelts analyzed were presented in Table 2, for Locations A, B and C respectively. The concentration of calcium differs significantly ($p < 0.05$) for all the soils analyzed. It was observed that soils from Location B had the highest calcium concentration, followed by those from Location C, while soils from Location A demonstrated the least value of calcium. According to classification of Shehu *et al*., (2015), the concentration of calcium for soil samples from all the Locations were within the high value (> 5 mg/kg).

The concentration of iron inside the shelterbelts in the three Locations were presented in Table 2. Inside the shelterbelts, the concentrations of iron at all the Locations differ significantly ($p < 0.05$) from each other with Location A having the highest value, followed by Location B, while Location C had the least value of 3.61 $\pm$ 0.2552, 2.55 $\pm$ 0.3670 and 1.78 $\pm$ 0.1100 ppm respectively. Iron concentrations at Location A, and B fell within the moderate level required by soils while that at Location C was within the low level according to NSPFS, (2005). Similarly, the moderately high concentrations of calcium in all the locations suggests the presence of limestone in the soil, which reduced iron concentrations. The concentrations of iron in the present study are lower than the ones reported by Shehu *et al.*, (2018).

The concentration of copper in the soils inside the shelterbelts in the studied areas were presented in Table 2. The concentrations of copper inside the shelterbelts differ significantly ($p<0.05$) with Location A having the highest concentration, followed by Location C, while Location B had the least concentration of 0.25 $\pm$ 0.0306, 0.19 $\pm$ 0.0252 and 0.09 $\pm$ 0.0208 ppm respectively. The concentration of copper at Location A fell within the moderate copper level while those at Locations B and C were considered low according to NSPFS (2005) classification. The concentrations of copper in the present study were lower than those reported by Shehu *et al.*, (2018).

The concentration of boron in the soils inside the shelterbelts in the studied areas were presented in Table 2. There was no significant ($p<0.05$) difference in boron concentrations at the different locations. The concentration of boron in all the soils analyzed fell within a moderate soil fertility condition (NSPFS, 2005). Results of the present study were similar to findings of Shehu *et al.*, (2019).

The concentrations of magnesium in the soils inside the shelterbelts as presented in Table 2 were 1.87 ± 0.1253, 5.47 ± 0.3612 and 2.08 ± 0.0757 ppm for Locations A, B and C respectively. The concentration of magnesium differs significantly ($p< 0.05$) for all the soils analyzed. It was observed that soils from Location B had the highest magnesium content, followed by those from Locations C, while soils from Location A demonstrated the least value of magnesium in all the samples. The concentration of magnesium for the soil samples were below the critical level of magnesium (10 mg/kg), (NSPFS, 2005; NAAIAP, 2014). However, these values were relative higher than those obtained by Shehu *et al.*, (2019). These values could be associated with limited rainfall within the studied areas which consequently reduced leaching of magnesium ions from the soils. The findings of the present study were in congruence with the results obtained by Lumula, (2021).

The concentration of manganese in the soils inside the shelterbelts in the studied areas were presented in Table 2. It could be seen that the concentrations of manganese differ significantly ($p < 0.05$) with Location C having the highest concentration, followed by Location A, while Location B had the least concentration of 5.51 ± 0.2272, 3.76 ± 0.1604 and 0.19 ± 0.0322 ppm respectively. According to NSPFS (2005) classification, concentration of manganese at Location C was considered slightly high, while those at Locations A and B were considered to be moderate and low respectively. The concentrations of manganese in the present study were lower than those documented by Shehu *et al.*, (2018).

Total nitrogen content of the soils within the shelterbelts (Table 2) followed a similar trend as the organic carbon. There was a significant ($p<0.05$) difference between the nitrogen content of the three shelterbelts examined, with Location A having the highest value (42.00 mg/Kg) while location C had the least (38.00 mg/Kg). Findings of this study presented a similar trend with those documented by Okon *et al.*, (2014), who reported a direct correlation between nitrogen content and organic carbon.

Concentrations of potassium in the soils inside the shelterbelts in Locations A, B and C as shown in Table 2 were 40.00 ± 0.8578, 30.00 ± 0.1442 and 42.00 ± 1.3391 mg/Kg respectively. Potassium concentration in the three Locations were significantly ($p < 0.05$) different from each other, with Location C having the highest concentration, followed by Location A, while Location B had the least concentration. From the results of these analyses, it could be observed that the concentration of potassium in all the soils examined in all the Locations were low and came short of the recommended critical level according to NSPFS (2005). The low potassium concentrations recorded in the soils analyzed could be partly related to the inherent low status of these soils resulting from complete crop residue removal by the farmers in the studied areas.

Concentration of sodium inside the shelterbelts in the three Locations were presented in Table 2. All the values were significantly ($p < 0.05$) different. It could be seen that sodium concentration at Location B was significantly higher (35.00 ± 0.2696) than those at the other two Locations, followed by Location C (29.00 ± 0.1249), with Location A having the least concentration (23.00 ± 0.4950). Since sodium is usually needed by plants in small quantity, the high values recorded in the present study were not desirable. Findings of the present study were higher than those reported by Shehu *et al.,* (2019).

The concentration of chlorine inside the shelterbelts (Table 2) at Locations A and C fell within the moderate level while that at Location B was considered low according to NSPFS (2005) classification. The concentrations at all the Locations showed significant ($p < 0.05$) difference with Location C having the highest value (39.40 ± 0.2452), followed by Location A (37.50 ± 0.7966) while Location B had the least concentration (30.20 ± 0.2359) mg/L respectively. The moderately high concentration of chlorine in the soils analyzed could be associated with the use of organic fertilizer (animal dungs) by the farmers in the area.

Concentration of sulphur in the soils inside the shelterbelts in the studied areas were presented in Table 2. The concentration of sulphur vary significantly ($p < 0.05$) from one location to another inside the shelterbelts, with Location C having the highest value, followed by location A while Location B had the least concentration of 0.61 ± 0.3676, 0.56 ± 0.6409 and 0.41 ± 0.1153 mg/Kg respectively. The concentration of sulphur in all the soils analyzed fell within the low soil fertility condition according to the ratings of NSPFS (2005). Results of the present study were lower than the findings of Shehu *et al.*, (2019) for soils within Northern Guinea Savanna and Sudan Savanna with average sulphur concentrations of 7.29 and 6.25 mg/Kg respectively. The low sulphur concentration recorded in the present study could be attributed to leaching due to the composition of the soils.

Concentrations of phosphorus in soils inside the shelterbelts in Locations A, B and C as shown in Table 2 were 1.21 ± 0.0404, 1.70 ± 0.1332 and 1.60 ± 0.0252 mg/Kg respectively. Phosphorus concentration in the three Locations were significantly ($p < 0.05$) different from each other, with Location B having the highest concentration, followed by location C, while Location A had the least concentration. It could be observed that the concentration of phosphorus in all the soils examined in all the Locations were quite low and came short of the recommended critical level. The low phosphorus levels recorded in the soils analyzed in all the Locations of the studied areas could be partly related to the inherent low status of these soils resulting from complete crop residue removal by the farmers in the study areas. A similar trend was reported by Shehu *et al.*, (2015) for some of the soils analyzed in their study that examined fertility status of selected soils in the Sudan Savanna Biome of Northern Nigeria.

The percentage organic carbon content inside the shelterbelts (Table 2) was significantly ($p < 0.05$) higher in location A (18.53%), followed by location B (15.21%) and lastly, location C (13.26%). The significantly high organic carbon content of all the soils evaluated in all the Locations could be attributed to the accumulation of organic matter over the years on the soil surface. The high value inside the shelterbelts could be associated with the decomposition of leaves from the trees within the shelterbelts. These values were higher than the critical level for soil organic carbon of 3.44% (NSPFS 2005; NAAIAP, 2014). Findings of the present study were in congruence with those of Okon *et al*., (2017).

Conclusion

Findings of the present study had shown that the soils were neutral with sandy clay loam texture. Results of the physicochemical properties revealed that concentrations of all the elements at the three locations were significantly ($p < 0.05$) different from each other, with exception of boron. The study demonstrated that concentrations of elements such as zinc, iron, copper, magnesium, manganese, potassium, chlorine, sulphur and phosphorus were lower that the recommended values. However, it was also seen from the analysis that while the concentration of boron was found to be moderate, those of calcium and organic carbon were considered to be slightly higher than the recommended values. It could be concluded that the soil nutrients within the studied areas slightly fell below the recommended soil fertility for Northern Nigeria Savanna soils. However, the presence of the shelterbelts could be responsible for keeping the nutrients at the determined concentrations as they would have prevented excessive leaching of soil nutrients due to the harsh weather condition of Kaura Namoda.

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