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Single Trees Litter Contribution to Soil Physiochemical Properties in Sudan Savanna Ecosystem, North-Western Nigeria

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ABSTRACT

Litter contribution of single trees to soil properties in Nigeria's Sudan Savanna was investigated. The tree species are *Sclerocarya birrea, Balanites aegyptiaca, Acacia nilotica, Azadirachta indica, Mangifera indica* and *Piliostigma reticulatum*. Total of 54 soil samples were collected at 15 cm depth and 5, 10 and 15 m away from the tree's trunks. Soil was analysed using standard laboratory procedures. Physical properties indicated high sand, low silt, clay and moisture which differed significantly (P<0.05) with tree species and distance. High porosity, low particle and bulk densities were obtained with no significant variation (P>0.05) between tree species. Chemical properties indicated slight acidic pH in vicinity of the trees from 5.10 at 15 m under *A. nilotica* to 6.30 at 5 m and 15 m under *S. birrea* and *A. indica*. Organic carbon ranged from 0.04 cmolkg at 15 m under *M. indica* to 2.30 cmolkg at 5 m and 15 m under *A. indica*. Nitrogen (0.077 g/kg) and phosphorus (0.49 g/kg) were higher at 5 m under *A. nilotica* and low (N=0.003 g/kg; P=0.01 g/kg) at 15 m under *B.aegyptiaca*, which in turn had higher Ca^{++} (1.06 cmol/kg) than the other species. Higher Mg^{++} (0.85 cmol/kg) was obtained at 5 m under *A. nilotica* while higher K^{+} (1.08), Na^{+} (0.65) and CEC (6.80) (cmolkg) were obtained at 5 m under *M. indica*. The soil closer to trees generally had better nutrients and pH statuses and the soil under *A. nilotica, A. indica, S. birrea, M. indica* and *B. aegyptiaca* had better properties than under *P. reticulatum*.

Keywords: Single trees, Litter, Soil physiochemical properties, Sudan savanna ecosystem, Sokoto, Nigeria.

INTRODUCTION

Improvement in soil fertility under agroforestry systems occurs mainly through addition of plant biomass. The importance of tree based land use systems in restoring soil fertility and improving the economy of farmers having small land holdings has been realized during the last 2 decades [1]. Trees accumulate considerable amounts of carbon and nutrients in their biomass, part of which is removed during harvest. The problem is greatest where whole tree is harvested, with gathering of branches and litter after timber removal. Also where burning is used for bush clearing, much of the carbon and nitrogen is lost [2]. Litter-fall is a major pathway for return of organic matter and nutrients from aerial parts of plants to the soil surface [3]. Trees have been known to play an important role in soil fertility management through addition of litter, decaying of roots, nutrients cycling and biological nitrogen fixation [4]. A good number of valuable trees have remained rather of local importance and yet to be domesticated including edible fruit and nut species both indigenous and naturalized [5,6]. Trees of all kinds provide immeasurable ecosystem services including carbon sequestration, continual replenishment of soil and removal of pollutants from the air [7].

Evaluation of litter production is important for understanding nutrient cycling, carbon fluxes, forest growth and interactions with environmental variables not only in forest ecosystems but also in farmsteads [8]. Tree species affect decomposition through direct and indirect effects. Direct effects occur through leaf litter quality while indirect effects relate to unique effects that the plant species created in the surrounding environment [9]. Being naturally adapted to local soils and climates, indigenous wild trees often survive environmental stresses better than the introduced species and these constitute important biological resources in the global agro-biodiversity context [10]. The current study sought to investigate the effect on soil physiochemical properties of litter fall under some indigenous tree species in part of the Sudan Savanna, Sokoto Northwestern Nigeria. This was to help strengthen the current drive towards the much needed conservation of indigenous plants species, which are more adapted to the climatic conditions and familiar to the local inhabitants, in addition to other benefits derivable from these plants including agroforestry.

MATERIALS AND METHODS

The Study was conducted in parts of Sokoto Metropolis, Northwestern Nigeria on latitudes 11°30 to 14°00' N longitudes 4°00 to 6°40 ’E and altitude 351.0 m above sea level, in the Sudan Savanna ecological zone [11]. Soil of the area is sandy to sandy loam in texture. It is friable and easily cultivated with poor water holding capacity. Like most other soil types of the dry savanna, the soil in the study area is young, lacking horizon development and thus classified as entisol [12]. Climate of the area is semi-arid characterized by erratic and scanty rainfall during the usually short wet seasons (June to October). The area also experiences long dry seasons that consist of a period of dry winds and dusty harmattan (November to February) and a hot dry period (March to May) [13]. Relative humidity of the area ranges from 21% to 49% in dry seasons and from 51% to 79% in wet seasons [14]. During the period of this study, precipitation data ranged between 458.19 mm and 755.03 mm with mean annual precipitation of 585.15 mm. Temperature ranged between 17.02°C in January to 41.45°C in April. Monthly average temperature of the area ranged from 22.13°C to 35.92°C and annual average temperature ranged from 22.90 to 35.98°C [11].

Collections, preparation and analysis of soil samples

The soil samples were collected at 15 cm depth from three different points, 5 m, 10 m and 15 m away from the trunks of the experimental trees namely, *Sclerocarya birrea, Balanites aegyptiaca, Acacia nilotica, Azadirachta indica, Mangifera indica and Piliostigma reticulatum.* A total of 54 core samples of the soil were collected at each time of collection, making up three replicates of the 18 representative soil treatments. The samples were air-dried, grounded and sieved using a 2 mm sieve before analysis.

Soil samples were subjected to analysis using established procedures outlined in Shieldrick and Wang and Adepetu to determine Soil particle size, Organic carbon content and Soil pH [15,16]. Particle size analysis was done using the hydrometer method, organic carbon was determined using the modified Walkly-Black wet oxidation method, whereas the soil pH was determined potentiometrically in 1:2.5 soil-water ratio using model, EL-720 digital pH Meter. Particle density, bulk density and porosity of the soil were determined by the Core method of Blake and Hartge and the results interpreted using the expressions in Lal and Shukla [17,18]. Soil moisture content was analyzed using Gravimetric technique as outlined in Klute [19]. For the determination of total nitrogen, available phosphorus and exchangeable bases: Ca^{2+}, Mg^{2+} K^{+}, Na^{+}, the methods outlined in Jaiswal were used [20]. Total Kjeldahl Nitrogen (TKN) method was used in nitrogen determination. The Olsen method of P extraction followed by subsequent calorimetric determination of P concentration was used for phosphorus determination. Exchangeable bases determination was done using the ammonium acetate extraction technique. Determination of K^{+} and Na^{+} was done by flame photometry while Ca^{2+} and Mg^{2+} were achieved by EDTA titration as outlined in Pereira et al. [21]. Effective CEC determination in the soil was by the ammonium acetate saturation method outlined in Wang et al. [22].

Data generated from the study were subjected to Analysis of variance (ANOVA) using general linear model of SAS to test the differences between the groups’ means for all the soil parameters [23]. Significant differences between the treatment means were determined using Duncan’s New Multiple Range (DNMR) test and P values <0.05 were regarded as significant [24].

RESULTS

Effect of tree species’ canopy litter on the soil physical properties

Clay proportion under *A. nilotica* (3.23) is significantly higher (P< 0.05) than that of the other tree species (1.27). The sand proportion under *B. aegyptiaca, A. nilotica* and *A. indica* (89.27) is significantly low (P< 0.05) compared to those under *M. indica* and *P. reticulatum* (91.27%). The least sand proportion is observed under *S. birrea* (88.00). Soil porosity is significantly higher (P< 0.05) at the vicinity of *B. aegyptiaca* (36.93), *A. nilotica* (36.33) and *P. reticulatum* (35.00) and low at the vicinity of *S. birrea* (34.13), *A. indica* (34.87) and *M. indica* (31.13). Particle density of the soil under *A. nilotica* (2.45) is greater than those of the other tree species. It is closely followed by *S. birrea, B. aegyptiaca, M. indica* (2.39). The particle density values under *A. indica* (2.37) and *P. reticulatum* (2.35) are slightly lower than the others’. There is no significant difference (P< 0.05) in particle density of soil under the different tree species. Bulk density is generally low across the tree species ranging from 1.53 under *B. aegyptiaca* and *A. indica* to 1.54 under *S. birrea, A. nilotica* and *P. reticulatum.* The least bulk density of 1.19 was observed under *M. indica*, which is significantly low (P< 0.05) compared to the other tree species. Moisture content is significantly high (P< 0.05) under *A. indica* (8.44), *M. indica* (8.27) and *B. aegyptiaca* (7.87) and significantly low under *P. reticulatum* (6.50*), S. birrea* (6.58) and *A. nilotica* (3.15) (**Table 1**).

Soil physical properties at varying distances away from the tree trunks

Result in **table 2** shows more silt (7.84% and 7.04%) and clay (9.61% and 9.12%) at 10 and 15 m respectively than 5.88% (silt) and 3.73% (clay) at 5 m away from tree trunk, under *S. birrea.* The highest silt proportion in this study was recorded at 5 m interval under *A. indica* (13.60%) followed by *A. nilotica* (11.76%) *P. reticulatum* (9.80%) and *M. indica* (7.84%). The silt proportions at 10 and 15 m intervals under *P. reticulatum* are 7.84% and 7.04% respectively and that obtained at 5 m interval under *M. indica* and 10 m interval under *P. reticulatum* is 5.69. The least silt values are obtained at 15 m interval under *P. reticulatum* (5.04%) and *B. aegyptiaca* (5.0%). Low equal clay proportion of 3.73% was obtained at 5 m interval under S. birrea, *A. nilotica, A. indica* and *P. reticulatum* as well as at 10 m interval under *A. nilotica, A. indica* and *M. indica*. The least clay proportions were obtained at 15 m interval under M. indica (3.04%), *A. nilotica* and *A. indica* (3.0%). At 10 and 15 m distances respectively, sand proportions are very high under *A. nilotica* (94.31 and 94.20%), *M. indica* (92.41 and 92.06%), *B. aegyptiaca* (92.35 and 92.04%). At 5 m interval under *S. birrea, B. aegyptiaca* and *A. nilotica* sand proportion is equally high (90.39%), so also under A. indica (76.67%). At 5 and 10 m intervals, under P. reticulatum, sand proportion is equally high (86.47%) and much closer to that at 15 m interval (86.0%).

Soil porosity (g/cm^3) is high at 5 m interval under both tree species with A. nilotica and *P. reticulatum* having the highest value (40.20) than B. aegyptiaca (39.30), M. indica (37.71), *A. indica* (36.80) and *S. birrea* (35.70). These values are higher than those at 10 m and 15 m intervals respectively under *A. nilotica* (24.50 and 24.30), *B. aegyptiaca* (22.90 and 22.60), *A. indica* (22.20 and 22.60), *M. indica* (22.60 and 22.10), *P. reticulatum* (20.60 and 20.40) and *S. birrea* (20.50 and 20.20). Particle density (g/cm^3) is greater at 5 m interval than at 10 m and 15 m intervals respectively under *B. aegyptiaca* (2.18>1.63 and 1.45), *A. nilotica* (2.0>1.44 and 1.44) and *P. reticulatum* (2.0>1.43 and 1.43). Particle density values are low at 5, 10 and 15 m intervals respectively under *S. birrea* (1.59, 1.49 and 1.10), *A. indica* (1.69, 1.31 and 1.38) and *M. indica* (1.70, 1.62 and 1.08). Bulk density values (g/cm^3) under all the tree species are higher at 10 m and 15 m intervals than at 5 m interval respectively *viz*: *M. indica* (3.11, 3.10 and 2.01), *A. nilotica* (2.76, 2.17 and 1.93), *A. indica* (2.61, 2.29, 1.90), *S. birrea* (2.41, 2.41 and 1.82), *B. aegyptiaca* (2.33, 2.34 and 1.67) and *P. reticulatum* (2.27, 2.50 and 1.77) (**Table 2**).

Table 1: Effect of canopy litter of varying tree species on the soil physical properties.

Tree spp	Parameters						
	Sand (%)	Silt (%)	Clay (%)	Moisture (%)	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Porosity (g/cm^3)
A	88.00^{b}	10.47^{a}	1.27^{b}	6.58^{c}	1.54^{a}	2.39^{a}	34.13^{a}
B	89.27^{b}	9.13^{b}	1.27^{b}	7.87^{b}	1.53^{a}	2.39^{a}	36.93^{a}
C	89.27^{b}	9.13^{b}	3.23^{a}	3.15^{d}	1.54^{a}	2.45^{a}	36.33^{a}
D	89.27^{b}	9.13^{b}	1.27^{b}	8.44^{a}	1.53^{a}	2.37^{a}	34.87^{a}
E	91.27^{a}	7.80^{c}	1.27^{b}	8.27^{a}	1.19^{a}	2.39^{a}	31.13^{a}
F	91.27^{a}	8.47^{c}	1.27^{b}	6.50^{c}	1.54^{a}	2.35^{a}	35.00^{a}
SE ±	0.541	0.371	0.448	0.853	0.09	0.06	2.15
Significance	*	*	*	*	NS	NS	NS

Values are expressed as mean ± standard error of means based on three replicates. Means in a column followed by same super script (s) are not significantly different (NS). * = significant (P< 0.05).

A= *S. birrea*; B= *B. aegyptiaca*; C= *A. nilotica*; D= *A. indica*; E= *M.* indica; F= *P. reticulatum*

Table 2: Soil physical properties at varying distances from canopy litter of the tree species.

Tree Species	Parameters						
Distance (m)	Sand (%)	Silt (%)	Clay (%)	Moisture	Bulk density (g/ cm^3)	Particle density (g/cm^3)	Porosity (g/ cm^3)
A							
5	90.39	5.88	3.73	0.1	1.82	1.59	35.7
10	82.55	7.84	9.61	0.2	2.41	1.49	20.5
15	82.16	7.04	9.12	0.12	2.41	1.1	20.2

B							
5	90.39	3.92	5.69	0.45	1.67	2.18	39.3
10	92.35	1.96	5.69	0.2	2.33	1.63	22.9
15	92.04	1.04	5	0.25	2.34	1.45	22.6
C							
5	90.39	11.76	3.73	0.05	1.93	2	40.2
10	94.31	1.96	3.73	0.05	2.76	1.44	24.5
15	94.2	1.22	3	0.05	2.17	1.44	24.3
D							
5	76.67	13.6	3.73	0.1	1.9	1.69	36.8
10	70.39	5.88	3.73	0	2.61	1.31	22.2
15	70.8	5.28	3	0	2.29	1.38	22.6
E							
5	84.47	7.84	5.69	0	2.01	1.7	37.71
10	92.41	3.92	3.73	0	3.11	1.62	20.6
15	92.06	3.64	3.04	0	3.1	1.08	20.1
F							
5	86.47	9.8	3.73	0.05	1.77	2	40.2
10	86.47	7.84	5.69	0	2.27	1.43	20.6
15	86	7.04	5.04	0.05	2.5	1.43	20.4
Values are based 5 m, 10 m and 15 m distances away from the trunks of the respective tree species. A= *S. birrea*; B= *B. aegyptiaca*; C= *A. nilotica*; D= *A. indica*; E= *M. indica*; F= *P. reticulatum*							

Effect of different trees' canopy litter on soil chemical properties

Organic carbon content (g/kg) is significantly higher (P< 0.05) under *P. reticulatum* (2.35), *A. indica* (2.20) and *M. indica* (2.19). Total nitrogen (g/kg) is significantly higher (P< 0.05) under *A. nilotica* (0.051) and *S. birrea* (0.044) than those under *A. indica* (0.028), *B. aegyptiaca* and *M. indica* (0.023) and the least of them all *P. reticulatum* (0.021). Available phosphorus (mg/kg) is significantly higher under *P. reticulatum* (0.40) and significantly low (P< 0.05) under the other tree species *viz: A. nilotica* (0.32), *A. indica* (0.31), *S. birrea* and *B. aegyptiaca* (0.30) and *M. indica* (0.29). Calcium (cmol/kg) is significantly higher (P< 0.05) under *B. aegyptiaca* (0.67) and significantly low (P< 0.05) under the other tree species *viz*: *P. reticulatum* (0.43), *S. birrea* (0.40), *A. indica* (0.37), *M. indica* (0.36) and *A. nilotica* (0.34). The value of 0.43 for Ca^{2+} is the same as that of *P. reticulatum*. Magnesium (cmol/mg) is significantly high (P< 0.05) under *A. nilotica* (0.55), *A. indica* and *M. indica* (0.50) but significantly low under *P. reticulatum* and *S. birrea* (0.47) and the least, *B. aegyptiaca* (0.43). All values of Mg^+ except for *A. nilotica*, *A. indica* and *M. indica* are low. Potassium (cmol/mg) is significantly higher (P< 0.05) under *M. indica* (0.78), *A. indica* (0.63) and *A. nilotica* (0.60) but significantly low (P< 0.05) under *B. aegyptiaca* (0.52), *S. birrea* (0.48) and P. *reticulatum* (0.46). CEC (cmol/kg) is significantly high (P< 0.05) under *M. indica* (6.13), *A. nilotica* (5.85) and *S. birrea* (5.73) and significantly low (P< 0.05) under *A. indica* (5.20), *B. aegyptiaca* and *P. reticulatum* (4.87). The high CEC values in this study vary significantly (P< 0.05) from a low CEC value of 4.87 to a high CEC value of 6.13. The low Na^+ values in the soil under *B. aegyptiaca* (0.19), *P. reticulatum* (0.20), *S. birrea* and *A. nilotica* (0.29) are significantly different (P< 0.05) from the high Na^+ values under *M. indica* (0.43) and *A. indica* (0.38) (**Table 3**).

Table 3: Soil chemical properties under the canopy litter of different tree species.

Tree species	Parameters								
	Mean pH	Org C (%)	TN (g/kg)	AvP (mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	CEC

					(cmol/k g)				
A	6.20^{a}	1.28^{c}	0.044^{a}	0.30^{c}	0.40^{b}	0.47^{b}	0.48^{b}	0.29^{b}	5.73^{a}
B	5.93^{a}	0.57^{d}	0.023^{b}	0.30^{c}	0.67^{a}	0.43^{b}	0.52^{b}	0.19^{c}	4.87^{a}
C	5.20^{a}	1.65^{c}	0.051^{a}	0.32^{c}	0.34^{b}	0.55^{a}	0.60^{a}	0.29^{b}	5.87^{a}
D	6.20^{a}	2.20^{b}	0.028^{b}	1.31^{a}	0.37^{b}	0.55^{a}	0.63^{a}	0.38^{a}	5.20^{a}
E	5.93^{a}	2.19^{b}	0.023^{b}	0.29^{c}	0.36^{b}	0.50^{a}	0.78^{a}	0.43^{a}	6.13^{a}
F	6.13^{a}	2.35^{a}	0.021^{b}	0.40^{b}	0.43^{b}	0.47^{b}	0.46^{b}	0.20^{c}	4.87^{a}
SE ±	0.06	0.050	0.009	0.025	0.045	0.023	0.027	0.034	0.155
Significance	NS	*	*	*	*	*	*	*	NS

Values are expressed as mean ± standard error of means based on three replicates. Means in a column followed by same superscript (s) are not significantly different (NS). * = significant (P<0.05).

A= *S. birrea*; B= *B. aegyptiaca*; C= *A. nilotica*; D= *A. indica*; E= *M. indica*; F= *P. reticulatum*

Soil chemical properties at varying distances away from the tree trunks

Organic carbon is higher at 5 m interval under *A. indica* (6.30), *P. reticulatum* (6.20) and *M. indica* (6.00). It is also higher at 15 and 10 m intervals respectively under *A. indica* (6.30 and 6.00). Organic C is generally low at 5 and 15 m intervals respectively under *A. nilotica* (1.98 and 1.18). It is also low at 10 m interval under *S. birrea* (1.00), *B. aegyptiaca* (0.78), *P. reticulatum* (0.58), *M. indica* (0.54) and at 15 m interval under *P. reticulatum* (0.28), *B. aegyptiaca* (0.08) and *M. indica* (0.04).

Total nitrogen is higher at 5 m interval under *A. nilotica* (0.077) and at 15 m interval under *S. birrea* (0.070), medium at 5 m interval under B. aegyptiaca, M. indica, at 10 m interval under *A. indica*, *A. nilotica* (0.035) and *B. aegyptiaca* (0.032). Nitrogen is content is least at 15 m interval under *A. indica* (0.007), *B. aegyptiaca* and *P. reticulatum* (0.004).

Phosphorus content is high at 5 m interval under *P. reticulatum* (0.60), *A. nilotica* (0.49), *A. indica* (0.48), *B. aegyptiaca* and at 10 m interval under *A. nilotica* (0.46). Medium P values were obtained 5 m interval under *S. birrea* (0.45), *M. indica* (0.44), at 10 m interval under *B. aegyptiaca*, *M. indica* and *A. indica* (0.42) as well as *S. birrea* and *P. reticulatum* (0.41). Low P values were obtained at 15 m interval under *P. retculatum* (0.19), *S. birrea* (0.04), *M. indica*, *A. indica*, *A. nilotica* (0.02) and *B. aegyptiaca* (0.01).

Higher Ca^{2+} content was recorded under *B. aegyptiaca* at 5 m interval (1.06), *P. reticulatum* at 10 m interval (0.65), *S. birrea*, *A. indica* and *P. reticulatum* at 5 m interval (0.60), *A. indica* at 5 m interval, *M. indica* and *A. nilotica* at 10 m interval (0.55). Calcium is relatively medium at 10 m interval under *B. aegyptiaca* (0.50), *A. nilotica*, *A. indica* (0.45), at 5 m interval under *M. indica* and 15 m interval under *B. aegyptiaca* (0.44). Low Ca^{2+} contents were obtained at 15 m interval under *M. indica* (0.10), *A. indica*, *P. reticulatum*, *S. birrea* (0.05) and *A. nilotica* (0.01). Magnesium is high at 5 m interval under *A. nilotica* (0.85), *A. indica*, *M. indica* (0.75), *S. birrea*, *P. reticulatum (*0.70), *B. aegyptiaca* at 5 m interval, *S. birrea*, *P. reticulatum* at 10 m interval (0.65), *B. aegyptiaca*, *A nilotica*, *A. indica* and *M. indida* at 10 m interval (0.60). Low Mg^{2+} levels were obtained at 15 m interval under *A. nilotica* (0.20), *A. indica*, *M. indica* (0.15), *S. birrea*, *B. aegyptiaca* and *P. reticulatun* (0.05).

Potassium is higher at 5 m interval under *M. indica* (1.08), *A. indica* (0.95), *A. nilotica* (0.90), *B. aegyptiaca* (0.79), *S. birrea* (0.72) and *P. reticulatum* (0.69). It is also high at 10 m interval under *A. indica* (0.82), *A. nilotica* (0.72), *M. indica* (0.67), *S. birrea* (0.62). Medium K^{+} contents were found under *B. aegyptiaca* and *P. reticulatum* at 10 m interval (0.56) and at 15 m interval under *M. indica* (0.59). Potassium is low at 15 m away from tree trunk under *B. aegyptiaca* (0.23), *A. nilotica* (0.18), *A. indica* and *P. reticulatum* (0.13) and *S. birrea* (0.10). High CEC levels were found at 5 m interval under *M. indica* (7.40), *A. indica*, *A. nilotica* (6.80) and *S. birrea* (6.20). The CEC level is medium at 5 m interval under *B aegyptiaca* and *P. reticulatum* (5.80), at 10 and 15 m intervals respectively under *M. indica* (5.70 and 5.30), *S. birrea* (5.60 and 5.40), *A. nilotica* (5.20 and 5.60), *P. reticulatum* (4.81 and 4.01), *A. indica* (4.80 and 4.00) and *B. aegyptiaca* (4.40 and 4.40). Sodium content of the soil is generally low ranging from 0.03 to 0.65 depending on tree species and distance from tree trunk. At 5 m interval, Na^{2+} under *M. indica* is 0.65, A. *indica* (0.57), *A. nilotica* (0.52), *S. birrea*, *B. aegyptiaca* and *A. indica* (0.43). At 10 m interval, Na^{+} reduced across the tree species *viz*: *A. indica* (0.43), *S. birrea* and *A. nilotica* (0.39), *B. aegyptiaca* and *M. indica* (0.35) and *P. reticulatum* (0.03). At 15 m away from tree trunk, Na^{+} values by species are *S. birrea* (0.04), *B. aegyptiaca* (0.08), *M. indica* (0.30), *A. indica* (0.14), *A. nilotica* and *P. reticulatum* (0.13).

Soil pH level is slightly acidic at 5 m interval across the tree species from 5.30 under *A. nilotica* to 6.30 under *S. birrea* and *A. indica*. It is more acidic at 10 m interval from 5.1 under *A. nilotica* to 6.0 under *S. birrea*, *A. indica* and *P. reticulatum*. Slight increase in pH level was observed at 15 m interval under *A. nilotica* (5.1), *B. aegyptiaca* (5.9), *P. reticulatum* (6.2), *S. birrea* and *A. indica* (6.3) (**Table 4**).

Table 4: Soil chemical Properties at varying distances away from the canopy litter of different tree species.

Tree spp	Parameters								
Dist. (m)	Mean pH	Org C (%)	TN (g/kg)	AvP(mg/kg)	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	CEC
					(cmol/kg)				
A									
5	6.3	0.92	0.035	0.45	0.6	0.7	0.72	0.43	6.2
10	6	1	0.028	0.41	0.55	0.65	0.62	0.39	5.6
15	6.3	1.92	0.07	0.04	0.05	0.05	0.1	0.04	5.4
B									
5	6	0.86	0.035	0.46	1.06	0.65	0.79	0.43	5.8
10	5.9	0.78	0.032	0.42	0.5	0.6	0.56	0.35	4.4
15	5.9	0.08	0.003	0.01	0.44	0.05	0.23	0.08	4.4
C									
5	5.3	1.98	0.077	0.49	0.55	0.85	0.9	0.52	6.8
10	5.2	1.8	0.035	0.46	0.45	0.6	0.72	0.39	5.2
15	5.1	1.18	0.042	0.02	0.01	0.2	0.18	0.13	5.6
D									
5	6.3	2.3	0.042	0.48	0.6	0.75	0.95	0.57	6.8
10	6	2	0.035	0.42	0.45	0.6	0.82	0.43	4.8
15	6.3	2.3	0.007	0.02	0.05	0.15	0.13	0.14	4
E									
5	6	2	0.035	0.44	0.44	0.75	1.08	0.65	7.4
10	5.9	0.54	0.025	0.42	0.55	0.6	0.67	0.35	5.7
15	5.9	0.04	0.01	0.02	0.1	0.15	0.59	0.3	5.3
F									
5	6.2	1.2	0.032	0.6	0.6	0.7	0.69	0.43	5.8
10	6	0.58	0.028	0.41	0.65	0.65	0.56	0.03	4.81
15	6.2	0.28	0.004	0.19	0.05	0.05	0.13	0.13	4.01

Values are based on 5, 10 & 15 m distances away from the trunks of the respective tree species.

A= *S. birrea*; B= *B. aegyptiaca*; C= *A. nilotica*; D= *A. indica*; E= *M. indica*; F= *P. reticulatum*. Org C = Organic Carbon, N = Nitrogen, AvP = Available phosphorus

DISCUSSION

The organic carbon content (g/kg) with range of 0.57 to 2.35 and a mean of 1.71 indicates low organic matter in the soil across the tree species, which vary considerably with the distance from the trees' trunks. This corroborates the finding of Malami et al. and Anka, who reported low organic carbon content in the area based on Esu ranking of <10 g/kg low; 10-15 g/kg medium; >15 g/kg high [4,25]. Its higher proportions under *P. reticulatum*, *A. indica* and *M. indica* may be due to litter fall which is higher under these species than the others. Eswaren et al. did reported earlier that organic matter content of mineral soils of the tropics are always ranging from a mere trace to as high as 20%-50% depending on availability of biomass and rate of decomposition [26].

The low nitrogen content of the soil in this study (0.021-0.051 g/kg) cuts across sampling locations irrespective of their distance away from the trees' canopies, amounts of litter fall and rates of decomposition. It is low by the rankings of both Esu and Landon [25,27]. This result is related to the universal assumption of low nitrogen content for tropical mineral soils as well as the low organic matter content of the soil [28]. According to Khai et al. and Galavi et al., availability of nitrogen in the soil is strongly influenced by organic matter content of the soil.

Available phosphorus content (mg/mg) in the soil (0.29-0.40) is low by the ratings of Esu and Landon [25,27]. This may be due to sparse distribution of the trees, poor leaf litter accumulation, low rates of organic matter decomposition and high rates of human activities around the tree species in the area as earlier reported by Malami et al. The pH range of the soil (5.20-6.20) across the tree species is from moderate to slight acidic. The soil is slightly acidic near tree trunk than further away. Result corroborates the work of Malami et al. with *A. nilotica*, *B. aegyptiaca* and *M. indica* being moderately acidic while *P. reticulatum*, *A. indica* and *S. birrea* being slightly acidic. The acidic nature of the soil pH agrees with the claim of Reich et al. that most of the sub Saharan West African alfisols have acidic surface [29].

Calcium content of the soil (0.34–0.67 cmol/kg) is low by Esu and Landon rankings of <0.75 low; 1.0-2.0 medium; >3.35 high [25,27]. The low Ca^{2+} may be due to low litter accumulation characteristic of the single trees. The finding agrees with Malami et al. that Ca^{2+} and Mg^{2+} are generally high under thick vegetation than single trees and that some species, in this case, *B. aegyptiaca*, *S. birrea* and *P. reticulatum* have more Ca^{2+} than the other tree species.

Magnesium composition (cmol/kg) in the soil (0.43-0.55) is medium by Esu ranking and low by Landon ranking, which indicated that Mg^{2+} level of 0.5 cmol/mg in soil is considered deficient in tropical environment [25,27]. Values of Mg^{2+} in the soil are greater than those of Malami et al. The higher values of Mg^{2+} under *A. nilotica*, *M. indica* and *A. indica* and its low values under *B. aegyptiaca*, *S. birrea* and *P. reticulatum* may be due to amounts of litter fall from the trees and their decomposition rates.

Soil K^{+} obtained in this study (0.46-0.78 cmol/kg) is lower than that of Malami (0.18-6.66 cmol/kg), with greater contents found around shelterbelts than single trees, but both studies had higher K^{+} values under trees than on bare ground. More K^{+} contents were also found under *M. indica*, *A. indica* and *A. nilotica* than the other tree species. Contribution of litter falls may have been responsible for these slight variations. By FAO ranking of 0-2.0 mg/L, the K^{+} content in this study can be considered normal [20].

Unlike Ca^{2+} and Mg^{2+} whose concentrations in the soil were higher under the trees than on bare ground, more Na^{+} concentrations were obtained on bare ground than closer to the trunk for all the tree species. This result corroborates the finding of Joshi that Ca^{2+} and Mg^{2+} are generally low where Na^{+} is high [30]. Low Na^{+} contents were found under all the tree species except *M. indica* and *A. indica* where Na^{+} was slightly higher but non sodic, as reported by Landon that soils having exchangeable sodium greater than 1.0 cmol/kg are considered potentially sodic [26].

The CEC values of the soil (4.87-6.13 cmol/kg) are considered low by the rankings of Esu and Landon of 6 cmol/kg low; 15 cmol/kg medium; >15-30 cmol/kg high [25,27]. The higher relative CEC values recorded under *M. indica, A. nilotica, S. birrea* and *A. indica* than *B. aegyptiaca* and *P. reticulatum* is attributable to much litter falls under the former than the later. More over the concentrations of exchangeable ions in this study are more under the former than the later species [31,32].

CONCLUSION

In conclusion, physical properties of the soil showed high soil porosity due to high sand, low clay and low silt proportions coupled with low moisture retention, which did not differ significantly across the tree species.

The soil chemical properties indicated significant variation across the tree species in organic carbon, total nitrogen, available phosphorus and exchangeable bases: Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} depending on species types and the soil in the vicinity. While higher nitrogen was reported under *A. nilotica*, and higher phosphorus under *A. indica*, more organic carbon was found both under *P. reticulatum*, *M. indica* and *A. indica*. Exchangeable bases showed slight variation across the tree species. Soil pH showed from slight to moderate acidic reactions while CEC is slightly higher with no significant variation across the tree species.

The long-term interactions between the single tree species with their peculiarities and the soil in the vicinity can be said to have created favourable conditions for decomposition of their own litter thereby creating affinity between the trees and their microenvironment hence the variations in some soil parameters across the tree species.

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