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Effects of Organic Residue of *Parkia biglobosa* Pods on Some Physicochemical Properties of Azare Farms, Bauchi State, Nigeria

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Abstract The effects of organic residue amendment on some physicochemical properties of Azare farms after varied incubation periods (0, 30 and 60 days) using the organic residue of *Parkia biglobosa* pods was investigated. A complete randomized experimental design was adapted. Each treatment was replicated three times and was incubated at room temperature. At the end of 0, 30 and 60 days, the following parameters were assayed using standard analytical methods: soil bulk density, organic matter, organic carbon, available phosphorus, total nitrogen and exchangeable bases (Ca, Mg, K and Na). The observed values showed spread levels of : soil bulk density (1.34 to 1.41 g/cm^3), organic matter (6.30 to 20.10 g/kg), organic carbon (3.52 to 11.60 g/kg), available phosphorus (13.24 to 15.81 cmol/kg), total nitrogen (0.77 to 1.75 g/kg) as well as exchangeable bases: Ca (3.45 to 3.97 cmol/kg), Mg (0.37 to 0.42 cmol/kg), K (0.29 to 1.72 cmol/kg) and Na (0.21 to 0.41 cmol/kg). The bulk density decreased with increase in incubation periods, while the organic carbon, total nitrogen and available phosphorus increased with increase in incubation periods. The exchangeable bases (Ca, Mg, K and Na) showed decline and increase in an irregular pattern. The organic residue of *Parkia biglobosa* pods significantly affected ($p < 0.05$) the nutrients of the soil as shown by the single factor analysis of variance and the least significant difference test. The organic residue of *Parkia biglobosa* pods is therefore recommended in enhancing the fertility indices of the soil samples investigated.

Keywords Organic residue, *Parkia biglobosa pods*, physicochemical properties, complete randomized experimental design, total nitrogen, available phosphorus, single factor analysis of variance and least significant difference

Introduction

Soil is widely considered as a fundamental resource for production of crops and agriculture as a whole. Continuous farming activities such as long period of cropping without the addition of any soil improving materials can impoverish the soil and when the soil is unable to meet the requirements of plants, it is considered to be constrained. Serious attention is therefore required to boost its fertility status [1]. Returning crop residue to the soil influences favourable effects on physical and chemical properties of soil. Plant residues can affect soil conditions such as pH and play vital role in soil fertility and cycling of elements in the soil [2]. Arable land in Northern Nigeria is an important area for the production of several crops namely cereals (millet, sorghum, maize, rice and wheat), legumes (cowpea, groundnut and soybean), vegetables (tomato, onion), root and tubers (cassava, yam and sweet potatoes) and many others [3]. Research has shown that the success of applying organic materials in the tropics is due to higher decomposition rates of plant residues and soil organic matter in humid tropical environment than under temperate conditions [4]. Organic materials have also been observed to increase microbial biomass and activity in soils, which suggests a more responsive microbial community in such soils [5]. The use of organic manures generally ensures effective and efficient management of soil by providing nutrients in correct quantity and proportions in environmentally beneficial forms [6].

The economic value of organic materials added to the soil is related to increasing crop yield and absolutely related to soil fertility as well as soil quality. Long term effect of organic amendment has many economic values to rural farmers [7]. This means that the use of organic amendment in crop production by farmers could help to reduce reliance on inorganic fertilizers and hence decrease the cost of production, increase profit and sustain better livelihood of the rural farmers in Northern Nigeria. The cost implications for the use of inorganic fertilizers by farmers in many States of Northern Nigeria have yielded decrease in crop production. The application of organic materials is however cheap and this might economically increase the yield of many vital crops in Northern Nigeria. Increase in crop productions will reduce hunger, malnutrition, poverty and other social crises in the whole of Northern Nigeria [8].

Parkia biglobosa is a common species of the parkland agro-forestry and this plays important roles in food and wood production, supply of timber, firewood, pulp and fibre through fodder, gum, drugs and dyes as well as restoration of soil fertility [9]. The fruits are brown in colour when ripe; it contains numerous black seeds embedded in yellowish sweet tasting pulp. In dry area, locust bean trees serve as potential sources of food, edible oil, fodder, lumber, fire wood and green manure [10]. The seeds are the most valued product of the tree in Nigeria and serve as food buffer during lean period, while reliable income accurse to the farmers involved in harvesting and marketing of the product. The uses also include food, medicine, manure, gum, shade, wind break, bee food, stabilization of degraded environment, livestock feed, fuel, fibre, fish poison among several others [11]. The aim of this study is to determine the effects of organic residue of *Parkia biglobosa* pods on some physicochemical properties of Azare farms, Bauchi State, Nigeria.

Materials and Methods

Materials

In the preparation of all the solutions, chemicals of analytical reagent grade purity and distilled water were used throughout the research work. All the glass and plastic wares utilized were thoroughly washed with detergent solution, then 20.00 % (v/v) nitric acid, rinsed with tap water and finally with distilled water.

Study Area

The study was conducted in Azare, Katagum Local Government Area, located on 11°40′27″N and 10°11′28″E and agriculture is the main stay of the economy of town.

Sampling of Soil Samples

Bulk soil samples were collected randomly at a depth of 0 – 30 cm using soil auger from ten (10) different farms in Azare town. The soil was combined together to form a composite soil sample, air - dried, ground using a wooden pestle and mortar as well as sieved through a 2 mm mesh in order to remove the “not soil and the impurities”. The sieved soil samples were labeled appropriately and used in the various treatments and for laboratory analyses.

Sampling of *Parkia biglobosa* Pods

The pods of *Parkia biglobosa* were collected randomly in Azare town; air-dried, ground using a wooden pestle and mortar, then sieved using a 2 mm sieve so as to obtain fine powder of the organic residue. The sieved sample was stored in air-tight plastic container and labeled prior to usage.

Experimental Design

The experiment was a complete randomized design consisting of three treatments (0, 30, and 60 days) and each was replicated three times. This forms a total of nine plastic pots that were used for the soil samples prepared in section 2.3. 1.00 kg of the soil sample was weighed into each of the nine plastic pots and 200.00 g of the organic residue of *Parkia biglobosa* pods prepared in section 2.4 was added to all the set–ups, except the control soil samples (0 day treatment). 50.00 cm^3 of water was added daily to only the 30 and 60 days treatments in order to keep the soil samples slightly moist. At the end of each treatment, the organic residue was removed and discarded. Soil samples from each treatment were collected and thoroughly mixed together to form a composite soil sample. This was air - dried, ground using a wooden pestle and mortar, sieved through a 2 mm sieve, labeled appropriately and then used for the soil chemical analyses required.

Laboratory Analyses

Determination of Bulk Density

The soil bulk density was determined using the method adopted by Hassan *et al.,* 2017a [12].

Determination of Organic Matter

The levels of organic matter in the soil samples were determined based on the method adopted by Hassan *et al.*, 2019a [13].

Determination of Organic Carbon

The organic carbon of the soil samples investigated was assayed using the Walkley – Black Method adopted by Hassan *et al.,* 2017a [12].

Determination of Available Phosphorus

Soil available phosphorus was determined using Bray method/molybdenum blue colorimetric method adopted by Funmilayo and Solomon, 2006 [14].

Determination of Total Nitrogen

The total nitrogen content of the soil samples at varied incubation periods was determined using Kjeldahl method [15].

Determination of Exchangeable Bases

Soil exchangeable bases at 0, 30 and 60 days respectively were separately extracted using ammonium ethanoate pH 7 buffer solution and then determined by means of Atomic Absorption Spectrophotometer Model AA320N [16].

Result and Discussion

Results

Some physicochemical properties of soil samples from Azare farms after varied treatments with the organic residue of *Parkia biglobosa* pods for 0 (Control), 30 and 60 days are presented in Table 1.

Table 1: Some Physicochemical Properties of Azare Farms after Varied Treatments with the Organic Residue of *Parkia biglobosa* Pods

Parameters	**Incubation Periods (days)**		
	Control	**FT**	**ST**
Bulk Density (g/cm^3)	$1.41^a \pm 0.01$	$1.36^b \pm 0.01$	$1.34^c \pm 0.01$
Organic Matter (g/kg)	$6.40^c \pm 0.30$	$15.10^b \pm 0.10$	$20.10^a \pm 0.00$
Organic Carbon (g/kg)	$3.52^c \pm 0.18$	$8.81^b \pm 0.07$	$11.60^a \pm 0.00$
Total Nitrogen (g/kg)	$0.77^c \pm 0.03$	$1.06^b \pm 0.03$	$1.75^a \pm 0.00$
Available Phosphorous (cmol/kg)	$14.21^b \pm 0.10$	$13.24^c \pm 0.01$	$15.81^a \pm 0.09$
Calcium (cmol/kg)	$3.97^a \pm 0.04$	$3.45^c \pm 0.01$	$3.74^b \pm 0.06$
Magnesium (cmol/kg)	$0.43^a \pm 0.01$	$0.39^b \pm 0.01$	$0.37^c \pm 0.01$
Potassium (cmol/kg)	$0.35^b \pm 0.01$	$0.29^c \pm 0.00$	$1.72^a \pm 0.02$
Sodium (cmol/kg)	$0.28^b \pm 0.01$	$0.41^a \pm 0.01$	$0.21^c \pm 0.00$

Values are mean ± standard error of the mean (n = 3). C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days). Values on the same row with the same superscript alphabets are statistically the same, whilst values on the same row with different superscript alphabets differ significantly ($p < 0.05$) as revealed by single factor analysis of variance and least significant difference test.

Discussion

Levels of Bulk Density after Varied Treatments

The bulk density of the soil samples investigated as shown in Table 1 ranged from 1.34 g/cm^3 (second treatment) to 1.41 g/cm^3 (control soil sample). The observed values are all lower than the critical limit (1.60 g/cm^3) meant for optimum growth of roots [12]. A similar decreasing trend was also reported [12]. Low soil bulk density is of advantage as this can enhance the penetration and growth of roots [17]. Low soil bulk density can also facilitate access to soil moisture as well as nutrient uptake which can lead to increase in crop yield [17]. Significant differences were found to exist ($p < 0.05$) as depicted in Table 2.

Table 2: Multiple Comparison of the Levels of Bulk Density (g/cm^3) of Azare Farms after Varied Treatments (LSD = 0.033)

	C: 1.41	**FT: 1.36**	**ST : 1.34**
C: 1.41		0.05	0.07
FT: 1.36			

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

Levels of Organic Matter after Varied Treatments

The levels of organic matter increased from 6.40 g/kg (control) to 20.10 g/kg (60 days) with 15.10 g/kg falling between the extreme observed levels. The increase in the levels of the organic matter content in both the 30 and 60 days treatment might be due to the decomposition of the organic residue pods investigated. Similar observed increasing trends were also reported [18] [19]. The presence of organic matter in soils is significant since it is necessary in maintaining soil structures, particularly in fine textured soils. It enhances the cation exchange capacity and hence decreases leaching losses of elements such as potassium and magnesium. It is a reservoir for soil nitrogen and enhances water retention capacity of soils. Table 3 revealed that statistical significant differences exist ($p < 0.05$) in the organic matter levels of soil samples after varied treatments with the organic residues of *Parkia biglobosa* pods.

Table 3: Multiple Comparison of the Levels of Organic Matter (g/kg) of Azare Farms after Varied Treatments (LSD = 0.69)

	ST: 20.10	**FT: 15.10**	**C : 6.40**
ST: 20.10		5.00	13.70
FT: 15.10			8.70

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

Levels of Organic Carbon, Total Nitrogen and Available Phosphorus after Varied Treatments

Table 1 shows the levels of the various parameters investigated. The concentrations of organic carbon ranged from 3.52 g/kg (control soil sample) to 11.60 g/kg (second treatment). The level of 8.81 g/kg (first treatment) fell between the spread experimental values. Based on the present study, it is therefore evident that the highest observed value of 11.60 g/kg (second treatment) can be rated as medium in terms of soil fertility index [19]. Ziblim *et al.,* 2014 also reported a similar increasing organic carbon trend when Voandzeia subterranean and Arachis hypogeal residues were treated into soil samples [20]. Table 4 revealed that the observed organic carbon values are significantly different ($p < 0.05$). Organic carbon content of soils facilitates the retention of soil micronutrients in both the unavailable and available forms in plants.

Table 4: Multiple Comparison of the Levels of Organic Carbon (g/kg) of Azare Farms after Varied Treatments (LSD = 0.221)

	ST: 11.60	**FT: 8.81**	**C : 3.52**
ST: 11.60		2.79	8.08
FT: 8.81			5.29

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

The levels of total nitrogen (g/kg) as shown in Table 1 ranged from 0.77 (control) to 1.75 (second treatment). The level of 1.06 g/kg total nitrogen fell in between the spread observed values. An increasing trend was earlier reported by Hassan *et al.*, 2019a [13]. A total soil nitrogen of less than 1.50, 1.50 to 2.00 and higher than 2.00 g/kg are characterized as low, medium and high respectively based on soil fertility rating [13]. The control soil sample can therefore be classified as having low nitrogen content. Treatment of the analyte has therefore facilitated the soil sample to a medium fertility. Table 5 shows that statistical significant differences exist ($p < 0.05$) when the control soil sample was treated with the organic residue of *Parkia biglobosa* pods. Nitrogen is used for the growth of plants. This is because it is a major component of all amino acids. A good supply of nitrogen stimulates root growth, development as well as the uptake of other nutrients [21].

Table 5: Multiple Comparison of the Levels of Total Nitrogen (g/kg) of Azare Farms after Varied Treatments (LSD = 0.096)

	ST: 1.75	**FT: 1.06**	**C : 0.77**
ST: 1.75		0.69	0.98
FT: 1.06			0.29

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

The concentrations of available phosphorus spread from 13.24 cmol/kg (first treatment) to 15.81 cmol/kg (second treatment) with 14.21 cmol/kg (control soil sample) falling in between the extreme observed values as shown in Table 1. Available phosphorus in soil samples of less than 10.00, 10.00 to 20.00 and higher than 20.00 cmol(+)/kg are characterized as having low, medium and high soil fertility respectively [13]. All the observed values therefore fell within the medium fertility indices of soil. It can be seen from Table 6 that significant differences of the levels of available phosphorus exist ($p < 0.05$) at varied treatments. Phosphorus enhances the physiology of plants which include the fundamental process of photosynthesis, flowering fruiting maturation as well as formation of co-enzymes. The growth of root especially development of lateral roots are also facilitated by phosphorus [21].

Table 6: Multiple Comparison of the Levels of Available Phosphorus (cmol(+)/kg) of Azare Farms after Varied Treatments (LSD = 0.29)

	ST: 15.81	**C: 14.21**	**FT : 13.24**
ST: 15.81		1.60	2.57
C: 14.21			0.97

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

Levels of Exchangeable Bases after Varied Treatments

The levels of calcium as shown in Table 1 ranged from 3.45 cmol/kg (first treatment) to 3.97 cmol/kg (control) with 3.74 cmol/kg (second treatment) falling in between the extreme experimental values. A similar decreasing calcium trend (Table 7) was also reported [20]. The decreasing trend might be because the element is used by decomposing micro-organisms. Soil fertility characterization based on the concentration of calcium rated soil as low fertility (less than 2.00 cmol/kg), medium (2.00 to 5.00 cmol//kg) and high fertility (greater than 5.00 cmol/kg). The soil sample investigated therefore fell within the medium soil fertility status.

Table7: Multiple Comparison of the Levels of Exchangeable Calcium (cmol/kg) of Azare Farms after Varied Treatments (LSD = 0.16)

	C: 3.97	**ST: 3.74**	**FT : 3.45**
C: 3.97		0.23	0.52
ST: 3.74			0.29

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

The levels of magnesium ranged from 0.37 cmol/kg (60 days treatment) to 0.42 cmol/kg (0 day treatment). Similar decreasing magnesium trend was also reported [22]. This might be due to the use of the element by microorganisms during mineralization and decomposition. Exchangeable magnesium lower than 0.30, 0.30 to 1.00 and greater than 1.00 cmol/kg are respectively regarded as low, medium and high based on soil fertility classifications. It is therefore evident that even after treating the analyte with the organic residue of *Parkia biglobosa* pods, the soil sample is still classified as having medium fertility index.

Table 8: Multiple Comparison of the Levels of Exchangeable Magnesium (cmol/kg) of Azare Farms after Varied Treatments (LSD = 0.037)

	C: 0.43	**FT: 0.39**	**ST : 0.37**
C: 0.43		0.04	0.06

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

The concentrations of exchangeable potassium as depicted in Table 1 spread from 0.29 cmol/kg (30 days treatment) to 1.72 cmol/kg (60 days treatment). The level of potassium in the control soil sample fell in between the spread extreme observed values. A more or less similar decreasing and increasing exchangeable potassium trend was also reported [19]. The observed value of potassium in the second treatment (60 days incubation period) was found to have statistical significant difference ($p < 0.05$) when compared with others as shown in Table 9. Considering the levels of observed potassium in the present study, the soil samples investigated are therefore said to have medium and high fertility indices respectively.

Table 9: Multiple Comparison of the Levels of Exchangeable Potassium (cmol/kg) of Azare Farms after Varied Treatments (LSD = 0.036)

	ST: 1.72	**C: 0.35**	**FT : 0.29**
ST: 1.72		1.37	1.43
C: 0.35			0.06

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

Table 1 shows that the concentrations of exchangeable sodium ranged from 0.21 cmol/kg (60 days treatment) to 0.41 cmol/kg (30 days treatment) with the observed value of the control analyte (0.28 cmol/kg) falling in between the spread experimental values assayed. The experimental exchangeable sodium in the first treatment significantly influenced ($p < 0.05$) all the observed values in the other treatments (Table 10). Based on the present study, the soil samples investigated can be said to attain medium and high fertility status respectively.

Table 10: Multiple Comparison of the Levels of Exchangeable Sodium (cmol/kg) of Azare Farms after Varied Treatments (LSD = 0.028)

	FT: 0.41	**C: 0.28**	**ST : 0.21**
FT: 0.41		0.13	0.20
C: 0.28			0.07

C = Control (0 day), FT = First Treatment (30 days), ST = Second Treatment (60 days)

Data Analyses

The observed values of the parameters investigated were subjected to standard error of the mean and single factor analysis of variance (ANOVA). The observed means that were significantly different ($p < 0.05$) were separated using least significant difference (LSD) at $p < 0.05$ and are depicted in Tables 2 to 10.

Conclusion

This research work indicated that treating Azare soil samples with the organic residue of *Parkia biglobosa* pods at 0, 30 and 60 days significantly affected ($p < 0.05$) the parameters investigated. It is therefore evident that the *Parkia biglobosa* pods can be used to enhance the fertility status of the soil samples studied.

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