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Research Article

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Capacity of Some Nutrients of Azare Farms, Bauchi State, Nigeria after Varied Treatments with *Parkia biglobosa* pods

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Abstract Studies were conducted to explore the capacity of some nutrients of Azare farms, Bauchi State, Nigeria after varied treatments with *Parkia biglobosa* pods. A complete randomized set-up was adapted; each treatment (0, 30 and 60 days) was replicated three times and maintained at 37 ˚C. The control soil samples (0 day treatments) were neither added *Parkia biglobosa* pods nor water. Other treatments (30 and 60 days) were separately added organic residue of *Parkia biglobosa* pods. 50.00 cm^3 of water was also added daily so as to keep the analyte slightly moist. At the end of the two treatments, *Parkia biglobosa* pods were removed and discarded. Soil samples from each treatment were separately collected and combined together to form a composite. This was air-dried, ground using a wooden mortar and pestle, sieved via a 2 mm mesh and the parameters of interest were analysed. The pH (H_2O) and pH ($CaCl_2$) were found to have respective spread values of 4.97 (60 days) to 6.66 (0 day) and 3.87 (60 days) to 5.30 (0 day). The cation exchange capacity (CEC) had spread values of 5.85 (0 day) to 12.22 cmol/kg (60 days). The levels of copper, manganese, iron and zinc (extractable micronutrients) had spread values of 1.47 (0 day) to 3.93 (30 days), 37.09 (0 day) to 56.96 (60 days), 128.21 (30 days) to 366.83 (0 day) and 9.92 (0 day) to 14.97 mg/kg (60 days) respectively. The levels of pH (H_2O), pH ($CaCl_2$) and extractable iron were found to be statistically different ($p < 0.05$) in an irregular manner. The observed values of CEC, copper, manganese and zinc were respectively found to be statistically not the same ($p < 0.05$) as revealed by single factor analysis of variance and the least significant difference test. The organic residue of *parkia biglobosa* pods is therefore recommended in facilitating the levels of copper, manganese, zinc (micronutrients) and the CEC of the soil samples investigated.

Keywords *Parkia biglobosa* pods, nutrients, complete randomized set-up, composite sample, residue, single factor analysis of variance, least significant difference test, pH and extractable micronutrients

Introduction

Agricultural soils in Northern Nigeria are significant areas that are needed for the production of many crops: cereals (millet, sorghum, maize, rice and wheat), legumes (cowpea, groundnut and soybean), vegetables (tomato, onion) as well as root and tubers (cassava, yam and sweet potatoes) [1]. The need to meet the ever increasing nutritional demands of the expanding human populations made sustainable agriculture and agro-based sectors a front burner environmental and social development issue in Sub-Saharan Africa [2]. The intensification of inorganic fertilizers in Northern Nigeria reduces the values and economic benefits of organic materials since the last 35 years or more. This led to increase in soil acidity, decline in soil quality and unsustainable soil fertility managements in dry land and Fadama areas of many states in the region [3].

The revitalization and/renewability of soil fertility under this circumstance, must readapt to the traditional old system of using only organic manures and organic materials in Nigerian cropping systems. This will help to transform our agricultural systems into a more sustainable and significant economic development [4][5][6]. In soil science, cation exchange capacity is used as a measure of fertility, nutrient retention capacity and the capacity to protect groundwater from cation contamination [7]. Soil pH affects nutrient availability by changing the form of the nutrient in the soil. Adjusting soil pH to a recommended value can facilitate the availability of important nutrients. Plants usually grow well at pH values above 5.5, while soil pH of 6.5 is usually regarded optimum for nutrients availability. The aim of this research work is to explore the capacity of some nutrients of Azare farms, Bauchi State, Nigeria after varied treatments with *Parkia biglobosa* pods.

Materials and Methods

Materials

In preparing all the solutions, chemicals of analytical reagent grade purity and distilled water were used during the research work. All the plastic and glass wares used were washed with detergent solution, 20.00 % (v/v) trioxonitrate (V) acid, rinsed with tap water and lastly with distilled water.

Sampling of *Parkia biglobosa* Pods

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

Sampling of Soil Samples

Soil samples in bulk were randomly collected 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 by means of a wooden pestle and mortar and 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 for the various treatments and laboratory analyses.

Research Design and Varied Treatments

The experiment was a complete randomized set-up comprising of three treatments (0, 30 and 60 days) and was replicated three times. This constitutes a total of nine plastic pots used for the soil samples prepared in section 2.3. Soil sample (1.00 kg) was separately weighed into each of the nine plastic pots. *Parkia biglobosa* pods powder (200.00 g) prepared in section 2.2 was individually added to the set–ups except the control (0 day treatment). Water (50.00 cm^3) was added on daily basis to the 30 and 60 day treatments so as to make the soil slightly moist. At the end of the treatments (30 and 60 days), the powdered *Parkia biglobosa* pods were removed and discarded from the soil samples. The soil samples from each treatment (0, 30 and 60 days) were separately collected, homogenized to form a composite, air-dried, ground using a wooden pestle and mortar, sieved through a 2 mm sieve and labeled accordingly. The analytes were then used for soil chemical analyses.

Laboratory analysis

Three replicate laboratory determinations were carried out for each parameter using various standard analytical methods adopted by different researchers. Particle size distribution was determined before treatment by the hydrometer method [8]. The soil pH was separately determined both in water and 0.01 mol/dm^3 of calcium chloride solution, Extractable micronutrients (Cu, Mn, Fe and Zn) were determined after treating the soil sample with 0.10 eq/dm^3 hydrochloric acid. The levels of the soil extractable micronutrients were assayed at their respective wavelengths using Buck Scientific Atomic Absorption Spectrophotometer Model AA320N [9]. Cation exchange capacity was determined using ammonium ethanoate pH 7 buffer solution [10].

Results and Discussion

Results

The particle size analysis of soil samples from Azare farms in Bauchi State, Nigeria before treatment with organic residue of *Parkia biglobosa* pods are shown in Table 1. The levels of pH (H_2O and $CaCl_2$ solution), micronutrients (Cu, Mn, Fe and Zn) as well as cation exchange capacity (CEC) are presented in Table 2.

Table 1: Particle Size Analysis of Soil Samples from Azare Farms

Parameters	Percent
Clay	16.32
Silt	18.00
Sand	65.68
Textural Class	Sandy Loam

Table 2: Levels of pH, Micronutrients and CEC of Azare Farms after Varied Treatments with Organic Residue of *Parkia biglobosa* Pods

Parameters	Incubation Periods (days)		
	Control	**FT**	**ST**
pH (H_2O)	$6.66^a \pm 0.08$	$5.75^b \pm 0.04$	$4.97^c \pm 0.09$
pH ($CaCl_2$)	$5.30^a \pm 0.04$	$4.61^b \pm 0.07$	$3.87^c \pm 0.02$
Copper (mg/kg)	$1.47^b \pm 0.05$	$3.93^a \pm 0.09$	$3.68^a \pm 0.00$
Manganesse (mg/kg)	$37.09^c \pm 0.21$	$44.99^b \pm 0.10$	$56.96^a \pm 0.06$
Iron (mg/kg)	$366.83^a \pm 8.67$	$128.21^c \pm 0.54$	$238.86^b \pm 0.21$
Zinc (mg/kg)	$9.92^c \pm 0.08$	$13.74^b \pm 0.07$	$14.97^a \pm 0.24$
CEC (cmol/kg)	$5.85^c \pm 0.03$	$7.50^b \pm 0.06$	$12.22^a \pm 0.16$

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, while values on the same row with different superscript alphabets are statistically different as revealed by single factor analysis of variance and the least significant difference test ($p < 0.05$).

Discussion

Textural Class

The textural class of the soil samples obtained from Azare farms was found to contain 16.32 % clay, 18.00 % silt and 65.68 % sand. The soil sample is therefore described as sandy loam. The texture of a soil affects its health. Soil health usually impacts directly on plant health. Similar soil texture before treatments were also reported [8][11].

Soil pH

The observed levels of soil pH (H_2O) after varied treatments ranged from 4.97 (second treatment) to 6.66 (control) with 5.75 (first treatment) falling between the extreme observed values of soil pH (Table 2). The levels of pH ($CaCl_2$) ranged from 3.87 (second treatment) to 5.30 (control) with 4.61 (first treatment) falling between the extreme observed values. A similar decreasing pH trend after a three year treatment with different organic residues of both plant and inorganic fertilizers was reported [12]. A decreasing pH trend when organic residues of plants origin were treated in soils for different periods of time was also reported [13].

The addition of plant materials to soil can cause soil pH to increase, decrease or remain unchanged [14-18]. A similar initial increase in pH over the first few weeks of residue decomposition followed by a decline was earlier reported [14-15, 19]. The direction and extent of soil pH change depends on the concentrations of excess base cations, organic anions, nitrogen in plant materials and the initial pH level of the soil [20]. The magnitude of the change in soil pH varies depending on plant residue application rate and the buffering capacity of the soil [21]. Increase in soil pH after plant residue addition occurs when initial soil pH values are lower than those of plant residues or when the amended soil is acidic [16, 22]. Based on the observed pH (H_2O) and pH ($CaCl_2$) values, the control soil samples can therefore be classified as slightly acidic and strongly acidic respectively [23]. Incubating the organic residue of *Parkia biglobosa* pods into the soil samples for 30 days (first treatment) transformed the pH (H_2O) and pH ($CaCl_2$) values to moderately acidic and very strongly acidic respectively [23]. At the end of the second treatment (60 days), pH (H_2O) and pH ($CaCl_2$) values were respectively transformed to very strongly acidic and extremely acidic [23]. Significant differences ($p < 0.05$) were found to exist in irregular manner in both pH (H_2O) and pH ($CaCl_2$) when the organic residues were applied to the soil samples investigated as shown in Tables 3 and 4.

Table 3: Multiple Comparison of pH (H_2O) Values of Azare Farms after Varied Treatments (LSD = 0.245)

	C : 6.66	**FT : 5.75**	**ST : 4.97**
C : 6.66		0.91	1.69
FT : 5.75			0.78

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

Table 4: Multiple Comparison of pH ($CaCl_2$) Values of Azare Farms after Varied Treatments (LSD = 0.16)

	C : 5.30	**FT : 4.61**	**ST : 3.87**
C : 5.30		0.69	1.43
FT : 4.61			0.74

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

Soil pH is fundamental as many plants and soil life forms need either acidic or alkaline environments. Soil pH facilitates the availability of nutrients and some diseases thrive only when the soil is either acidic or alkaline.

Soil Extractable Micronutrients

The levels of copper are shown in Table 2 with the observed values ranging from 1.47 mg/kg (control) to 3.93 mg/kg (30 days). The level of the 60 day treatment (3.68 mg/kg) fell in between the spread observed values. Hassan *et al.*, 2019a and Aldulhamid and Mustapha, 2009 reported a more or less the same trend [9, 24]. The rise in total soil copper with application of organic matter may be attributed to adsorption of Cu^{2+} ions on organic matter as sorption and formation of complexes with organic matter can influence the bioavailability of copper [25]. Extractable micronutrients are usually needed by plants in very small amounts and are therefore important for the healthy growth of plants [26].

Table 6: Multiple Comparison of Extractable Copper Values of Azare Farms after Varied Treatments (LSD = 0.401)

	FT: 3.93	**ST: 3.68**	**C : 1.47**
FT: 3.93			2.46
ST: 3.68			2.21

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

The levels of copper in the analytes investigated were significantly affected ($p < 0.05$) by the organic residue of *Parkia biglobosa* pods after varied treatments (Table 6).

The concentrations of extractable manganese as depicted in Table 2 ranged from 37.09 mg/kg (control) to 56.96 mg/kg (60 days) with the level of manganese after 30 days of treatment (44.99 mg/kg) falling between the two extreme experimental values. Manganese availability in soils is controlled by factors such as organic matter, pH, $CaCO_3$ and redox conditions [27]. During the decomposition of organic matter, a number of organic acids are formed and this can lower soil pH and increase the intensity of manganese in soils. The plant residue can therefore facilitate the availability of manganese in soils [28]. Tables 7 revealed that the 60 day treatment significantly affected ($p < 0.05$) the levels of manganese at the 30 and 0 (control) day treatments.

Table 7: Multiple Comparison of Extractable Manganese Values of Azare Farms after Varied Treatments (LSD = 0.48)

	ST: 56.96	**FT: 44.99**	**C : 37.09**
ST: 56.96		11.97	19.87
FT: 44.99			7.90

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

The levels of iron in the test samples as shown in Table 2 spread from 128.21 mg/kg (30 days) to 366.83 mg/kg (control) with the value in the second treatment (238.86 mg/kg) falling between the two extreme observed values. The variations in the concentrations of iron after varied treatments may be as a result of low observed pH value [28] and consumption of iron by microorganisms. Iron is relevant in electron transport in some enzymes that are associated with chlorophyll formation [26]. Table 8 shows that significant differences ($p < 0.05$) exist in irregular manner.

Table 8: Multiple Comparison of Extractable Iron Values of Azare Farms after Varied Treatments (LSD = 17.69)

	C: 366.83	**ST: 238.86**	**FT : 128.21**
C: 366.83		127.97	238.62
ST: 238.86			110.65

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

The concentrations of zinc determined ranged from 9.92 mg/kg (control soil sample) to 14.97 mg/kg (60 days). The level of 13.74 mg/kg (30 days) fell between the lowest and highest observed values (Table 2). The increase in the levels of zinc in the treated soil samples may be due to dissolved organic compounds that formed complexes with zinc and this can enhance its mobility [29][30]. Zinc is a vital nutrient required for the production of chlorophyll that aids plant growth, improves root development, flowering and fruit production [26]. Table 9 indicates that statistical significant differences exist ($p < 0.05$).

Table 9: Multiple Comparison of Extractable Zinc Values of Azare Farms after Varied Treatments (LSD = 0.53)

	ST: 14.97	**FT: 13.74**	**C : 9.92**
ST: 14.97		1.23	5.05
FT: 13.74			3.82

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

Soil Cation Exchange Capacity (CEC)

The levels of CEC as shown in Table 2 ranged from 5.85 cmol/kg (control soil sample) to 12.22 cmol/kg (60 days of treatment). An observed value of 7.50 cmol/kg (30 days treatment) fell between the observed spread values of CEC. Similar increasing trends were also reported when soil samples were treated with different organic residues of plant origin at varied periods of time [10][31][32]. In the absence of CEC, nutrients in the soil would be completely leached downward in the soil and hence lost [33]. The relatively high level of CEC could be as a result of high buffering capacity of the soil as well as high retention of nutrients. This shows that plants will highly benefit from the applied nutrients and eventually this will facilitate crop yield [9].

Table 10 revealed that CEC values at the second treatment (12.22 cmol/kg) significantly influenced ($p < 0.05$) the levels of CEC at the first treatment and the control soil sample.

Table 10: Multiple Comparison of CEC Values of Azare Farms after Varied Treatments (LSD = 0.34)

	ST: 12.22	**FT: 7.50**	**C : 5.85**
ST: 12.22		4.72	6.37
FT: 7.50			1.65

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

Data Analyses

The experimental values were subjected to standard error of the mean and single factor analysis of variance (ANOVA). Statistical analyses revealed that there were significant differences ($p < 0.05$) in the levels of Cu, Mn and

Zn (extractable micronutrients) as well as CEC. The levels of pH (H_2O), pH ($CaCl_2$) and extractable iron were found to have significant differences, but in irregular pattern.

Conclusion

Results of the present study indicated that treating soil samples obtained from Azare farms with the organic residue of *Parkia biglobosa* pods at varied treatments of 0, 30 and 60 days significantly affected ($p < 0.05$) the levels of copper, manganese, zinc (extractable micronutrients) and CEC. The levels of pH (H_2O), pH ($CaCl_2$) and extractable iron were also significantly influenced ($p < 0.05$), but in an irregular manner. It is therefore evident that *Parkia biglobosa* pods are good sources of the nutrients investigated and can be used to facilitate the levels of the nutrients in Azare farms.

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