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Effects of the Organic Residue of *Typha Domingensis* on Some Physicochemical Properties of Soils at Dass, Bauchi State, Nigeria

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Abstract The effect of the organic residue of Typha domingensis on some physicochemical properties of soils at Dass, Bauchi State, Nigeria was conducted. The experiment was a complete randomized design, which comprised of four treatments separately replicated three times. Each treatment consisted of 2.00 kg of soil incubated at 35°C with 300.00 g of the organic residue of the plant material. The mixtures were added 100.00 cm^3 of water daily. The control soil samples (first treatment, 0 day) were neither added the organic residue, water nor even incubated. At the end of each treatment (0, 15, 30 and 45 days), soil samples were separately taken, homogenized, air-dried and the physicochemical properties under investigation were determined using various standard procedures. The results revealed that treating the organic residue of Typha domingensis facilitated the levels of the organic matter, organic carbon, total nitrogen and available phosphorus of Dass soil from 5.67 (15 days) to 6.05 (45 days), 3.37 (15 days) to 3.64 (45 days), 1.00 (0 day) to 3.50 g/kg (45 days) and 6.91 (0 day) to 25.41 mg/kg (45 days) respectively. The concentrations of manganese, copper, zinc and iron (soil extractable micronutrients) indicated spread values of 0.19 (control or 0 day) to 54.45 (45 days), 0.25 (0 day) to 0.85 (45 days), 6.03 (0 day) to 13.44 (45 days) and 0.60 (0 day) to 41.16 mg/kg (45 days) respectively. The physicochemical properties investigated were individually found to be significantly affected ($p \leq 0.05$) using One-Way Analysis of Variance (ANOVA) and this was further corroborated using the Least Significant Difference test. It is therefore evident that the organic residue of the noxious Typha can be utilized to improve all the parameters determined in Dass soil especially after thirty or forty-five days of treatment.

Keywords Noxious Typha, soil extractable micronutrients, organic matter, organic carbon, total nitrogen, organic residue, available phosphorus, One-Way Analysis of Variance and Least Significant Difference

1. Introduction

Soil is formed by the gradual breaking of rocks into small fragments. It consists of soil particles, organic matter (humus), water, air, mineral salts and soil organisms [1]. Soil particles are the products of weathering. They form a basic skeletal structure with uneven pore spaces. Their sizes and chemical nature largely determine the properties of soil [1]. Soil structure is the arrangement of soil particles into aggregates [2]. These may have various shapes, sizes and degrees of development or expression. Soil texture refers to clay, silt and sand composition. Sand and silt are the

products of physical weathering, while the soil is the product of chemical weathering. Soil content is particularly influential on soil behavior due to a high retention capacity for nutrients and water.

The decomposition of plant and animal remains, form a layer of black, jelly-like organic material called humus on top of the soil [1]. This is drawn into the soil by soil organisms like the earth-worm. Decomposers continuously break-down humus to release inorganic substances such as nitrates and phosphates hence enrich the soil nutrient content. Humus darkens the soil and also facilitates the water retaining capacity of the soil. It also improves soil structure as it helps to stick soil particles together in crumbs, hence increasing the pore space.

Lack of detailed information on soil characteristics is one of the main factors hindering agricultural development in Nigeria [3]. Soil, the natural medium for the growth of plants has a direct impact on yield and quality of crops growing on it. Measurement of the fertility of an agricultural soil provides much about its productive potential. Fortunately, producers can control fertility by managing the plants nutritional status [4]. Nutrient status is an unseen factor in the growth of plants, except when imbalances become so severe that visual symptoms appear on the plant.

At present, the greatest challenge before Nigerian agriculture is to boost food production and productivity as well as the sustainability of agriculture in general [5]. There are problems that impose limits on these objectives or goals which raise serious concerns about national food security. These include deterioration of soil fertility, increase in cost of production and low diversity of production systems [6].

The application of research techno-logy to agriculture is becoming of increasing importance in a world with a rapidly rising expectation of higher standard of nutrition and living [7]. Ineffective and unplanned use of agricultural land in the tropical regions is one of the major problems militating agricultural productivity. The evidence of this ugly situation in agricultural land use is shown in land degradation, depletion of organic matter and nutrients, soil aggregate instability and soil compaction amongst other soil constraints [8].

Low fertility of Nigerian soils is the main constraint in achieving high productivity goals. In both rain-fed and irrigated systems, nutrient replenishment through fertilizers and manures remain far below the crop removal, thereby causing mining of native reserves over the years [9]. Soil degradation is becoming a major concern. Loss of organic matter has been identified as one of the main factors contributing to declining soil productivity [2]. The amount of organic carbon, which is a measure of organic matter in a soil, depends on a number of factors and this reflects the balance between accumulation and break-down. The main factors are climate, soil type, vegetative growth, topography and tillage.

The soils of Northern Nigerian Savan-nah have inherent low fertility. They are characterized by low activity kaolinic clay, coarse textural surfaces, slightly acidic to basic pH, low levels of soil organic matter and nutrient holding capacity [10]. In order to improve the soils for sustainable agriculture, farmers apply inorganic fertilizers so as to obtain high yield of crops. However, due to high cost of these fertilizers, as a result of reduction of government subsidy on fertilizers coupled with scarcity, most peasant farmers cannot afford to buy or purchase fertilizers [11]. Inorganic fertilizers have harmful effects on soil physical, chemical and biological properties after a long term and improper use [10].This has resulted in low crop yield, yet the poor farmers are not encouraged to use organic residues to increase plant productivity [12].

Developing countries such as Nigeria are blessed with a large number of organic residues that are not put into use. It is expected that the average nutrient status of a soil would be improved when addition of organic residues are made into it. Efficient application of organic residues would there-fore alleviate the problem of declining land productivity in a soil with low nutrient status [12]. Irrespective of the enormous organic residues potential in Nigeria, very small amount is used to improve soil fertility and crop production. *Typha* (*spp*) also contains valuable nutrients that could be recycled back into the land in order to improve soil fertility and increase the sustainability of farming system. The process of plant residue decomposition leads eventually to the synthesis of humus [10]. The aim of this research work is to determine the effect of the organic residue of *Typha domingensis* on some soil physicochemical properties of soils at Dass, Bauchi State, Nigeria.

2. Materials and Methods

2.1. Materials

In the preparation of all the solutions, chemicals of analytical reagent grade purity and distilled water were used. All the glass and plastic wares used were thoroughly washed with detergent solution, repeatedly rinsed with water and the solution to be used therein.

2.2. Methods

2.2.1. Sampling of *Typha domingensis* Plant

The sampling of *Typha domingensis* was carried out using Table of random numbers along Kano road in Bauchi, Bauchi State, Nigeria. The plants were collected from ten (10) different points within the same sampling location and mixed up in order to ensure sample homogeneity.

The plant was identified in the Department of Biological Sciences, Abubakar Tafawa Balewa University, Bauchi, as *Typha domingensis pers*. The plant samples were washed with water to get rid of extraneous substances from the sampling location. The samples were again weighed, air-dried for sixty (60) days to a constant mass, followed by cutting them into smaller pieces. The rhizomes, stems and leaves were again air-dried for thirty (30) days, ground in a wooden pestle and mortar, sieved to pass through a 2 mm mesh in order to obtain the finest possible powder for analyses. The sieved samples were kept in air-tight plastic containers and labeled appropriately prior to analyses.

2.2.2. Sampling of Soil Samples

Bulk soil samples were collected using table of random numbers at a depth of 0-30 cm by means of soil auger from Dass. The sampling was done from ten (10) different sampling points and then homogenized, air-dried, ground using a wooden pestle and mortar and finally sieved through a 2 mm mesh to get rid of the "not-soil and impurities" prior to laboratory analyses.

2.2.3. Treatments and Experimental Design

The experiment was a complete randomized design, which comprised of four treatments (0, 15, 30 and 45 days) replicated three times [13]. This summed up to twelve plastic pots used for the experiment for the soil samples under investigation. 2.00 kg of the soil sample was weighed into each of the pots, followed by the addition of 300.00 g of the organic residue of *Typha domingensis* into each of the pots. The set ups were incubated for 0 (control), 15, 30 and 45 days in the laboratory at 35ºC. Within the incubation period, 100.00 cm^3 of water was added daily into each pot in order to keep the soil slightly moist. At the end of each incubation period, all the soil samples from a particular treatment were collected, thoroughly mixed together, air-dried, ground using a wooden pestle and mortar, sieved through a 2 mm mesh and used for chemical analyses. Neither water nor the organic residue of *Typha domingensis* was added into the controls.

2.3. Laboratory Methods

Different standard analytical methods adopted by many researchers were employed. Four replicate determinations were carried out for each parameter investigated.

2.3.1. Determination of Soil Organic Matter

The organic matter content of Dass soil at different incubation periods (0, 15, 30 and 45 days) was determined [14], [15].

2.3.2. Determination of Soil Organic Carbon

The soil organic carbon content was determined based on the method adopted by Davidescu and Davidescu, 1982; Ademoroti, 1996 and Kolo *et al.*, 2009 [7], [16] and [17] respectively.

2.3.4. Determination of Soil Total Nitrogen

Total soil nitrogen was determined using Micro-Kjeldahl method [13].

2.3.5. Determination of Available Soil Phosphorus

The digestion of soil sample for the colorimetric determination of phosphorus was carried out using the method adopted by Ademoroti, 1996 [17]. Vanado-molybdate colorimetric technique was thereafter employed for the colorimetric determination of soil phosphorus at different incubation periods (0, 15, 30 and 45 days).

2.3.6. Determination of Soil Extractable Micronutrients

The method involved extracting the soil micronutrients (Mn, Cr, Zn and Fe) from soil samples using 0.10 eqdm^{-3} hydrochloric acid. Their concentrations were determined at different wavelengths by means of a Buck Scientific Atomic Absorption Spectrophoto-meter Model 210/11 VGP [12], [18] and [19].

3. Results and Discussion

The results of the different physicochemical properties of Dass soil assayed at various treatments (0, 15, 30 and 45 days) with the organic residue of *Typha domingensis* are presented in Figures 1 to 8.

3.1. Results

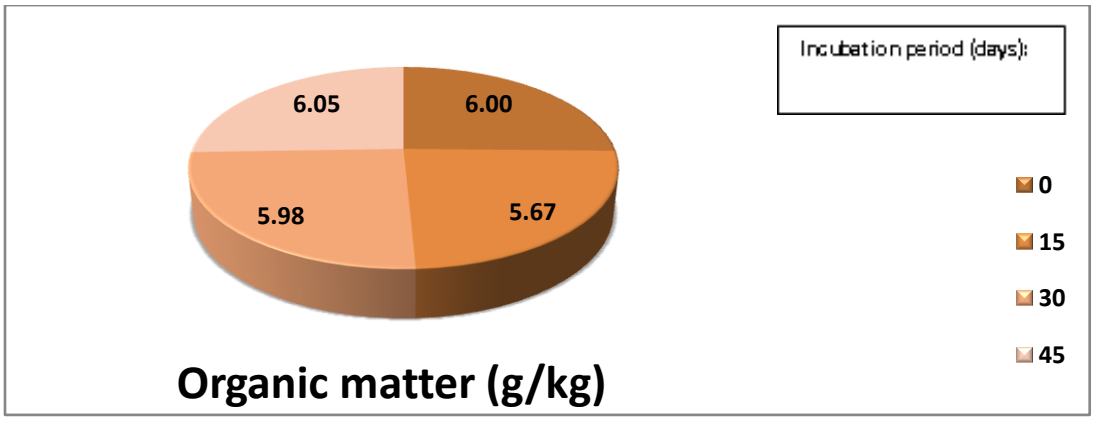

Figure 1: *Variation of organic matter content of Dass soil with incubation periods*

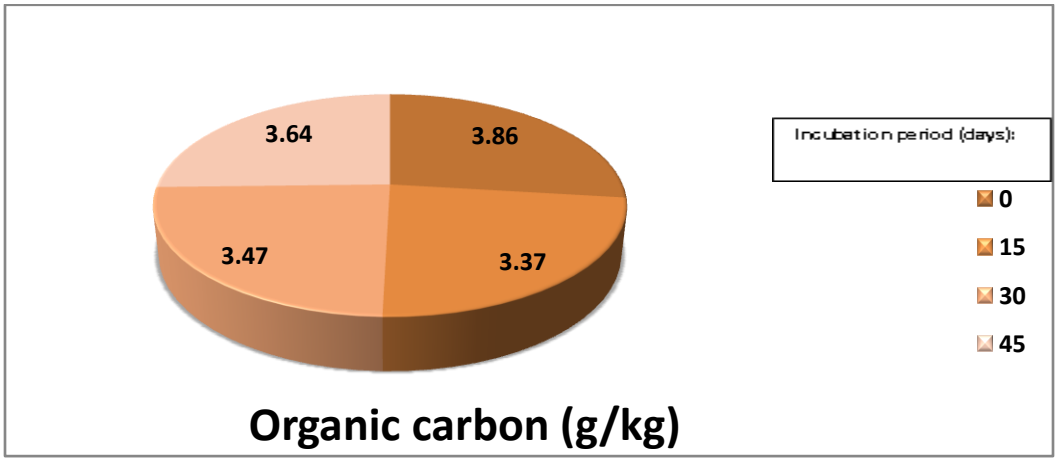

Figure 2: *Variation of organic carbon content of Dass soil with incubation periods*

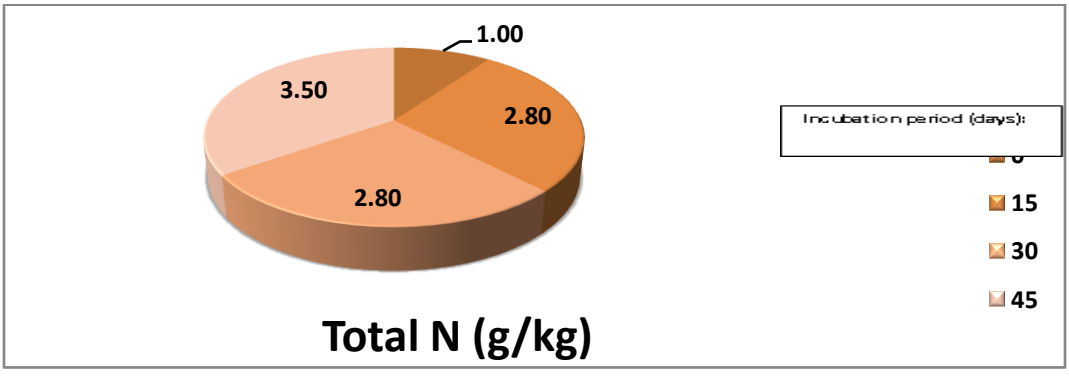

Figure 3: *Variation of total nitrogen content of Dass soil with incubation periods*

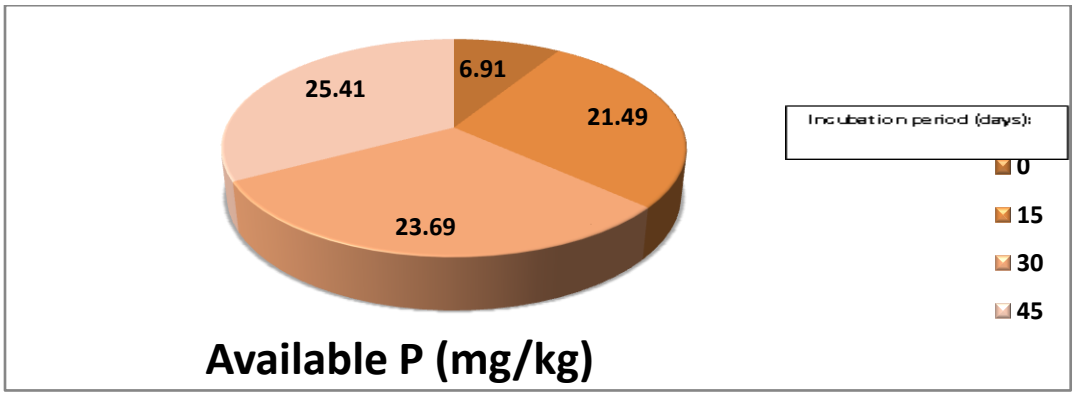

Figure 4: *Variation of available phosphorus content of Dass soil with incubation periods*

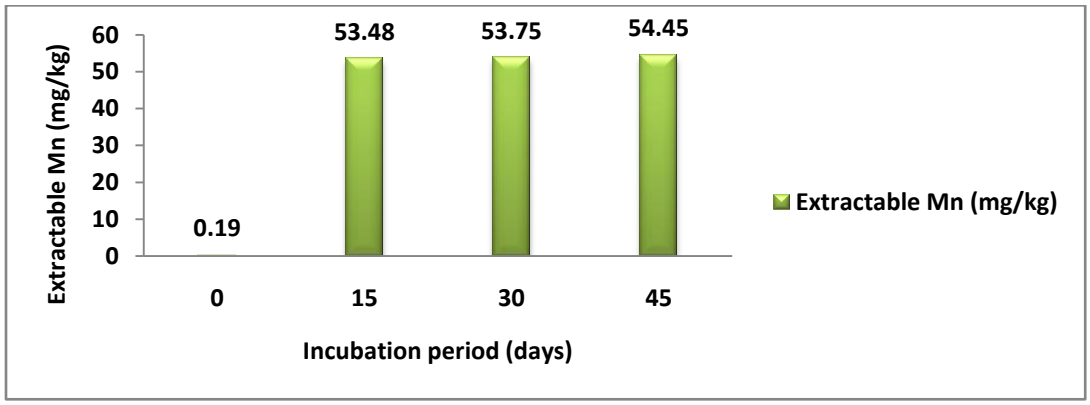

Figure 5: *Variation of extractable manganese content of Dass soil with incubation periods*

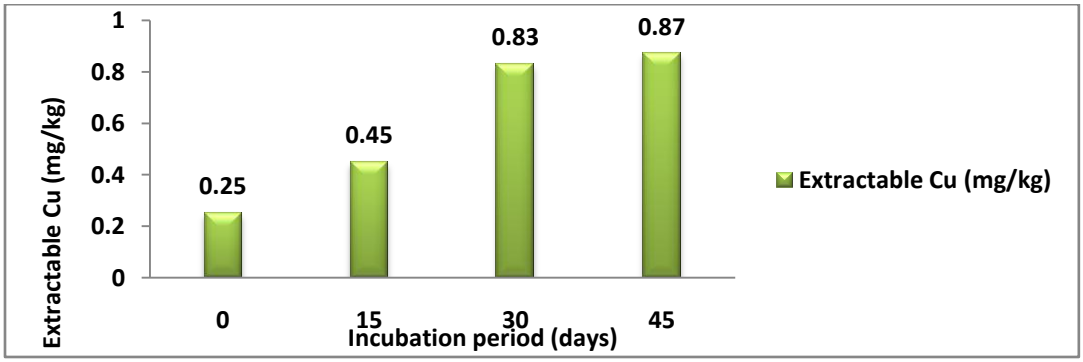

Figure 6: *Variation of extractable copper content of Dass soil with incubation periods*

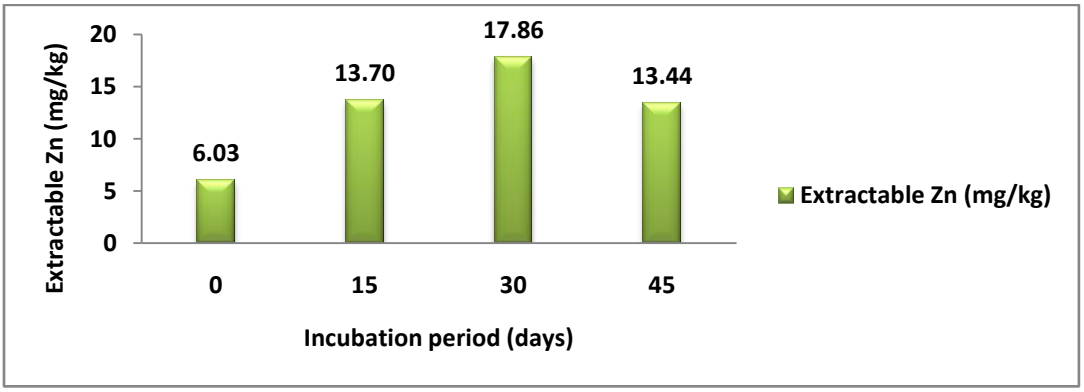

Figure 7: Variation of extractable zinc content of Dass soil with incubation periods

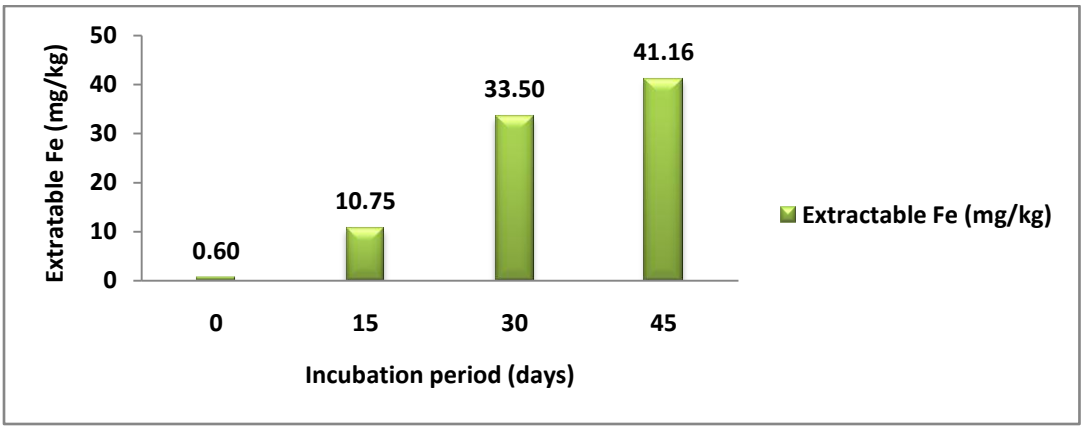

Figure 8: *Variation of extractable iron content of Dass soil with incubation periods*

3.2. Discussion

3.2.1. Organic matter content

The organic matter content of Dass soil as shown in Figure 1 was found to be 5.67 g/kg (first incubation period) to 6.05 g/kg (third incubation period). Table 1 revealed that the value in the third incubation period significantly affected the values in the second and first incubation periods, but does not affect the control value (zero incubation period) at $p \leq 0.05$. The mean observed values are greater than the reported literature value of 1.00 – 2.00 % in a cultivated soil zone [2].

Table 1: Treatment Means Difference of Organic Matter Content of Dass Soil ($LSD_{0.05} = 0.044$)

	TI: 6.05	**C: 6.00**	**SI: 5.98**	**FI: 5.67**
TI: 6.05			0.07	0.38
C: 6.00				0.33
SI: 5.98				0.31

C = Control, FI = First Incubation Period (15 days), SI = Second Incubation Period (30 days), TI = Third Incubation Period (45 days)

The importance of organic matter in soils cannot be over-emphasized. Organic matter is relevant in maintaining soil structures, especially in fine textured soils. It also facilitates cation exchange capacity thereby reducing leaching losses of such elements like magnesium and potassium [20]. It is a reservoir for soil nitrogen and enhances water holding capacity of soils. Soils with low organic matter content may have less available copper, zinc, manganese and iron than soils with moderate amounts of organic matter [21]. The observed decreased and increased trends in the organic matter content of the soil samples could be due to their being used by the microorganisms during the incubation periods. Most living things found in soils, including plants, insects, bacteria and fungi, are dependent on organic matter for nutrients and energy. Soils often have varying degrees of organic matter in different states of decom-position [2].

3.2.2. Organic carbon content

The levels of organic carbon in Dass soil ranged from 3.37 g/kg (15 days) to 3.64 g/kg (45 days) as depicted in Figure 15. These values are lower than the control value (3.86 g/kg). The value in the third incubation period similarly affected ($p \leq 0.05$) the values at the second and first incubation periods as shown in Table 2.

Table 2: Treatment Means Difference of Organic Carbon Content of Dass Soil ($LSD_{0.05} = 0.044$)

	C: 3.86	**TI: 3.64**	**SI: 3.47**	**FI: 3.37**
C: 3.86		0.22	0.39	0.49
TI: 3.64			0.17	0.27
SI: 3.47				0.10

Molindo, 2008 [12] reported decreasing values of organic carbon when soybean and cow dung were respectively incubated into soil samples. The values obtained are lower when compared with the critical limits of low organic carbon (less than 10.00 g/kg) and medium organic carbon (10.00 - 15.00 g/kg) as reported by Kparmwang *et al*., 1998 [22]. This agrees with the findings of Balasubramanian *et al.,* 1984 [23] that organic carbon content of upland savannah soils ranged from 0.0059 to 1.53 % and also observed increased organic carbon content from Sudan savannah to southern savannah due to increasing production of organic matter with increasing rainfall from north to south in the savannah region. The demerit of low organic carbon means low retention of micronutrients in both the available and unavailable forms in plants.

3.2.3. Total nitrogen content

The concentration of nitrogen determined at Dass soil as shown in Figure 3 ranged from 1.00 g/kg (control) to 3.50 g/kg (45 days of incubation). Table 3 revealed that the value in the third incubation period significantly ($p \leq 0.05$) affected the concentration of nitrogen in the second, first and control incubation periods respectively.

Table 3: Treatment Means Difference of Total Nitrogen Content of Dass Soil ($LSD_{0.05} = 0.008$)

	TI: 3.50	**SI: 2.80**	**FI: 2.80**	**C: 1.00**
TI: 3.50		0.70	0.70	2.50
SI: 2.80				1.80
FI: 2.80				1.80

The critical value of nitrogen in soils was reported to be between 1.50 to 2.00 g/kg [24]. Total soil nitrogen of less than 1.50, 1.50 to 2.00 and greater than 2.00 g/kg are considered as low, medium and high respectively in terms of fertility indices [22]. The soil samples investigated therefore fell above the critical limits. Nitrogen is used for growth because it is a main constituent of all amino acids, which are the building blocks of all proteins, including the enzymes that control virtually all biological processes [1]. A good supply of nitrogen stimulates root growth, development as well as the uptake of other nutrients.

3.2.4. Available phosphorus content

Figure 4 revealed the level of available phosphorus determined in Dass soil with variation in the incubation periods. The values spread from 6.91 (control) to 25.41 mg/kg (45 days of incubation). Increasing the incubation period as shown in Table 4 significantly ($p \leq 0.05$) influenced the levels of available phosphorus in Dass soil at the incubation periods tested.

Table 4: Treatment Means Difference of Available Phosphorus Content of Dass Soil ($LSD_{0.05} = 0.017$)

	TI: 25.41	**SI: 23.69**	**FI: 21.49**	**C: 6.91**
TI: 25.41		1.72	3.92	18.50
SI: 23.69			2.20	16.78
FI: 21.49				14.58

The critical range of available phosphorus in soil was reported to be 10.00 to 16.00 mg/kg [25]. Available soil phosphorus of less than 10.00, 10.00 to 20.00 and greater than 20.00 cmol/ (+)/kg are regarded as low, medium and high respectively in terms of fertility status [22]. All the values obtained therefore fell above the critical limits. Phosphorus encourages many aspects of plant physiology such as fundamental processes of photosynthesis, nitrogen fixation, flowering, fruiting and maturation. Root growth, particularly development of lateral roots and fibrous rootlets are also encouraged by phosphorus [1].

3.2.5 Extractable micronutrients contents

Trace elements that were determined are collectively known as extractable micro-nutrients (Mn, Cu, Zn and Fe). The levels (mg/kg) of manganese, copper, zinc and iron respectively ranged from 0.19 (control) to 54.45 (45 days), 0.25 (control) to 0.87 (45 days), 6.03 (control) to 13.44 (45 days) and 0.60 (control) to 41.16 (45 days) as indicated in Figures 5 to 8. Incubating the soil samples with the organic residue of *Typha domingensis* as depicted in Figures 5

to 8 were seen to significantly ($p \leq 0.05$) affected all the values of the extractable micronutrients obtained when compared with the control.

Table 5: Treatment Means Difference of Extractable Manganese Contents of Dass Soil ($LSD_{0.05} = 0.109$)

	TI: 54.44	SI: 53.75	FI: 53.48	C: 0.19
TI: 54.44		0.70	0.97	54.26
SI: 53.75			0.27	53.56
FI: 53.48				53.29

Table 6: Treatment Means Difference of Extractable Copper Contents of Dass Soil ($LSD_{0.05} = 0.044$)

	TI: 0.87	SI: 0.83	FI: 0.46	C: 0.25
TI: 0.87			0.41	0.62
SI: 0.83			0.37	0.58
FI: 0.46				0.21

Table 7: Treatment Means Difference of Extractable Zinc Contents of Dass Soil ($LSD_{0.05} = 0.605$)

	SI: 17.86	FI: 13.70	TI: 13.44	C: 0.25
SI: 17.86		4.16	4.42	11.83
FI: 13.70				7.67
TI: 13.44				7.41

Table 8: Treatment Means Difference of Extractable Iron Contents of Dass Soil ($LSD_{0.05} = 0.921$)

	TI: 41.16	SI: 33.50	FI: 10.75	C: 0.25
TI: 41.16		7.66	30.41	40.56
SI: 33.50			22.75	22.90
FI: 10.75				10.15

Increasing the number of incubation periods gave all the extractable micronutrients that were statistically at par with the control. Increase in the number of incubation periods therefore produced all the extractable micronutrients that were statistically significant with the control values. A more or less similar trend was also reported by Abdulhamid and Mustapha, 2009 [18]. The extractable micronutrients are only needed by plants and animals in very small amounts, they are nonetheless essential for the healthy growth of plants [2]. The variations could be due to different buffering capacities. Buffering capacity is the rate in which some nutrients or elements are transformed from a bound to a soluble state [16].

3.3. Statistical Analyses

The results obtained were subjected to One-Way Analysis of Variance (ANOVA). The Least Significant Difference test ($p \leq 0.05$) was further used to corroborate the significant differences that exist among the experimental means for all the parameters determined.

4. Conclusion

From the results obtained, it is evident that the organic residue of *Typha domingensis* affected the physicochemical properties of soils at Dass, Bauchi State, Nigeria. The Least Significant Difference test further revealed that the organic residue of the weed significantly affected the levels of the parameters investigated ($p \leq 0.05$) particularly after thirty or forty-five days of treatment. The organic residue of the plant can therefore be used as a potential source of the parameters determined.

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