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Impact of different sources of mulch on soil chemical properties of an ultisol in Umudike south east Nigeria

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ABSTRACT

This research was conducted at the Teaching and Research Farm of Abia State University Umudike, to evaluate the impact of different sources of mulch on soil chemical properties of an Ultisol in Umudike South East Nigeria. The experiment comprised of five (5) treatments namely, Control = 0t/ha, R1 – Ricemill waste 10/ha, R2 - Ricemill waste 15/ha, S1 - Sawdust =10t/ha, S2 - Sawdust = 15t/ha. The experiment was laid out in a Randomized Complete Block Design (RCBD) with the treatments replicated three (3) times to give a total of fifteen (15) plots. Raw data obtained was analyzed using analysis of variance (ANOVA) and significant means were separated using Fisher least significant difference (F-LSD) at probability level of ($P<0.05$). The results obtained showed that total exchangeable acidity significantly ($P<0.05$) reduced in mulched plots compared to the control. Soil pH, available phosphorous, total nitrogen, organic carbon and exchangeable cations of mulched plots were significantly ($P<0.05$) higher than the control. Similarly, Effective cation exchange capacity (ECEC), percentage base saturation and C: N ratio was significantly ($P<0.05$) higher when compared with the control. Sawdust application at the rate of 15t/ha significantly ($P<0.05$) increased pH, organic carbon, available phosphorous, effective cation exchange capacity (ECEC), percentage base saturation and C: N ratio compared to control and ricemill at 15t/ha. However, Ricemill waste at 10t/ha and 15t/ha significantly ($P<0.05$) increased soil total nitrogen and sodium (Na) content compared to control and sawdust at different rates. Ricemill waste and sawdust mulch positively influenced soil chemical properties and could be recommended for enhancement of soil chemical properties in Umudike South East Nigeria.

Keywords: Impact, Mulch, Ricemill, Sawdust, Soil Properties.

1. INTRODUCTION

Soil fertility maintenance is a major concern in the tropics, particularly in this South-East Agro ecological zone of Nigeria. The rapid depletion of nutrients and poor physical condition of the soil are strong limitation to crop production (Okonkwo *et al*., 2011). Tropical soils are beset with problems of high acidity, acute nutrient deficiency and soil erosion (Ekpe, 2008). They are equally low in cation exchange capacity (CEC) with little or no mineral reserve, low water holding capacity and low soil pH. Due to high cost and scarcity of chemical fertilizer, it has become necessary to source for agro industrial wastes which could be used as manure for crops in tropical countries. Recently research focused on the potential of these organic materials as soil improvers and sources of nutrients. The waste which has been proved as effective organic fertilizers include animal waste, wood ash, rice husk, sawdust, and other crop waste (Awodun, 2007). Organic mulching with different materials such as rice husk, sawdust, groundnut shell, grasses etc, when correctly applied on the soil surface as shades serves as barrier against moisture losses from the soil, causing slow surface run-off, mitigate soil temperature, increase soil water content which contribute to better long term growth by improving the organic matter content and releasing minerals into the soil (Salahudeen and Sadeer, 2018).

Mulching is an agricultural technique that uses organic materials (sawdust, straw, leaves ricehusk etc) and synthetic materials to improve soil productivity (Svetlana et al., 2020). Mulching is used to retain moisture in the soil, modify soil temperature, supply nutrients, improve soil structure and control weeds (pandey *et al*., 2016). Research has shown that organic mulch provides many benefits to crop production through soil and water conservation enhance soil biological activity and improve chemical and physical properties of soil (Esther *et al*., 2019). However, the utilization of these organic wastes such as ricemill waste and sawdust by farmers is still poor despite the nutrient composition of these materials (Wuese *et al*., 2018). The relative neglect of these wastes as soil amendments has partially been attributed to their bulkiness, low nutrient quality and high C: N ratio. Based on this, the best approach in the utilization of these waste is converting them to ashes or complementing them with high nitrogen source materials to increase their mineralization process (Wuese *et al*., 2018).

Agricultural waste such as ricemill waste and sawdust is important for its value as fertilizer as well as its ability to improve soil physic-chemical properties (Herath *et al*., 2013). The potential of organic waste such as ricemill waste and sawdust in improving soil physio-chemical properties has been reported in many studies (Lu *et al.,* 2014). Jien and Wang, 2013 reported an increase in soil pH, exchangeable potassium, calcium, magnesium and cation exchange capacity (CEC) due to application of ricemill waste to the soil. Also Vidana *et al*., (2016) reported an increase in soil physio-chemical properties due to application of ricehusk to the soil. Shu-aib *et al*., (2020) reported an increase in soil physical and chemical properties of soil due to application of ricehusk and sawdust to the soil. Application of industrial waste has become popular in agriculture because of its benefits in improving soil properties and association with its high organic matter content. Few information regarding the use of organic waste such as ricemill waste and sawdust as mulch is limited in South East Nigeria. This research was therefore aimed at assessing the impact of different sources of mulch on soil chemical properties of an Ultisol in Umudike South East Nigeria.

2. MATERIALS AND METHOD

2.1. Site Description

The study was carried out at the teaching and research farm of Abia State University Umudike. The study site was situated on latitude $5^0 25'$ N and Longitude $7^0 35'$ E in the rain forest ecological zone of South East Nigeria at an altitude of about 122m above sea level (Uche, 2006). The study site had a humid tropical climate, annual temperature of 27-29^0 and annual rainfall of 2,500mm which runs from March to December with its peak in July. The dry season last from December to March with a dry dust and cold intervals. The soil of the study area is classified as Ultisols using the USDA soil classification and Acrisol. Ultisols, are highly acidic, coarse textured and highly leached upland soils. The major vegetation found in the experimental site is the secondary forest which represents what was left of the tropical rain forest. Some species found are oil palm (*Elaeis guinensis*), *Alchomea cordifolia* and *Maniophytum fuluvm.* The dominant grasses include *Panicum maximum*, *Pennisetum purpereum* while *Cetrocema pubecece* are the dominant shrubs. Sweet potatoes, pepper and vegetables such as okra and fluted pumpkin are some of the crops commonly planted either on mounds, ridges or flats.

2.2. Site Preparation

A total land area of $240m^2$ (20×12) was used for the study. The experimental site was mechanically ploughed and harrowed. Measuring tapes, pegs and ropes were used in mapping out the treatment plots. Fifteen experimental plots measuring 3m×3m were used for the experiment. Each plot was separated by 1m to prevent treatments from interfering with each other.

2.3. Experimental Materials and Treatments Allocation

Sawdust was collected from Umuahia Central Timber Market and ricemill waste was collected from the ricemill industry at Bende Local Government Area in Abia state Nigeria. The test crop telfairia seeds were obtained from National Rootcrops Research

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Institute Umudike. The telfairia seeds were planted two weeks before treatments application. The treatments and their respective rates are 0 – Control, Ricemill Waste (R1) –10t/ha, Ricemill Waste (R2) –15t/ha, Sawdust (S1) –10t/ha and Sawdust (S2) –15t/ha.

2.4. Experimental Design/Field Layout

The experiment was laid out in a randomized complete block design (RCBD) with treatments replicated three times as shown in figure 1.

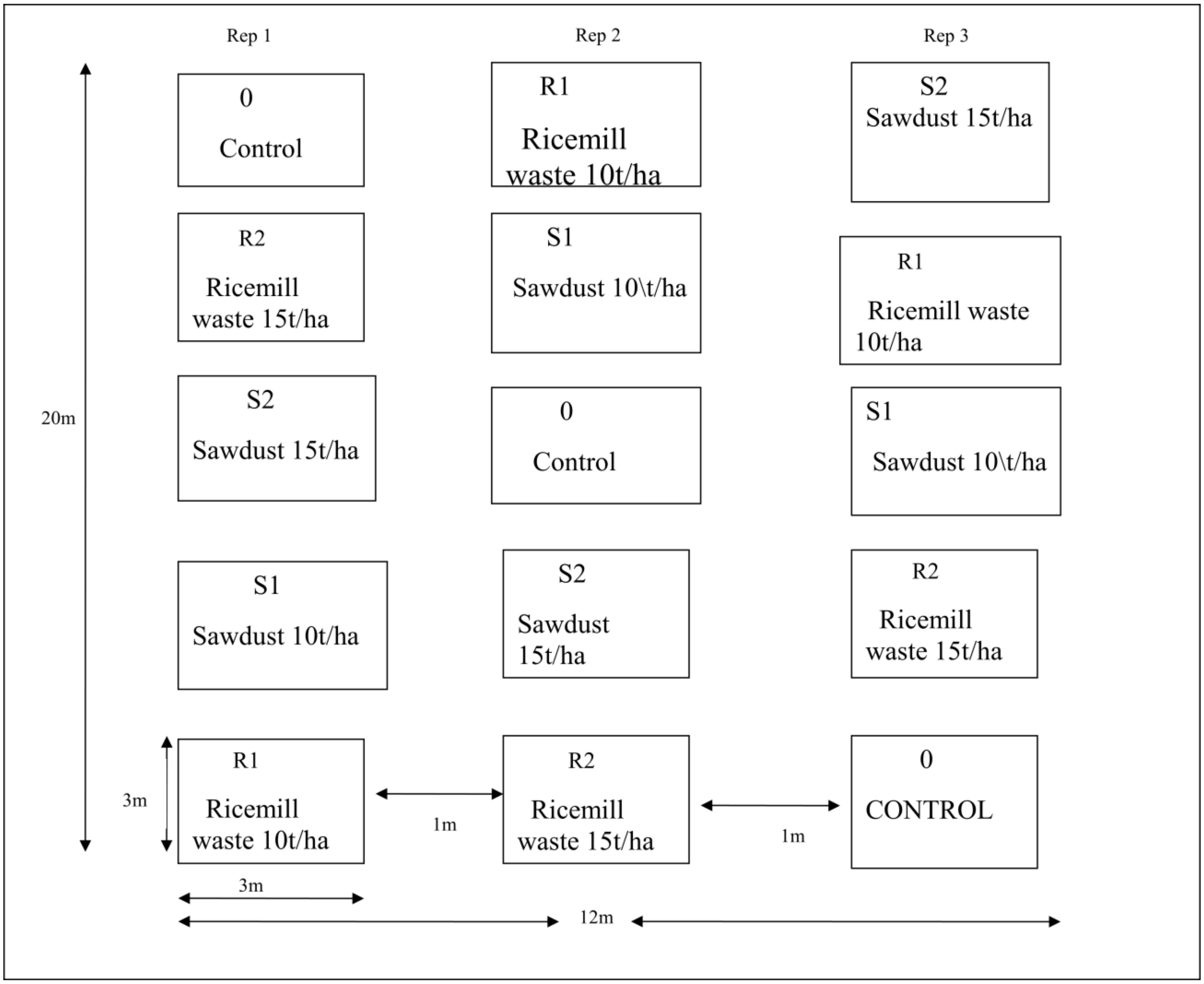

Figure 1: Field layout of the Experimental Site

2.5. Data Collection

Soil samples were collected with soil augar at 0-20 cm soil depth across the field for routine analysis. All collected samples were air dried, crushed and sieved using 2mm sieve in preparatory for chemical properties determination.

2.6. Laboratory Analysis

The laboratory soil analysis was carried out at Soil Science Laboratory of National Rootcrops Research Institute Umudike and the following soil properties were determined;

2.7. Soil Chemical Properties

Organic carbon was determined by the Walkley and Black (1934) wet-oxidation method as modified and described in manual of soil, plant and water analysis (Eno *et al*.,2009). Available phosphorous was determined by Bray and Kurtz No.2 (1945) method adopted by Juo (1979) in which the phosphorous was extracted with 1ml NH_4F and 0.5ml Hydrochloric acid. Colour development was achieved by adding “reagent B”. Available phosphorous was determined calorimetrically using a photo calorimeter. Total nitrogen was determined by micro Kjeldahl digestion and distillation method of Bremner (1965) as recently modified and described in the manual of soil and water analysis (Eno *et al*., 2009) using concentrated H_2SO_4 and a sodium copper sulphate catalyst mixture. Soil pH was determined in the laboratory with a glass pH meter at a ratio of 1:2.5 water ratios. Exchangeable cations (Ca, Mg, Na and K) were extracted with ammonium acetate solution. Exchangeable calcium and magnesium was determined by the ethylene diaminetetracetic acid titration method as described by Black (1965), whereas exchangeable potassium and sodium were determined by flame photometry method. Exchangeable acidity (EA) was determined by the titrimetric method Bray and Weit (1999). Total exchangeable acidity (TEA) was determined by the summation of H^+ and Al^{3+}.

$$TEA = (H^+ + Al^{3+}) \quad \text{Equation (1)}$$

Effective Cation Exchange Capacity was determined by the summation of exchangeable acidity (Al^{3+} and H^+) and exchangeable bases).

$$ECEC = (Al^{3+} \text{ and } H^+) + (Ca^{2+}, Mg^{2+}, Na^+ \text{ and } K^+) \quad \text{Equation (2)}$$

Percentage base saturation was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

$$\% BS = \frac{TEB}{ECEC} \times 100 \quad \text{Equation (3)}$$

2.8. Statistical Analysis

Data generated were subjected Analysis of variance (ANOVA) based on the procedure outlined by Gomez and Gomez (1984). Means were separated using Fisher least significant difference (F-LSD) at a probability level of 5%.

3. RESULTS AND DISCUSSION

3.1. Chemical Properties of the Experimental Site before the application of Mulch Materials.

Table 3.1: Chemical Properties of the Soil of the Experimental Site

Soil Parameters/Minerals	Values
pH in H_2O (1:2:5)	5.07
Organic Carbon (%)	0.47
Total Nitrogen (%)	0.12
Available phosphorous (mg/kg)	21.0
Calcium (Ca) (Cmol/kg)	1.33
Magnesium (Mg) (Cmol/kg)	0.10
Potassium (K) (Cmol/kg)	0.83
Sodium (Na) (Cmol/kg)	0.07
Exchangeale Acidity(Cmol/kg)	1.40
ECEC (Cmol/kg)	3.73

The chemical properties of soil of the experimental site is shown in Table 3.1, the result showed that the soil is acidic with pH vale of 5.07, organic carbon content and total nitrogen were both low with vales of 0.47% and 0.12% respectively. Available phosphorus was high with value of 21mg/kg. Exchangeable cations, Ca, Mg, K, and Na were also low, with calcium having the highest value of 1.33 and sodium the lowest value of 0.07 Cmol/kg. ECEC was also low with value of 3.733Cmol/kg, while exchangeable acidity 1.40 Cmol/kg. The low ECEC could be explained by the low soil organic matter content and the highly weathered and leached nature of the soil.

3.2 The Nutrient Composition of Sawdust and Ricemill Waste used for the study.

The chemical properties of sawdust and ricemill waste used for the study are shown in Table 3.2.

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Table 3.2: Nutrient Composition of Sawdust and Ricemill Waste used for the study

Properties	Sawdust	Ricemill Waste
Organic Carbon (%)	5.20	12.32
Total Nitrogen (%)	0.28	0.93
Available phosphorous (mg/kg)	0.15	0.83
Calcium (Ca) (mg/100g)	0.70	0.60
Magnesium (Mg) (mg/100g)	0.18	0.12
Potassium (K) (mg/100g)	0.28	0.18
Sodium (Na) (mg/100g)	0.08	0.06
C: N Ratio	18.57	13.24

The analytical result of the nutrient composition of ricemill waste and sawdust used for the study is shown in Table 3.2. The result showed that ricemill waste was high in carbon, moderate in total nitrogen and low in phosphorus with values of 12.32%, 0.93% and 0.83(mg/kg) respectively. While calcium, magnesium, potassium ad sodium were also low with values of 0.60, 0.12, 0.18, and 0.06 Cmol/kg respectively. Similarly the result also showed that sawdust was also high in carbon and magnesium content with values of 5.20% and 0.18 (mg/100g) respectively, while total nitrogen, available phosphorous and sodium content was low with values of 0.28%, 0.15(mg/kg) and 0.08 (mg/100g) respectively.

3.3. Effect of Ricemill Waste and Sawdust on Soil Chemical Properties

The result of the effect of ricemill waste and sawdust is shown in Table 3.3.

3.3.1. Soil PH_w

The result of the effect of mulching the soil with ricemill waste and sawdust on soil pH_w showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil pH_w with values of 1.06 and 1.33 pH_w respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil pH_w significantly ($p<0.005$) relative to the control with 2.05 and 2.43 pH_w respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 0.99 and 1.10 higher in soil pH_w compared to 10t/ha and 15t/ha of ricemill waste application. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase in soil pH_w compared to other mulched plots. These observed increases in soil pH_w as a result of mulching with these materials could be attributed to the supply of calcium ions by the wastes and this is in agreement with the observations of Njoke *et al.*, (2007). Svetlana *et al*., (2020) noted an increase in soil pH due to application of organic waste.

Table 3.3: Effect of Ricemill Waste and Sawdust on Soil Chemical Properties

Legend: 0 =Control, R1 = Ricemill Waste 10t/ha, R2 = Ricemill Waste at 15t/ha, S1 = Sawdust at 10t/ha, S2 = Sawdust at 15t/ha, OC =

TRET	$P^{H}W$	OC (%)	T N (%)	AVP (mg/k)	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	EA	ECEC	C:N	BS (%)
					→ Cmol/kg ←							
0	4.50^{a}	0.50^{a}	0.06^{a}	28.44^{a}	1.20^{a}	1.23^{a}	0.05^{a}	0.16^{a}	2.10^{e}	4.74^{a}	8.33^{a}	55.69^{a}
R1	5.56^{b}	2.10^{b}	0.22^{d}	39.55^{b}	2.00^{b}	1.83^{b}	0.13^{b}	1.18^{c}	1.42^{b}	6.56^{b}	9.54^{b}	78.35^{b}
R2	5.83^{c}	2.98^{c}	0.18^{c}	40.72^{c}	2.19^{b}	1.99^{b}	0.15^{b}	1.23^{c}	1.23^{a}	6.79^{c}	16.55^{c}	81.88^{c}
S1	6.55^{d}	2.20^{b}	0.12^{b}	56.70^{d}	2.33^{b}	3.70^{c}	0.83^{c}	1.10^{b}	1.75^{d}	9.71^{d}	18.33^{d}	81.97^{c}
S2	6.93^{e}	3.22^{d}	0.16^{b}	64.30^{e}	2.50^{b}	4.30^{d}	0.86^{c}	1.04^{b}	1.65^{c}	10.35^{e}	20.13^{e}	84.05^{ds}
F-LSD P =0.05	0.13	0.14	0.05	1.36	0.62	0.48	0.07	0.12	0.005	0.17	0.81	0.82

Organic carbon, TN = Total Nitrogen, AVP = Available phosphorous, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, EA = Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity, C: N= Carbon to nitrogen ratio, BS = Base Saturation.

Note: Figures with the same superscript are not statistically significant.

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3.3.2 Organic Carbon (%)

The result of the effect of mulching the soil with ricemill waste and sawdust on soil organic carbon showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil organic carbon with values of 1.60 and 2.48% respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil organic carbon significantly ($p<0.005$) relative to the control with 1.70 and 2.72% respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, there was no significant ($p<0.005$) difference when plot mulched with sawdust at 10t/ha was compared with plots mulched with ricemill waste at 10t/ha. However, sawdust application at 15t/ha recorded 0.24% higher organic carbon compared with ricemill waste at 15t/ha. The observed increases in the organic carbon of the mulched plots relative to the control could be explained in terms of the nature of the mulch materials which are high in carbon content probably due to the age of the material. This increase in soil organic carbon by addition of organic mulches has been reported by Ojikpong and Michael Kekong, (2019).

3.3.3 Total Nitrogen (%)

The result of the effect of mulching the soil with ricemill waste and sawdust on total nitrogen showed that relative to the control (0.06)%, total nitrogen increased significantly ($p<0.005$) with increasing rate of ricemill waste application. The application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased total nitrogen with values of 0.12 and 0.16% respectively compared with the control. Similarly application of sawdust at the rate of 10t/ha and 15t/ha increased total nitrogen significantly ($p<0.005$) relative to the control with values of 0.06 and 0.10 %respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 0.10 and 0.02 % lower in total nitrogen compared to 10t/ha and 15t/ha of ricemill waste application respectively. However, application of ricemill wastes at 10t/ha and 15t/ha particularly at 15t/ha recorded the highest significant ($p<0.005$) increase in soil total nitrogen. The observed increases in soil total nitrogen of the mulched plots relative to the control could be due to the mineralization of nitrogen from the decomposing mulch material. The superiority of ricemill waste over sawdust could be explained by the wider C: N ratio of sawdust.

3.3.4 Available Phosphorous (Mg/kg)

The result of the effect of mulching the soil with ricemill waste and sawdust on soil available phosphorous showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil available phosphorous with values of 11.11 and 12.28 Mg/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil available phosphorous significantly ($p<0.005$) relative to the control with 28.26 and 35.86 Mg/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 17.15 and 23.58 Mg/kg higher in soil available phosphorous compared to 10t/ha and 15t/ha of ricemill waste application respectively. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase in both rates. These observed increases in soil available phosphorous as a result of mulching with these materials could be due to the increase in soil pH that can unlock fixed P in acidic soils and this is in line with the findings of Abdulaziz Alharbi,(2017).

3.3.5 Calcium, (Ca)

The result of the effect of mulching the soil with ricemill waste and sawdust on calcium showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased calcium content with values of 0.80 and 0.99 Cmol/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased the calcium content significantly ($p<0.005$) relative to the control with value of 1.13 and 1.30 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, there was no significant ($p<0.005$) difference recorded among the different rates of sawdust used and the different rates of ricemill waste used rather their values varies. The observed increases in the exchangeable cations (Ca, Mg, K and Na) as a result of mulching with these materials could be attributed to the high level of organic carbon in the waste. Similar results were documented by Ayeni, (2010) and Ojikpong and Michael Kekong, (2019).

3.3.6 Magnesium (Mg)

The result of the effect of mulching the soil with ricemill waste and sawdust waste on magnesium content showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased the soil magnesium content with values of 0.60 and 0.76 Cmol/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil magnesium content significantly ($p<0.005$) relative to the control with values of 2.47 and 3.07 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 1.87 and 1.99 Cmol/kg

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higher in soil magnesium content compared to 10t/ha and 15t/ha of ricemill waste application. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase compared to sawdust at 10t/ha and ricemill waste at 10t/ha and 15t/ha. This confirms the report of Udom *et al*, (2017) who noted that application of organic manure to the soil increase ca^{2+}, Mg^{2+}, k^{+}, and Na in the soil.

3.3.7 Potassium (K)

The result of the effect of mulching the soil with ricemill waste and sawdust on the potassium content showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil potassium content with values of 0.08 and 0.10 Cmol/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil potassium content significantly ($p<0.005$) relative to the control with values of 0.78 and 0.81 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 0.70 and 0.71 Cmol/kg higher in soil potassium content compared to 10t/ha and 15t/ha of ricemill waste application. However, there was no observed significant difference between sawdust at 10t/ha and 15t/ha. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase in soil potassium content compared to other mulched plots. This agrees with the result of Agbede and Adekiya, (2016) who reported increase in soil potassium with the application of organic waste.

3.3.8 Sodium (Na)

The result of the effect of mulching the soil with ricemill waste and sawdust on sodium content showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil sodium content with values of 1.02 and 1.07 Cmol/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased the sodium content significantly ($p<0.005$) relative to the control with values of 0.94 and 0.88 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust at 10t/ha and 15t/ha recorded 0.08 and 0.19 Cmol/kg lower in soil sodium content compared to application of ricemill waste at 10t/ha and 15t/ha. However, there was no significant ($p<0.005$) difference observed between 10t/ha and 15t/ha of ricemill waste application and 10t/ha and 15t/ha of sawdust application. Although application of ricemill waste at 15t/ha recorded the highest increase in sodium contents.

3.3.9 Exchangeable Acidity (EA)

The result of the effect of mulching the soil with ricemill waste and sawdust on exchangeable acidity showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) reduced the exchangeable acidity with values of 0.68 and 0.87 Cmol/kg respectively. Similarly application of sawdust at the rate of 10t/ha and 15t/ha reduced soil exchangeable acidity significantly ($p<0.005$) relative to the control with values of 0.35 and 0.45 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust at 10t/ha ad 15t/ha reduced exchangeable acidity significantly ($p<0.005$) with values of 0.33 and 0.42 Cmol/kg compared to ricemill waste at 10t/ha and 15t/ha. However, ricemill waste at 15t/ha recorded the highest significant ($p<0.005$) reduction in soil exchangeable acidity compared to other mulched plots. These reductions observed in the mulched plots could be attributed to the increased exchangeable cations contained in the mulching material. There are also reports of increased basic cations in the soil and reduction in soil acidity due to ricehusk and sawdust application. (Njoke and Mbah., (2012) and Azu *et al*.,2021).

3.3.9.1 Effective Cation Exchange Capacity (ECEC)

The result of the effect of mulching the soil with ricemill waste and sawdust on soil effective cation exchange capacity (ECEC) showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil effective cation exchange capacity (ECEC) with values of 1.82 and 2.05 Cmol/kg respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil effective cation exchange capacity (ECEC) significantly ($p<0.005$) relative to the control with values of 4.97 and 5.61 Cmol/kg respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 3.15 and 3.38 Cmol/kg higher in soil effective cation exchange capacity (ECEC) compared to 10t/ha and 15t/ha of ricemill waste application respectively. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase in soil effective cation exchange capacity (ECEC) compared to other mulched plots. Similar results were supported by Amenkhienan *et al*., (2019).

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3.3.9.2 C: N Ratio

The result of the effect of mulching the soil with ricemill waste and sawdust on C: N ratio showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased soil C: N ratio with values of 1.21 and 8 .22 respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased soil C: N ratio significantly ($p<0.005$) relative to the control with values of 10.00 and 11.80 respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 8.79 and 3.58 higher C: N ratio compared to 10t/ha and 15t/ha of ricemill waste application respectively. Thus sawdust application at 15t/ha recorded the highest C: N ratio compared to other treated plots. However, plots which received sawdust mulch at various rates were higher than plots that received ricemill waste at various rates; this indicates predominance of immobilization over mineralization. According to Havlin *et al*., (2006) a C: N ratio of about 10 is considered a satisfactory condition for normal microbial activities in humus decomposition and a C: N ratio of above 20 indicates the predominance of immobilization process over mineralization resulting in the release of little nitrogen into the soil.

3.3.9.3 Percentage Base Saturation

The result of the effect of mulching the soil with ricemill waste and sawdust on Percentage Base Saturation showed that relative to the control, application of ricemill waste at 10t/ha and 15t/ha significantly ($p<0.005$) increased the percentage base saturation with values of 22.66 and 26.19(%) respectively. Similarly application of sawdust at the rate of at 10t/ha and 15t/ha increased the soil percentage base saturation significantly ($p<0.005$) relative to the control with values of 26.28 and 28.36(%) respectively. Also when sawdust at 10t/ha and 15t/ha was compared with ricemill waste at 10t/ha and 15t/ha, sawdust recorded 3.62 and 2.17(%) higher in soil percentage base saturation compared to 10t/ha and 15t/ha of ricemill waste application respectively. However, there was no significant ($p<0.005$) difference observed when 15t/ha of ricemill waste application was compared with 10t/ha of sawdust application. Thus sawdust application at 15t/ha recorded the highest significant ($p<0.005$) increase in soil percentage base saturation compared to other mulched plots. Sabir and Zia (2015) reported similar result that soil ECEC and percentage base saturation increased with the addition of organic waste to the soil.

4. CONCLUSION

The result of this study showed that ricemill waste and sawdust applied at different rates (10t/ha and 15t/ha) improved soil organic carbon content, total nitrogen, soil pH, exchangeable cations and base saturation in the soil when compared with the control. Mulching the soil with ricemill waste (10t/ha and 15t/ha) and sawdust (10t/ha and 15t/ha) reduced the acidity of the soil because of its contributions to the exchangeable cations in the soil. Increase in available phosphorous and ECEC was observed with increase in the rate of mulch applied. Application of sawdust at 15t/ha was more significant in improving the soil chemical properties in Umudike South East Nigeria.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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