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Changes in selected soil physico-chemical properties as affect by application of spent mushroom substrate (SMS) and yield of upland rice in Owerri, Southeast, Nigeria

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ABSTRACT

Spent Mushroom Substrate (SMS) is a type of organic amendment found to be a good nutrient source for crop production mainly because of its rich nutrient status, high cation exchange capacity and slow mineralization rate which retains its rich nutrient as an organic amendment. This research work was carried out at the Centre for Agricultural Research and Extension, Federal University of Technology, Owerri (FUTO). It investigated the effect of spent mushroom substrate (SMS) on soil properties and performance of upland rice in Owerri, Southeast Nigeria. The experiment was evaluated using five treatments at rates of SMS 0 t/ha, NPK 300 kg/ha, SMS 5 t/ha, SMS 10 t/ha and SMS 15 t/ha and were incorporated into the soil two weeks before planting; the treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The field layout measured 13 m by 6.5 m; each plot measuring 2 m by 1.5 m with a 0.5 m alley between plots. The SMS treatment was sourced from mushroom farms located at Aba in Aba North Local Government Area, Abia State and at Irete in Owerri West Local Government Area, Imo State while NPK was sourced from the Imo State Agricultural Development Project (ADP). The test crop used was FARO 56/NERICA 2 upland rice variety sourced from the Imo ADP; rice plants were sown at spacing of 30 cm ×30 cm. Soil samples were collected at depth of 0 – 20 cm using soil core sampler attached to soil auger; the soil samples were analysed for selected physico-chemical properties. Yield parameters measured included: filled grain, unfilled grain, total grain yield, percentage unfilled grain and percentage filled grain. Statistical analysis was carried out using Analysis of Variance (ANOVA) and significant means were separated using the Fisher's Least Significance Difference (F-LSD) at p=0.05. Results obtained revealed that soil of the study area was predominantly sandy. Moisture content (9.33 %) was highest in SMS 15 t/ha and varies significantly from moisture content values of control plot (7.40) and NPK treated plots (7.49). Bulk Density was lowest in NPK treated plots (1.40 g/cm^3); but it was significantly equal to SMS 15 t/ha (1.41 g/cm^3).

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Basically, SMS treated plots recorded significant increase in soil physico-chemical properties with increase in application rate when compared with control and NPK treated plots, except in bulk density and exchangeable acidity where it significantly reduced with increased rate of application of SMS. Lower values of soil physico-chemical properties obtained at harvest could be attributed to nutrient uptake by plants during vegetative growth. The application of SMS positively affected the yield of the test crop when compared with the control and NPK plots. All rates of SMS applied during the experiment significantly improved soil physico-chemical properties and the yield of upland rice. Spent Mushroom Substrate (SMS) 10 t/ha was seen as the best application rate suitable for the yield of upland rice because it gave the highest grain yield; hence, it is recommended to farmers in the study area for yield improvement of upland rice production without adversely affecting human health.

Keywords: Mushroom, Substrate, yield, upland, rice

1. INTRODUCTION

Southeastern Nigeria is a humid tropical rainforest characterized by high precipitation which causes runoff, leaching of nutrient elements and soil erosion (Onweremadu, Ihem, Onwudike, Ndukwu, Idigbor & Asiabaka, 2011); hence, lowering soil fertility and increasing soil degradation. In Southeastern Nigeria, the predominating Ultisols have a number of soil related constraints to agricultural productivity, poor structural stability and high susceptibility to erosion and drought (Opara-Nadi, 2000). Ultisols have low mineral reserve, are highly weathered and leached and have low fertility status. Due to the increasing dependence on inorganic fertilizers in growing food crops like rice which has led to a long term detrimental effect in the soil and excessively high expenditure on the farmers, application of organic materials to the soil is a favourable strategy for sustainable long term agricultural production with minimal effects to the soil. Addition of organic amendments like spent mushroom substrate (SMS) in increasing rate, improved soil chemical properties. Organic amendments have buffering capacities and hence, buffer soil pH; making the soil more resistant to pH changes in the soil and improves soil cation exchange capacity (Ogbodo *et al*., 2009). Spent mushroom substrate also increased percentage nitrogen content (Unal, 2015). Ekpe, Ihemtuge, Okoye, Ahukaemere, Onuora, Okere and Nwaigwe (2017) noted that mineralization of organic wastes resulted in the release of organic bound nutrients in the soil; significantly nitrogen, phosphorus, potassium and organic matter.

For sustainable agricultural practice, the use of integrated farm system has to be adopted and a lot of research should be geared towards actualizing this purpose. One of such research is the one involving the use of Spent Mushroom Substrate (SMS) in agriculture. Spent mushroom substrate is the soil-like material remaining after a crop of mushrooms have been harvested. It adds nutrients to soil, helps to neutralize acidic soils, facilitates plant growth in barren areas and equally adds organic matter and structure to the soil by improving soil properties such as aeration, CEC, organic matter, biological activities, water holding capacity, etc. (Yadav, Singh, Verma & Vijay, 2001). Spent Mushroom Substrate (SMS) is an organic amendment which is a good nutrient source for crop production, mainly because of its rich nutrient status, high cation exchange capacity (CEC) and slow mineralization rate which retain its nutrient as an organic matter. Due to its nutrient values, SMS can be used in organic farming to improve soil water infiltration, water holding capacity, permeability and aeration. Spent Mushroom Substrate has many useful features which include a relatively low bulk density, a low level of heavy metals and absence of plant pathogens and weed seeds (Zhang & Sun, 2014). Spent Mushroom Substrate is a source of humus formation and humus is known to provide plant micronutrients, improve soil aeration, soil water holding capacity and contributes to the maintenance of soil structure (Mustapha and Kadiri, 2010).

Approximately 90% of the world's rice (Oryza sativa L.) is produced in Asia. Rice is a staple food for many people in the world. It is the world's most important wetland crop. It is cultivated worldwide in an approximate area of 153.96 million hectares, which is more than ten percent of the arable land. Asia contributes fifty-nine percent (59%) of world's population and accounts for ninety-two percent (92%) of global rice production (Anon, 2003). The Food and Agriculture Organization in 2016 rated Nigeria as the 18^{th} largest producer with an output of 146.5 million metric tons (FAO, 2016). Ebonyi State produces more than fifty percent (50%) of the total Nigerian output of rice and through improved technology, rice production can be increased (Ekpe & Alimba, 2013). Upland rice is rice grown on dry soil rather than flooded rice paddies. Upland rice being drought resistant has minimal environmental factors that could affect its yield. It matures between 90 - 120 days; duration good enough for many cycles of production in one year under irrigation practice. It is because rice is very important to the Nigerian urban and rural populations, early maturing characteristics and nutritional value that it was chosen as a test crop in this experiment involving changes in selected soil physico-chemical properties as affect by application of spent mushroom substrate (SMS) and yield of upland rice in Owerri, southeast, Nigeria.

2. MATERIALS AND METHOD

Site Description

The study was carried out at the Centre for Agricultural Research and Extension of the Federal University of Technology, Owerri, Imo State, Nigeria. The site is located on latitude 5°22′52.752″N and longitude 6°59′34.6488′′E (Handheld Global Positioning System). Owerri is in the tropical rainforest zone of Southeast Nigeria. It is located between latitude $05^0 25^1$ and $05^0 32^1$ North and longitude $06^0 57^1$ and $07^0 71^1$ East. The climate of Owerri is typical of humid tropics with fairly even and uniform temperature throughout the two seasons- dry and raining seasons each year. The raining season (March - October), is characterized by clouds, driven by light wind from the ocean, relatively constant temperature, frequent rains and high humidity from May to October. Rainfall peaks are in July and September; mean annual rainfall ranges between 2000 – 2500 mm. Rainfall distribution is bimodal (March - July and Mid-August - October). Dry season sets in from November; the wind becomes dusty,"Hamattan" bringing in drier air from the Sahara Desert. It is notable with very little rainfall, hotter days, cooler nights and lower humidity ending in February.

Cultural Practices

This included planting/sowing activities, weed control, pest/disease control and harvesting. Rice seeds were planted directly into the soil after four days of treatment application by dibbling. Four to five seeds were sown at 2 – 3 cm soil depth. Rice seeds were dibbled at a spacing of 0.30 × 0.30 m. Five seeds were planted per hole and at two weeks after planting, the seedlings were thinned down to three seeds per hole to give a plant population of 333,333 seedlings per hectare. Weeding was done regularly as possible to ensure that the farm was weed free throughout the growing season of the plant. Scare crows and nets were used on the farm to prevent pests. Insecticide (Termi Dust) was applied two times in an interval of two weeks. The rice grains were harvested when the grains became hard and started turning yellow/brown at four months after planting; 30 - 45 days after flowering.

Data Collection

The pre-planting and post-planting samples were collected at 0 – 30 cm soil depth. Fifteen (15) samples were collected; one sample from each block using soil auger attached with core samplers for bulk density, porosity and moisture content determination. Soil samples were collected randomly from the experimental site. These samples were sealed and labeled, then transported to the laboratory for analysis. Spent Mushroom Substrate (SMS) was incorporated into the soil at rates of 0 t/ha, 5 t/ha, 10 t/ha, 15t/ha and NPK 300 kg/ha each, replicated three times. The following grain yield parameters were weighed and calculated: total grain yield, weight of filled grain, weight of unfilled grain, percentage filled and unfilled grain.

Field Layout, Experimental Design and Statistical Analysis

The field layout comprised fifteen (15) plots, each measuring 2 m × 1.5 m with a 0.5 m alley between plots. The total area of the field layout was 84.5 m^2. Samples collected were analyzed in the laboratory on soil physico-chemical properties. The experiment comprised of five (5) treatments replicated three (3) times, and laid out in a Randomized Complete Bock Design (RCBD). Raw data generated from the research was subjected to Analysis of Variance (ANOVA). Significant means were dictated using Fishers-Least Significant Difference (F-LSD) at 5% probability level.

3. RESULTS AND DISCUSSION

The results of the soil physico- chemical properties before treatment application are presented in Table 1.

Table 1: Pre-Planting Soil Characteristics before Application of Spent Mushroom Substrate

Soil Properties	Value
Physical Properties	
Sand	92.28%
Silt	4.10%
Clay	3.62%
Textural Class	sandy
Moisture Content	18.32%
Bulk Density	1.25g/cm^3
Particle Density	2.65g/cm^3

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Total Porosity	52.80%
Chemical Properties	
Soil pHw (1:2.5)	5.86
Soil pH_{KCl}	4.92
Organic Carbon	1.22%
Organic Matter	2.10%
Total Nitrogen	0.13%
Available Phosphorus	10.92mg/kg
Aluminum	0.85cmol/kg
Hydrogen	0.50cmol/kg
Calcium	3.76 ″
Magnesium	1.81 ″
Sodium	0.05 ″
Potassium	0.03 ″
Total Exchangeable Bases	5.65 ″
Total Exchangeable Acidity	1.35 ″
Effective Cation Exchange Acidity	7.00 ″
Percentage Base Saturation	80.72%

Physical Properties of the Soil before Treatment Application

Particle size analysis of the study site gave 92.28 % sand, 3.62 % clay and 4.10 % silt content; having the soil of the study site to be predominantly sandy; permitting ease in the downward movement of water in the soil; this is of benefit to shallow-rooted crops like upland rice. Lafitte, Yongsheng, Yan and Li (2007), stated that soils with good aeration favour crop growth under sprinkler irrigation system; hence, good for the cultivation of upland rice. Bulk Density of 1.25 g/cm^3 was recorded; the result shows that soil of the study site has the potency to support rice production. The study site recorded a Total Porosity of 52.80 %. Bulk density indicates soil quality and is inversely related to other soil properties, including total porosity (Wei, Teng-Fei, Yong, Anthony and Wan-Jun, 2014). There is an inverse relationship between the soil bulk density and total porosity. A high bulk density of the soil reveals low total porosity while low bulk density indicates high soil porosity. Long term cultivation lowers porosity because of reduction in soil organic matter and peds (Brady & Weil, 2002).

Soil Chemical Properties before Application of Treatment

Results showed that soil pH in water was 5.86 while in potassium chloride (KCl) was 4.92; this shows moderate acidity and good for rice cultivation in dry conditions (Howeler, 2002). Organic carbon of 1.22 % and Organic matter of 2.10 % were recorded. This shows a relatively poor organic carbon and matter contents of the soil due to consistent anthropogenic activities; hence, poor in maintaining a stable structure. (Patrick, Stephen, Peter, Moses, Drake, Twaha & Adrain, 2013) stated that the minimum value for maintaining stable structure in tropical soils is 2% organic carbon and 3.4 % organic matter. Total Nitrogen of 0.13 % was low. Available Phosphorus of 10.92 mg/kg was medium in content. Calcium 3.76 cmol/kg was medium, magnesium 1.81 cmol/kg was high, sodium 0.05 cmol/kg was low and potassium 0.03 cmol/kg was equally low. All basic cations, apart from magnesium were within tolerable toxic limits for crop growth. Total Exchangeable Bases recorded a value of 5.65 cmol/kg and Total Exchangeable Acidity 1.35 cmol/kg. Effective Cation Exchange Capacity had value of 7.00 cmol/kg. Percentage Base Saturation was high at 80.72 %. This suggests that base cations were present in the soil solution; displacing acidic cations at the exchange site; hence, will have high fertility status and support crop growth.

Effect of Spent Mushroom Substrate on Soil Physical Properties at Harvest

The effect of the treatment on soil physical properties are presented on Table 2.

Moisture Content (%)

Significant differences were not recorded when the percentage moisture content of the control plots were compared with the other treatments and when the NPK treatment was compared with the SMS treatment plots. Significant differences were not recorded when the percentage moisture content of the plots treated with SMS were compared with one another. However, variations existed in the values among all the treatments. There were 0.12, 0.24 and 0.38 % less moisture content in the plots treated with T2, T4 and T5 respectively when compared with the control, but was 0.02 % higher than T3. The highest mean difference of 0.38 % moisture content was recorded when T5 was compared with T1. Comparison of the NPK with the SMS revealed that T4 and T5 outperformed the NPK treatment by producing 0.12 and 0.26 % higher moisture content, but NPK treated plots outperformed T3 by producing 0.14 % higher moisture content. However, in the comparison of the different rates of SMS treatment plots respectively, the highest moisture content was recorded from plots treated with 15 t/ha SMS This value was 0.14 % higher than those recorded from the 10 t/ha SMS treated plots. The trend of the improvement of soil moisture content showed that T1< T2< T3< T4<T5. This showed that increasing rate of application of SMS resulted in increase in the soils ability to hold moisture; this could be attributed to favourable soil-water relationship which improved with the addition of SMS as stated by (Reed, 2007 and Ogbodo *et al*., 2009). Organic materials in form of SMS performed the function of binding soil particles together. The bond soils will prevent ease of moisture loss through evaporation and deep percolation, this may explain why the highest rate (SMS 15 t/ha) proved to be superior to the rest of the treatments.

Table 2: Effect of Spent Mushroom Substrate Treatment on Soil Physical Properties at Harvest

Treatment	% Moisture Content	Bulk Density (g/cm³)	Total porosity	% Sand	% Silt	% Clay	Textural class
T1	7.92[a]	1.48[d]	44.13[a]	91.73[c]	4.73[b]	3.53[a]	Sandy soil
T2	8.04[a]	1.41[c]	46.65[b]	92.07[c]	4.40[a]	3.53[a]	Sandy soil
T3	7.90[a]	1.39[b]	47.29[c]	91.07[b]	5.40[c]	3.53[a]	Sandy soil
T4	8.16[a]	1.37[a]	48.10[d]	90.73[b]	4.73[b]	4.53[b]	Sandy soil
T5	8.30[a]	1.37[a]	48.29[d]	89.73[a]	5.40[c]	4.87[b]	Sandy soil
FLSD (p=0.05)	NS	0.01	0.44	0.47	0.29	0.47	

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

NS = Not Significant.

Legend: T1 = SMS 0 t/ha, T2 = NPK 300 kg/ha, T3 = SMS 5 t/ha, T4 = SMS 10 t/ha and T5 = SMS 15 t/ha

Bulk Density (g/cm³)

There were significant differences when the bulk density value of the control plots was compared with these from the other treatments and when values from the NPK treated plot was compared with those from the SMS treated plots. Significant differences also existed when the values of the bulk density from the plots treated with SMS were compared with one another. There were 0.07, 0.09, 0.11and 0.11 lower bulk density in the plots treated with T2, T3, T4 and T5 respectively when compared with the control. The highest mean difference was recorded when T2 was compared with T1. More so, NPK treated plots recorded 0.02, 0.04 and 0.04 lower bulk density when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. However, comparison of the different rates of SMS treated plots showed that T3 had 0.02 higher bulk density than T4 and T5 respectively. The highest bulk density content was recorded in the control plots. This value was 0.07 g/cm³ higher than those recorded from NPK treated plots. This showed that this bulk density trend followed thus: T1> T2 > T3 > T4 = T5. The result showed that increasing rate of application of SMS resulted in decrease in the bulk density of the experimental soil. The lower values of bulk density (< 1.5) observed is desirable for optimum movement of air and water through the soil as postulated by Hunt & Gikes (1992). The reduced bulk density values in SMS applied plots compared with higher value of the control plot is one of the functions of SMS as an organic amendment which decreases soil bulk density; enhancing soil structure (Ogbodo *et al*., 2009). This result agrees with the findings of Mbagwu (1992) and Curtin & Mullen (2007). This reduction in bulk density could be due to the binding effects of SMS on soil particles into aggregates.

Total Porosity (%)

There were significant differences when % total porosity of the control plots were compared with other treatments and when NPK treatment was compared with the SMS treated plots. More so, significant differences were recorded when the SMS treated plots were compared with one another. Control plots recorded 2.52 %, 3.16 %, 3.97 % and 4.16 % lower % total porosity when compared with T2, T3, T4 and T5 plots respectively. Comparison of the NPK treated plots with the SMS treated plots revealed 0.64 %, 1.45 % and 1.64 % higher % total porosity in SMS 5 t/ha, SMS 10 t/ha and SMS 15 t/ha respectively. Furthermore, SMS 15 t/ha recorded higher % total porosity of 1.00 and 0.19 in SMS 10 t/ha and SMS 15 t/ha respectively. The highest % total porosity was recorded from SMS 15 t/ha; this value was 0.19 % higher than those recorded from the SMS 10 t/ha treated plots. Increase in the application rate of SMS gave rise to increase in total porosity; this could be attributed to reduction in bulk density which increased total porosity as stated by Mbagwu (1992) and Ogbodo *et al.*, (2009); the lower the soil bulk density, the higher the total porosity; the lower the compaction as a result of promotion of aggregation of soil properties on application of organic amendments which has binding effect on soil properties in aggregates.

Particle Size Analysis (%)

Particle size result showed that the soils were predominantly sandy. The result showed that there were significant differences in the sand content in all the plots. Significant differences also existed when NPK treated plots were compared with SMS treated plots. Among the SMS treated plots, significant differences also existed. Control plots recorded 0.67, 1.00 and 2.00 % higher sand contents when compared with T3, T4 and T5 plots respectively, but less value of 0.34 when compared with T2. NPK treated plots recorded 1.00, 1.33 and 2.33 % more sand content when compared with SMS 5 t/ha, 10 t/ha and SMS 15 t/ha respectively. Spent Mushroom Substrate (SMS) 5 t/ha recorded higher sand content when compared with SMS 10 t/ha and 15 t/ha with higher values of 0.34 and 1.34 % respectively. A decrease in sand content was recorded with increased rate of application of SMS. Control plots recorded 0.33 % higher silt content when compared with NPK treated plots, but 0.67 % less silt content when compared with SMS 5 t/ha and SMS 15 t/ha; however, control plots recorded same value with SMS 10 t/ha treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots recorded less silt content when compared with SMS 5 t/ha, SMS 10 t/ha and SMS 15 t/ha treated plots with values of 1.00, 0.33 and 1.00 % respectively. When compared with one another, SMS 5 t/ha and 15 t/ha treated plots recorded equal but more silt content value of 0.67 % than SMS 10 t/ha. Control treated plots recorded less clay content values of 1.00 and 1.33 % when compared with SMS 10 t/ha and 15 t/ha respectively, but the same value when compared with NPK and 5 t/ha treated plots. NPK treated plots recorded less clay content values of 1.00 and 1.34 %, when compared with SMS 10 t/ha and 15 t/ha respectively, but the same clay content value with SMS 5 t/ha. When the SMS treated plots were compared with each other, SMS 5 t/ha recorded less clay content of 1.00 and 1.34 % in 10 t/ha and 15 t/ha respectively. The highest clay content was recorded from SMS 15 t/ha. This value was 0.34 % higher than those of SMS 10 t/ha treated plots. An increase was observed with increase in application rate of SMS. The slight significant differences could be attributed to the addition of amendments which did not change the predominant sandy nature of the soils of the area because they originated from the same parent material.

Soil Chemical Properties at Harvest

The effect of treatment on soil chemical properties at harvest is presented in Table 3.

Table 3: Effect of Spent Mushroom Substrate Treatment on Soil Chemical Properties at Harvest

Treatment	pH in water	pH in Kcl	% OC	% OM	% N	AP mg/100g	EAl^{3+}Cmol /kg	H$^+$Cmol /kg	Ca^{2+} Mg/100g	Mg^{2+} Mg/100g	K$^+$ Mg/100g	Na$^+$ Mg/100g	TEA Cmol /kg	Mg/100g	ECEC	% BS	C/N	Ca /Mg	Na/K
T1	5.68^b	4.99^b	1.05^a	1.81^a	0.06^a	0.644^a	0.80^c	0.50^c	1.34^a	0.62^b	1.07^a	1.85^b	1.30^d	4.88^a	6.18^a	78.92^a	17.50^d	2.21^a	1.73^d
T2	5.57^a	4.91^a	1.03^a	1.78^b	0.10^d	0.633^a	0.76^b	0.54^d	1.37^a	0.53^a	2.54^e	1.67^a	1.30^d	6.11^b	7.41^b	82.38^b	10.30^a	2.67^b	0.66^a
T3	5.93^c	5.31^c	1.24^b	2.13^c	0.08^b	0.718^b	0.76^b	0.45^a	1.98^b	0.73^c	1.50^b	2.05^c	1.21^c	6.26^b	7.47^b	83.73^c	15.35^b	2.73^b	1.37^c
T4	6.05^d	5.54^d	1.36^c	2.34^d	0.09^c	0.855^c	0.74^b	0.45^a	2.23^c	1.06^d	1.86^c	2.36^d	1.19^b	7.51^c	8.70^c	86.28^d	15.11^b	2.09^a	1.26^b
T5	6.20^e	5.66^e	1.60^d	2.76^e	0.10^d	0.925^d	0.67^a	0.49^b	2.56^d	1.22^e	2.36^d	2.95^e	1.10^a	9.09^d	10.19^d	89.15^e	16.00^b	2.10^a	1.25^b
FLSD (p =0.05)	0.04	0.05	0.03	0.06	0.00	0.031	0.02	0.03	0.08	0.06	0.15	0.11	0.01	0.22	0.22	0.49	0.65	0.32	0.10

Legend: T1 = SMS 0 t/ha, T2 = NPK 300kg/ha, T3 = SMS 5t/ha, T4 = SMS 10t/ha and T5 = SMS 15t/ha

NOTE: Figures with the same superscripts are not statistically significant.

NS = Not Significant.

pHw and pH$_{KCl}$

The result of the effect of treatment on soil pH in water showed that there were significant differences when the pHw from the soil of the control plots were compared with other treatments and also when NPK treated plots were compared with SMS treated plots. Significant differences were equally recorded when the pHw from the SMS treated plots were compared with each other. Control plots recorded lower pHw values of 0.25, 0.37 and 0.52 when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively, but higher value of pHw of 0.11 when compared with NPK treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots also recorded lower pHw values of 0.36, 0.48 and 0.63 when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. SMS 5 t/ha recorded lower values of 0.12 and 0.27 when compared with SMS 10 t/ha and 15 t/ha respectively. The highest pHw value was

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recorded from plots treated with SMS 15 t/ha with value of 0.15 higher than 10 t/ha SMS treated plots. According to the ratings of Babalola *et al* (1998), control plots and NPK 300 kg/ha plots were moderately acidic, SMS 5 t/ha, SMS 10 t/ha and 15 t/ha were slightly acidic. This indicated good pHw conditions for rice cultivation (Howeler, 2002). Soil pH regulates chemical and biological reactions in the soil.

In pH_{KCl}, significant differences were also observed when pH_{KCl} of the control plots were compared with other treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots also recorded significant differences when compared with SMS treated plots. There were significant differences When SMS treated plots were compared with one another. The result showed that control plots had lower values of pH_{KCl} of 0.32, 0.55 and 0.67 pH_{KCl} when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha plots respectively, but higher value of 0.08 when compared with NPK treated plots. NPK treated plots also recorded lower values of 0.40, 0.63 and 0.75 pH_{KCl} when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. When the SMS treated plots were compared with one another, SMS 5 t/ha had lower values of 0.23 and 0.35 when compared with 10 t/ha and 15 t/ha respectively. The highest pH value was recorded in SMS 15 t/ha treated plots; having 0.12 value more than SMS 10 t/ha treated plots. There was an increase in pH value with increase in the application rate of SMS. The lower pHw value recorded in NPK fertilizer explains it's acidifying effect while the higher values in SMS treated plots shows it's buffering capacity on the soil (Ogbodo *et al*., (2009) and Medina *et al*., (2009).

Organic Carbon (%)

There were significant differences when the control treated plots were compared with other treated plots, when NPK treated plots were compared with SMS treated plots and when SMS treated plots were compared with one another. Control treated plots recorded higher organic carbon value of 0.02 % when compared with NPK treated plots, but recorded less organic carbon contents of 0.19, 0.31and 0.55 % when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The NPK treated plots also recorded less organic carbon contents of 0.21, 0.33 and 0.57 % when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. When the SMS treated plots were compared among each other, SMS 5 t/ha recorded less contents of 0.12, and 0.36 when compared with 10 t/ha and 15 t/ha respectively. The highest organic carbon content was recorded in SMS 15 t/ha with 0.24 values higher than 10 t/ha. The trend of the improvement of soil organic carbon content showed that T2< T1< T3< T4<T5. Increased rate of application of SMS resulted to increased soil organic carbon in the soil. The increased values of SOC on SMS treated plots were in agreement with the findings of Hairu *et al*., (2016); Adeli *et al*., (2009) and Ogbodo *et al*., (2009), who stated that as an organic amendment, SMS increases soil productivity.

Total Nitrogen (%)

Higher rates of SMS treated plots recorded higher Nitrogen values than control plots. There were significant differences when then % total nitrogen of the control plots were compared with those of the other treated plots. Significant differences were also observed when NPK treated plots were compared with SMS treated plots; when SMS treated plots were compared with one another, significant differences were also observed. Control treated plots recorded lower nitrogen values of 0.04, 0.02, 0.03 and 0.04 % when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Nitrogen, Phosphorus and Potassium (NPK) treated plots recorded higher nitrogen values of 0.02 and 0.01 when compared with SMS 5 t/ha and 10 t/ha, but was the same value with SMS 15 t/ha. When the SMS treated plots were compared with each other, SMS 15 t/ha recorded higher nitrogen values of 0.01 and 0.02 when compared with 10 t/ha and 5 t/ha respectively. The highest nitrogen was recorded in SMS 15 t/ha and NPK treated plots. This value was 0.01 higher than SMS 10 t/ha treated plots. Total nitrogen increased with increase in the application rate of SMS; this is in agreement with the findings of Medina *et al*., (2009), Unal (2015) and Ekpe *et al*., (2017). They stated that as an organic amendment, SMS was found to be nutritionally rich in nitrogen when used as a soil improver.

Available Phosphorus- AP (mg/100g)

The result showed that SMS treated plots released more available phosphorus into the soil than the NPK treated plots, and control plots while the NPK treated plots recorded the lowest value. There were positive differences in available phosphorus content when the control treated plots were compared with other treatment plots. Significant differences also existed when NPK treated plots were compared with the SMS treated plots. There were also significant differences when a comparison was made among the SMS treated plots. Control treated plots recorded 0.074, 0.211, and 0.281 mg/100g lower available phosphorus when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively, but recorded higher value of 0.11 ppm p/g when compared with NPK treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots had less available phosphorus values of 0.085, 0.222 and 0.282 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. When the SMS treated plots were

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compared among each other, 15 t/ha recorded higher values of 0.207 and 0.070 mg/100g when compared with 5 t/ha and 10 t/ha respectively. The highest value was recorded from SMS 15 t/ha with higher value of 0.070 mg/100g than those of 10 t/ha. The trend in improvement of soil available phosphorus content showed that T2< T1< T3< T4<T5. Increase in phosphorus values was recorded with increase in the application rate of SMS; this is in line with the findings of Unal (2015) and Hairu *et al* (2016). Phosphorus aids in the fruiting of crops and in photosynthetic process of the plants.

Exchangeable Aluminum- Al^{3+} (Cmol/kg)

There were significant differences in exchangeable aluminum content of the control treated plots when compared with control plots, when NPK treated plots were compared with SMS treated plots and when SMS treated plots were compared with one another. Control treated plots had more exchangeable aluminum values of 0.04, 0.04, 0.06 and 0.13 when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Nitrogen Phosphorus and Potassium (NPK) treated plots had higher contents of 0.02 and 0.09 Cmol/kg when compared with SMS 10 t/ha and 15 t/ha respectively, but recorded equal value with SMS 5 t/ha treated plots. When the SMS treated plots were compared with each other, SMS 5 t/ha had higher values of 0.02 and 0.09 Cmol/kg exchangeable aluminum than 10 t/ha and 15 t/ha respectively. The highest value was recorded in control plots with 0.064 Cmol/kg higher content than both NPK and SMS 5 t/ha. An increase in the application rate of SMS led to a decrease in aluminum content in SMS treated plots; this is attributed to increased pH values with increased application rate of SMS which buffered the soil solution. Organic matter increase also led to reduction in aluminum.

Hydrogen- H^+ (Cmol/kg)

There were significant differences in hydrogen content when the control plots were compared with other treated plots. Significant differences also existed when NPK treated plots were compared with SMS treated plots. Even among the SMS treated plots, significant differences were recorded. Control plots recorded higher hydrogen values of 0.05, 0.05 and 0.01 Cmol/kg when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively, but had lower value of 0.04 when compared with NPK treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots had higher hydrogen values of 0.09, 0.09 and 0.05 Cmol/kg when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Among the SMS treated plots, 15 t/ha had higher hydrogen values of 0.04 Cmol/kg when compared with both SMS 5 t/ha and 10 t/ha treated plots. NPK treated plots recorded the highest hydrogen content with higher value of 0.04 when compared with control plots. The trend in the improvement of soil hydrogen showed that T2 > T1 > T5 > T4 = T4. Hydrogen concentration values decreased with increased application rate of SMS. The increase in SMS treated plots could be attributed to nutrient migration during irrigation or rainfall.

Calcium- Ca^{2+} (mg/100g)

There were significant differences in the calcium content of the control plots when compared with the other treated plots and when NPK treated plots were compared with SMS treated plots. When SMS treated plots were compared with one another, positive differences were also recorded. Control plots had less calcium content of 0.03, 0.64, 0.89 and 1.22 mg/100g when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Nitrogen, Phosphorus and Potassium (NPK) treated plots recorded less calcium content of 0.61, 0.86 and 1.19 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Spent Mushroom Substrate (SMS) 15 t/ha recorded more calcium of 0.58 and 0.33 mg/100g when compared with 5 t/ha and 10 t/ha respectively. The highest calcium content was recorded in SMS 15 t/ha; this value was 0.33 mg/100g higher than those of the 10 t/ha treated plots. Increase in calcium content was recorded with increase in application rate of SMS; this is in line with the findings of Unal (2015); the soil is rated high.

Magnesium – Mg^{2+} (mg/100g)

The result showed that SMS 15 t/ha released more magnesium into the soil than other treatment plots. There were significant differences in magnesium content when control plots were compared with other treatment plots. Significant differences were also observed when NPK treated plots were compared with SMS treated plots. Among SMS treated plots, significant differences also existed. Control plots recorded lower magnesium values of 0.11, 0.44 and 0.60mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively, but recorded higher value of 0.09 mg/100g when compared with NPK treated plots. NPK treated plots also had lower magnesium values of 0.20, 0.53 and 0.69 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Spent Mushroom Substrate (SMS) 15 t/ha had higher magnesium values of 0.49 and 0.16 mg/100 g when compared with SM 5 t/ha and 10 t/ha treated plots respectively. The highest value was recorded in SMS 15 t/ha; this value was 0.16 mg/100g more than the value recorded from the 10 t/ha treated plots.

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Potassium- K^+ (mg/100g).

There were significant differences in soil potassium content when the control plots were compared with other treatment plots. Significant differences were also observed when NPK treated plots were compared with SMS treated plots and when SMS treated plots were compared with one another. Control plots recorded lower potassium mean difference of 1.47, 0.43, 0.79 and 1.29 mg/100g when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Nitrogen, Phosphorus and Potassium (NPK) treated plots had higher potassium mean difference of 1.04, 0.68 and 0.18 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Spent Mushroom Substrate (SMS) 15 t/ha recorded higher potassium values of 0.86 and 0.50 mg/100g when compared with SMS 5 t/ha and 10 t/ha treated plots respectively. The highest value of potassium content was recorded in NPK treated plots; this value was 0.18 mg/100g higher than those recorded from the SMS 15t/ha treated plots. The trend in the improvement of soil potassium showed that Potassium values increased with increase in application rate of SMS: this is in line with the findings of Unal (2015); the soil is rated low in potassium content.

Sodium - Na^+ (mg/100g)

There were significant differences in soil sodium content when the control plots were compared with other treatment plots and when NPK treated plots were compared with SMS treated plots; even among SMS treated plots, significant differences were also observed. The control plots had less sodium content values of 0.21, 0.51 and 1.10 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively, but recorded higher value of 0.18 mg/100g when compared with NPK treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots also recorded less sodium content values of 0.38, 0.69 and 1.28 mg/100g when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest value of sodium was recorded in SMS 15 t/ha; this value was 0.59 mg/100g higher than those from the 10 t/ha treated plots. The trend in the improvement of soil sodium content showed that an increase in sodium content was recorded with increase in the application rate of SMS. This quantity of sodium content could be toxic in the long-term usage because it could lead to degradation of soil structure; this is in agreement with the findings of Moral *et al.*, (2008), who observed high accumulation of sodium in the soil as a result of high sodium content in organic amendments; the soil is rated low in sodium content.

Total Exchangeable Acidity (TEA) – Al^{3+} and H^+ (Cmol/kg)

There were significant differences in TEA when the control plots were compared with other treatment plots. Significant differences also existed when NPK treated plots were compared with SMS treated plots and Among SMS treated plots. Control plots had higher TEA values of 0.09, 0.11 and 0.20 Cmol/kg when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively, but recorded same value with NPK treated plots. Nitrogen, Phosphorus and Potassium (NPK) treated plots recorded higher TEA values of 0.09, 0.11 and 0.20 Cmol/kg than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. When the SMS treated plots were compared among each other, SMS 5 t/ha had higher TEA values of 0.02 and 0.11 Cmol/kg than 10 t/ha and 15 t/ha treated plots respectively. The highest TEA value was recorded in control plots and NPK treated plots; they had value of 0.09 Cmol/kg more than SMS 5 t/ha treated plots. The trend in the improvement of soil TEA content showed that T1 = T2 > T3 > T4 > T5. TEA values reduced with increase in application rate of SMS; this could be attributed to increase in soil pH on addition of SMS in increasing rate, which neutralized/ buffered the soil solution; reducing acidity. This results agrees with the findings of Sanchez (1976), who stated that on sites that have a tendency to iron, aluminum or hydrogen toxicity, humifying organic matter works to combat toxic metal concentrations by forming complexes with a high molecular weight; where there is absence or little presence of organic matter, aluminum or hydrogen toxicity cannot be combated; this confirms the increase in aluminum and hydrogen saturation in the control plots than in those applied with SMS.

Total Exchangeable Bases (TEB) (mg/100g)

Significant differences existed in TEB when the control plots were compared with other treatment plots. Significant differences also existed when NPK treated plots were compared with SMS treated plots. Among SMS treated plots, significant differences also existed. Control plots had TEB values of 1.23, 1.39, 2.63 and 4.21 mg/100g lower than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots recorded values of 0.15, 1.40 and 2.98mg/100g lower than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. SMS 15 t/ha recorded TEB values of 5.82 and 3.00 mg/100g more than 5 t/ha and 10 t/ha treated plots respectively. The highest TEB value of 9.09 mg/100g was recorded in the SMS 15 t/ha treated plots. This value was 1.58 mg/100g more than those of 10 t/ha treated plots. The trend in improvement of soil TEB showed that increased application rate of SMS increased TEB in SMS treated plots; this is attributed to increases in soil pH and organic matter content which increases basic

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cations at the exchange complex and brought them into the soil solution. This agrees with the findings of Mbagwu (1992) and Ogbodo *et al*., (2009).

Effective Cation Exchange Capacity (ECEC) (mg/100g)

There were significant differences observed in ECEC when control plots were compared with other treatment plots. Significant differences were also observed in ECEC when NPK treated plots were compared with SMS treated plots. Among the SMS treated plots, significant differences also existed. Control plots recorded ECEC values of 1.23, 1.29, 2.52 and 4.01 mg/100g lower than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots recorded ECEC values of 0.06, 1.29 and 2.79 mg/100g lower than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. SMS 15 t/ha recorded ECEC values of 2.72 and 1.49 more than SMS 5 t/ha and 10 t/ha treated plots respectively. SMS 15 t/ha recorded the highest value of 10.19; this value was 1.49 mg/100g more than SMS 10 t/ha treated plots. Effective Cation Exchange Capacity (ECEC) increased with increase in application rate of SMS; this is attributed to increase in organic matter content and agrees with the findings of Ogbodo *et al*., (2009) who stated that organic amendments have the capacities to improve soil ECEC.

Base Saturation (BS) (%)

Base saturation values recorded significant differences when control plots were compared with other treatment plots. Significant differences were also observed when NPK treated plots were compared with SMS treated plots and when SMS treated plots were compared with one another. Control plots recorded % base saturation values of 3.46, 4.81, 7.36 and 10.23 % lower than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots had % base saturation values of 1.35, 3.90 and 6.77 % lower than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. SMS 15 t/ha recorded % base saturation values of 5.42 and 2.87 % higher than SMS 5 t/ha and 10 t/ha treated plots respectively. The highest % base saturation value was recorded in SMS 15 t/ha treated plots; this value was 2.87 % more than those of SMS 10 t/ha treated plots. Base saturation increased with increased rate of application of SMS; this result is in agreement with the results from Ogbodo *et al*., (2009) who stated that organic matter content and basic cations in the soil are increased with increase in organic matter.

Carbon and Nitrogen ratio (C/N)

Carbon nitrogen ratio recorded significant differences when control plots were compared with other treatment plots and when NPK treated plots were compared with SMS treated plots. Among SMS treated plots, significant differences were observed when SMS rates were compared with one another. Control plots C/N values of 7.20, 2.15, 2.39 and 1.50 % more than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots recorded C/N values of 5.05, 4.81 and 5.70 % lower than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. When the SMS treatments were compared among each other, SMS 15 t/ha recorded C/N values of 0.65 and 0.89 % higher than 5 t/ha and 10 t/ha treated plots respectively. The highest C/N value of 17.50 was recorded in control plot. This value was 1.50 % higher than those of SMS 15 t/ha treated plots. The trend in the content of soil C/N showed that T1 > T5 > T3 > T4 > T2. Irregular flow of values of C/N was recorded with increase in the application rate of SMS. The values recorded fall between the slow fractions C/N of 10-25 as stated by Brady and Weil (2002). Values that ranged from 15-30 indicate food energy supply of soil microbes which increases the decomposition rate of organic matter and nitrogen (Deng *et al*, 2013).

Calcium and Magnesium ratio (Ca/Mg)

There were significant differences in Ca/Mg when the values from the control plots were compared with other treatment plots, when the Ca/Mg from the NPK treated plots were compared with those from the SMS treated plots and when SMS treated plots were compared with one another. Control plots recorded Ca/Mg values of 0.46 and 0.52 lower than NPK and SMS 5 t/ha treated plots, but recorded higher values of 0.12 and 0.11than SMS10 t/ha and 15 t/ha treated plots respectively. NPK treated plots had Ca/Mg value of 0.06 lower than SMS 5 t/ha treated plots, but values of 0.58 and 0.57 higher than SMS 10 t/ha and 15 t/ha treated plots respectively. When SMS treated plots were compared with each other, SMS 5 t/ha recorded Ca/Mg values of 0.64 and 0.63 higher than SMS 10 t/ha and 15 t/ha treated plots respectively. The highest value of 2.73 was recorded in SMS 5 t/ha. This value was 0.06 more than those of NPK treated plots. The values of Ca/Mg recorded can enhance good plant growth as stated in the findings of Schulte & Kelling (1993).

Sodium and Potassium ratio (Na/K)

There were significant differences in Na/K content when the values obtained from the control plots were compared with those obtained from the other treated plots. Significant differences were also observed in Na/K when NPK treated plots were compared with SMS treated plots. When SMS treated plots were compared with one another, significant differences were also observed. Control plots had Na/K values of 1.07, 0.36, 0.47 and 0.48 % higher than Na/K values than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Nitrogen, Phosphorus and Potassium (NPK) treated plots recorded Na/K values of 0.70, 0.60 and 0.59 lower than SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. When the SMS treated plots were compared with each other, SMS 5 t/ha recorded values of 0.11 and 0.12higher than 10 t/ha and 15 t/ha treated plots respectively. The highest value of 1.73 was recorded from the control plots. This value was 0.36 higher than those of SMS 5 t/ha. The trend in the value of soil Na/K showed that T1 > T3 > T4 > T5 > T2. An increase in the application rate of SMS resulted in the lowering of the Na/K. Akintunde *et al*., (2000) stated that the medium fertility range of Na/K is 1:3; the values recorded in the Na/K is below the medium fertility range and are said to be low; hence, the soil is rated low.

Effect of Spent Mushroom Substrate on Rice Grain Yield

The effect of spent mushroom substrate on rice grain yield and yield components are presented in Table 4.

Table 4: Rice Grain Yield and Yield Components

Treatment	Total Grain Yield (t/ha)	Filled Grain (t/ha)	Unfilled Grain (t/ha)	% Unfilled Grain	% Filled Grain
T1	13.64^{a}	6.77^{Na}	6.87^{a}	50.37^{a}	49.63^{a}
T2	15.94^{a}	13.67^{a}	2.27^{a}	14.24^{a}	85.76^{b}
T3	16.67^{a}	7.50^{Na}	9.17^{a}	55.00^{a}	45.00^{a}
T4	45.23^{b}	24.90^{b}	20.33^{b}	55.05^{a}	44.95^{a}
T5	17.74^{a}	8.57^{a}	9.17^{a}	51.69^{a}	48.31^{a}
FLSD (p=0.05)	17.01	10.85	7.68	14.28	14.28

Legend: T1 = SMS 0 t/ha, T2 = NPK 300 kg/ha, T3 = SMS 5 t/ha, T4 = SMS 10 t/ha, T5 = SMS 15 t/ha.

NS = Not Significant

Note: means with the same superscripts are not statistically significant.

Total Grain Yield (t/ha)

Significant difference were not recorded in Total grain yield when control plots were compared with other treatments, except with total grain yield recorded from the SMS 10 t/ha and 15 t/ha treated plots. Significant difference was recorded in total grain yield when NPK treated plots were compared with SMS treated plots, except in 5 t/ha where there was no significant difference. When SMS treated plots were compared with one another, significant difference was recorded. Control plots had lower total grain yield values of 2.30. 3.03, 31.59 and 4.10 t/ha when compared with those from NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots recorded lower yield of 0.73, 29.29 and 1.80 t/ha when compared with the total grain yield from SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. SMS 10 t/ha recorded higher total grain yield values of 28.56 and 27.49 t/ha when compared with SMS 5 t/ha and 15 t/ha respectively. The highest value of 45.23 t/ha was recorded from SMS 10 t/ha. This value was 27.49 t/ha more than those of 15 t/ha. An increase in total grain yield was recorded with increase in the application rate of SMS, except in SMS 15 t/ha where it reduced; this is in agreement with the findings of Ogbodo *et al*., (2009) who reported that at rates of SMS 15 t/ha and above, low level of rice grain yield was observed, improved grain yield was recorded in SMS 10 t/ha than in SMS 15 t/ha; the low level of grain yield in plot treated with 15 t/ha when compared with the 10 t/ha high yield could be attributed to excess supply of nutrients that favour more vegetative growth. Agba *et al*., (2012) had similar finding in maize where there was reduction in yield beyond optimal level of SMS 20 t/ha.

Filled Grain (t/ha)

No significant difference was recorded in filled grain when the control plots were compared with the other treatments, except in the NPK and SMS 10 t/ha treated plots where significant difference existed. The NPK treated plots also recorded no significant difference when compared with SMS treated plots, except in the SMS 10 t/ha treated plots where significant difference was recorded. No significant difference was also recorded when SMS treated plots were compared with one another, except in the SMS 10 t/ha treated plots where significant difference was recorded. However, variations in values were recorded across all treatments. Control plots had lower filled grain values of 6.90, 0.73, 18.13 and 1.80 t/ha when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. NPK treated plots recorded lower grain yield of 11.23 t/ha when compared with SMS 10 t/ha, but higher grain yield of 6.17 and 5.10 t/ha when compared with SMS 5 t/ha and 15 t/ha respectively. Spent Mushroom Substrate (SMS)

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10 t/ha recorded higher filled grain yield of 17.40 and 16.33 t/ha when compared with SMS 5 t/ha and 10 t/ha respectively. The highest filled grain yield of 24.90 t/ha was recorded from SMS 10 t/ha; this value was more than 11.23 t/ha those of NPK treated plots. The filled grain yield showed an irregular trend, thus: T4 > T2 > T5 > T3 > T1.

Unfilled Grain (t/ha)

There were significant differences recorded in unfilled grain yield when control plots were compared with the other treatments, except in NPK treated plots where no significant difference existed. There were also significant differences when SMS treated plots were compared with one another. Control plots had higher unfilled grain yield of 4.60 t/ha when compared with NPK treated plots, but less unfilled grain yield of 2.30, 13.46 and 2.30 t/ha when compared with SMS 5 t/ha , 10 t/ha and 15 t/ha respectively. Nitrogen, Phosphorus and Potassium (NPK) treated plots had lower unfilled grain yield of 6.90, 18.06 and 6.90 t/ha when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Spent Mushroom Substrate (SMS) 10 t/ha recorded higher unfilled grain yield of 11.16 t/ha when compared with 5 t/ha and 15 t/ha treated plots. NPK treated plots recorded significantly different unfilled grain yield when compared with those from the SMS treated plots .The highest unfiled grain value was recorded from SMS 10 t/ha. This value was 11.16 t/ha more than those of 15 t/ha and 5 t/ha. Result of the unfilled grain followed this irregular trend: T4 > T5 = T3 > T1 > T2.

Percentage Unfilled Grain

Significant difference was not recorded in % unfilled grain when control plots were compared with other treatments and no significant difference also when NPK treated plots were compared with SMS treated plots. Among the SMS treated plots, no significant difference was also observed. However, variations in values were observed across all treatments. Control plots had more % unfilled grain value of 36.13 % when compared with NPK treated plots, but recorded less values of 4.63, 4.68, 1.32% when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Spent Mushroom Substrate (SMS) 10 t/ha recorded higher values of 0.05 and 3.36% when compared with 5 t/ha and 10 t/ha respectively. The highest value of 55.05 % was recorded from SMS 10 t/ha. The values recorded stemmed from the unfilled grain values.

Percentage Filled Grain

There were significant differences in percentage filled grain when control plots were compared with other treatments and also significant differences when NPK treated plots were compared with SMS treated plots. Also, significant difference existed when SMS treated plot were compared with one another. Control plots had more % filled grain values of 4.63, 4.68 and 1.32 % when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively, but less value of 36.13 % when compared with NPK treated plots. NPK treated plots recorded more % filled grain values of 40.76, 40.81 and 37.45 % when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. Spent Mushroom Substrate (SMS) 15 t/ha recorded more values of 3.31 and 3.36 % when compared with 5 t/ha and 10t/ha respectively. The highest value was recorded from NPK treated plots. This value was 36.13 % higher than those of control plots. Result of % filled grain showed that T2 > T1 while T3< T4<T5. Values recorded stemmed from the weight of filled grains.

4. CONCLUSION

Generally, spent mushroom substrate treated plots were found to increase soil physico-chemical properties with increase in application rate compared to control plots and NPK treated plots, except in exchangeable acidity (aluminum and hydrogen contents) and in bulk density. SMS increased grain yield of upland rice. All treatment rates of SMS application can be used to improve the grain yield of upland rice in an ultisol; SMS 10 t/ha rate being highly recommended because it recorded the best yield and beyond this rate, it was observed that upland rice grew more vegetatively; having less grain yield. Spent Mushroom Substrate has little or no adverse effect on human health. It is non-hygroscopic and odourless. Therefore, SMS use as organic matter is recommended in an ultisol for upland rice production without compromising the health of both farmers and consumers. It is available and has little or no cost; hence, farmers can adopt its use.

Conflict of interest

The authors declare that they have no conflict of interest.

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Data and materials availability

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

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