EFFECT OF SPENT MUSHROOM SUBSTRATE (SMS) ON SOME SELECTED SOIL PHYSICO-CHEMICAL PROPERTIES AND THE GROWTH OF UPLAND RICE 100 DAYS AFTER PLANTING IN OWERRI, IMO STATE, NIGERIA.

MGBEAHURU, C. I., EKPE, I. I., OTI, N. N., ONWEREMADU, E.U & UJU, E.U.
Email: chibuihemmgbeahuru@gmail.com
Phone: 07038986490 or 08124519411

ABSTRACT
This research work was carried out at the Centre for Agricultural Research and Extension, Federal University of Technology, Owerri (FUTO) to investigate the effect of spent mushroom substrate (SMS) on soil physic-chemical properties and growth of upland rice in Owerri, Imo State, 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; each of the treatments were replicated three times in a Randomized Complete Block Design (RCBD).The field measured 13 m by 6.5 m; each plot measuring 2 m by 1.5 m with a 0.5 m alley between plots. Rice plants were sown at spacing of 30 cm ×30 cm. Soil samples were collected at depth of 0-30cm using soil core sampler and analysed for physico-chemical properties. The growth parameters measured were: plant height, root weight, leaf area and number of tillers. Statistical Analyses were 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 showed that soils were 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) and was statistically equal to SMS 15 t/ha (1.41 g/cm^3). The 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 in exchangeable acidity where it significantly reduced with increased rate of application of SMS. The application of SMS positively affected the growth of the test crop usedwhen compared with control and NPK plots, except in root weight where SMS 15 t/ha was statistically equal to control plots; other SMS rates were also statistically equal to NPK treated plots; this could be attributed to high content of sodium (salt) which may have inhibited good root development. Increase in the application rate of SMS led to increase in number of plant tillers; statistically, leaf area of all the treatment rates were equal. All rates of SMS applied during the experiment significantly improved soil physico-chemical properties and the growth of upland rice. The SMS 15 t/ha was seen as the best application rate suitable for the vegetative growth of upland rice; this could be attributed to its highest nitrogen content. Hence, it is recommended to farmers in the study area for growth improvement of upland rice production.

KEY WORDS: Spent Mushroom Substrate, Soil Physico-Chemical Properties, Growth, Upland Rice, Nitrogen Phosphorus and Potassium, Plots.

INTRODUCTION

Low soil fertility status has been identified as the major cause of poor soil productivity and crop yields in many African countries due to sub-optimal fertilizer use and continuous cropping (Nyakaogu, 2012).Southeastern Nigeria is a humid tropical rainforest characterized by high precipitation which causes runoff, leaching of nutrient elements and soil erosion (Onweremadu*et al*., 2011); thus lowering soil fertility and increasing soil degradation. Continous farming on poor soils without replenishing lost soil nutrients leads to low agricultural productivity due to decline in soil fertility (Bationo*et al*., 2012). Fertilizers are widely regarded as an essential input in crop production. However, research findings have shown that the use of fertilizer alone cannot be relied on to overcome the challenge of low soil fertility (Jenseen, 1993) because of its unavailability and high cost to most small holder farmers (Bationo*et al*., 2012). This low soil fertility status has posed a challenge and can be addressed by the use of organic inputs that are cheap and readily available alternatives. 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. Soil amendment includes all inorganic and organic substances mixed into the soil to achieve a better soil condition regarding plant productivity. Soil amendments increase aeration, nutrient holding capacity and drainage and decreases excessive water holding capacity.

Spent mushroom substrate(SMS) 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, e.t.c (Yadav*et al*., 2001). Hence, SMS can be used in organic farming to improve soil water infiltration, water holding capacity, permeability and aeration.Application of organic materials to the soil is a favourable strategy for sustainable long term agricultural production with minimal effects to the soil. The increasing dependency on inorganic fertilizers in growing food crops like rice has led to a long term detrimental effect in the soil and excessively high expenditure on the farmers.

Rice is the world's most important wetland crop. It provides 35-80% of total calorie uptake to more than 2.7 billion people. 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).Rice is a crop that requires sufficient supply of water for growth and yield; the rainforest zone of SouthEast Nigeria does not have an even distribution of rainfall throughout the year; hence, the need for irrigation practices. Due to the high cost of inorganic fertilizers like NPK, it is important to assess the use of spent mushroom substrate (SMS) in improving soil properties since it is less economical and can improve productivity, even better than inorganic fertilizers.It has been found to be nutritionally rich with respect to its Nitrogen, Phosphorus and Potassium content and having high cation exchange capacity; it has the ability to replace farm yard manure for the purpose of raising cereal and horticultural crops (Ahlawat*et al*., 2007). Spent mushroom substrate amendment on loamy soil produced significantly greater plant height, stem girth, number of leaves and total leaf area than compared to loamy soil without spent mushroom substrate (SMS) treatment in the growth of Cowpea and Tomato (Mustapha and Kadiri, 2010). Harris (1992) stated that application of SMS to a Potato crop improved the moisture holding capacity of the soil and this resulted to increased plant uptake of nutrients.Application of SMS brought about significant increase on growth attributes and yield of maize (taller maize plants and better nutrient supply), leaf area index also increased with SMS amendment (Zhao *et al*., 2003). Zhao *et al*., (2003) stated that nutrients, especially nitrogen, increases leaf area index in maize plots treated with nitrogen source like SMS and decreased leaf area index of plants without application of nitrogen source as a result of nutrient deficiency; specifically nitrogenOgbodo*et al* (2009) reported that there was significant increase in plant height when organic amendment was added to the soil planted with rice. Significant increase in the plant height of rice (taller plants) was observed when organic amendment was applied as a result of improved fertility; larger leaf index was also reported (Ogbodo*et al*., 2009).

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, located on latitude 5°22'52.752"N and longitude 6°59'34.6488''E (Handheld Global Positioning System Receiver). 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 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 2000-2500mm. Rainfall distribution is bimodal (March-July and Mid-August-October). Dry season sets in from November; the wind becomes dusty,"Hamathan" 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, spacing/plant population, weed control, pest/disease control and harvesting.Rice seeds were planted directly into the soil after two weeks after treatment application by dibbling. Spacing: four to five seeds were sown at a depth of 2-3cm.Rice seeds were dibbled at 30 × 30 cm. Four to five seeds were planted per hole and at two weeks after planting, the seedlings were tined down to three seeds per hole to give a plant population of 333,333 seedlings per hectare. Weeding was done as regularly as possible to ensure that the farm was weed free throughout the growing season of the plant. The first weeding was carried out fourth week after planting.Scare crows were used on the farm to prevent bird 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; which was 30-45 days after flowering.

Data Collection.

The pre-planting and post-planting samples were collected at 0-30cm soil depth. Fifteen (15) samples were collected; one sample from each block using core sampler attached with soil auger 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. Samples collected were analyzed in the laboratory for soil physico-chemical properties. 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 and replicated three times. The following agronomic parameters were measured, weighed and calculated: plant height, root weight, leaf area and number of tillers.

Field Layout, Experimental Design and Statistical Analysis.

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

RESULTS AND DISCUSSION

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

Physical Properties

According to Table 1, Particle size analysis of the study site showed that soil of the study site is predominantly sandy; permitting ease in the downward movement of water in the soil; this was of benefit to shallow-rooted crops like upland rice. Lafitte *et al*(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 Mg/m^3 was recorded on the study site; this could be attributed to soil compaction due to consistent cultivation, particle size of 2.65 $Mg/m^3$was also recorded. Hunt and Gikes (1992) and FAO (1996), postulated that it is desirable to have low bulk density (< 1.5 g/cm^3) for optimum aeration in the soil; the result shows that soil of the study site has the capacity to support rice production. The study site recorded a Total Porosity of 52.80 %; this could be attributed to the low bulk density of the soil. Bulk density indicates soil quality and is inversely related to other soil properties, including total porosity (Wei *et al*., 2014). High bulk density indicates low soil porosity and soil compaction while low bulk density indicates high soil porosity and soil compaction. Long term cultivation lowers porosity because of reduction in soil organic matter and peds (Brady & Weil, 2002).

Chemical Properties

Results showed that soil pH in water was 5.86 while the pH 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 organic matter contents of the soil due to consistent anthropogenic activities that breakdown soil aggregates; hence, poor in maintaining a stable structure

Table 1: 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 loam
Moisture Content	18.32%
Bulk Density	1.25Mg/m^3
Particle Density	2.65Mg/m^3
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 cmol/kg
Magnesium	1.81cmol/kg
Sodium	0.05cmol/kg
Potassium	0.03cmol/kg
Total Exchangeable Bases	5.65cmol/kg
Total Exchangeable Acidity	1.35cmol/kg
Effective Cation Exchange Acidity	7.00cmol/kg
Percentage Base Saturation	80.72%

Patrick *et al*., (2013) stated that the minimum value for maintaining stable structure in tropical soils is 2 % organic carbon and 3.4 % organic matter. This soil sample did not meet up this requirement. Total Nitrogen of 0.13 % was low; this low nitrogen content in the soil could hinder good crop growth because nitrogen is an essential nutrient in crop growth, especially vegetatively (Ogbodo*et al*., 2009), 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 according to the Soil Science Society of Nigeria Conference (1998). 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 basic 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 (SMS) on soil physico-chemical properties (at the end of vegetative growth) after 100 days of planting.

Soil physical properties

Table 2 below shows the effect of spent mushroom substrate (SMS) on particle size distribution, moisture content (%), bulk density (Mg/m^3) and total porosity (%).

Moisture Content (%)

There were significant differences when the percentage moisture content of the control plots were compared with other treatments and when the NPK treatment was compared with the SMS treatment plots.Significant differences were also recorded when the percentage moisture content of the plots treated with SMS were compared with one another. There were 0.09, 0.58, 0.93 and 1.93 % higher moisture content in the plots treated with T2, T3, T4 and T5 when compared with the control.The highest moisture content was recorded from plots treated with 15 t/ha SMS. The trend of the improvement of soil moisture content showed that T5 > T4 > T3 > T2 > T1.This showed that increasing rate of application of SMS resulted in increase in the soils ability to hold moisture; could be attributed to favourable soil-water relationship which improved with the addition of SMS as stated by (Brady & Weil, 1996, Reed 2007 and Ogbodo*et al*., 2009). Organic materials in form of SMS perform the function of binding soil particles together. The bond soils will prevent ease of moisture loss through evaporation. This may explain why the highest rate (SMS 15 t/ha) proved to be superior to the rest of the treatments.

Bulk Density (Mg/m^3)

There were significant differences when the bulk density of the control plots were compared with other treatments and when NPK treatment was compared with the SMS treated plots. Significant differences also existed when the bulk density of the plots treated with SMS were compared with one another. There were 0.08, 0.01, 0.05 and 0.07 less bulk density contents in the plots treated with T2, T3, T4 and T5, respectively when compared with the control.The highest bulk density content was recorded in the control plots. This showed that T1> T3 > T4 > T5 > T2. The result showed that increasing rate of application of SMS resulted in decrease in the bulk density of the soil.

Table 2: Effect of Spent Mushroom Substrate Treatment on Soil Physical Properties After 100 Days of Planting

Treatment	% Moisture content	Bulk Density (Mg/m^3)	Total porosity	% sand	% silt	% clay	Textural class
T1	7.40[a]	1.48[c]	44.15[a]	91.91[a]	4.00[b]	4.09[a]	Sandy soil
T2	7.49[b]	1.40[a]	44.53[a]	91.24[a]	3.33[a]	5.43[b]	Sandy soil
T3	7.98[c]	1.47[c]	47.17[c]	91.24[a]	4.67[c]	4.09[a]	Sandy soil
T4	8.33[d]	1.43[b]	46.19[b]	90.57[a]	4.33[b]	5.09[b]	Sandy soil
T5	9.33[e]	1.41[a]	46.83[b]	90.24[a]	5.33[c]	4.43[a]	Sandy soil
FLSD (p=0.05)	0.06	0.01	0.71	NS	0.42	0.42	

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
NS = Not significant.
Note: Means with the same superscript are not statistically significant.

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 and 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 (an organic amendment) which decreases soil bulk density; enhancing soil structure (Ogbodo*et al*., 2009; Curtin and Mullen, 2007 and Mbagwu, 1992). This reduction in bulk density could be due to the binding effects of SMS on soil particles into aggregates as a result of increase in microbial population which enabled the formation of soil aggregates.

Total Porosity (%).

There were significant differences when the % total porosity of the control plots were compared with other treatments and when NPK treatment was compared with the SMS treated plots. Again, significant differences were recorded when the SMS treated plots were compared with one another. Control plots

Particle Size Distribution (%)

Particle size result showed that the soils were predominantly sandy. The result showed that there were no statistically significant differences in the sand content in all the plots, though there were variations in values of the soil particles analyzed. Control plots recorded 0.67, 0.67, 1.33 and 1.67 % higher sand contents when compared with T2, T3, T4 and T5 plots respectively. Control plots recorded 0.67 % higher silt content when compared with NPK treated plots, but 0.67 %, 0.33 % and 1.33 % less silt content when compared with SMS 5 t/ha, SMS 10 t/ha and SMS 15 t/ha respectively. Control treated plots recorded less

pH in water (pHw)

Soil pH regulates chemical and biological reactions in the soil. The result showed that there were significant differences when the pHw of the control plots were compared with other treatments and also when NPK treated plots were compared with SMS treated plots. Significant differences were also recorded when SMS treated plots were compared with each other. Control plots recorded the same value when compared with NPK treated plots, but recorded lesser values of 0.51, 0.60 and 0.72 when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. The highest pH value was recorded from plots treated with SMS 15 t/ha with value of 0.12 higher than 10 t/ha SMS treated plots. The trend of the improvement of soil pH value showed that T5 > T4 > T3 > T2 = T1. This showed 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 which is in line with the findings of Ogbodo*et al*., (2009) and Medina *et al*.,(2009).Gunes*et al*., (2004) stated that high pH values from 6.0 affects root development which encourages suitable growth for growing seedlings and also for the availability of nutrients.According to the ratings of Babalola*et al* (1998), control plots and NPK

recorded 0.38 %, 3.02 %, 2.04 % and 2.68 % lower % total porosity when compared with T2, T3, T4 and T5 plots respectively. The highest % total porosity was recorded from SMS 5 t/ha.The result showed that the treatments varied in the % total porosity, thus T3 > T5 > T4 > T2 > T1. The result showed an irregular flow in the plots treated with SMS in increasing rate of application; this could be attributed to nutrient migration. The improvement in total porosity in the plots treated with SMS when compared with control plots could be attributed to reduced bulk density. Ogbodo*et al* (2009) and Mbagwu (1992) stated that organic amendments reduced soil bulk density and increased total porosity; 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 to form aggregates.

clay content values of 0.67, 1.00 and 0.33 %, but the same value when compared with NPK, SMS 10 t/ha ,15 t/ha and 5 t/ha respectively. The significant differences in the silt and clay contents 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. (Brady& Weil, 2008).

Chemical Properties at 100 days After planting

Table 3 below shows result on the effect of spent mushroom substrate (SMS) on soil chemical properties at 100 days after planting.

300 kg/ha plots were moderately acidic, SMS 5 t/ha and SMS 10 t/ha were slightly acidic while SMS 15 t/ha was neutral. This indicated good pHw conditions for rice cultivation (Howeler, 2002)

Organic Carbon (%)

There were significant differences in the soil % organic carbon when the control treated plots were compared with other treatment plots. Significant differences were also recorded when NPK treated plots were compared with SMS treated plots; among SMS treated plots, significant differences were also recorded. Control plots recorded the same value with NPK treated plots, but recorded lesser organic carbon contents of 0.30, 0.75 and 1.17 when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest organic carbon content was recorded in SMS 15 t/ha with 0.42 value higher than 10 t/ha. The trend of the improvement of soil organic carbon content showed that T5 > T4 > T3 > T2 = T1. Increased rate of application of SMS resulted to increased soil organic carbon in the soil. The increased values of organic carbon in plots treated with SMS is in line with the findings of Adeli*et al*., (2009), Ogbodo*et al*.,(2009) and Hairu*et al*., (2016). As an organic amendment, SMS increases soil organic carbon; hence, enhancing soil productivity.

Total Nitrogen (%)

Higher rates of SMS treated plots recorded higher Nitrogen values than control plots, but less than NPK treated plots. Control treated plots recorded lower nitrogen values of 0.06, 0.03, 0.05 and 0.06 % when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 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. The trend of the improvement of soil total nitrogen content showed that T5 = T2 > T4 > T3 > T1. Total nitrogen increased with increased rate of application of SMS; this is in line with the findings of Medina *et al*., (2009) and Unal (2015), who stated that SMS was found to be nutritionally rich in nitrogen and has a considerable agronomic value when used as soil improver. Ekpe*et al*., (2017) also noted that mineralization of organic wastes resulted in the release of organic bound nutrients in the soil; significantly nitrogen, phosphorus, potassium and organic matter.

Table 3: Effect of Spent Mushroom Substrate Treatment on Soil Chemical Properties After 100 Days of Planting

Treatment	pH in water	pH in Kcl	% OC	% OM	% N	AP mg/100g	EAl^{3+}Cmol/kg	H^{+}Cmol/kg	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	TEA Cmol/kg	TEB Cmol/kg	ECEC	% BS
T1	5.97ᵃ	5.18ᵃ	1.61ᵃ	2.78ᵃ	0.10ᵃ	0.831ᵃ	0.79ᵇ	0.46ᵉ	2.61ᵃ	1.06ᵃ	2.11ᵃ	3.94ᵃ	1.25ᵈ	9.72ᵃ	10.97ᵃ	88.63ᵃ
T2	5.96ᵃ	5.20ᵃ	1.60ᵃ	2.77ᵃ	0.16ᵈ	1.841ᵉ	0.88ᵈ	0.40ᵈ	2.52ᵃ	1.12	3.78	3.96ᵃ	1.28ᵉ	13.38ᶜ	14.66ᶜ	91.23ᵇ
T3	6.48ᵇ	5.80ᵇ	1.91ᵇ	3.30ᵇ	0.13ᵇ	1.359ᵇ	0.82ᶜ	0.30ᵇ	3.60ᵇ	1.45ᶜ	3.55ᵇ	4.32ᵇ	1.12ᶜ	12.92ᵇ	14.04ᵇ	92.03ᶜ
T4	6.57ᶜ	5.96ᶜ	2.36ᶜ	4.06ᶜ	0.15ᶜ	1.496ᶜ	0.77ᵇ	0.27ᵃ	4.12ᶜ	1.74ᵈ	4.73ᶜ	5.14ᶜ	1.04ᵇ	15.74ᵈ	16.78ᵈ	93.79ᵈ
T5	6.69ᵈ	6.09ᵈ	2.78ᵈ	4.79ᵈ	0.16ᵈ	1.577ᵈ	0.66ᵃ	0.34ᶜ	4.28ᶜ	2.00ᵉ	6.18ᵉ	6.28ᵈ	1.00ᵃ	18.74ᵉ	19.74ᵉ	94.94ᵉ
FLSD (p=0.05)	0.03	0.03	0.02	0.03	0.00	0.031	0.02	0.02	0.22	0.05	0.16	0.16	0.00	0.28	0.28	0.15

→ Cmol/kg ← (Ca²⁺ to Na⁺)

Legend: OC = Organic Carbon, OM = Organic Matter, N = Nitrogen, AP = Available Phosphorus, EA = Exchangeable Acidity, H= Hydrogen, Ca = Calcium, K = Potassium, Na = Sodium, Mg = Magnesium, TEA = Total Exchangeable Acidity, TEB = Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation.
NOTE: Means with the same superscript are not statistically significant.
NS= Not Significant

Available Phosphorus (mg/100g)

The result showed that NPK treated plots released more available phosphorus into the soil than the SMS treated plots, while the control treated plot recorded the lowest value. There were significant differences in the available phosphorus content when the control treated plots were compared with other treatment plots. Control treated plots recorded 1.011, 0.528, 0.666 and 0.746 mg/100g less available phosphorus when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The trend in improvement of soil available phosphorus content showed that T2 > T5 > T4 > T3 > T1. There was increase in phosphorus values as the rate of application of SMS increased; this is in line with the findings of Unal (2015) and Hairu*et al*., (2016). Lower values recorded in SMS 5 t/ha and SMS 10 t/ha could be attributed to the fact that some nutrients in high quantity can limit the availability of others.

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

There were significant differences in exchangeable aluminum content when the control treated plots were compared with other treatment plots. Significant differences were also recorded when NPK treated plots were compared with SMS treated plots. When the SMS treated plots were compared with one another, significant differences were also recorded. Control treated plots had lesser exchangeable aluminum of 0.09 and 0.03 Cmol/kg when compared with NPK and SMS 5 t/ha treated plots respectively, but higher values of 0.02 and 0.13 when compared with SMS 10 t/ha and 15 t/ha respectively. The highest value was recorded in NPK treated plots with 0.06 Cmol/kg higher than SMS 5 t/ha. The trend in improvement of soil exchangeable aluminum showed that NPK > SMS 5 t/ha > SMS 0 t/ha > SMS 10 t/ha > SMS 15 t/ha. It was observed that aluminum values reduced in increasing order of application of SMS; this could be attributed to the increase in soil pH which buffered the soil solution. Increase in organic matter content that helped in reducing acidity: aluminum and hydrogen being the acidic cations.

Hydrogen – H^+ (cmol/kg)

There were significant differences in hydrogen content when the control treated plots were compared with other treatment 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 treated plots recorded higher hydrogen values of 0.06, 0.16, 0.19 and 0.12 Cmol/kg when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. Control treated plots recorded the highest hydrogen content with higher value of 0.06 cmol/kg when compared with NPK treated plots. The trend in the improvement of soil hydrogen showed that T1 > T2 > T5 > T3 T4. Hydrogen concentration values decreased with increased application rate of SMS, except in SMS 15 t/ha where it increased. The reduction in concentration could be attributed to increase in organic matter.

Calcium – Ca^{2+} (Cmol/kg)

There were significant differences when control treated plots were compared with other treatment 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 recorded. Control treated plots had higher calcium value of 0.09 Cmol/kg when compared with NPK treated plots, but lower calcium values of 0.99, 1.51 and Cmol/kg when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha respectively. The highest calcium content value was recorded in SMS 15 t/ha; this value was 0.16 Cmol/kg higher than those of the 10 t/ha treated plots. The trend in the improvement of the soil calcium content showed that T5 > T4 > T3 > T1 > T2. Increased calcium content was observed with increased application rate of SMS; this is in line with the findings of Unal (2015).

Magnesium - Mg^{2+} (Cmol/kg)

There were significant differences in magnesium content when control treated 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 treated plots recorded lower magnesium values of 0.06, 0.39. 0.68 and 0.94 Cmol/kg when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest value was recorded in SMS 15 t/ha; this value was 0.26 Cmol/kg more than the value of 10 t/ha treated plots. The trend in the improvement of soil magnesium content showed that T5 > T4 > T3 > T2 > T1. Increased magnesium content was observed with increased application rate of SMS; this is in agreement with the findings of Wisniewska and Pankiewirz (1989) and Unal (2015).

Potassium- K^+ (Cmol/kg)

There were significant differences in soil potassium content when the control treated plots were compared with other treatment 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 recorded. Control plots recorded lower potassium values of 3.67, 1.44, 2.63 and 4.08 Cmol/kg when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest value of potassium content was recorded in SMS 15 t/ha; this value was 0.40 Cmol/kg higher than the value obtained from the NPK treated plots. The trend of the improvement of soil potassium content showed that T5 > T2 > T4 > T3 > T1. T2 recorded higher value of potassium when compared with T4, T3 and T1 respectively. Increase in potassium content was recorded with increase in the application rate of SMS; this is in line with the results of Unal (2015) who reported that organic materials like SMS increased soil potassium content.

Sodium - Na^+ (Cmol/kg).

There were significant differences in soil sodium content when the control treated plots were compared with other treatment plots. Significant differences were also recorded when NPK treated plots were compared with SMS treated plots; even among SMS treated plots, significant differences were observed. The control treated plots had less sodium content values of 0.02, 0.38, 1.20 and 2.34 Cmol/kg when compared with NPK, 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 1.14 Cmol/kg more than those of the 10 t/ha treated plots. The trend in the improvement of soil sodium content showed that T5 > T4 > T3 > T2 > T1.An increase in sodium content was recorded with increase in the application rate of SMS. This increase in sodium content could be toxic in the long-term usage because it could lead to soil salinization; this is in agreement with the findings of Moral *et al.*, (2008), who observed accumulation of sodium in the soil as a result of high sodium content in organic amendments.

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. Among SMS treated plots, significant differences were also recorded. Control plots had less TEA value of 0.03 Cmol/kg when compared with NPK treated plots, but recorded higher TEA values of 0.13, 0.21 and 0.25 Cmol/kg when compared with SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest TEA value was recorded in NPK treated plots; they had value of 0.03 Cmol/kg more than control treated plots. The trend in the improvement of soil TEA content showed that T2 > T1 > 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 thereby reducing acidity. This is in line 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 – Ca^{2+}, Mg^{2+}, Na^+, K^+) (Cmol/kg).

There were significant differences in TEB when the control treated 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 treated plots had TEB values of 3.66, 3.21, 6.02 and 9.03 Cmol/kg less than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest TEB value of 18.74 mg/100g was recorded in the SMS 15 t/ha treated plots. This value was 3.00 Cmol/kg more than those of 10 t/ha treated plots. The trend in improvement of soil TEB showed that T5 > T4 > T2 > T3 > T1.Tthis is attributed to the increase in soil pH and organic matter content which displaced acidic cations at the exchange site and increased basic cations. This result is in line with the findings of Ogbodo et al., (2009) and Unal (2015) who stated that SMS increased exchangeable bases with increased rate of application. Mbagwu (1992) also stated that increase in exchangeable bases was due to increase in application of organic residues.

Effective Cation Exchange Capacity (ECEC).

There were significant differences observed in ECEC when control treated 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 3.99, 3.08, 5.82 and 8.79 less than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. SMS 15 t/ha recorded the highest value of 19.74; this value was 2.96 more than SMS 10 t/ha treated plots. The trend in the improvement of soil ECEC showed that T5 > T4 > T2 > T3 > T1. Effective Cation Exchange Capacity (ECEC) increased with increase in application rate of SMSuptil T4 and T2 increased more than T2 and T1. This is attributed to increase in organic matter content and agrees with the findings of Ogbodo*et al*., (2009) and Ekpe et al., (2017) who stated that organic amendments have buffering capacities; making soil more resistant to pH fluctuations and improves soil ECEC.

Base Saturation- BS (%)

Base saturation values recorded significant differences when control treated plots were compared with other treatment 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 recorded. Control plots recorded % base saturation values of 2.60, 3.40, 5.16 and 6.31 % less than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest % base saturation value was recorded in SMS 15 t/ha treated plots; this value was 1.15 % more than those of SMS 10 t/ha treated plots. The trend in the improvement of % soil base saturation showed that T5 > T4 > T3 > T2 > T1. Increase in base saturation was observed with increase in the application rate of SMS; this is attributed to increase in organic matter content and basic cations (Ca^{2+}, Mg^{2+}, Na^{2+} and K^{+}) in the soil and agrees with the findings of Ogbodo*et al*.,(2009).

Selected Rice Growth Parameters at 100 days after planting

Table 4 shows result of the effect on spent mushroom substrate on selected rice growth parameters at 100 days after planting.

Plant height (cm)

No significant difference was recorded in plant height when the values from the control plots were compared with others from the treatments; though there were variations in values, except in SMS 10 t/ha where significant difference existed in plant height when compared with the control.Nitrogen, Phosphorus and Potassium (NPK) treated plots were not also significantly different from SMS treated plots. Significant difference in plant height was recorded when SMS treated plots were compared with one another.Control plots had less values of 1.63, 2.47 and 5.03 cm in plant height than those from the NPK, SMS 5 t/ha and 10 t/ha treated plots respectively, but recorded plant height value of 0.03 more than SMS 15 t/ha. The highest plant height of 49.93 cm was recorded from SMS 10 t/ha; this value was 2.56 cm more than those of SMS 5 t/ha. The trend in plant height improvement showed that T4 > T3 > T2 > T1 > T5. SMS 15 t/ha recorded the lowest value while SMS 10 t/ha recorded the highest value. Irregular flow in the trend of SMS treated plots was observed.Spent Mushroom Substrate (SMS) treated plots recorded higher values than NPK treated plots except in SMS 15 t/ha where it was lower. Increase in plant height on addition of SMS is in line with the findings of Ogbodo*et al*., (2009) who reported that there was increase in plant height when organic amendment was added to the soil. The higher content of salt recorded in SMS 15 t/ha may have negatively affected plant height of the plots.

Root weight (t/ha)

There were significant differences in root weight when the values from the control plots were compared with other treatments and when NPK treated plots were compared with SMS treated plots. Spent Mushroom Substrate (SMS) treated plots also recorded significant differences when compared with one another. Control plots had root weight values of 0.48, 0.82, 1.17 and 0.18 t/ha less than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest root weight of 2.65 t/ha was recorded from SMS 10 t/ha; this value was 0.33 t/ha more than those of SMS 5 t/ha. The trend in the improvement of root weight showed that T4 > T3 > T2 > T5 > T1.The increase in root weight on application of SMS at the highest rate of 10 t/ha SMS is in line with the findings of Ogbodo*et al*., (2009) who stated that decrease in soil bulk density led to improvement in soil physical and chemical properties of the crop environment for improved root growth, improved aeration and soil porosity which brought about increase in grain yield of rice on application of organic amendment like SMS. Lower value of SMS 15 t/ha could be attributed to higher sodium content which may have negative effect in root growth, plant height and weight as collaborated by Moral *et al*., (2008).

Table 4: Effect of Spent Mushroom Substrate on Selected Rice Growth at 100 Days After Planting

Treatment	Plant height (cm)	Root weight (t/ha)	Leaf area (cm^2)	Number of Tillers
T1	44.90[a]	1.48[a]	3261.27[a]	14.33[a]
T2	46.53[a]	1.96[b]	3612.82[a]	15.00[a]
T3	47.37[a]	2.32[b]	3632.66[a]	22.00[b]
T4	49.93[b]	2.65[b]	4817.44[a]	24.00[c]
T5	44.87[a]	1.66[a]	5048.24[a]	26.33[d]
FLSD (p=0.05)	2.39	0.40	1204.48	1.45

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.
Means with the same superscript are not statistically significant
NS = Not Significant

Leaf Area (LA- cm^2)

No significant difference in leaf area was recorded when control plots were compared with other plots and also when NPK treated plots were compared with SMS treated plots. More so, no significant difference was recorded among the SMS treated plots. However, variations existed in leaf area across the treatments. Control plots had leaf area values of 351.55, 371.39, 1556.17 and 1786.97 cm^2 less than NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots. The highest value was recorded from SMS 15 t/ha and has value of 230.81 more than those of 10 t/ha. The trend in the improvement of leaf area showed that T5 > T4 > T3 > T2 > T1. Increase in leaf area value was observed with increase in the application rate of SMS as stated by Mustapha and Kadiri (2007). Zhao *et al*., (2003) also stated that increase in nutrients like nitrogen increased leaf area index of crops with increase in the application rate of SMS.

Number of Tillers

There were significant differences in tiller number when control plots were compared with other treatments and when NPK treated plots were compared with SMS treated plots. Significant differences also existed when SMS treated plots were compared with one another. Control plots had lower values of 0.67, 7.67, 9.67 and 12.00 when compared with NPK, SMS 5 t/ha, 10 t/ha and 15 t/ha treated plots respectively. The highest tiller number of 26.33 was recorded from SMS 15 t/ha. This value is 2.33 more than those of 10 t/ha. The trend in the improvement of tiller numbers showed that T5 > T4 > T3 > T2 > T1. Increase in the application rate of SMS increased the number of tillers in SMS treated plots; this agrees with the findings of Ahlawat*et al*., (2007) and Fairhurst*et al*., (2007) who stated that SMS is nutritionally rich in nitrogen, phosphorus and potassium; increase in their contents will increase tiller number in cereal crops.

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 bulk density and in exchangeable acidity (aluminum and hydrogen contents) where a decline was recorded in SMS values as a result of increase in total porosity, pH and organic matter, which buffered the soil solution; basic cations displacing acidic cations at the exchange site and enters into the soil solution. Spent Mushroom Substrate (SMS) increased rice growth in increasing rate of application after one hundred days of planting; 15 t/ha treated plots recorded the highest vegetative growth level, this could be attributed to the highest nitrogen value obtained from SMS 15 t/ha treated plots. Hence, SMS can serve as an organic material in improving the growth of rice because it is economical, healthy and easily available without relying on inorganic materials like the NPK fertilizer which is not economical and readily available.

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