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Response of upland rice (*Oryzasativa*) varieties to poultry manure and spent mushroom substrate in humid agro-ecology of south –south, Nigeria

Orluchukwu*, Joseph Amadi, Chinonyelum Ugwu

Department of Crop and Soil Science, University of Port Harcourt, Nigeria

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Key words: Growth, Yield, Upland rice, Poultry manure, Spent mushroom substrate.

Abstract

This study on the response of upland rice varieties to poultry manure and spent mushroom substrate in humid agro-ecology of south–south, Nigeria was carried out in 2015 cropping season at the Teaching and Research farm of University of Port Harcourt, Nigeria. It was aimed at determining the best organic material that will enhance the yield and growth properties of upland rice varieties in the area studied. The treatments used were spent mushroom substrate (SMS) and poultry manure (PM) while five varieties of upland rice (NERICA 1, NERICA 2, NERICA 3, NERICA 4, and NERICA 5) were grown. The experiment was a factorial experiment laid out in randomized complete block design (RCBD) with three replications. From the statistical analysis, the results shows that there was no significant difference at P=0.05 in the effect of the organic materials across all the five rice varieties. However, the results indicated that poultry manure showed the highest performance in both growth and yield parameters measured over SMS and the control except in NERICA 5 where SMS gave a higher growth rate and yield in all the parameters measured than in poultry manure. Therefore, farmers should be encouraged to incorporate the use of organic materials especially poultry droppings in growing their crops as it provides a cheaper source of plant required nutrients

* **Corresponding Author:** Orluchukwu ✉ josephorluchukwu@yahoo.com

Introduction

Rice (*Oryza sativa*) is the most widely consumed staple cereal crop in Nigeria, West Africa and the world at large. It is a very important food crop as it accounts for a large portion of the world's calorie consumption in many parts of the world especially Africa, Asia, the Middle East and Latin America (Vaughan *et al.,* 2008), thus it can be said that rice has a major influence on human nutrition and food security. In Nigeria, it is estimated that the average man consumes approximately 24.8kg of rice per year which accounts for 9 percent of their annual calorie intake or requirement (IRRI, 2001). Rice consumption in the developing countries of the world had been on the rise due to changes in demographic profile of the populace (Bamidele *et al.,* 2010) and the ease of its preparation (Ojogho and Erhabor, 2011). Rice production is constrained by biotic and abiotic factors, especially among resource challenged farmers in Africa, where rainfall pattern was observed to be more erratic than before (Lafitte *et al.*, 2002), likely to be caused by changes in global climate.

Poultry manure contains 13 of the essential nutrients that are needed by plants. These include nitrogen, potassium, phosphorus, calcium, magnesium, sulphur, manganese, copper, zinc, chlorine, boron, iron and molybdenum (Chastain *et al., 1999)*.

The amount of nutrient contained in poultry manure will vary based on the quality of the feed, supplements, medications and water consumed by the birds. The application rate is based on the nitrogen requirement of the plant. Not all of the nitrogen in poultry manure is immediately available for plant use. Greater part of the nitrogen in poultry manure is present as ammonium and ammonia. Ammonia NH3+ is a gas and it is easily lost to the air by volatilization. Volatilization can occur during storage, in the poultry house and during and after application. The ammonia is made available to the plants by a process called mineralization. Organic nitrogen is not available to plants until the poultry droppings are completely decomposed to ammonium via mineralization. It is important to note however that mineralization doesn't occur immediately and not all of the organic nitrogen is mineralized.

Spent mushroom substrate (SMS) is the remnant of substrates (sawdust or any other agricultural substrates) used to cultivate mushrooms (Jonathan *et al.*, 2012).Spent mushroom substrate (SMS), is an excellent source of all the major and micro nutrients requires by plants as well as organic matter. According to a research in 1997 carried out by TEAGASC, the total nutrient levels along with the dry matter content indicates an average content of 8.0kg nitrogen, 3.9kg of phosphorus and 7.9kg of potassium per ton of fresh SMS.

Edible mushrooms are a group of fungi species (Basidiomycetes) that grow naturally on tree trunks, leaves, root of trees as well as decaying woody materials (Stamets, 2000), They are Achlorophylous organisms and thus can be grown in jars, bottles devoid of sun light. From these mushrooms are deposits of lots of nutrients, very vital for the use as crop enhancer (Lindequist *et al.*, 2005). Nutrients such as vitamins, minerals and micro and macro nutrient have been detected in most oyster mushrooms (Jonathan *et al.*, 2012).

However, when SMS is allowed as waste in the environment it can be a source of environmental pollution hence posing environmental hazard. Such negative or hazardous effect can be turned around to fortune, when used as a substrate for growing agricultural crops. The use of organic waste such as spent mushroom compost in growing agricultural crops especially leafy vegetable has been recognized in recent times as a possible means of enhancing sustainable agriculture or sustainable production of food crops (Okokon *et al.*, 2009).

The application of organic materials to the soil is a favorable strategy for sustainable long term agricultural production with minimal detrimental effects to the soil (Agrayako and Asante, 2005).

The increasing dependency on inorganic fertilizers in

growing food crops especially rice has led to long term detrimental effects on the soil and excessively high expenditure on the farmers. This study is therefore directed towards exploring the benefits of incorporating organic substances such as plant and animal waste, in the growing of rice with the aim of improving yield and increasing the gross output of the farmers. It is also aimed at determining the best readily available organic materials that would increase the yield and growth of upland rice varieties and also to determine the responses of the different rice varieties to the organic materials used.

Materials and methods

Experimental site

This experiment was carried out at the Faculty of Agriculture Teaching and Research Farm, University of Port Harcourt, Choba, Rivers State. University of Port Harcourt lies on latitude 4° 31' to 5° 00N and longitude 6°45' to 7°00E with an average temperature of 27°C, relative humidity of 78% and an average rainfall that ranges from 2500 – 4000mm (Nwankwo and Ehirim, 2010).

Cultural practices

A plot size of 14m x 11m, equivalent to 0.0154 ha, was cleared manually. The plot was divided into 9 sub plots of 3m x 4m each with walkways of 1m in between them to ease movement during cultural operations. The sub plots were arranged into three blocks and the treatments were assigned into the sub plots and laid out in a factorial arrangement fitted into a randomized complete block design (RCBD) with three replicates. Each sub plot was then further divided into five units to accommodate the five varieties of rice planted. Each unit was measured 3m x 0.8m. Planting was done at the beginning of July after the rains were fully established.

This was done by seed dibbling in holes of less than 2cm depth. Plant spacing was 25cm within rows and 30cm between rows. Planting density was two seeds per hole. The treatments (Spent mushroom substrate and poultry manure) were applied at eight weeks after planting at the rate of 150kg/ha respectively while the control had no treatment. This was based from the results of the soil analysis and the chemical analysis of the treatments. The initial soil samples were collected from a depth of 15cm of the soil and taken for laboratory analysis using the procedure of Mylavarapus and Kennellery (2002). The nutrient elements composition of the spent mushroom substrate (SMS) and poultry manure (PM) were determined before their application to the soil using the laboratory analysis procedure of AOAC (2005).

Data collection

Data collection was done at an interval of two weeks and appropriate data was collected based on the stage of crop development. The data collected as growth parameters are: emergence count, plant height, number of leaves, and number of tillers; while the yield parameters collected was on fresh weight panicles and tillers, and dry weight of panicles and tillers. Data was taken randomly from 4 plants in each unit of every sub plot. The mean of the four was calculated and that gave the representative sample of the population. Growth parameters were collected at 6, 8, 10 and 12 weeks after planting (WAP) respectively.

Emergence count was taken seven (7)days after planting (DAP) and the percentage emergence was calculated. The procedure taken for collection of plant height was by using a centimeter measuring rule/tape which was taken from the plant base to the tip of the highest leaf. The number of leaves was recorded by counting. Number of tillers was counted to determine the number of panicles to expect. After harvesting manually, the panicles and tillers were weighed separately and the weights were recorded as fresh weight. The tillers and panicles were sun dried and weighed after two weeks and recorded as dry weight.

Statistical Analysis

The data obtained was analyzed statistically using analysis of variance (ANOVA). The means were separated by using least significant difference (LSD) at 5% level of probability (Steele and Torrie, 1960).

Results

Chemical analysis of soil and organic materials

The results of the chemical analysis of the composite soil samples taken from the experimental site before planting and those of SMS and PM are shown in Table1. The result indicates that total nitrogen of the soil recorded 0.078% while available phosphorous and potassium was 6.67mg/kg and 1.11cmol/kg respectively. The soil pH (6.2) is slightly acidic. For organic manures used, poultry manure gave a lower nutrient content of nitrogen (0.18%), phosphorous (9.58 mg/kg) and potassium (0.19cmol/kg) compared to spent mushroom substrate which had 0.18% for nitrogen, 7.0mg/kg for phosphorous and 3.36cmol/kg for potassium. The pH for Poultry manure was 7.5 while the spent mushroom substrate had 5.8.

Table 1. Chemical composition of soil, poultry manure and spent mushroom substrate.

Materials	N (%)	P (mg/kg)	K (cmol/kg)	pH
Soil	0.078	6.67	1.11	6.2
Poultry manure	0.18	9.58	0.19	7.5
Spent mushroom substrate	0.186	70.0	3.36	5.8

Growth parameters

Emergence count

Emergence count was done seven (7) days after planting and the result is shown in Table 2. This was to determine the rate of percentage emergence of the various rice varieties. A total number of 20 seeds were sown per sub-plot. The results show that NERICA 2 gave the highest emergence of 80% while NERICA 3 had the lowest percentage emergence of 38%.

Plant height

In Table 3, the plant height at both 6 and 10 weeks after planting did not show any significant difference statistically (P = 0.05) for all three treatments. However from observations and the raw data collected from the plot, the highest plant height was for poultry droppings in all rice varieties with NERICA 4 having 98.0cm at 10 weeks after planting (WAP), as compared to SMS which had the lowest plant height of 71.9cm, while in 6 WAP NERICA 4 had the highest plant height of 47.2cm and the lowest value of 27.5cm in NERICA 5 of SMS.

Number of leaves

The number of leaves for each plant was counted on a two week interval. This was done as a means of monitoring the vegetative growth of the plant. The highest number of leaves was recorded for poultry dropping, NERICA 5 at 10 weeks with 30 leaves while the lowest number of leaves (10) at 10 weeks was for NERICA 4 in both poultry and SMS as indicated in Table 3. Statistically, there is no significant difference in the number of leaves across all treatments (P = 0.05).

Table 2. Mean percentage emergence count of rice varieties at 7 DAP.

Varieties	*% emergence count at 7 DAP*
NERICA 1	55
NERICA 2	80
NERICA 3	38
NERICA 4	58
NERICA 5	46

Number of tillers

The number of tillers is a growth parameter used to estimate the reproductive ability of the rice plant. The number of tillers for each variety was counted and their means calculated as represented in Table 3. At 6 WAP, the number of tillers for all varieties was at an average. As the weeks progressed and further decomposition and mineralization of the organic materials occurred, it was noticed that the varieties treated with poultry droppings had the highest number of tillers, 6, 8, 5, 7 and 9 in 10WAP than those treated with SMS and in control. However, the difference in numbers of tillers did not differ significantly P = 0.05 across the treatments and varieties.

Table 3. Mean data for growth parameters of the rice varieties.

Treatment	Plant height (cm)		Number of leaves		Number of tillers	
	6 WAP	10 WAP	6WAP	10WAP	6 WAP	10 WAP
NERICA1 - Control	31.8	92.5	8	20	1	5
NERICA 1 – PM	40.9	92.8	7	24	1	6
NERICA 1 – SMS	32.6	86.6	7	23	1	6
NERICA 2 - Control	35.2	76.6	7	20	1	6
NERICA 2 – PM	38.1	85.7	7	23	2	8
NERICA 2 – SMS	34	82.8	7	22	1	6
NERICA 3- Control	34.8	85.8	8	15	1	3
NERICA 3 – PM	44.6	86.1	8	18	2	5
NERICA 3 – SMS	29.2	75.3	6	18	2	4
NERICA 4 – Control	29.7	77.8	5	10	1	2
NERICA 4 – PM	47.2	98.0	8	13	2	7
NERICA 4 – SMS	40.1	71.9	6	10	0	3
NERICA 5 – Control	36.4	85.7	5	20	1	5
NERICA 5 – PM	27.4	91.5	7	20	1	3
NERICA 5 – SMS	37.5	92.7	5	17	2	9
LSD	10.997	13.728	2.1198	8.7593	0.8744	2.3295

Yield parameters

Weight of panicles

The fresh weight of the panicles was determined by weighing the freshly cut panicles using a sensitive weighing balance. Poultry droppings recorded the highest weight in all varieties except NERICA 5 where the highest weight was in SMS with a weight of 18.5g and the lowest fresh panicle weight was in NERICA 3 (SMS) at 3.3. Statistically, the differences in weight was not significant at P= 0.05.

The panicles were sun dried for about one week and their weights were taken. The means of the panicle weight are represented in Table 4. The highest dry weight was in NERICA 5 SMS (13.6) while the lowest was also in NERICA 3 SMS (2.8).

Weight of tillers

The tillers were cut from the base of the plant and weighed fresh. The means were taken as related to the treatments applied. The tiller weights are represented in Table 4. The highest fresh tiller weight was recorded at NERICA 5 SMS (75.4g) while the lowest was recorded at NERICA 4 control (29.6g) while the highest dry tiller weight was recorded for NERICA 4 poultry (46.7g).However for both fresh and dry weights, there was no significant difference recorded at P=0.05.

Discussion

The result indicates that the soil pH value is 6.2 and it is within the pH range of 5.5 to 6.3 that is required if maximum availability of nutrient in the soil is needed to occur for proper plant growth (Stewart, 2006).

Also from the result, it is evidenced that Nitrogen and phosphorus were inadequate in the soil compared to potassium. By this result, N and P are below the critical level outlined by Ibedu *et al.,* (1988). This low value could be attributed to eco-physiological effect from excessive rainfall, low moisture content, leaching of nutrients, horizontal removal of nutrients through soil erosion, solar radiation, high temperature characterized by tropical soils, continuous cultivation of the soil used for previous experiments in the experimental site hence the need for soil amendment in form of organic materials application such as poultry droppings and spent mushroom substrate.

Table 4. Mean yield parameters of the rice varieties.

Treatments	FWOT	D W O T	F W O P	D W O P
NERICA 1- Control	16.5	11.5	9.3	7.3
NERICA 1- PM	56.3	33.7	16.5	12.5
NERICA 1- SMS	53.7	23.4	13.8	9.9
	16.5	17.1	10.5	7.4
NERICA 2- Control				
NERICA 2- PM	93.1	34.4	14.9	11.4
NERICA 2- SMS	38.2	34.4	14.4	10.4
	29.7	22.6	5.3	4.3
NERICA 3- Control				
NERICA 3- PM	32.6	17.8	5.9	4.9
NERICA 3- SMS	27.4	13.3	3.3	2.8
	29.6	27.7	12.3	9.1
NERICA 4- Control				
NERICA 4- PM	72.6	46.7	14.9	12.1
NERICA 4- SMS	48.8	23.7	9.6	7.1
	58.4	22.4	10.1	6.7
NERICA 5- Control				
NERICA 5- PM	48.6	32.7	17.9	13.6
NERICA 5 - SMS	75.4	34.9	18.5	14.0
LSD	40.587	16.754	8.143	5.9669

KEY: FWOT- Fresh weight of tillers, DWOT- Dry weight of tillers, FWOP- Fresh weight of panicles, DWOP- Dry weight of panicles.

On percentage emergence which was taken seven (7) days after planting, the highest number of emerged seedlings was recorded in NERICA 2 with a count of 80% while the lowest emergence count was recorded in NERICA 3 with 38%. The reason for this variation was due to inherent variability among the cultivated varieties.

On growth parameters (plant height, number of leaves and number of tillers) measured, the differences in plant heights of the rice varieties planted after organic substances had been applied could be due to the fact that it takes a longer time for organic materials to decompose and release nutrients for plant growth (Chastain *et al.,* 1999) at 6 and 8 weeks. The highest plant height was in poultry manure at 10 WAP with NERICA 4 (98.0). The highest plant height was recorded in poultry droppings in all the five rice varieties especially at 10 WAP. This in accordance to the findings of Hussein *et al.,* (1997) where he recorded better performance which was associated with poultry manure over other organic manures as was evidenced in many agronomic plants. Also, the better performance in terms of plant height obtained was in agreement with the studies carried out by Opeke (1997), Imobighe (2004) and Okunomo *et al.* (2006) when they used *Acasia senegal.*

The poultry manure gave the best number of leaves in all the rice varieties in 10 WAP which is an indication that better leaf production could be enhanced by the application of organic manure. This was confirmed by Edmeades and Lafitte (1993) when he applied Poultry manure > Cow dung > Control > Piggery manure to *Acacia senegal.*

For number of tillers, the highest figure was recorded in poultry manure across all the five rice varieties planted in 10 WAP. This goes to support the work of

Obi and Ebo (1995), who reported that poultry manure improves the chemical and biological properties of soil which in turn increases crop productivity. This also follows the fact that poultry manure contains phosphorous which supports the vegetative growth of plants (Mengel and Kirby, 1979). It is also due to the fact that poultry manure contains phosphorus which supports the vegetative growth of plants (Mengel and Kirby, 1979).

On the yield components, the rice varieties were also affected by the organic materials used. Theresult shows the effect of the treatments on the fresh and dry weight of the tillers, fresh and dry weight of panicles. The best performing variety was NERICA 5 in both poultry and SMS treatments with the highest fresh weight being NERICA 5 in SMS treatment (18.5g). The dry panicle weight shows poultry having the highest weights across all varieties except NERICA 2. This shows that the rice varieties treated with poultry droppings had a higher dry matter content than those treated with SMS. This same trend was also repeated in the figures for fresh and dry weight of tillers where the highest fresh weight was recorded in SMS treatment and the highest dry weight was recorded in poultry droppings treatment. Similar results were achieved by Ezeibekwe *et al.,* (2009) where he had highest flowering, fruiting and fruit biomass with poultry manure.

The result obtained from this experiment indicates that application of both organic materials positively affected the growth and yield of the rice varieties, especially when compared with the control plots where no organic material was applied. This is in agreement with the observations of Dada *et al*., (2014) and Ojobor *et al*., (2014) who stipulated that application of organic materials to the soil would improve the growth and yield properties of the crops grown as well as the soils physical and chemical properties.

Conclusion

The best growth and yield characteristics were obtained from the plots treated with poultry droppings. The highest panicle weight was recorded in plots treated with poultry manure. Highest plant height and number of tillers was also recorded in plots with poultry manure.

This is in accordance with the findings of Orluchukwu and Adedokun (2014), who also recorded higher growth and yield in the pineapples treated with poultry manure over those treated with SMS. Budhar*et al.,* (1991) also supports this assertion through his experiment where he recorded the highest grain yield with poultry manure.

Based on the results of the experiment, it is recommended that poultry manure be adopted as a favorable organic material for growing the rice varieties planted with the exception of NERICA 5 which showed the best yield performance in the plots treated with spent mushroom in both panicle weight and tiller/stem weight.

Farmers should be encouraged to incorporate the use of organic materials especially poultry droppings in growing their crops as it provides a cheaper source of plant required nutrients. Further studies should be carried out to determine the exact levels of the various organic components to be used to achieve maximum yield in rice and other crops. Also comparison studies should also be carried out between organic materials and inorganic materials.

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