USE OF ABATTOIR WASTEWATER COMPOST AS ORGANIC FERTILIZER FOR RICE PRODUCTION ON A ULTISOL IN DELTA STATE, NIGERIA

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ABSTRACT

The research was conducted to monitor the influent of abattoir wastewater compost on rice growth and yield in Benin-Owah River Basin in Illah, Delta State, Nigeria. The compost was applied at 0, 2.5, 5.0, 10 t/ha, and NPK15:15:15 at 250 kg/ha laid in randomized complete block design with four replicates. Rice seeds were sown for two years, and residual effects were evaluated in the third year. Rice plant height, stem circumference, and the number of tillers was measured at two weeks intervals while rice yields have taken at harvest. Soil samples were taken yearly to monitor nutrient changes. Data obtained were analyzed with analysis of variance and mean separated with Duncan Multiple Range Test at $\alpha_{0.05}$. In the first year, NPK15:15:15 significantly gave the highest dry matter (6.28 ± 1.45 t/ha) and grain yield (2.4 ± 0.53 t/ha). While in the second year, 10 t/ha treatment produced the dry matter (7.69 ± 1.60 t/ha) and grain yield (2.6 ± 0.53 t/ha). In a residual study, the highest grain yield (2.8 ± 0.72 t/ha) was produced in the plot treated with 10 t/ha, and it also gave the highest pH, organic carbon, total nitrogen, and available P content. The compost at the rate of 10 t/ha can increase soil fertility and rice yield.

Contribution/ Originality
The study has substantiated that compost formulated with abattoir wastewater and rice dusk should be used as a soil amendment for rice production. It also gives opportunities for farmers and agriculturists to start considering alternative use of the waste materials for fertilization because the materials contain nutrient elements. The paper has not been published or presently submitted anywhere for publication.

How to cite: Smart Augustine Ojobor and Collins N Egbuchua (2020). Use of Abattoir wastewater compost as organic fertilizer for rice production on a ultisol in Delta State, Nigeria. Asian Journal of Agriculture and Rural Development, 10(2), 682-689.

1. INTRODUCTION

Wastes generated through agricultural processing caused negative effects on the environment, creating potential danger such as foul odour and forming breeding grounds for pathogen but can be converted through proven technology into valuable material which can be used as a soil amendment (Schneider *et al*., 2010 and Gayathri *et al*., 2019). Commonly used methods of wastes disposal are landfilling and open incineration. Landfilling method can contaminate groundwater through leaching, and even as the population increases, it is difficult to find a suitable site for wastes disposal. Open incineration has a tendency to increase air pollution that requires expensive techniques to control its emissions. Animal production and processing generate large amounts of waste with an outdated waste management system, most notably in developing countries. The increase in waste generation also accelerates greenhouse gas production that had a negative impact on the ecosystem (Huynh *et al*., 2006).

Wastewater is one category of wastes that emerges from agricultural activities, and it increases with the increasing population. Some sources of wastewater include cassava processing, beverage industry, abattoir, rubber factory, fertilizer factory, and palm oil processing mill, etc. (Liu and Haynes, 2011). Abattoir is one primary source of wastewater among the industries due to the drive to increase meat production for the growing population. Still, the challenges facing the sector is how to manage the indiscriminate disposal of the wastewater in the environment (Omole and Ogbeyi, 2013). The wastewater is composed of urine, blood, water, dissolved solids, pieces of meat, manure. According to Olarewaju and Olofayo (2004), wastewater contains minerals, metals, and microorganisms. It was used for irrigation, and the results showed that it significantly increased plant growth, total herbage production, and nutrients uptake (Sparling *et al*., 2006 and Castro *et al*., 2011). The abattoir wastewater can be a source of water and soil nutrients, so; it is important to assess its potential for compost making. If the wastewater with low C:N ratio (6:2) is used to compost rice dust (C:N ratio 83:1), it will enhance the quality of the rice dust, which can be used for soil amendment (Thiyageshwari *et al.*, 2018). Advantage can be taken off the rice dust that is available in rice farming communities (Adeoye *et al*., 2005). Limited information on the use of abattoir wastewater for compost making, is hindering its utilization (Adeoye *et al*., 2005 and Ojobor, 2018).

Composting is a technology that is successfully used to convert organic waste into useful and stable material through microbial activities, and it is viewed as a flexible technology than incineration (Rockson, 2014). Use of abattoir wastewater and rice dust for compost making will reduce the cost of inorganic fertilizers, the stress it unleashed on farmers to obtained it due to nonavailability, and also reduce the negative impact on the environment. Composting the wastes for soil amendment now that the federal government of Nigeria is emphasizing on food sufficiency through crop production will play a significant role in improving soil fertility. The Nigeria government food self-sufficiency policy can only be achieved through good soil management practices that can improve the declining soil fertility (Vanlauwe *et al*., 2001). The current practice of using inorganic fertilizer cannot improve the declining soil fertility but with an organic fertilizer that is made with known quality. Therefore, if the abattoir wastewater is carefully used for compost making, it can be used to amend soil fertility of a *Ultisol* at the Benin-Owah River Basin, Illah, Delta State. The community is allocated over 3,000 ha of land for rice, but due to poor soil fertility, only 550 ha is being used. Hence, this study monitored the influent of abattoir wastewater compost for rice production in Benin-Owah River Basin, Illah, Delta State, Nigeria.

2. METHODS

2.1. Location of study
The study was conducted at the Benin-Owah River Basin, Illah, Oshimilli North L. G. A., Delta State, Nigeria (Coordinates: 6°25′26″N 6°38′56″E) during 2017 and 2018 cropping year in a

Ultisol. A FARO 52 rice variety was sown in a completely randomized block design. The site was previously used for rice cultivation, and the last harvest was in 2015 and was left fallow in 2016. The dominant weeds in the area were *Chromolaena odorata* and *Aspilia africana*. The compost was applied at 2.5, 5, and 10 t ha^{-1} while NPK15:15:15 was at 250 kg/ha with control in four replicates. Application of compost was made a week before sowing in an area of 361 m^2 that was demarcated into a plot of 3m by 4m, and a space of 1m was used to separate the plots at a spacing of 25cm by 30cm.

2.2. Composting
Rice dust (RD) was obtained from Onicha rice mill, Anambra State, and abattoir wastewater (Aww) was obtained from Ogbe-Ogonogo market, Asaba, Delta State, Nigeria. One hundred kilograms of RD and 35 liters of Aww were used to mix each heap in three replicates. The materials were turned and mixed periodically and moisture content was maintained at 60% by adding Aww for 12 weeks. The materials were characterized for their nutrient concentration before composting: the RD had: 24.5% organic carbon (OC), 0.30% total nitrogen (TN), 0.18% phosphorus (P), 0.21% potassium (K), 0.16% calcium (Ca), 0.50% magnesium (mg), C:N ratio of 85:1 and pH of 7.1 while Aww had: 14.6% OC, 2.12% TN, 2.01% P, 0.66% K, 0.33% Ca, 0.73% Mg, C:N ratio of 6.1 and pH of 7.8. After composting the material was further characterized with the following values: OC (21.8%), TN (0.76%), P (3.11%), K (1.32%), Ca (1.15%), Mg (1.44%), C:N ratio (28.7) and pH of 7.2.

2.3. Data collection
Growth data [height (cm), stem circumference (cm), and a number of tillers] were measured at two weeks intervals from three weeks after sowing (3 WAS). Yields data were measured at harvest. Samples of soil were taken for pre-planting soil evaluation and yearly for post-harvest soil analysis. Soil texture, pH, OC, TN, P, K, Ca, Mg, Na, exchangeable acidity were measured while ECEC and base saturation were calculated.

2.4. Laboratory analysis
The soil samples were analyzed at the International Institute of Tropical Agriculture, Ibadan, Oyo State. Soil texture was according to Bouyoucos (1951). Soil pH was in 1:2 soil- water suspensions. Walkley Black Method was used for organic carbon determination (see Walkley and Black, 1934). 1N ammonium acetate was used to extract exchangeable bases while flame photometer was used to measure K and Na, Mg and Ca were read with Atomic Absorption Spectrophotometer (Jackson, 1964). Bray-1 was used to extract available P (Bray and Kurtz, 1945). Macro-Kjeldahl method was to determining total nitrogen (Jackson, 1962). Exchangeable acidity was determined, according to Black (1975).

2.5. Statistical analysis
Analysis of variance was used to analyze the data with SAS Institute, Inc. (2012) and mean were separated with Duncan Multiple Range Test (DMRT) at 0.05 probability level.

3. RESULTS

3.1. Chemical properties of the soil before fertilizer application and at harvest
The soil was strongly acidic (pH 5.4), OC (1.8 g/kg) and TN (0.9 g/kg) were low. Available P (11 mg/kg) was medium, effective cation exchange capacity (6.9 cmol/kg) was low and base saturation was high (Table 1). Soil pH increased significantly with a higher rate of compost. Plot treated with 10 t ha^{-1} had the highest soil pH values. Soil pH values increased significantly. Rates of compost did not correspond to increasing soil OC in the first year but did in the second year. The 10 t ha^{-1} of compost gave the highest OC in both years (2.7±0.53 gkg^{-1} and 8.5±2.94 gkg^{-1}, respectively). Total nitrogen did not increase appreciably in the first year though 10 t ha^{-1} had the highest value. In the second year, there was a significant difference ($p<0.05$), and 10 t ha^{-1} also had the highest (1.6±0.37

gkg^{-1}) while the lowest was found in control (0.5±0.37 gkg^{-1}). In both years, there were significant incremental differences in values of available phosphorus. The 10 t ha^{-1} of compost had the highest P (12±2.15 and 18±4.72 mgkg^{-1}, respectively) while NPK treatment had 8±2.15 and 9±4.72 mgkg^{-1}, respectively). The 10 t ha^{-1} had the highest K, Ca, Mg, Na and ECEC in both years. The same level of compost gave the highest base saturation.

Table 1: Soil fertility before and after fertilizer application

	pH	OM	N	P	K	Ca	Mg	Na	ECEC	BS
		----g/kg-----		Mg/kg		---------------cmol/kg--------------------				g/kg
				Soil chemical properties before fertilizer application						
	5.4	1.8	0.9	11	1.3	2.2	1.7	0.1	6.9	923
				Soil chemical properties after fertilizer application						
Rates						2017				
0	5.0c	1.5b	0.5	6de	0.2	1.1b	1.1	0.1	2.7b	926b
2.5	5.3a	2.6a	0.6	7cd	0.2	1.2b	1.2	0.2	3.0a	933b
5.0	5.4a	2.6a	0.6	10b	0.3	1.7a	1.3	0.2	3.7a	946a
10	5.5a	2.7a	0.7	12a	0.4	1.8a	1.4	0.2	4.0a	950a
NPK	5.0c	1.6b	0.6	8c	0.2	1.2b	1.2	0.1	3.0a	900c
SD	0.21	0.53	0.06	2.15	0.08	0.29	0.102	0.049	0.487	17.8
			Ns		Ns		Ns	Ns		
					2018					
0	4.9b	1.5d	0.5d	4e	0.2d	1.0b	1.0e	0.1	3.0c	767c
2.5	5.5a	10.1b	1.1b	12c	0.4c	2.2a	2.5c	0.3	5.9b	915a
5.0	5.6a	10.3b	1.3b	14b	0.6b	2.3a	2.9b	0.4	6.8a	912a
10	5.7a	12.5a	1.6a	18a	0.8a	2.7a	3.4a	0.5	7.9a	937a
NPK	4.9b	1.5c	0.9c	9d	0.4c	2.0a	1.9d	0.1	5.2b	846b
SD	0.35	4.12	0.37	4.72	0.20	0.56	0.831	0.16	1.65	62.2
								Ns		

Means with the same letters in each column are not significantly different at $\alpha_{0.05}$
Note: Ns – not significant, SD – standard deviation

3.2. Effect of treatments on rice growth and yield

In the first year, the NPK plot produced the tallest plants (Table 2). In the second year, plots amended with 10 t ha^{-1} of compost gave the tallest plants while the control had the least. Stem circumference significantly increased (Table 3) with NPK treatment producing plant the highest circumference in both years. The control plot had no-tiller in both years (Table 4). In the first year, plots with 10 t ha^{-1} of compost treatment and NPK had two tillers each, 5 t ha^{-1} had one tiller while 2.5 t ha^{-1} had no farmer. In the second year, 10 t ha^{-1} had three tillers, 5 t ha^{-1} and NPK treatments had two tillers each while 2.5 t ha^{-1} had one tiller. The NPK treatment produced the highest dry matter yield in the first year, and in the second year, 10 t ha^{-1} of the compost had the highest dry matter yield (Table 4). The NPK treatment also produced the highest grain yield in the first year, while 10 t ha^{-1} had the highest in the second year.

Table 2: Plants height (cm) at 3-11 weeks after sowing

Application rates (t ha^{-1})	Was after sowing									
	3	5	7	9	11	3	5	7	9	11
			2017					2018		
0	19.2	29.1b	35.0c	40.4c	46.3e	17.4d	24.1d	29.0d	32.4d	36.0d
2.5	19.1	31.0b	41.2b	50.4b	59.8d	22.3b	32.1c	42.8c	53.3c	64.7c
5.0	19.0	29.8b	41.5b	52.9b	62.5c	20.4c	35.9b	46.6b	56.9b	67.3b
10.0	19.0	30.5b	41.7b	53.4b	64.0b	25.5a	36.9a	50.8a	65.1a	78.7a
NPK	20.8	32.7ab	43.4a	55.0a	66.0a	21.3b	32.0c	42.6c	55.8b	65.3c

| SD | 0.69 Ns | 1.22 | 2.88 | 5.23 | 7.00 | 2.63 | 4.50 | 7.32 | 10.90 | 14.14 |

Means with the same letters in each column are not significantly different at $\alpha_{0.05}$
Note: Ns – not significant, SD – standard deviation

Table 3: Stem circumference (cm) at 3-11 weeks after sowing

Application rates (t ha^{-1})	Was after sowing									
	3	5	7	9	11	3	5	7	9	11
			2017					2018		
0	0.19a	0.24a	0.24b	0.24c	0.24d	0.19b	0.23	0.23c	0.23d	0.23d
2.5	0.14bc	0.23a	0.28b	0.33b	0.36c	0.18c	0.23	0.28b	0.33c	0.38c
5.0	0.13c	0.24a	0.28b	0.33b	0.36c	0.18c	0.22	0.28b	0.33c	0.38c
10.0	0.13c	0.17b	0.26b	0.33b	0.41b	0.18c	0.22	0.30a	0.37b	0.47a
NPK	0.19a	0.25a	0.36a	0.48a	0.51a	0.20a	0.24	0.31a	0.39a	0.49a
SD	0.028	0.029	0.041	0.077	0.087	0.004 Ns	0.006 Ns	0.028	0.055	0.092

Means with the same letters in each column are not significantly different at $\alpha_{0.05}$
Note: Ns – not significant, SD – standard deviation

Table 4: Number of tillers, dry matter and grain yield

Application rates (t ha^{-1})	Number of tillers/plant	yield t ha^{-1}		Number of tillers/plant	yield t ha^{-1}	
		Dry matter	Grain yield		Dry matter	Grain yield
		2017			2018	
0	0b	2.83c	0.97d	0d	2.68d	0.93d
2.5	0b	3.29c	1.51c	1c	5.21c	1.17c
5.0	1a	5.32b	1.91b	2b	5.71b	2.31b
10.0	2a	6.16a	2.33a	3a	7.69a	2.60a
NPK	2a	6.28a	2.40a	2b	5.55a	2.01a
SD	0.894	1.45	0.53	1.02	1.60	0.65

Means with the same letters in each column are not significantly different at $\alpha_{0.05}$
Note: SD – standard deviation

3.3. Effects of residual nutrient treatments on rice growth and yield

Plot treated with 10 t ha^{-1} of compost had the tallest plants (69 ± 12.8 cm), 5.0 t ha^{-1} and NPK plots had 67.2 ± 12.8 and 66.4 ± 12.8 cm, respectively while the control had 35.1 ± 12.8 cm (Table 5). The 10 t ha^{-1} of compost gave the fattest stem circumference (0.40 ± 0.069 cm), and control had 0.20 ± 0.069 cm. Treatment 5.0 t ha^{-1} and NPK were not significantly different, but both were higher than 2.5 t ha^{-1}. The number of tillers (3) was higher in plots treated with 10 t ha^{-1} of compost. The highest dry matter yield was produced in the plot treated with 10 t ha^{-1} (8.12 ± 1.80 t ha^{-1}) and was significantly higher than the lower rates. Grain yield was significantly different, 10 t ha^{-1} of compost produced the highest grain yield (2.8 ± 0.72 t ha^{-1}).

Table 5: Residual effects of treatments on growth and yield of rice

Application rates (t ha^{-1})	Plant height (cm)	Stem circumference (cm)	Number of tillers	Dry matter -------t	Grain yield ha^{-1}-----
0	35.1d	0.20c	0d	2.53d	0.67d
2.5	63.8c	0.35b	1c	5.63c	1.86c
5.0	67.2b	0.36b	2b	6.19b	2.46b
10.0	69.4a	0.40a	3a	8.12a	2.81a

NPK15:15:15	66.4b	0.36b	0d	5.69c	1.96c
SD	12.77	0.069	1.17	1.80	0.71

Means with the same letters in each column are not significantly different at $\alpha_{0.05}$
SD – standard deviation

4. DISCUSSION

Soil pH of the site was adequate for crop growth and production, but the nutrients were low. Low contents of OC, TN, and medium-range of P are an indication that there is a need to improve the fertility of the soil (FMARD, 2012). Therefore, the cultivation of the site without the soil amendment cannot guarantee optimum crop yield.

There was gradual soil pH increment with increasing application of the compost. This could be the alkaline nature of the compost. Its application increased soil pH as it mineralized (Santillan *et al.*, 2014). The process of compost mineralization decreased cation fixation that played a significant role in raising the soil pH (Thiyageshwari *et al.*, 2018). Soil pH values in compost plots were higher than NPK15:15:15 plot that decreases. This could be due to the acid-neutralizing potential of the compost during and after decomposition.

The compost expressed a comparatively higher concentration of nutrient elements than the NPK 15:15:15 and control treatment. It enhanced soil fertility by increasing the nutrient contents and soil organic carbon. The abattoir wastewater, according to Matheyarasu *et al.* (2015), contains some percentage of elements in organic forms and, if converted to available form during decomposition, can increase the soil nutrient. Organic carbon contents in compost plots were higher, and it might be the fact that waste from abattoir typically contains compounds that are characterized with organic components (Coker *et al.*, 2001; Nafarnda *et al.,* 2006). It could also be responsible for the gradual increase with application levels in both years-the compost enhanced total nitrogen at harvest. Omole and Longe (2008) attributed the high level of total nitrogen to the feces, blood, urine, undigested protein, and digested protein in abattoir wastewater that leads to high microbial decomposition and subsequently releasing nitrogen in the soil. Matheyarasu *et al.* (2016) also found that abattoir wastewater supplies readily available nitrate-N, ammonia-N, and available P for plant growth. It might also cause a higher level of total nitrogen observed in compost plots. Mineralization of the successive application of the compost also increased phosphorus in the soil.

Improve soil fertility promoted rice growth, as evidenced by the increased rice yields. Plants treated with compost did better than those in control and NPK plots. Though the NPK treatment did better in the first year, there was a turning point in the second year, where compost treated plants recorded the highest. This shows the potential of the abattoir wastewater compost in improving the soil chemical properties. Glick (2012) and Matheyarasu *et al.* (2016) noted that the used of abattoir wastewater for irrigation increase crop growth by facilitating nutrients supply and also inhibit the effects of pathogens on crops. This could account for the increased growth and development that resulted in higher dry matter and yield production. Sparling *et al.* (2006) noticed that the abattoir wastewater application significantly increased the annual and total herbage production, and N and P uptake from soils. Rice plants were taller in the second year due to increased nutrient released, and this gave room for higher rice yields. The increased nutrients released from compost resulted in a high rate of cell division that enhanced dry matter and rice grain yield production (Mengel and Kirby, 1987).

Higher residual nutrient pool in compost plots, as shown in the results, could be ascribed to the slow mineralization of nutrients that led to a higher growth rate, as evident with the application of 10 t ha^{-1} of the compost. It proves that the abattoir wastewater compost had residual value. Improved soil fertility due to abattoir compost application increases rice yields (Glick, 2012). As

soil fertility was enhanced, nutrients were released to the rice plant for growth and development; this, however, reflected in higher grain yield of rice produced (Picchioni *et al*., 2012).

5. CONCLUSION

Abattoir wastewater and rice dust were used for compost formulation to produced rice at the rate of 2.5, 5.0, 10 t/ha and NPK15:1515 at the rate of 250 kg/ha with a control on an ultisols for two years. In the first year, NPK15:15:15 gave the highest growth and yield of rice; however, 10 t/ha of the compost had highest in the second year. While in residual nutrients study, 10 t/ha of the compost significantly increased rice yield and soil chemical properties. Therefore, the abattoir wastewater compost proves to be effective for rice production.

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