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The effects of bat guano manure as alternative organic fertilizer in rice production in Delta State, Nigeria

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Abstract

Field experiment was conducted in Delta State University, Asaba Campus during 2018 and 2019 raining seasons to evaluate the influence of different rates of bat guano manure as organic fertilizer in rice production. The bat guano was applied at 0 (control), 2.5, 5.0 and 10.0 t/ha. The experiment was laid out in a randomized complete block design replicated four times for the two years. On weekly bases, plant height and plant leaf area were measured while number of tillers, dry matter and grain yield were measured at harvest. Data obtained were subjected to analysis of variance and means were separated with Duncan Multiple Range Test at 5% level of probability. Results showed that bat guano manure significantly influence the growth and yield of rice. The growth and yield parameter of rice increases with all the bat guano rates but 10 t/ha rate recorded the highest estimates in both years. This indicates that the bat guano manure can be successfully used as alternative organic fertilizer in production of rice in the study area.

Keywords: Asaba Campus; Bat manure; Delta State; Grain yield; Soil fertility

Introduction

Total dependence on inorganic fertilizer in crop production has shown its dark side as the soils are losing their fertility and such soils requires higher quantities of the fertilizer for their improvement. The inorganic fertilizers immediately released nutrient to crops in an unfixed state (Sun *et al.*, 2004 and Hatibu, 2018) and the nutrient easily leaches out beyond the root zone in the soil. With the farmers' realization of the increasing risks associated with crop production using inorganic fertilizer, organic fertilizer resources had been used as soil builder, plant fertilizer and crop protection (Shaikh *et al*., 2018). When organic fertilizers are applied they decompose and mineralized by microorganisms. The processes fix the minerals in soil making it easier for plants absorption (Sun *et al.*, 2004 and Hatibu, 2018).

To overcome the problems associated with the inorganic fertilizer, farmers and agriculturist have reverted to the use of organic fertilizers to improve the declining soil fertility (Mehdi and Jalal, 2012; Michael *et al*., 2012 and Shetty *et al*., 2013). Different forms of organic fertilizer such as cowdung, goat manure and poultry droppings have been successfully used to improve soil fertility and these manures are becoming more popular, but very little is known about bat guano manure as organic fertilizer for the rice production (Sridhar *et al*., 2006) in Delta State. Bat guano is the feces of bat rich in carbon, nitrogen, phosphorus, potassium and other vital minerals. Sridhar *et al.* (2006) and Hatibu (2018) reported that the bat guano contains 2 - 6% N, 1.5 - 10% P, 1.5 - 10% K, 3.5 - 9% Ca, 1.5 - 8% Mg, 0.4 - 0.8% Mn, 0.2 - 0.5% Cu, 0.5 - 1.3% Fe, 0.2 - 0.4% Zn and pH 4 - 5.6 with narrow C/N ratio compare to other organic material.

The nutrient compositions in bat guano can be used to improve soil fertility (Shetty *et al*., 2013) and it contains microbes that help to clear any toxins and also control fungi and nematodes in the soil. These beneficial properties of the bat manure have not gained popularity in Delta State farming communities. Ample of bat manure deposits are found in several places in Delta State which can be commercially exploited as organic fertilizer like what is done in many countries such as Mexico, Indonesia, Jamaica (Shetty *et al*., 2013). Hence, the study intends to assess the impact of different rates of bat guano on the growth and yield of rice in Asaba, Delta State, Nigeria.

Materials and Methods

Description of Experimental sites

Asaba: Asaba is in rainforest zone with coordinates of 6.2533º N and 7.7031º E. The soil is an Ultisol classified as Typic tropaquult (Egbuchua, 2007).

Preliminary work: land clearing, ploughing and preparation of beds were done manually. Soil samples for initial routine analysis were randomly collected using 2 mm sieve mess at air dried room temperature. Particle size distribution, soil pH, organic carbon, total N, available P, exchangeable K, Ca, Mg, Na, and exchangeable acidity were measured (Table 1) while ECEC and base saturation were calculated. Soil samples were analyzed in Analytical Laboratory, Delta State University, Asaba, following established procedures.

Materials used: The rice variety use for this experiment was obtained from International Institute of Tropical Agriculture, Ibadan, Oyo State. Bat guano was collected from two deposits (Main library and female hostel) in Delta State University, Asaba campus. Mosquito nets were used to fence the plot against rodent attack.

Methods and Experimental Design: The bat guano manure was applied a week before sowing at 0 (without bat guano), 2.5, 5.0 and 10. 0 t ha^{-1} rates. Five seeds of the rice were sown per hole using spacing of 30 cm by 25 cm but plants were later thinned to four stands two weeks after sowing during the 2018 and 2019 raining seasons. The experiment was laid out in a Randomized Complete Block Design replicated four times. The plot size was 21 m by 19 m while subplots size were 4.5 m by 4 m separated by 1 m alley in other to ease cultural practices operations. Weeding was done manually as at when due with hoe and cutlass.

Data collection: Plant height and leaf area were measured weekly but number of tillers/plant, dry matter and grain yield (t ha^{-1}) were measured at harvest.

Data analysis: Data collected were subjected to analysis of variance using SAS Institute Inc. (2012) and significant means were separated using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

Results

Particle size analysis and chemical properties of pre-planting soils

The plot used during 2018 experiment was sandy loam with pH value of 5.5 (strongly acidic). The organic carbon (17.2 g/kg) and total N (1.0 g/kg) were low but available P of 12 mg/kg was moderate. The effective cation exchange capacity (7.5 cmol/kg) was low while base saturation was high (Table 1). In a similar vein, the site used in 2019 was sandy clay loam with soil pH of 5.0. Organic carbon and total N were low, available P was moderate, exchangeable bases were low, effective cation exchange capacity was also low but base saturation was high.

Growth and yield parameters of rice

Plant height: Plant height for each rate of bat guano fertilizer application, rice plant height increased significantly from 6 – 9 weeks after sowing during 2018 raining season, while significant differences in plant height were recorded for plant height from 3 – 9 weeks after sowing in 2019 wet season. From 6 weeks after sowing application of 10 t/ha of bat guano had the tallest plants, that were statistically significant during 2018 cropping season, but plant height of rice was statistically significant at 3 – 9 weeks after sowing in 2019 raining season. The next plant height estimates that recorded significant difference at 6 – 9 WAS for both years cropping seasons was application of 5 t/ha bat manure rate, while the shortest plants were recorded in the control plots (Table 2).

Leaf area: Similarly, Table 3 showed that rice plants recorded significant leaf area for all bat guano rates at 6 – 9 WAS in 2018 but for 2019 wet season, significant difference was recorded at 5 – 9 WAS. In both years of rice evaluation, 10 t/ha rate of bat manure had plants with highest leaf area, followed by the 5 t/ha guano fertilizer.

Tiller number, dry matter and grain yield: From Table 4, all the rates of bat guano fertilizers recorded significant difference in number of tillers, dry matter and grain yield in both years evaluated. From both years of the study, 10 t/ha of bat manure had the highest tiller number (4 and 5, respectively), dry matter (6.5 and 7.0, respectively) and grain yield (6.5 and 2.68, respectively). The number of tillers, dry matter and grain yield estimates for 2019 wet season were higher than the estimates of 2018. In a similar vein, the 5 t/ha rate of bat manure recorded higher estimates for tiller number, dry matter and grain yield in both years of evaluation.

Table 1: Pre-planting soil texture and chemical properties in both sites

Soil properties	Values	
	2018	2019
pH (H_2O) 1:2	5.5	5.0
O C (gkg^{-1})	17.2	15.4
Total N (gkg^{-1})	1.0	1.3
Available P ($mgkg^{-1}$)	12	10
Exchangeable bases ($cmolkg^{-1}$)		
Ca	2.3	1.3
Mg	1.8	1.4
K	1.5	1.5
Na	1.3	1.1
Exch. Acidity	0.6	0.7
ECEC	7.5	6.0
Base Saturation (gkg^{-1})	920	883
Soil texture (gkg^{-1})		
Sand	704	696
Silt	211	94
Clay	85	210
Textural Class	Sandy loam	Sandy clay loam

Table 2: Plant height (cm) of rice at 3 - 9 weeks after sowing in both sites

Application rates	Weeks after sowing						
(t/ha)	3	4	5	6	7	8	9
Year (2018)							
0	25.1	29.6	32.4	35.6c	38.0c	43.5d	49.3d
2.5	24.4	28.7	34.4	39.8b	45.4cb	52.0c	58.0c
5.0	24.6	28.1	35.6	39.9b	47.4b	55.8b	63.8b
10.0	23.8	27.5	35.6	42.4a	51.6a	59.2a	67.7a
	Ns	Ns	Ns				
Year (2019)							
0	21.4b	25.8b	27.3b	31.4c	34.7c	39.0d	45.1d
2.5	25.1a	29.9a	36.8a	42.5ab	47.3b	53.2c	60.3c
5.0	24.9a	28.9ab	36.0a	41.6ab	48.0ab	57.4b	64.8ab
10.0	26.1a	27.3b	37.1a	43.8a	52.1a	61.7a	67.9a

Means within each column with the same letters are not significantly different at $\alpha_{0.05}$

Note: ns – not significant

Table 3: Leaf area (cm^2) of rice at 3 - 9 weeks after sowing in both sites

Application rates	Weeks after sowing						
(t/ha)	3	4	5	6	7	8	9
Year (2018)							
0	14.1	16.4	18.4	21.2b	24.0d	28.3d	31.0d
2.5	13.2	15.9	19.8	24.4a	29.0c	33.0c	37.0c
5.0	13.2	16.1	20.2	25.0a	31.4b	36.4b	42.2b
10.0	12.6	15.3	19.6	25.7a	32.6ab	48.0a	45.4a
	Ns	Ns	Ns				
Year (2019)							
0	12.3	14.7	16.3b	19.4c	21.5d	26.4d	28.2d
2.5	13.8	16.5	20.1a	25.5b	32.1c	35.1c	41.0c
5.0	14.0	16.8	20.8a	27.4a	34.5b	39.4b	45.7b
10.0	13.3	16.5	21.5a	27.0a	37.1a	49.9a	50.1a
	Ns	Ns					

Means within each column with the same letters are not significantly different at $\alpha_{0.05}$

Note: Ns – not significant

Table 4: Number of tillers, dry matter and grain yield of rice in both sites

Application rates (t/ha)	Number of tillers/plant	t ha^{-1} Dry matter	Grain yield
Year (2018)			
0	0d	3.13d	1.13d
2.5	1c	3.61c	1.61c
5.0	2b	4.69b	1.97b
10.0	4a	6.55a	2.40a
Year (2019)			
0	0d	2.68d	0.96d
2.5	2c	4.04c	1.70c
5.0	4b	5.12b	2.40b
10.0	5a	7.03a	2.68a

Means within each column with the same letters are not significantly different at $\alpha_{0.05}$

Discussion

Soil pH values were adequate for rice production in both sites, but the low organic carbon and total nitrogen level with moderate range of available phosphorus is an indication that the soils used for the experiment were nutrient deficient and therefore need to be amended for sustainable production in both sites (FFD, 2012).

The bat guano rates significantly affected plant height, leaf area, number of tillers, dry matter and grain yield during the field experiment, probably due to the nutrients release from bat guano. The positive effect of bat guano could be attributed to the high content of nutrients most especially nitrogen and phosphorus (Shetty *et al*., 2013 and Almohammedi *et al*., 2014) that promote plant growth and grain yield. Sothearen *et al*. (2014) reported that crops treated with bat guano manure experienced higher growth rate compared to the chemical fertilizer despite its lower N-P-K content. This could be attributed to the presence of organic matter, calcium, magnesium, iron, aluminum and zinc content of the bat manure. Shetty *et al*. (2013) and Shaikh *et al*. (2018) attributed the positive effects of bat guano to the nutrients its releases which involved in plant metabolism and photosynthesis that led to carbohydrate synthesizes.

Bat guano can stimulate rice growth due to the nutritional value which increases plant height and fruit branches per plant as earlier reported by Karagöz and Hanay (2017) in wheat production. The significant differences found in rice yield could be attributed to enhance plant height, leaf area and most especially number of tillers influenced by bat guano rates in the supply of nutrients to yield components like rice grain (Ridine *et al*., 2014). Ridine *et al*. (2014) and Shaikh *et al*. (2018) reported that bat guano increases soil organic matter content and supplies balanced elements that stimulates plant growth and higher grain yield.

Conclusion

The study on the influence of bat guano rates on the growth parameters and grain yield of rice in two years revealed that the bat guano manure rates significantly increased growth parameters and yield of rice when compared with plants on the control plots. The 10 t/ha rate of the bat guano manure recorded the highest rice plant height, leaf area, number of tillers, dry matter and grain yield.

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