Influence of Formulated Palm Mill Effluent and Bat Guano Mixture on Maize Performance and Soil Chemical Properties in Delta State, Nigeria

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ABSTRACT

Background: Utilization of palm mill liquid effluent and bat guano as organic fertilizer was initiated in year 2019 and 2020. The palm oil mill effluent and bat guano were used to produce compost and was tested on maize and soil properties in Asaba, Delta State.

Methods: The compost was applied at 0, 2.5, 5.0, 7.5 and 10 ton/ha and replicated four times in randomized complete block design for two years. Plant height, leaf area, stem girth were assessed at maturity whereas yield parameters and soil chemical properties measured at harvest. Data collected were analysed with analysis of variance and means separated with Duncan's multiple range test at 5% level of probability.

Result: Compost significantly increased maize yields and soil properties. The 10 t/ha gave the highest dry matter yield (22.1±2.71 and 36.2±7.47 t/ha), weight of 1000 grains (324±41.0 and 364±63.3) and grain yield (5.2±1.04 and 6.4±1.61 t/ha) in both years, respectively. It also, had the highest soil pH value, organic carbon, total nitrogen and available phosphorus. The palm mill liquid effluent and bat guano mixtures have the potentials to be used as organic fertilizer for maize production.

Key words: Abraka, Agricultural waste, Compost, Maize yield, Organic fertilizer, Soil fertility.

INTRODUCTION

Accumulated organic wastes from agricultural processes are negatively impacting the environment causing serious consequences on living things. It is now imperative in Nigeria to properly manage the wastes to protect the environment from further degradation. In some countries, the wastes are seen as raw material for fertilizer production (Umar *et al*. 2013). Massive expansion of palm oil farm in Nigeria which consequently interprets to load of palm oil effluent generation will increase the attendant management problem (Umar *et al*. 2013). The wastes generation is inevitable and even the processing techniques cause large quantity of liquid waste (Verla *et al*., 2014). It was documented that about 5-7.5 tons of liquid wastes are generated from 1 ton of crude palm oil produce and has been successfully converted to organic fertilizer in Malaysia (Umar *et al*. 2013). This Malaysia practice can also be adopted in Nigeria.

As a biological source, composting the waste could be a good option for sustainable environmental management as it contains high organic matter that can be easily decomposed. Chemical analysis have that it is rich in N, P, K, Ca and Mg can be used to improve soil fertility as a low cost source of nutrients (Khairuddin *et al*., 2016). The fruits contain about 22% oil and the remaining 78% are normally generated simultaneously as wastes during milling (Chong *et al*., 2017). The details on the uses of the large quantity of palm oil effluent with other solid organic materials are limited indicating that its full potential has not been fully evaluated. Study had shown that it can be used for crop production (Roy *et al*., 2013). Combining the palm mill liquid effluent with bat guano as organic fertilizer will definitely influence the ecosystem positively. The bat guano is useful as organic fertilizer and soil building material (Allocati *et al.,* 2016). The concentration of macro and micro nutrient contents of bat guano make it useful as fertilizer material (Sridhar *et al.,* 2006). Bat guano was successfully used with other manures such as bio-slurry in appropriate ratios and this helped according to Ciancio *et al.* (2014) to improve maize yield.

Organic wastes have been proven to improve the properties of soil and crop yields (Diacono and Montemurro, 2015). Recycling the wastes as organic fertilizer will beneficially influence the environment and also drastically reduce the need for synthetic fertilizers. The high dependency on synthetic fertilizers in acidic ultisols with high rainfall regime is no longer sustainable due to its frequent applications. These can easily be addressed with the use of locally formulated fertilizers (Ojobor *et al*., 2020).

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Therefore, adopting waste recycling as management technology would be advantageous as the nutrients will be used for crop production and at the same time reducing the rate of environmental pollution (Edgaras and Irina, 2018).

Maize (roasted and boiled maize) is one of the most important cereals which provides employment and significantly contributes to food security drive in Nigeria (Adiaha, 2018). Domestic demand exceeds production precipitating to an increase in maize import. The problem is not lack of technology but that of converting the technology as instruments for farm growth (Olaniyan, 2015). Optimum maize production can only be achieved if the local farmers are supported in adopting nutrient management technique that involves the use of agricultural wastes readily available for fertilizer formulation. Hence, the current research was aimed to evaluate treated palm mill liquid effluent and bat guano mixtures as possible fertilizer for maize production in Abraka, Delta State, Nigeria.

MATERIALS AND METHODS

The study was conducted at the Delta State University Demonstration Farm, Abraka (longitude 5°47′ N and latitude 6°06′ E) with a bi-modal rainfall that breaks in August. The rain starts by March and ends in early November while dry season commences in late November and ends in February. Mean relative humidity is 83.0% with annual temperature of 30.5°C. Sowing was done in May, 2019 and 2020 in a land area of 345 m^2. The land was cleared, tilled and mapped into six (6) blocks and four (4) beds (3×3 m) each as replicates, giving a total of 24 beds, 1 m in-between blocks and beds. Maize seeds (EVDT-W99 STR variety) were sown three per hole and later thinned to one after emergence at a spacing of 75×25 cm in a randomized complete block design. Polythene was used to line the ground to prevent palm mill liquid effluent leakages before separately heaped 100 kg of bat guano was mixed with twenty liters of the effluent. The heaps were properly turned and manually mixed with ten (10) liters of the effluent at two weeks intervals and allowed to cure for 12 weeks. The palm mill liquid effluent had pH of 4.7, total organic carbon of 24.4%, total nitrogen of 3.34% and C:N of 7.3 whereas bat guano had pH of 5.7, organic carbon of 26.4%, total nitrogen of 4.60% and C:N of 5.7. The treatments were earlier applied creating a room for mineralization two weeks before sowing at the rates of 0 (T_1) 2.5 (T_2), 5.0 (T_3), 7.5 (T_4) and 10 (T_5). Plant height: taken at the base to the tip of the leaf with meter rule. Leaf area: Length and breadth of three leaves (highest, middle and lowest) and the value were multiplied by the correction factor (0.75) (Montgomery, 1911) was used obtained leaf area. Stem girth were assessed at maturity and dry matter yield, weight of 1000 seeds and grain yield at harvest. The plots were manually kept weed free with hoe and cutlass and harvesting was done at 12 weeks after sowing.

Soil samples were taken randomly at 30 cm depth with soil auger before and at harvest, air-dried at room temperature and analysed in IITA, Ibadan. Particle size was measured using hydrometer method (Bouyoucos 1951), organic carbon by Walkley-Black method (Nelson and Sommers, 1982), total nitrogen by macro-Kjeldahl method (Jackson, 1962), phosphorus by Bray and Kurtz (1945). Exchangeable bases were extracted with 1N NH4Ac, K and Na was measured with flame photometer, Mg and Ca with atomic absorption spectrophotometer, pH was taken at a ratio of 1:2 (soil : water).

Statistical analysis

Data collected were analyzed with analysis of variance using SAS Institute, Inc. (2012), differences in means were separated using Duncan multiple range test at 5% level of probability.

RESULTS AND DISCUSSION

Properties of soil before sowing

The pre-planting soil analysis showed pH of 5.8, organic carbon (1.9%) and total nitrogen (0.09%). Available P was 8.9 mg/kg, exchangeable K was 1.12 cmol/kg, cation exchange capacity of 12.6 cmol/kg and base saturation of 56% while the textural class was sandy loamy (Table 1).

Growth parameters of maize

Plant height was significantly influenced in both years (Table 2). In the 1st year, the rates were not different significantly but were statistically higher than the control. In the 2nd year, plant height increased gradually with the corresponding increase of compost application up to 10 t/ha. Leaf area increased significantly as 10 t/ha of compost application had the highest leaf area. Plant girth was also influenced significantly in both years. In the 1st year, plots treated with 2.5 t/ha had highest plant girth than 5.0 and 7.5 t/ha whereas, plant girth

Table 1: Soil physico-chemical characteristics of the experimental site.

Chemical analysis		Particle size analysis	
Soil characteristics	Values	Soil characteristics	Values (%)
pH	5.8	Sand	75.2
Organic carbon	1.90%	Silt	17.3
Total nitrogen	0.09%	Clay	7.5
Available phosphorus	8.6 mg/kg	Textural class	Sandy loam
Available potassium	1.12 cmol/kg		
Cation exchange capacity	12.6 cmol/kg		
Base saturation	56%		

Table 2: Growth parameters of maize at maturity.

Rates of compost (t/ha)	Plant height (cm)		Leaf area (cm^2)		Plant girth (cm)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	121b	118d	441c	424e	1.2d	1.1d
T_2	133a	136c	481b	528d	1.5bc	1.4c
T_3	129a	156c	484b	568c	1.4c	1.6b
T_4	134a	184b	492ab	601b	1.4c	1.9a
T_5	138a	202a	514a	672a	1.8a	1.9a
SD	5.76	30.6	25.2	82.2	0.23	0.31

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

Table 3: Yield parameters of maize at harvest.

Rates of compost (t/ha)	Dry matter yield (t/ha)		Weight of 1000 grains		Grain yield (t/ha)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year
T_1	16.7cd	13.4d	200c	185d	2.2d	1.9e
T_2	20.4ab	20.4c	282b	268c	3.6c	3.8d
T_3	18,2bc	22.6bc	280b	310b	3.5c	5.2c
T_4	20.1ab	25.8b	291b	342a	4.3b	5.8b
T_5	22.4a	36.2a	324a	364a	5.2a	6.4a
SD	2.71	7.47	40.9	63.3	1.04	1.61

Means within each column with the same letters are not significantly different at α_{05}.

SD = Standard deviation.

increased gradually with increase in manure application up to 10 t/ha in the 2nd year.

Yield parameters of maize at harvest

Dry matter yield in the treated plots were statistically higher (Table 3). In the 1st year, 10 t/ha had the highest followed by 2.5 t/ha while in 2nd year, it increased gradually with increase in manure application to 10 t/ha. The treatments also influenced weight of 1000 grains in both years but in the 1st year, 2.5, 5.0 and 7.5 t/ha were not significantly different while in the 2nd year, it gradually increased as rates of application increased. Control plots had the lowest grain yield. Plots with 10 t/ha had the highest in both years.

Properties of soil at harvest

Soil pH was significantly different in both years (Table 4). Organic carbon was not significantly affected in the 1st year but as the rates of application increased, higher organic carbon was recorded. For instance, 10 t/ha of the compost gave the highest organic matter content. Treatment increment led to higher total nitrogen except in the 1st year that plots that received 5.0 and 7.0 t/ha had lower nitrogen than those with 2.5 t/ha. Increase in treatment in the 2nd year led to increase in corresponding total nitrogen. Available P was not significantly different in the 1st year whereas in the 2nd year, there was a turning point whereby, increase in the rate of application increased the available P content. Magnesium and potassium followed similar trend with available P for both years. The cation exchange capacity was not significantly influenced in 1st year of the treatment application of 2.5 t/ha. However, as rate of application increased to 10.0 t/ha in 2nd year. There was tremendous increase in yield. The same trend was observed with respect to percentage base saturation as plots treated with 10 t/ha in both years had the highest yield.

Soil pH value was within the range recommended for tropical soils for crop production. It was reported that maize has poor tolerance for soil pH less than <5.5 (Mohd Nizar *et al.*, 2018). Therefore, aluminum and manganese toxicity that reduce root development will not be a problem (Kamprath, 1970). Organic carbon and total nitrogen were below established critical level (FMARD, 2012). Available P and K were also below the critical level (Adeoye and Agboola, 1985). Cation exchange capacity was also below the critical level indicating poor nutrient retaining capacity of the soil (FMARD, 2012).

Increased soil pH in treated plots indicating the role of applied manure proved that the manure could be used to boost soil buffering capacity (Olowoake *et al.*, 2018). Most nutrients will be available for maize uptake with the increased soil pH (Mohd Nizar *et al.*, 2018). The manure increased soil organic matter that boosts organic carbon availability (a major source of energy for microorganisms) which subsequently leading to higher soil biological diversity (Rumpel *et al.* 2015). The breakdown of organic matter releases nutrients into the soil in plants available forms. The soil natural buffer capacity that was lost due to soil degradation was recovered due to increased organic carbon. The magnesium and calcium released from the compost promoted cation exchange capacity which consequently improved soil texture and structure. According to Mohd Nizar *et al.* (2018), the magnesium and calcium can also facilitate chlorophyll processes that depend on both elements.

Table 4: Soil chemical properties at harvest in both years.

Rates of compost (t/ha)	pH (H_2O)	OC	TN	Avail P mg/kg	Ca	Mg	K	Na	CEC	BS %
		--------%--------			---------------------------cmol/kg--------------------------------					
1st year										
T_1	5.8c	1.80b	0.09d	8.4a	1.21d	1.07d	1.01e	0.82e	10.2b	46.2b
T_2	5.9b	2.10a	0.15b	8.7a	2.44a	1.86c	1.52c	0.98d	14.4a	60.4a
T_3	6.0a	1.94ab	0.14c	8.5a	2.01c	2.10b	1.44d	1.24c	13.8a	59.2a
T_4	6.0a	1.95ab	0.14c	8.6a	2.20b	2.00b	1.83a	1.38a	13.9a	60.1a
T_5	6.0a	2.10a	0.16a	8.7a	2.22b	2.41a	1.74b	1.34b	14.2a	62.0a
SD	0.03	0.10	0.03	0.10	0.41	0.45	0.29	0.20	1.49	5.62
2nd year										
T_1	5.7c	1.68d	0.17e	8.1d	1.10d	1.00e	0.98e	0.80e	9.4c	44.7c
T_2	6.0b	2.42c	0.21d	10.2c	2.53c	2.24d	2.42d	1.22d	14.7b	60.2b
T_3	6.1ab	2.88c	0.26c	11.4c	2.98b	2.68c	2.88c	2.23c	16.4a	62.4ab
T_4	6.2a	3.28b	0.31b	14.2b	3.01b	3.14b	3.43b	2.46b	16.8a	63.8a
T_5	6.2a	3.88a	0.36a	16.7a	3.46a	3.87a	4.62a	2.84a	17.2a	64.5a
SD	0.19	0.75	0.10	3.02	0.81	0.98	1.56	0.77	2.88	7.36

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

SD = Standard deviation, BS = Base saturation.

The increase in CEC values showed that the soil have greater capacity to retain cations, this will increase the amount of element that will be available to the crop. Many researchers have advocated the use of organic fertilizers because of this desirable property (Ojobor *et al*., 2020). In addition, it was established that bat guano with other farm manures in appropriate proportion can be used to overcome nutrient deficiencies in farms.

Manure application of 10 t/ha of compost improved maize height, girth, leaf area and yields, these were strongly reliant on plant nutrient uptake. For example, potassium functions by controlling cell expansion, membrane potential and transport including other catalytic processes. Apart from the major elements, palm mill liquid effluent and bat guano contained micronutrients like iron that controls chlorophyll synthesis (Osman *et al*., 2020). The micronutrients encouraged good maize growth. Plots that received 10 t/ha of compost released higher nitrogen which might have enhance the production of more mesophyll cells resulting to thicker leaves structure (Osman *et al*., 2020) This could increase the rate of photosynthesis in maize plants treated with higher rates of the manure (Ubani *et al*., 2017).

CONCLUSION

Palm mill liquid effluent and bat guano are organic materials that plant nutrients and were used to formulate compost for their potentials to be assessed on maize and soil chemical properties. The compost was applied at 2.5, 5.0, 7.5 and 10 ton/ha with a control for two years. The treatments significantly improved soil chemical properties and maize yield. Application of 10 t/ha was more effective on soil properties and maize yield. This showed that the palm mill liquid effluent with bat guano mixtures can be successfully used to formulate compost for maize production in Delta State.

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