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Evaluation of Fertilizer Types on the Growth and Yield of Maize *(Zea mays)*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors COO, JFA and ASA designed and wrote the protocol for the study including the statistical analysis. Authors ACO and COO managed literature searches and wrote the final draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to evaluate the growth and yield of maize to compost, organomineral fertilizer, and mineral fertilizer at Iyaganku and Moniya farm sites in Ibadan, Oyo State, Nigeria. Treatments consisted of Organomineral fertilizer (A), Compost (B), Fresh compost (C), Mineral fertilizer (D = N.P.K. 15:15:15), and Control (E = no fertilizer). Experimental design was randomized complete block design replicated four times. Compost treatments (45 kgNha-1) were applied at one week before sowing while N.P.K. 15:15:15 fertilizer (300 Kg N ha-1) was applied two weeks after sowing. The growth and yield data collected were analyzed using Analysis of Variance (ANOVA) of GENSTAT Discovery software. Significant means were compared using Duncan Multiple Range Test (DMRT) at p = 0.05. The results of the analysis revealed no significant difference in the number of leaves and stem girth at 8 weeks after sowing (WAS) at Iyaganku. Tallest maize plants were recorded from plots treated with A and B. Also, treatments showed no significant difference in the dry weight (g/cob) of husked and unhusked maize at harvest. At Moniya, plots treated with A produced high number of leaves while lowest number of leaves were recorded from control plots and plots treated with B, C, and D. Similarly, no significant difference was observed in stem girth,

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plant height, dry weight (g/cob) of husked and unhusked maize at harvest between control plots, and plots treated with C, and D. Larger stem girths, tallest plants, dry weight (g/cob) of husked and unhusked maize at harvest were observed in plots treated with A and B. The results from Moniya farm site suggest that organomineral fertilizer and compost have the potential to enhance the growth and yield of maize in studied location.

Keywords: Maize; Compost; Organomineral fertilizer; growth; yield.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals in Sub-Sahara Africa. In Nigeria, it is the primary staple food of about 112 million small holder livelihoods [1]. It has a wider range of uses and widely distributed compared to other cereals [2]. According to Relief Web, 2017 [3], the increasing rate of demand for maize for different purposes had not been met with the local production due to several limitations of which low soil fertility [4] is one of the most paramount. Maize is a very high nutrient-demanding crop, requiring adequate nutrition for maximum performance [5]. Maize requires major nutrients especially nitrogen (N), phosphorus (P) and potassium (K) as well as micronutrients for proper growth and development. [6]. In order to promote good crop performance, increased yield per cultivated area, and ensure sustainable soil fertility, farmers use different types fertilizers, such as organic, inorganic and organomineral fertilizers.

Organic fertilizer (manure and composts) are affordable and capable of improving soil health. In addition to adding N, P, and K to the soil, organic fertilizers can add micronutrients (copper, iron, manganese and zinc) to soil for plant use [7]. Organic fertilizers are available in large quantities from industrial waste from brewery fertilizers like molasses, agricultural and domestic waste such as cocoa pods, rice bran, bean pod, yam and cassava peelings, rice straws, grasses, Tithonia leaves, sorted town refuses, sewage and city wastes, poultry droppings, animal dungs, human feaces and urine, etc. [8]. However, the use of organic fertilizers have limitations such as bulkiness, high cost of labour and slow rate of mineralization.

On the other hand, inorganic fertilizers {e.g N.P.K, Single Super phosphate (S.S.P) and Urea} provide nutrients in readily available form for plant use [9]. However, some of the limitations with the use of inorganic fertilizers are ease of leaching, volatilization, high cost of procurement, and environmental pollution such as contamination of surface and groundwater [10,11].

The use of inorganic fertilizers in combination with organic fertilizers (organomineral fertilizers) have been reported to possess complimentary benefits such as enhancing soil nutrients, maintaining soil physical properties and increasing crop yield [12,13,14,15]. Ayeni [16] reported increase in the yield of maize and improvement in soil nutrients by combined poultry manure and NPK 20:10:10 fertilizer. Similarly, nutrient uptake and yield of *Amaranthus cruentus* was enhanced by the combined application of kola pod husk with NPK fertilizer [17].

In Sub-Sahara Africa, most soils are often associated with declined soil fertility as a result of erosion and several other poor soil management practices [18]. In southwest Nigeria, nutrients depletion due to continuous cropping and non-replenishment limits maize grain yield [19]. Therefore, it is pertinent to intensify efforts into studies that would provide insights on sustainable soil fertility management and improving the productivity of crops. The aim of this study was comparative assessment of the growth and yield of maize to composts, inorganic fertilizer (N.P.K 15:15:15), and organomineral fertilizer in two fields in Oyo State, Nigeria.

2. MATERIALS AND METHODS

The experiment was conducted between September and November, 2009 at Sustainable Ibadan Project compound (S.I.P), Iyaganku and Onilu farm settlement, Moniya, both within Ibadan, Oyo state. Land clearing was manually done and this was followed by seed beds preparation using hoe and garden fork. Maize (*Zea mays*) was simultaneously planted on both sites. The materials used for study were maize (OBA super IV), Organomineral fertilizer (A), Compost (B), Fresh compost (C), {applied at the rates of 45kgN ha^{-1}}, Mineral Fertilizer N.P.K 15:15:15 {300 kgN ha^{-1}} and Control - No fertilizer. The experiment was laid as a

Randomized Completely Block Design (RCBD) in four replicates. Each plot size was 11.25 m^2 and the spacing of 75 cm x 25 cm with one plant per stand was adopted giving a plant population of 60 stands per plot. Compost application was by spot method and covered with soil for one week before sowing at the rate of 45 $kgNha^{-1}$ and N.P.K 15:15:15 two weeks after sowing at the rate of 300KgN ha^{-1}.Weeding was done manually as at when due with cutlass. The growth parameters of the maize plant were observed at 4, 6 and 8 weeks after sowing (WAS) while the cobs were harvested at 12 weeks after sowing (WAS) and oven dried to constant weight at 60°C and expressed as g/plant.

At both Moniya and Iyaganku sites, the experimental soils were slightly acidic {P^H=6.3: 6.2}, low in N (0.7 g kg^{-1}: 0.8 g kg^{-1}), P (8 mg kg^{-1}: 12 mg kg^{-1}) and K (0.2 cmol kg^{-1}: 0.3 cmol kg^{-1}) [20], while the textural classes were loamy sand (www.ncrs.usda.gov/.../class) [Table 2]. Particle size distribution was determined by hydrometer method [21], as cited by Tel and Hargarty [22], using sodium hexametaphosphate (calgon) as the dispersing agent. Soil pH was determined using distilled water (1.1) using glass electrode on ELL pH meter [23]. Organic carbon was determined using dichromate wet oxidation method [24] and value of organic matter was obtained by multiplying the Organic carbon value by a factor of 1.724. Total nitrogen (N) was determined by macro Kjeldahl procedure [25]. Available phosphorus was determined by the method of Bray and Kurtz [26] and determined colourimetrically using Molybdenum blue Method, while K, Ca, and Mg were first extracted using neutral normal (NH_40Ac), thereafter K was determined by flame photometry, and Ca by spectrophotometry, using the atomic absorption spectrophotometer. Micronutrients (Mn, Fe and Cu) were extracted with Mehlich extractant and determined with Buck Scientific Atomic Absorption Spectrophotometer (AAS) model 210/211VGP. Crop production parameters observed were number of leaves, plant heights measured with a meter rule taken from ground level to the last fully opened leaf, Stem girth measured with vernier calipers at 10cm on the stem above the soil level, and dry weight of maize. The results of the experiment were subjected to Analysis of Variance (ANOVA) of GENSTAT Discovery software significant means were compared using Duncan Multiple Range Test (DMRT) at p = 0.05.

Table 1. Primary macronutrient composition of the composts

Fertilizer source	Nutrients composition (g kg^{-1})		
	Nitrogen	**Phosphorus**	**Potassium**
Organomineral fertilizer	2.075	0.185	4.87
Compost	2.15	0.195	5.26
Fresh compost	0.185	0.08	1.97

Table 2. Pre-planting chemical properties of the experimental soils

Parameters		Values	
		Iyaganku	**Moniya**
pH (H,O)		6.3	6.2
O.C(g kg^{-1})		8.1	5.4
Total N(g kg^{-1})		0.8	0.7
Av. P (mg kg^{-1})		12	8
Exchangeable bases (cmol kg^{-1})	Ca	3.9	1.1
	Mg	0.7	0.4
	K	0.3	0.2
	Na	0.9	0.9
Extractible micronutrients (mg kg^{-1})	Mn	140	134
	Cu	2	1
	Fe	124	72
	Zn	13	4
Mechanical compositions (g kg^{-1})	Sand	906	886
	Silt	24	34
	Clay	70	80
Textural class	Loamy sand	Loamy sand	

3. RESULTS AND DISCUSSION

3.1 Soil Analysis

The pre-planting chemical properties of the soil used for the experiment are presented in Table 2. The results revealed that at both sites, the experimental soils were slightly acidic, loamy sand in texture, low and below critical level in total nitrogen, total carbon and moderate in exchangeable K. Also, at Moniya, the available P was low but moderate in Iyaganku site [27,28, 29,30]. Therefore, the low soil nutrients depict the need for soil amendments for better crop performance.

3.2 Moniya Site

Fertilizer types had varied influence on the growth parameters (number of leaves, plant heights and stem girths) and the yield of maize in this location. At 6 and 8WAS of maize, Organomineral fertilizer gave the highest mean number of leaves (8.13: 10.88) followed by the compost (7.73: 8.75) while the control had the least (5.88: 6.38) [Table 3]. The higher number of leaves of maize recorded from the organomineral plots, further confirms similar report by Rachid and Ryan [5]. The stem girths differed significantly ($P \leq 0.05$) to the fertilizer treatments at 4 and 6WAS. Organomineral fertilizer (4.41 cm: 7.71 cm) gave the highest mean stem girths followed by the compost (4.21cm: 6. 98 cm) and the control had the least (2.83cm: 4.08 cm) at 4 and 6WAS respectively {Table 4}. This result reconfirms the work of Osemwota et al. [31] who reported significant ($P \leq 0.05$) influence of organomineral fertilizer to stem girth of maize. Similarly, the fertilizer types had effects on the plant height of maize. At 6 and 8WAS, Organomineral fertilizer had the highest mean plant height (48.88 cm: 118.38 cm) followed by the compost (44.75 cm: 105.25 cm) while the control gave the least (25.69 cm: 49.75 cm) respectively [Table 5]. This result is in agreement with the findings of Olowoake et al. [32] who reported that the combination of organic and mineral fertilizer performed better on plant height than when each of them is solely used. Overall, number of leaves, stem girths and plant heights of maize responded better with Organomineral fertilizer and the compost treatment. There were no significant ($P \leq 0.05$) effects on the stem girths and plant heights of maize between the control plot and plots with fresh compost, and NPK 15:15:15 at harvest in this location.

The fertilizer types had significant ($P \leq 0.05$) effect on the yield (dry weights) of maize (Table 6). Compost plot (B) had the highest mean dry weights for both the husked and unhusked maize (162.50 g/cob; 153.50 g/cob) followed by the Organomineral plot (A) (156.25 g/cob:143.50 g/cob) and NPK (119 g/cob; 115.67 g/cob) while the control plot gave the least (100.38 g/cob; 94.33 g/cob). The lowest yields produced by the plots without fertilizer treatment could be due to deficiency of nutrients as revealed by the low nutrient status of the soil from the initial pre-chemical analysis. This agrees with statement by FAO [33] that increment in maize production occurred at higher levels of fertilizer application.

Also, compost and Organomineral fertilizer plots produced better yields compared to other treatments. This result might be attributed to rapid mineralization of N from inorganic fertilizer and steady release of N in organic fertilizer which might have met the N requirement of crop at critical stages. This recomfirms the work of Maheshbabu et al. [34] w ho reported that manure acts as nutrient reservoir and upon decomposition are released slowly during entire growth periods leading to higher seed yield and yield components. The significant effects produced by the yield of maize to the fertilizer treatments is in consonance with the findings of Aliyu [35,36].

3.3 Iyaganku Site

The fertilizer types showed varied effects on the growth components as well as the yield of maize. At 8WAS, compost plot B produced the highest mean number of leaves (10.50) followed by Organomineral fertilizer A, (10.13) and NPK (9.63) while the control had the least (9.50) [Table 3]. This result can be further corroborated by Akanbi et al. [37] who reported that organic fertilizer has capability to improve soil structure, retain nutrient and water, improves aeration aids better response of crops to fertilizer. Similar findings was reported by Abedi et al. [38] Efthimiadou et al. [39] Kazemeini et al. [40] that application of inorganic fertilizer with compost to crops have the advantage of providing nutrients to meet crop nutrition requirements and maintain soil health.

Table 3. Effect of treatments on the number of leaves of maize at Moniya and Iyaganku sites

Treatment	Iyaganku			Moniya		
	4WAS	**6WAS**	**8WAS**	**4WAS**	**6WAS**	**8WAS**
A	6.13	9.00	10.13	5.75	8.13a	10.88a
B	7.17	9.50	10.50	5.88	7.73a	8.75ab
C	6.13	8.25	9.90	5.00	6.67ab	7.00b
D	6.25	8.27	9.63	5.17	6.17ab	8.33ab
E	6.13	8.38	9.50	4.75	5.88b	6.38b
	Ns	Ns	Ns	Ns		

Organomineral fertilizer = A, Compost = B, Fresh compost =C, Mineral fertilizer (N.P.K. 15:15:15) = D, and Control (no fertilizer) = E, Ns: Not significant, WAS = Weeks after sowing. Means with the same letter(s) in a column are not significantly different by the Duncan Multiple Range Test (DMRT) at P≤0.05.

Table 4. Effect of treatments on the stem girth (cm) of maize at Moniya and Iyaganku sites

Treatment	Iyaganku			Moniya		
	4WAS	**6WAS**	**8WAS**	**4WAS**	**6WAS**	**8WAS**
A	3.91	8.19	8.96	4.41a	7.71a	8.93a
B	4.05	8.22	9.57	4.21a	6.98a	8.54a
C	3.43	7.25	8.98	2.90b	4.82b	7.22ab
D	3.46	7.70	8.50	2.83b	4.17b	7.42ab
E	3.51	7.56	9.77	2.83b	4.08b	6.18b
	Ns	Ns	Ns			

Organomineral fertilizer = A, Compost = B, Fresh compost =C, Mineral fertilizer (N.P.K. 15:15:15) = D, and Control (no fertilizer) = E, Ns: Not significant, WAS = Weeks after sowing. Means with the same letter(s) in a column are not significantly different by the Duncan Multiple Range Test (DMRT) at P≤0.05.

Table 5. Effect of treatments on the plant height (cm) of maize at Moniya and Iyaganku sites

Treatment	Iyaganku			Moniya		
	4WAS	**6WAS**	**8WAS**	**4WAS**	**6WAS**	**8WAS**
A	22.33a	54.54	108.13a	29.75a	48.88a	118.38a
B	23.33ab	59.67	104.83a	27.56a	44.75a	105.25a
C	18.63abc	49.50	86.13b	18.25b	27.58b	66.83b
D	18.64abc	49.50	86.13b	19.83b	28.08b	65.50b
E	17.31c	52.25	91.75ab	17.38b	25.69b	49.75b
	Ns	Ns	Ns			

Organomineral fertilizer = A, Compost = B, Fresh compost =C, Mineral fertilizer (N.P.K. 15:15:15) = D, and Control (no fertilizer) = E, Ns: Not significant, WAS = Weeks after sowing. Means with the same letter(s) in a column are not significantly different by the Duncan Multiple Range Test (DMRT) at P≤0.05.

Table 6. Effect of treatments on the dry weight (g/cob) of maize at Moniya and Iyaganku sites

Treatment	Iyaganku		Moniya	
	Husked (g/cob)	**Unhusked**	**Husked (g/cob)**	**Unhusked**
A	99.38	91.13	156.25a	143.50a
B	133.33	121.17	162.50a	153.50a
C	139.88	127.25	112.00b	113.13b
D	110.88	98.00	119.00b	115.67b
E	163.50	152.50	100.38b	94.33 b

Organomineral fertilizer = A, Compost = B, Fresh compost =C, Mineral fertilizer (N.P.K. 15:15:15) = D, and Control (no fertilizer) = E, Ns: Not significant, Means with the same letter(s) in a column are not significantly different by the Duncan Multiple Range Test (DMRT) at P≤0.05.

5. CONCLUSION AND RECOMMENDATION

Fertilizer applications are of great importance to maize production. At Moniya site, Organomineral fertilizer plots produced highest number of leaves, stem girths, and plant heights. Larger stem girths, tallest plants, and better dry weights (g/cob) of husked and unhusked maize at harvest were observed in plots treated with A and B. At Iyaganku, fertilizer types had no significant effects in the number of leaves and stem girth at 8 weeks after sowing (WAS). Tallest maize plants were recorded from plots treated with A and B. Also, treatments showed no significant difference in the dry weight (g/cob) of husked and unhusked maize at harvest. Therefore, organomineral fertilizer and compost have the potentials to enhance the growth and yield of maize in Moniya site.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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