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Determination of the Optimum rate of Organic Fertilizer for Yield of Cucumber (Cucumis sativus) and Effect on Soil Properties on an Alfisol

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Abstract

A field experiment was carried out on an Alfisol at the Federal College of Agriculture, Ibadan in 2011 and 2012 cropping season to evaluate the effect of Aleshinloye compost (commercial compost produced at Ibadan, Nigeria) on cucumber and soil properties. The experimental design was Randomized Complete Block with six treatments replicated three times. The treatments were compost at 0, 10, 20, 30, 40 kg N/ha and NPK 15-15-15 at 30 kg N/ha. Data were collected on number of leaves, vine length, leaf area, vine girth and fruit yield. Post cropping soil samples were collected to determine the effect of the treatments on soil chemical properties. Data collected were subjected to Analysis of Variance (ANOVA) and means separated using Duncan Multiple Range Test (DMRT). The result showed that 30 kg N/ha of compost gave the highest cucumber fruit yield (30.7 t/ha), which was significantly different from other rates in 2011. Also, in 2012, 30 kg N/ha compost gave the highest fruit yield (30.21 t/ha) which was not significantly different from 40 kgN/ha (29.56 t/ha) and NPK (29.32 t/ha). The control gave the least fruit yield (15.1 and 16.02t/ha) in 2011 and 2012 respectively. Application of compost improved the soil pH, Organic carbon and Mg compared to NPK and control. Therefore, 30 kg N/ha of the commercial compost used for this study could be used to produce optimum fruit yield of cucumber and improve the chemical properties of soil in the study area and area with similar agroecology.

Keywords: Alfisol, compost, cucumber, soil properties

Détermination du taux optimal d'engrais organique pour le rendement du concombre (Cucumis sativus) et effet sur les propriétés du sol sur un Alfisol

Abstrait

L'expérience en champ a été menée entre 2011 et 2012 sur l'Alfisol du Collège fédéral d'agriculture d'Ibadan afin d'évaluer l'effet du compost Aleshinloye (compost commercial produit à Ibadan, Nigéria) sur les propriétés du concombre et du sol. L'expérimentation a été faite sur un dispositif en bloc complètement randomisé avec six traitements réalisé en trilpliquet. Les traitements étaient constitué du compost à gradient de concentration, 0, 10, 20, 30, 40 kg N / ha et du NPK 15-15-15 à la dose de 30 kg N / ha. Des données sur le nombre de feuilles, la longueur de la vigne, la surface foliaire, la circonférence de la vigne et le rendement en fruits ont été relevés lors de nos expérimentation. Des échantillons de sol après la culture ont été prélevés afin de déterminer l'effet des traitements sur les propriétés chimiques du sol. Les données obtenues ont été soumises à une analyse de variance (ANOVA) pour la comparaison des moyennes suivies du test de comparaison multiple Duncan Multiple Range (DMRT) pour la comparaison des différents traitements. Nos résultats ont montré que l'amendement du sol au compost à la dose 30 kg N / ha donne un rendement en fruits de concombre plus élevé (30,7 t / ha) et significativement différent des autres traitements en 2011. De plus, à la même dose, on enregistre un rendement en fruits plus élevé en 2012 (30,21 t / ha) qui n'est pas significativement différent de la dose 40

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kgN / ha (29,56 t / ha) et du NPK (29,32 t / ha). Par ailleurs, on enregistre des faibles rendements en fruits dans le traitement témoin entre 2011 et 2012 (15,1 et 16,02 t / ha). L'application de compost a amélioré le pH du sol, le carbone organique et le Mg par rapport au NPK et au contrôle. Ainsi, le compost commercial à la dose 30 kg N / ha utilisé dans le cadre de cette étude pourraient être utilisés pour optimiser le rendement de production des fruits de concombre et améliorer les propriétés chimiques du sol dans la zone d'étude et dans les autres zones agroécologiques similaire.

Mots clés: Alfisol, compost, concombre, propriétés du sol

Introduction

Cucumber (*Cucumis sativa L.*) is one of the monoecious annual crops in the Cucurbitaceae family that has been cultivated by man for over 3,000 years (Adetula and Denton, 2003; Okonmah, 2011). It originated from Asia but is now cultivated worldwide. It is highly nutritious and the edible portion is about 85% when peeled. Soft and succulent, the vegetable crop is cherished by man and eaten in salads or sliced into stew in tropical regions. Its juice is often recommended as source of silicon to improve the health and complexion of the skin. Cucumber is a very good source of vitamins A, C, K, and B6, potassium, pantothenic acid, magnesium, phosphorus, copper and manganese (Vimala *et al*., 1999) The ascorbic acid and caffeic acid contained in cucumber help to reduce skin irritation and swollenness (Okonmah, 2011) In spite of the increasing relevance of cucumber in Nigeria, low yields are obtained in farmers' fields because of declining soil fertility due to continuous cropping. Cultivating cucumber on soil with low fertility results in bitter and misshapen fruits which are often rejected by consumers (Aiao, 2015). Hence, there is need to improve the fertility status of the soil in order to have quality fruit that is highly acceptable by the consumer. Meanwhile, it has been reported that the use of organic fertilizer enhanced crop quality and promote healthy produce compared to mineral fertilizer thereby ensuring safe food consumption (Petre *et al*., 2016). Moreover, continuous use of mineral fertilizer can have detrimental effects on soil properties because it can lead to soil acidification and compaction while organic fertilizer is environmental friendly and improves soil structure (Hepperly *et al*., 2009; Natsheh and Mousa, 2014).

Although, some studies have been done on the response of cucumber to fertilizer application in southwest Nigeria, there is dearth of information on the actual Nitrogen (N) rate from organic fertilizer for optimum cucumber production. There is therefore need to calibrate organic fertilizer for cucumber yield in the region based on nitrogen which is the most limiting nutrient. The compost evaluated in this study is a commercial product produced by Alesinloye Fertilizer Company in Ibadan. The compost is being produced from market wastes and cow dung. This study was therefore carried out to investigate the effect of this compost on growth, yield of cucumber and soil chemical properties.

Materials and Methods

The field experiment was carried out on the experimental site of Federal College of Agriculture, Ibadan during the raining season of 2011 and 2012. Ibadan is in the derived savanna zone of Nigeria on latitude 7°25.0'N and longitude 3°50.5'E with an altitude of about 122 meters above sea level. The soil of the location has been described as an Alfisol (Smyth and Montgomery, 1962). Land preparation was done mechanically by ploughing and harrowing after which a composite soil sample (0-15 cm) was collected for laboratory analysis to determine the nutrient status of the soil using standard procedures. The land was marked into three blocks of six plots each. The plot size was 3 m x 3 m, with 0.5 m between the plots and 1 m between each replicate. The experimental design used was Randomized Complete Block. Compost was incorporated on the experimental plots at the rates of 0, 10, 20, 30 and 40 kg N/ha one week before sowing while NPK 15:15:15 mineral fertilizer was applied at the rate of 30 kg N/ha at two weeks after sowing. The variety of cucumber used for this study was Poinsett which is recommended for the environment (Olaniyi *et al*., 2009). Cucumber seeds were sown at a spacing of 75 cm x 50 cm and at the rate of three seeds per hole and later thinned to two plants/stand at 2 weeks after sowing.

Data collection commenced at four weeks after sowing. Five plants per plot were randomly tagged for data collection. The parameters measured were number of leaves, leaf area, vine length, vine girth and fruit yield. Post cropping soil samples were collected from each plot after harvesting to determine the effect of treatments on soil chemical properties. Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated using Duncan Multiple Range Test (DMRT). Correlation analysis between the growth parameters and yield of cucumber was also carried out.

Results

The soils used for the experiment in 2011 and 2012 were slightly acidic with pH of 5.4 and 6.2, respectively (Table 2). The total N were low (0.8 and 0.9 g/kg respectively) as they were below the critical level of 1.6 – 2.0 g/kg while the available P values (4.2 and 6 mg/kg, respectively) were also below the critical level of 7-20 mg/kg. The K status of soil used in 2011 was low (0.2 cmol/kg) while that of soil used in 2012 was marginal (0.4 cmol/kg) because it was higher than the critical level of 0.31 cmol/kg. The soils were low in organic carbon (9.0 and 9.4 g/kg respectively) as the value was below the critical level of 10 – 14 g/kg (FFD, 2012).

The effect of treatments on the number of leaves of cucumber at 4, 6 and 8 weeks after sowing (WAS) in 2011 and 2012 were shown in Figure 1. The result showed that in 2011, the number of leaves increase with increase in the rate of compost and peaked at 30kgN/ha at all the weeks after sowing (WAS) while NPK treatments gave the highest number of leaves at 4 and 6 WAS. Similar result was obtained in 2012 except that the performance of NPK is similar to that of 30kgN/ha compost treated plants. The control treatments consistently produced the lowest number of leaves in both years. The result showed that the number of leaves increases for all treatments across the weeks after sowing (WAS). It was observed that the difference in the number of leaves was wider between 4 and 6 WAS compared with between 6 and 8 WAS.

The effect of treatments on the leaf area of cucumber at 4, 6 and 8 weeks after sowing (WAS) in both 2011 and 2012 were shown in Figure 2. The result is similar to what was obtained for number of leaves except that the difference in the leaf area between 6 and 8 WAS was lesser. The effect of treatments on the vine length of cucumber at 4, 6 and 8 weeks after sowing (WAS) in 2011 and 2012 is shown in Figure 3. The trend of observation was similar to what was obtained for number of leaves except that the performance of 30 kgN/ha compost treatment is similar to that of NPK in 2011 and 2012. The effect of treatments on the vine girth of cucumber at 4, 6 and 8 weeks after sowing (WAS) in 2011 and 2012 was shown in Figure 4. The result showed that on the average, the 30 kgN/ha compost treatment gave the highest vine girth among all the other rates of treatments across the weeks after sowing in the two years.

The result of the fruit yield of cucumber presented in Table 3 showed that there was significant difference among the treatment in the yield in both years. In 2011, compost applied at 30 kgN/ha gave the highest mean yield (30.76 t/ha) which was significantly ($P < 0.05$) higher than other treatments. In 2012, compost at 30 kgN/ha gave the highest yield (30.12 t/ha) which was not significantly different from the values obtained from compost at 40 kgN/ha (29.56 t/ha) and NPK fertilizer (29.32 t/ha) but significantly different from other rates The control gave the least values (15.1 and 16.02 t/ha respectively) in 2011 and 2012.On the average, cucumber performance in the two years with compost at 30 kg N/ha gave the highest yield (30.49 t/ha) which was not significantly different from compost at 40 kg N/ha (28.84 t/ha) and NPK fertilizer (28.67 t/ha) but significantly higher than other treatments while the control treatment gave the least value (15.56 t/ha).

The Relationship between growth parameters and yield of cucumber (Table 4) showed that there is high positive correlation between vine length (r = 0.912) and fruit yield in 2011 as well as between number of leaves (r = 0.924), leaf area (r = 0.867), vine length (r=0.991), vine girth (r=0.851) and fruit yield in 2012.

The result of soil chemical properties presented in Table 5 showed that there were significant differences among the differently treated plots in terms of pH, organic carbon, available P, K and Na but the differences were not significant on total N, Ca and Mg in 2011. Compost applied at 30 and 40 kgN/ha significantly increased the pH (5.8 and 5.7, respectively), Organic carbon (13.6 and 13.6 g/kg respectively), available P (16.8 and 16.2 mg/kg, respectively), K (0.3 cmol/kg) and Na (0.5 cmol/kg). In 2012, there was no significant difference in pH, total N, available P, Ca and Mg. However, the difference was significant on organic carbon, K and Na. Plots treated with 30 and 40 kgN/ha compost gave organic carbon values (12.7 and 12.9 g/kg respectively) that were significantly different from value obtained from other treatments.

Table 1: Proximate analysis of the commercial compost used for this study

Parameter	pH	Organic carbon	N	P	Ca	Mg	K	Mn	Fe	Cu	Zn
		(%)						(mg/kg)			
Value	7.6	23	1.4	1.08	1.98	0.07	1.78	73.37	60.56	10.50	104

Table 2: Physical and chemical properties of pre-cropping soils

Parameters	2011	2012
pH (H_20) (1:1)	5.4	6.2
OC (g/kg)	9.0	9.4
Total N (g/kg)	0.8	0.9
Available P (mg/kg)	11.2	12.7
Exchangeable cations (cmol/kg)		
Ca^{++}	0.8	1.2
Mg^{++}	0.5	0.7
K^{+}	0.2	0.4
Na^{+}	0.3	0.2
Exchangeable acidity($Al^{3+}+H^{+}$)	0.1	0.1
Particle size (g/ kg)		
Sand	812	686
Silt	112	105
Clay	76	209
Textural class	Loamy sand	Sandy loam

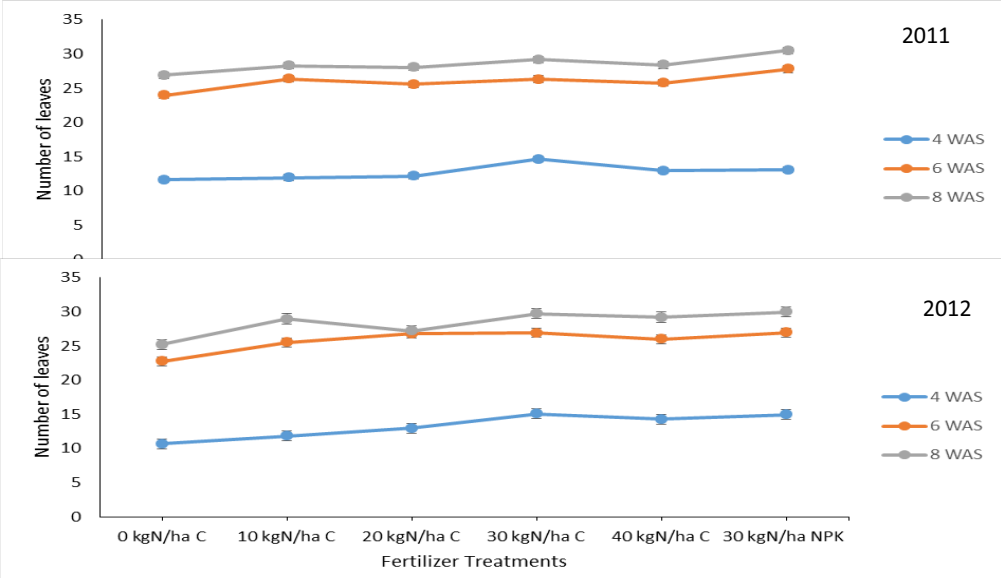

Figure 1. Effect of fertilizer treatments on number of leaves of cucumber

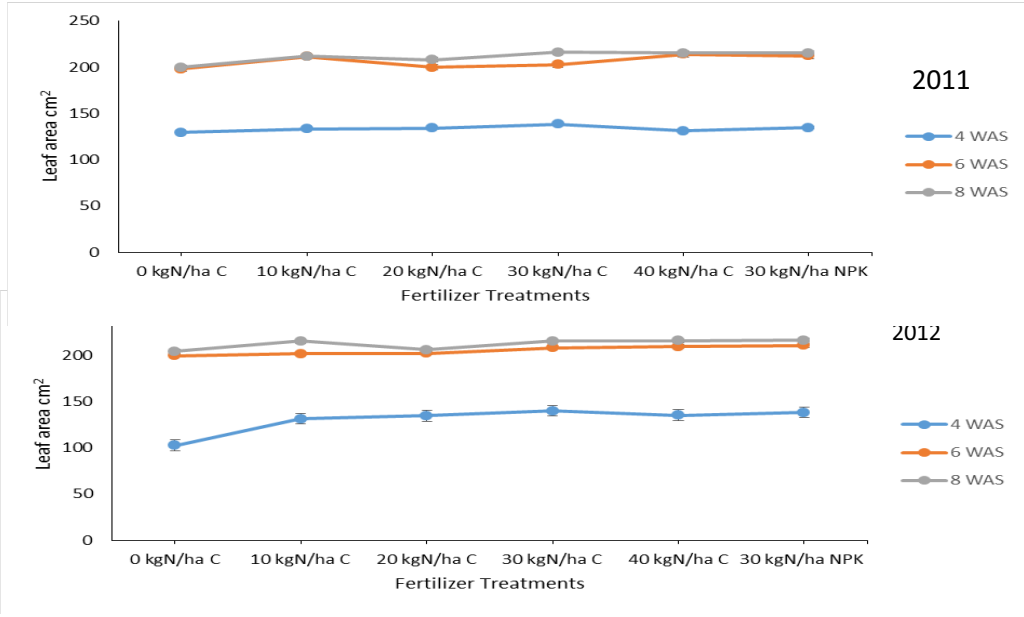

Figure 2. Effect of fertilizer treatments on leaf area of cucumber

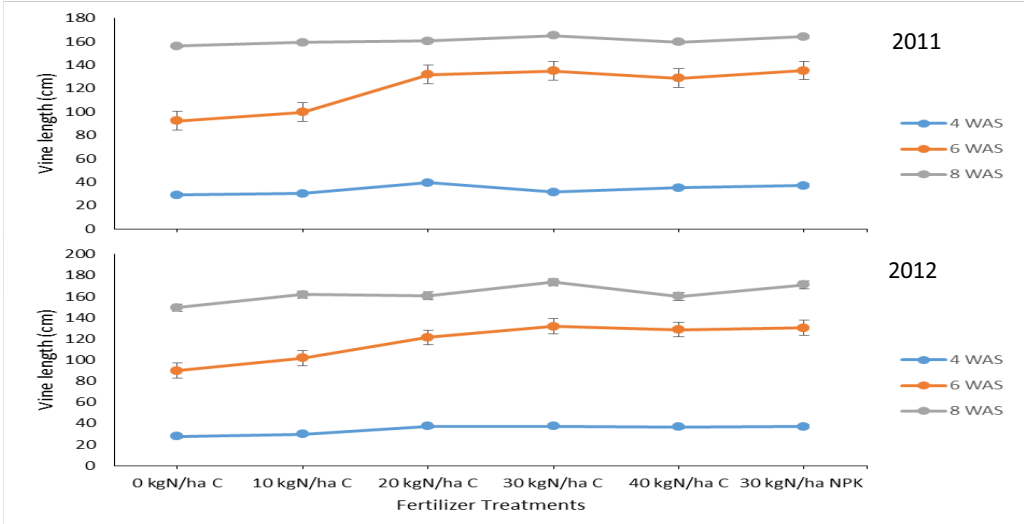

Figure 3. Effect of fertilizer treatments on vine length of cucumber

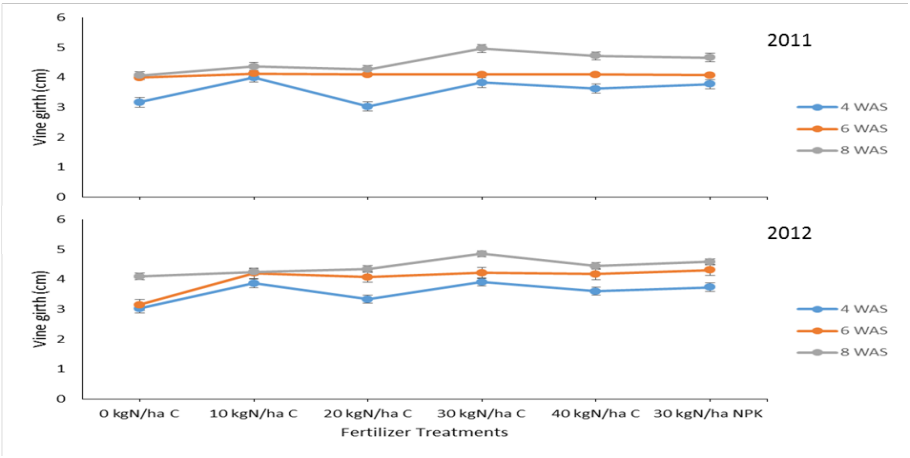

Table 3: Effect of fertilizer treatments on fruit yield (t/ha) of cucumber

Compost (kgN/ha)	2011	2012	Average
0	15.1d	16.02d	15.56d
10	23.7c	22.02c	22.86c
20	27.87b	26.98b	27.43b
30	30.76a	30.21a	30.49a
40	28.12b	29.56a	28.84a
NPK	28.01b	29.32a	28.67a

Means with same letter (s) in a column are not significantly different at P≤0.05 by DMRT

Table 4 : Relationship between growth parameters and yield of cucumber

Growth parameters	Yield	
	2011	2012
No. of leaves	0.712ns	0.924**
Leaf area	0.386ns	0.867*
Vine length	0.912*	0.991**
Vine girth	0.754ns	0 .851*

**, *; Correlation is significant at 0.05 and 0.01, respectively

Table 5: Chemical analysis of the soil as affected by fertilizer treatments after cucumber harvest

Year	Compost	pH (H_20)	Organic Carbon	Total N	Avail. P	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}
	(kgN/ha)		(g/kg)		(mg/kg)	(cmol/kg)			
2011	0	5.3c	11.2c	1.1	11.8d	0.7	0.8	0.2b	0.4b
	10	5.4b	11.8c	1.1	13.2c	0.7	1.1	0.2b	0.4b
	20	5.5b	12.5b	1.0	13.9c	0.8	0.9	0.2b	0.4b
	30	5.8a	13.8a	1.3	16.8a	0.9	1.5	0.3a	0.5a
	40	5.7a	13.6a	1.3	16.2a	0.8	1.3	0.3a	0.5a
	NPK	5.3c	12.9b	1.4	15.8b	0.6	1.2	0.2b	0.4b
2012	0	6.1	9.7c	0.8	11.8	0.6	1.3	0.4b	0.2b
	10	6.3	10.1b	1.1	12.9	0.6	1.4	0.4b	0.2b
	20	6.3	10.3b	1.2	13.7	0.7	1.7	0.4b	0.2b
	30	6.5	12.7a	1.2	13.9	0.7	1.5	0.4b	0.3a
	40	6.4	12.9a	1.1	15.1	0.8	1.8	0.5a	0.3a
	NPK	6.2	10.5b	1.2	14.9	0.7	1.6	0.4b	0.3a
		ns		ns	ns	ns	ns		

ns: not significant, means with same letter (s) in a column are not significantly different at P≤ 0.05 by DMRT

Discussion

Fertilizer is one of the most important inputs contributing to crop production because it improves yield and quality. The soil used for this study was moderately acidic, a pH found to be suitable for cucumber production. The soil is low in nutrients which are the general characteristics of most tropical soils (Lawal *et al*., 2012; Senjobi *et al*., 2013), hence, the soil is suitable for fertilizer trial.

Application of compost generally resulted in growth which compared favourably with NPK fertilizer (Okoli and Nweke, 2015; Kayode *et al*., 2018). Significant higher growth advantage exhibited by cucumber with application of compost or NPK over the control throughout the growth period, had proved that there is better growth performance in cucumber when organic or/and inorganic fertilizers are used to improve soil nutrient. The sharp difference between the result of the growth parameters at 4 and 6 WAS suggested that the cucumber plant is still in active growth while the slim difference in the result between 6 and 8 WAS indicated that the cucumber has entered development phase whereby the photosynthate is channeling towards fruit formation. This indicated 6 WAS as the peak of growth for the variety of cucumber used for this study.

Organic fertilizer comparing favorably with mineral fertilizer in terms of yield at the same N-rate indicates the potential of organic fertilizer as a good alternative to mineral fertilizer for cucumber production. This suggest that organic fertilizer could make its nutrients available compared to mineral fertilizer for cucumber production and this is in line with the findings of Natsheh and Mousa (2014) and AyanfeOluwa (2019) where organic fertilizer compared favorably with mineral fertilizer at the same N-rate of application for cucumber and maize production, respectively. This result confirmed the findings of (Ghanbarian *et al*., 2008; Akande *et al*., 2010; Sodimu, 2013) that application of organic material could ameliorate soil nutrient to improve crop production. The enhancement of fruit production by cucumber plant with application of fertilizer could be linked to the positive effect of availability of adequate amount of nutrients for plant uptake which improved their synthesis and translocation of photosynthates from the source to the sink. The growth

parameters correlating to fruit yield indicated that the better the performance of the cucumber crop in terms of growth as reflected by the growth parameters the higher the fruit yield. This is simply because the higher the vegetative surfaces exposed for photosynthesis the higher the volume or proportion of photosynthates available for yield. This explains why compost at 30 and 40 kgN/ha and NPK at 30 kgN/ha with highest growth parameters recorded the highest yield. This is in line with the report of Chinatu (2015) that growth parameters determine the amount of photosynthates available to plants for growth and yield. Adeniji and Aremu (2007) reported that the proportion of the photosynthates allocated to the reproductive parts during flowering and fruit set go a long way to determine the reproductive characters of crops. This result confirmed the findings of Chinatu *et al.* (2017) and Umeh (2018) where fruit yield correlated with the growth parameters of cucumber plants.

Some of the soil chemical properties observed were significantly influenced by compost application in both 2011 and 2012. The increase in the pH of the experimental soils could be as a result of the buffering capacity of compost applied which could be traced to higher concentrations of basic cations in the compost which raised pH levels (Ogunlade, 2008). The compost improving the soil organic carbon showed that the compost sequestered part of its organic carbon. The compost improving the phosphorus, potassium and sodium showed that it retained its nutrients against leaching. This finding confirmed the past findings about the strength of compost to improve soil properties (Ghanbarian *et al*., 2008; Akande *et al*., 2010).

Conclusion

The result of this study revealed that compost is comparable with NPK mineral fertilizer in terms of yield and compost has positive effects on post soil chemical properties than NPK mineral fertilizer. The Alesinloye compost used for this study could be recommended for cucumber fruit production at the rate of 30 kg N/ha for optimum yield in the study area and area with similar agroecology.

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Effect of Organic and Inorganic Fertilizers on the Agronomic Performance and Proximate Content of Amaranth (Amaranthus Cruentus L.) in Osun State Nigeria

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Abstract
Field experiment was conducted in 2017 during dry cropping season in Osun State University, College of Agriculture, Teaching and Research Farm (Latitude 7˚, 52'37 ˚N and Longitude 4˚, 18"3,76 E) Ejigbo Campus, Nigeria. The study assessed the growth rate, yield and the proximate composition of *Amaran thus cruen tus* as influenced by organic and inorganic nutrient sources. Poultry manure and cow dung at 10 tons/ha each were the organic nutrient sources used while Urea at 50kg/ha and NPK at 100kg/ha were the inorganic nutrient sources. The experiment was carried out in a Randomized Complete Block Design (RCBD) with four replicates. Data were taken on the fresh biomass, dry matter weekly which was used to calculate the crop growth rate, relative growth rate and net assimilation rate. At 5 weeks after planting, amaranth was harvested and analyzed for the proximate contents. Growth, yield and the proximate composition from the application of poultry manure were significantly (P≤0.05) better compared with other nutrient sources. Yield from poultry manure was 9.91 tons/ha, urea was 8.1 tons/ha, NPK was 7.6 tons/ha, cow dung was 7.5 tons/ha and control 6.75 tons/ha. Protein content of plants under poultry was 12.5% while the ash content that depicts the mineral concentration in the plant was 21.2%. These were the highest values observed as well compared to other nutrient sources. In conclusion poultry manure favors the cultivation of amaranth vegetable in terms of yield and proximate composition.

Keywords: Leafy vegetable, manure, growth rate, protein, mineral.

EFFET DES ENGRAIS BIOLOGIQUES ET INORGANIQUES SUR LES PERFORMANCES AGRONOMIQUES ET LA TENEUR EN PROXIMAT DE L'AMARANTH (amaranthus cruentus L.) DANS L'ÉTAT D'OSUN AU NIGÉRIA

Abstrait
L'expérience sur le terrain a été menée en 2017 pendant la saison des cultures sèches à l'Université d'État d'Osun (au Collège d'agriculture, à la ferme d'enseignement et de recherche (Latitude 7˚, 52'37 ˚N et Longitude 4 , 18"3,76 E) Campus d'Ejigbo, Nigéria). Le taux de croissance, le rendement et la composition immédiate d'Amaranthus cruentus L. en fonction des sources de nutriments organiques et inorganiques ont été évalué lors de cette 'étude. Le fumier de volaille et la bouse de vache à 10 tonnes

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/ ha chacun étaient les sources de nutriments organiques utilisées, tandis que l'urée à 50 kg / ha et le NPK à 100 kg / ha étaient les sources de nutriments inorganiques. L'expérience a été réalisée dans un modèle de bloc complet randomisé (RCBD) avec quatre reliquats. Les données ont été prises sur la biomasse fraîche, la matière sèche par semaine et ont été utilisées pour calculer le taux de croissance des cultures, le taux de croissance relatif ainsi que le taux d'assimilation net. Cinq semaines après la plantation, l'amarante a été récoltée et analysée pour le contenu immédiat. La croissance, le rendement et la composition immédiate de l'application de fumier de volaille étaient significativement meilleurs (P ≤ 0,05) par rapport à d'autres sources de nutriments. Le rendement du fumier de volaille était de 9,91 tonnes / ha, l'urée était de 8,1 tonnes / ha, le NPK était de 7,6 tonnes / ha, la bouse de vache était de 7,5 tonnes / ha et le témoin 6,75 tonnes / ha. La teneur en protéines des plantes sous la volaille était de 12,5% tandis que la teneur en cendres qui représente la concentration en minéraux dans la plante était de 21,2%. En conclusion, le fumier de volaille favorise la culture du légume amarante en termes de rendement et de composition immédiate.

Mots clés: Légumes à feuilles, fumier, taux de croissance, protéines, minéraux.

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Introduction

Amanranthus cruentus commonly called amaranth is an African leafy vegetable and the most popularly cultivated in the South Western Nigeria, especially by the rural women, both in the raining season and with irrigation also cultivated in the dry season. It belongs to the family amanranthus cruentus is recognized as possible contributors of both micronutrients and bioactive compounds to the diet of populations in Africa (Smith and Eyzaguirre, 2007).

Amaranth is used mainly as a leafy vegetable, prepared by cooking and consumed as vegetable dish or as an ingredient sauces. The leaves and tender stems are cooked or fried in oil and mixed with meat, fish, cubit seeds, groundnut and palm oil. This is eaten with the main dish of cereals or tubers. The powdered dry leaves are used in sauces during the dry season (Grubbens and Denton, 2004).

The vegetable is a good source of protein, easily cooked and it retains adequate content of several dietary minerals (Costea et al, 2006). Amaranth has excellent nutritional value because of their high content of essential micronutrients such as β-caroten, iron, calcium, vitamin c and folic acid (Priya et. al., 2007).

There are a limited number of studies linking agronomy of Amaranthus cruentus as a leafy vegetable with its nutritional quality and health benefits. There is a global concern as well on the conventional agriculture that utilizes synthetic nutrient source to boost plant growth. This study hence was aimed at evaluating the effects of organic and inorganic nutrient sources on the plant growth, yield and the proximate content of amaranthus cruentus.

Materials and Methods

The study was carried out at Osun State University, College of Agriculture Teaching and Research Farm (Latitude 7, 52'37N and longitude 4, 18'13, 76'E) Ejigbo Campus. The field experiment was carried out during the late cropping season (September – December 2017). The experiment design used was randomized complete block design (RCBD). Nutrient sources used were: N:P:K 15:15:15 fertilizer at 100kg/ha, Urea at 50kg/ha, Poultry manure and Cow dung at 10tons/ha each, all were replicated four times. The organic manure was incorporated into the soil two weeks before planting and wetting was done thoroughly. The total number of experimental beds was 20. *Amaranthus cruentus* seeds were broadcasted on the beds of 2m x 2m at 9g per bed. Weeding was effected manually and data were collected weekly on the biomass weight and dry matter from where the crop growth rate, relative growth rate and net assimilate rate were calculated as follows:

$$\mathbf{CGR} = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

Relative growth rate was calculated as follows:

$$\mathbf{RGR} = \frac{(\ln W_2 - \ln W_1)}{(T_2 - T_1)}$$

Net assimilation rate was calculated as follows:

$$\mathrm{NAR} = \frac{(\ln W_2 - \ln W_1)}{(T_2 - T_1)(W_2 - W_1)}$$

Where: $w1$ = Dry weight of the plant at time $t1$ and
$w2$ =Dry weight of the plant at time $t2$
ln = Natural log,

At 5 weeks after planting, the vegetable was harvested and composite samples on dry weight basis were analyzed for the proximate (Moisture content, Ash content, Crude fiber, Crude protein, Crude fat, Carbohydrates) using Association of Official Agricultural Chemists (AOAC, 1995) methods.

Results

The result of the analysis of the soil of the experimental site is shown in Table 1. The result indicated that pH (H_2O) was 6.57 and pH ($CaCl_2$) was 5.68, organic carbon (%) 1.32, organic matter (%) 2.27, phosphorus (ppm) 35.41 while the particle size of silt, clay and sand were 7.50%, 4.38%, 88.12% respectively. The exchangeable bases (Meg/100g) of Na^+ was 29.52, K^+ 1.07,

Ca^{2+} 6.00, Mg^{2+} 7.20.

The nutritional chemical properties of poultry manure and cow dung indicated that Phosphorus P (%) of poultry was 1.81 and cow dung manure was 0.72. Ca (%) in poultry manure was 4.56 and cow dung 2.37, K (%) poultry manure was 1.38 while cow dung manure was 0.82. The Na (%) of poultry manure was 0.21 while the cow dung manure was 0.13, the N (mg/kg) of poultry manure reads 3.12 and the poultry manure was 1.81 (Table 2).

The result of the Crop growth Rate (CGR) of *Amaranthus cruentus* as influenced by organic and inorganic nutrient sources was presented on Figure 1. The CGR was significantly ($P \leq 0.05$) highest in poultry manure. The CGR (g/m^2/day) of plants under poultry manure, cow dung, urea, NPK and control were 4.9, 3.8, 1.9, 1.5 and 4.8 respectively.

Relative Growth Rate (RGR) of *Amaranthus cruentus* as influenced by the nutrient sources was presented on Figure 2. The same trend of CGR was observed in RGR at $P \leq 0.05$. Plants treated with poultry manure had the highest RGR (3.9g/g/day).

Net Assimilation Rate (NAR) of *Amaranthus cruentus* as influenced by nutrient sources is presented on Figure 3. The NAR was significantly highest in plants treated with poultry manure ($4g/m^2$/day) compared with cow dung, urea, NPK and control.

Nutrient sources' effects on the biomass yield at maturity (5 weeks) is shown on Figure 4. Yield from urea was 8.1 tons/ha, NPK was 7.6 tons/ha, cow dung was 7.5 tons/ha, control 6.75 tons/ha, while the highest was observed in plants that received poultry manure (9.91 tons/ha).

The proximate composition of *Amaranthus cruentus* at 5 weeks after planting as influenced by nutrient sources is presented on Table 4. Protein content of plants under poultry was 12.5% while the ash content that depicts the mineral concentration in the plant under same nutrient source was 21.2%. The highest carbohydrate content (57.4%) was obtained in plants under NPK, moisture content of plants that received cow dung was highest (15%), while fat content was high in urea with 0.97%.

Table 1: Chemical properties of the soil of the experimental site

CHEMICAL PROPERTIES	COMPOSITION
pH (H_2O)	6.57
pH ($CaCl_2$)	5.68
Organic carbon (%)	1.32
Organic matter (%)	2.27
Phosphorus (ppm)	35.41
PARTICLE SIZE	
% Silt	7.50
%Clay	4.38
%Sand	88.12
EXCHANGABLE BASES (Meg/100g)	
Na+	29.52
K+	1.07
Ca2+	6.00
Mg2+	7.20
Textural class	Sandy Loam soil

Table 2: Chemical properties of poultry manure and cow dung

PARAMETERS	POULTRY MANURE	COW DUNG
P%	1.81	0.72
Ca %	4.56	2.37
K %	1.38	0.82
Na%	0.21	0.13
N (mg/kg)	3.12	1.83
Fe (mg/kg)	1.61	1.25
Cu (mg/kg)	0.004	0.002
Zn (mg/kg)	0.013	0.004
Mn (mg/kg)	0.09	0.38

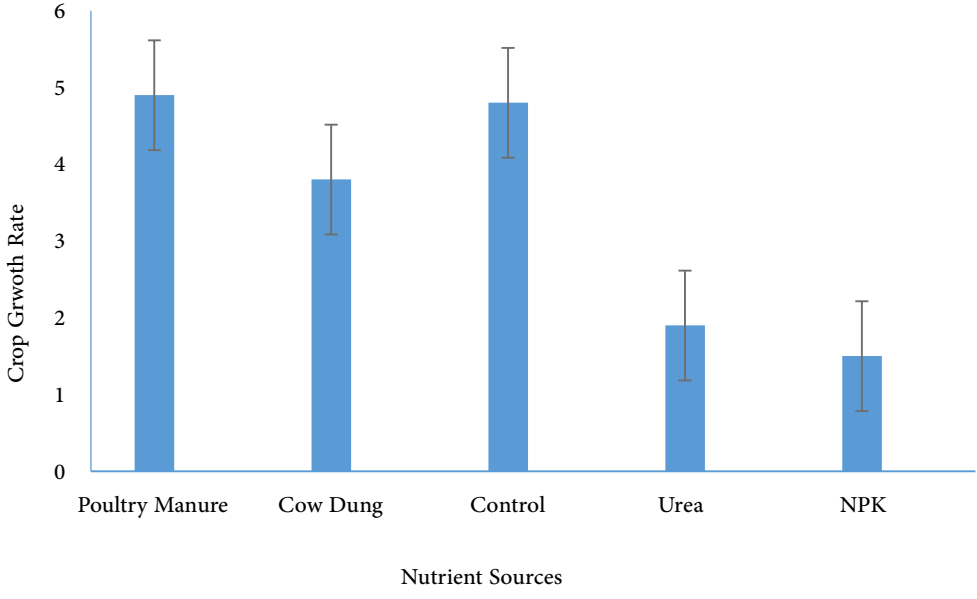

Figure 1: Crop Growth Rate (g/m^2/day) of *Amaranthus cruentus* from 14 days to 35 days of planting

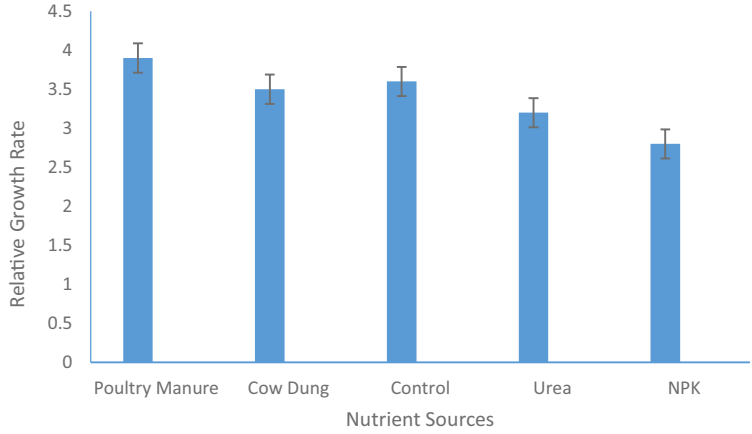

Figure 2: Relative Growth Rate (g/g/day) of *Amaranthus cruentus* from 14 days to 35 days of planting.

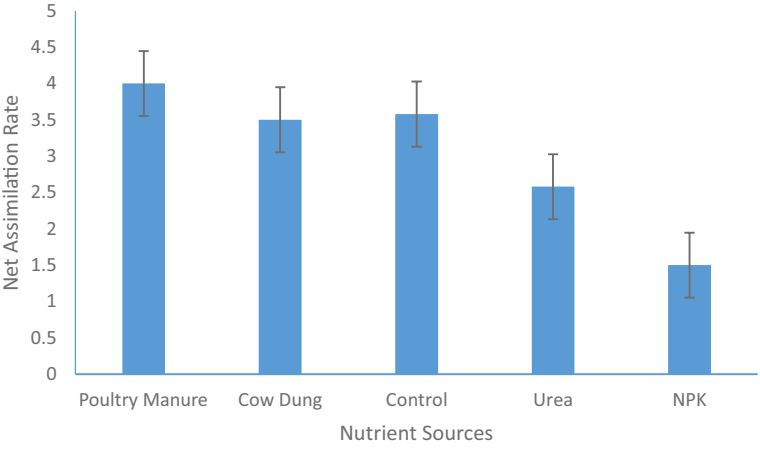

Figure 3: Net Assimilation rate (g/cm^2/day) of *Amaranthus cruentus* from 14 days to 35 days of planting.

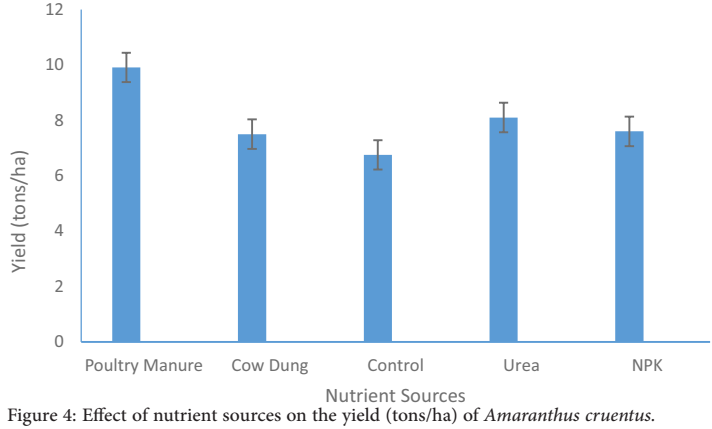

Figure 4: Effect of nutrient sources on the yield (tons/ha) of *Amaranthus cruentus*.

Table 3: Effect of nutrient sources on the proximate content (%) of *Amaranthus cruentus at* week 5 after planting on dry weight basis

	MOISTURE CONTENT	ASH CONTENT	CRUDE FIBRE	CRUDE PROTEIN	CHO	KCAL	FAT CONTENT
Poultry manure	9.9^{b}	21.2^{a}	5^{e}	12.5^{a}	52.3^{c}	221.8^{b}	0.94^{a}
Cow dung	15^{a}	17.5^{c}	6.5^{c}	12.2^{b}	50.6^{d}	2214.9^{c}	0.95^{a}
NPK	8.9^{cd}	16.0^{d}	7.9^{a}	11.7^{c}	57.4^{a}	238.7^{a}	0.94^{a}
Urea	8.4^{d}	19.5^{b}	6.1^{d}	11.8^{c}	55.6^{b}	232.5^{a}	0.97^{a}
Control	9.5^{bc}	16.1^{d}	7.2^{a}	11.9^{c}	56.3^{ab}	236.1^{a}	0.94^{a}
LSD (P<0.05)	0.44	0.29	0.19	0.18	1.25	5.03	0.02

Values with the same letter along the column are not significantly different P< 0.05 from each other

Discussion

Soil analysis showed that the nutrient status of the soil is low in N, P and K. Therefore, crop response to both organic and inorganic nutrients application is expected under such soil conditions (Anikwe *et al.* 1999). The poor fertility status is due to the continuous cultivation of the soil over the years, as a result, most Nigerian soils are deficient in N, P and K which are the three major nutrients needed by plants (Aduayi *et al.* 2002).

Crop growth rate is the rate of dry matter production per plant per unit time. Relative growth rate is the slope of a curve that represents logarithmic growth over a period of time while net assimilation rate directly indicates the rate of net photosynthesis. The overall performance of Amaranth as seen by crop growth rate, relative growth rate and net assimilation rate was good determinant to the plant yield. In this study, application of poultry manure at 10 tons/ha enhanced growth and growth rate of Amaranth. This is expected as seen in the N value of poultry manure. Depletion and or shortage of N indicates that either the crop will not be able to maintain its leaf area expansion rate or cannot maintain its leaf and plant N concentration. Either of this will have negative effects on crop growth (Akanbi *et al*., 2010). Hence N supply by poultry manure in this study increased growth and yield as a result of higher photosynthetic rate brought about by its application. Isah *et al*., (2014), in a similar study on tomato also observed a related trend of increased supply of N nutrient having a positive effect on the crop growth rate.

Application of poultry manure gave highest growth rate compared to the inorganic nutrient sources, this contradicts the findings of Adeyemi *et al*., (1999). This may be due to different rates of application as well as prevailing environmental conditions. However, in all the growth parameter measured and yield, organic manure gave better yield and growth compared to the inorganic nutrient sources, this corroborates studies carried out on the same plant species (Oloyede *et al.,* 2019).

Nitrogen is a fundamental component of amino acids, which are the molecular building blocks of protein, hence measuring nitrogen inputs and losses can be used to study protein metabolism. Protein functions in the formation of cells and repair of worn out tissues in human body. Most of the constituents of the proximate especially the protein content of *A. cruentus* in this study was highest in plants that received poultry manure and this is much expected considering the N value in poultry manure. This was in line with research done by (Olaniyi and Ajibola, 2008) in their study on effect of inorganic and organic fertilizer of tomatoes; they also observed a higher influence of organic manure on the proximate content of tomato compared to the plants that received inorganic fertilizer.

Conclusion and Recommendation

Poultry manure from the result of these studies and at the location where these studies were carried out gave superior growth rate, yield and proximate composition in *A. cruentus.*

Organic nutrient sources both poultry manure and cow dung gave better output in terms of biomass yield and proximate composition of *A. cruentus.*

For optimal growth, yield and proximate composition of *A. cruentus*, poultry manure is recommended.

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Effect of Rates and Duration of Gliricidia Biochar and Poultry Manure on Chemical Properties of Soil in Minna, North Central, Nigeria

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Abstract
Pot experiment was carried out in the screen house of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. The objective of the study was to investigate the effectiveness of different rates and duration of *Gliricidia Biochar* (GB) and Poultry Manure (PM) on some chemical properties of soil sampled every two months in Minna. The treatments consisted of nine rates of GB and PM (control, 10, 20, 30, 40 GB and 10, 20, 30, 40 PM t ha^{-1}) and three duration of sampled at 2, 4 and 6 months and analyzed for their chemical properties. The experiment was a factorial fitted to Complete Randomized Design (CRD) with three replications. Laboratory analysis of soil chemical properties was conducted. All data collected were subjected to ANOVA at 5% level of significant and the means were separated using Duncan Multiple Range Test (DMRT). Irrespective of the rates of application of GB and PM, there was a significant increase in pH, organic carbon, effective cation exchange capacity, total nitrogen and available phosphorus over the control. Also, the results showed a significant increase of the above parameters with the durations of these amendments. No significant interaction existed between the rates and duration of GB and PM application on the above parameters recorded during the experiment.

Keywords: : Gliricidia Biochar, Poultry Manure, Chemical properties, Rates of application

Effect of Rates and Duration of Gliricidia Biochar and Poultry Manure on Chemical Properties of Soil in Minna, North Central, Nigeria

Abstrait
La sensibilisation et la perception des pratiques agricoles respectueuses de l'environnement pourraient être un facteur déterminant de l'adoption de l'agriculture biologique comme moyen de subsistance. La présente étude a examiné les caractéristiques socio-économiques des agriculteurs, les activités de subsistance, ainsi que la sensibilisation et la perception des répondants sur les pratiquesécologiques à Isaga, Abeokuta North Local Government Area of Ogun State, South Western Nigeria (latitude 7,2114 ° N et longitude 3,1378 ° E). La technique d'échantillonnage aléatoire simple a été adoptée dans la sélection de 90 agriculteurs de la zone d'étude. Les données collectées ont été analysées à l'aide des outils de la statistiques descriptive (fréquence et pourcentages) et Pearson Product Moment Correlation (PPMC). L'âge moyen, l'expérience agricole, la taille de l'exploitation et la taille du ménage étaient respectivement de 36 ans, 8 ans, 2 acres et 5 personnes. L'étude a montré que 56% des personnes interrogées avaient une éducation formelle, la majorité (70%) était des agriculteurs de sexe masculin, 62% étaient au courant des pratiques respectueuses de l'environnement par les agents de vulgarisation et 28% pratiquaient une agriculture respectueuse de l'environnement entre 1 et 5 ans. Maintien et durabilité de la fertilité des sols garantis la sécurité des produits alimentaires issus de pratiques respectueuses de l'environnement (x = 3,62, ET ± 1,54), une agriculture respectueuse de l'environnement a augmenté la productivité agricole par le maintien du peuplement biologique du sol (x = 3,56, ET ± 1,73). Une relation significative (p <0,05) existait entre l'âge (r = 0,001), la taille de l'exploitation (r = - 0,01), la taille du ménage (r = - 0,02), l'expérience agricole (r = 0,01) et les pratiques écologiques. L'étude a conclu que les répondants ont une perception positive de l'agriculture écologique. L'étude a

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recommandé qu'un atelier soit organisé pour les agriculteurs par les agences agricoles compétentes en vue de promouvoir un écosystème de qualité et d'accroître la participation à une agriculture respectueuse de l'environnement.

écologiques à Isaga, Abeokuta North Local Government Area of Ogun State, South Western Nigeria (latitude 7,2114 ° N et longitude 3,1378 ° E). La technique d'échantillonnage aléatoire simple a été adoptée dans la sélection de 90 agriculteurs de la zone d'étude. Les données collectées ont été analysées à l'aide des outils de la statistiques descriptive (fréquence et pourcentages) et Pearson Product Moment Correlation (PPMC). L'âge moyen, l'expérience agricole, la taille de l'exploitation et la taille du ménage étaient respectivement de 36 ans, 8 ans, 2 acres et 5 personnes. L'étude a montré que 56% des personnes interrogées avaient une éducation formelle, la majorité (70%) était des agriculteurs de sexe masculin, 62% étaient au courant des pratiques respectueuses de l'environnement par les agents de vulgarisation et 28% pratiquaient une agriculture respectueuse de l'environnement entre 1 et 5 ans. Maintien et durabilité de la fertilité des sols garantis la sécurité des produits alimentaires issus de pratiques respectueuses de l'environnement (x = 3,62, ET ± 1,54), une agriculture respectueuse de l'environnement a augmenté la productivité agricole par le maintien du peuplement biologique du sol (x = 3,56, ET ± 1,73). Une relation significative (p <0,05) existait entre l'âge (r = 0,001), la taille de l'exploitation (r = - 0,01), la taille du ménage (r = - 0,02), l'expérience agricole (r = 0,01) et les pratiques écologiques. L'étude a conclu que les répondants ont une perception positive de l'agriculture écologique. L'étude a recommandé qu'un atelier soit organisé pour les agriculteurs par les agences agricoles compétentes en vue de promouvoir un écosystème de qualité et d'accroître la participation à une agriculture respectueuse de l'environnement.

Mots clés: moyens de subsistance, sources d'informations, perception, écosystème de qualité, agriculture respectueuse de l'environnement.

Introduction

Arable soils of the tropics are degraded quickly physically, chemically and biologically as a result of continuous cropping with persistent use of inorganic fertilizers, increase soil acidity and physical degradation while crop yield may fall. Some of the fertilizers aggravate nutrient imbalance due to lack of soil testing programme (Ojeniyi, 2002). These soils are low in organic matter, basic cations, available phosphorus and total nitrogen. This low level of organic matter has made the soils susceptible to major chemical, physical and biological limitations which reduce crop yields (Jones and Wild, 1975).

The use of organic materials as a source of nutrients is a well established practice among the small farming sector in many countries including Nigeria.

Biochar is a recent organic material used as a soil amendment to improve soil nutrients for crop production. They are produced during a process known as pyrolysis from the thermo-conversion of biomass under little or no oxygen supply for use in soil as an amendment. When biochar is applied to the soil, it increases the soil chemical properties. This is observed in the amount of N retention in the soil, increased organic carbon content, pH cations exchange capacity, decreased exchange acidity, sulphur and zinc (Cheng, *et al*., 2008).

They are produced from a wide variety of feed stocks. *Gliricidia* feedstock for the production of biochar was from *Gliricidia sepium*, a N fixing tree species that grow wildly on fallow lands in the southern and middle belt agro – ecological zones of Nigeria and which does not appear to have any other higher net resources value than to be converted to biochar (Fagbenro, *et al*., (2016).

Poultry manure is also a major organic material that is used by a wide range of the farmers as a soil amendment that provides high nutrient content (N P K) and other essential nutrients (Farhad, *et al*, 2009). When compared with chemical fertilizers, it also add organic matter to the soil to improve soil structure, aeration, soil moisture holding capacity and water infiltration rates (Nguyen, 2010). Increase in soil nitrogen and phosphorus was reported by (Thomas and Aluko, 2016) as the rates of application of poultry, goat and dairy cow manures increases.

Therefore, the objective of the study was to investigate the effectiveness of different rates and duration of *Gliricidia* Biochar (GB) and Poultry Manure (PM) on some chemical properties of soil in Minna.

Results and Methods

A pot trial was conducted at the screenhouse of the Department of Soil Science and Land Management, Federal University of Technology, Minna (Latitude 9053'N and Longitude 6045'E). Minna falls under the Southern Guinea Savannah agro – ecological zone of Nigeria. The climate of the area is sub – humid tropical with Mean Annual Rainfall of about 1284 mm with the Mean Maximum Temperature of around 35.5^{o}C (Ojanuga, 2006). The soil used in the pot trial was collected from the Teaching and Research Farm of Federal University of Technology, Minna at the depth of 0 – 20cm using soil auger. The soils were air dried, crushed and sieved through 2mm mesh and the pre-treatment analysis carried out (Table 1).

The treatment consisted of: (i) control (no amendment), four rates of *Gliricidia* biochar (GB), (10, 20, 30 and 40 t ha^{-1}) and four rates of Poultry manure (PM) (10, 20, 30 and 40 t ha^{-1}). (ii). Three sampling duration (2, 4 and 6 months after the establishment of the experiment). The experiment was a 9 x 3 factorial fitted to Completely Randomized Design (CRD) with three replications.

Two kilogram of soil samples thoroughly mixed with the amendments was weighed into eighty one poly pots (drainage holes were earlier made on each of the poly pot but covered with lining materials before filling with the soil). And on weekly basis, the soil columns were wetted with 700 ml of water. Five hundred

grams soil sample were collected at interval of 2 months after the establishment of the experiments.

Soil samples were air-dried and gently crushed to pass through 2 mm and 0.5 mm sieve. pH values of the samples were determined in 1.0N $CaCl_2$ solution using a soil - solution ratio of 1:2.5 (McLean, 1982). Organic carbon was determined by the Walkley-Black wet oxidation method (Allison, 1965). Exchangeable basic cations were extracted with neutral 1N NH_4OAc with potassium (K) and sodium (Na) determined by flame photometry and calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometry. Exchange acidity was determined by shaking the samples with 1.0 M KCl and titrating them with 0.1 M NaOH. Available P was determined by the Bray P1 method (Bray and Kurtz, 1945). Effective cations exchange capacity was obtained by summation of the exchangeable basic cations. Total nitrogen (TN) was determined by the micro Kjeldhahl method.

The data generated was subjected to analysis of variance (ANOVA) at 5 % level of significance, while the means were separated using Duncan Multiple Range Test (DMRT).

Results and Discussions

The properties of the soil before the application of the treatment (Table 1) shows that the soil was sandy loam in texture with 668 gkg^{-1}, 160gkg^{-1} and 172gkg^{-1} of sand, silt and clay respectively. The soil is moderately acidic in reaction and low in organic carbon (8.24 gkg^{-1}), total nitrogen (0.45gkg^{-1}) and available phosphorus (8.89$mgkg^{-1}$). These values and the others in Table 1 imply that the soil used for the trial was low in fertility. Jones and Wild (1975) reported that low to medium organic carbon rate for savanna soil was attributed to paucity of vegetation cover, rapid mineralization of organic matter, inadequate return of crop residue, bush burning and short fallow periods.

In Table 2, the result shows that all the treatments applied increased the soil pH more than the control. However, the increment of pH when 10tha^{-1} was not significant, but the significant increase was observed as the rates of application increases for both GB and PM. It was also observed that there was a significant difference in pH as the duration increases. When organic materials are applied to the soil, basic cations are released which will certainly improved the base saturation of the soil and thereby reducing the soil acidity. Soil reaction is an important factor in controlling the nutrient availability and processes that take place in the soil (Onwuka and Nwangu, 2016).

Results for the organic carbon (OC) and total nitrogen (TN) (Table 2) shows that there is a significant increase in both OC and TN content of the soil as the rates of application of GB and PM increases. It was further observed that the TN increases with the OC simultaneously. This could be due to the fact that organic matter is the major source of N in the soil. Higher OC and TN of the treated soil over non treated confirm the fact that GB and TN is an excellent source of soil amendment providing both organic matter and N. It could also be attributed to the presence of N P and K contained in the GB and PM. The positive effect of biochar may be due to a number of factors which may include gradual abiotic and biotic oxidative release of nutrients and humic substances contained in the biochar (Chan *et al*., 2008;Fagbenro *et al.*, 2016).

The level of available phosphorus (Table 2) increased significantly with the addition of GB and PM over the control and observed that there is a greater increase at different levels of their application. The increase in N and P after the application of GB and PM could be as a result of increase in microbial activities which could aid the decomposition of organic forms of N and P in the soil (Uwah *et al*., 2014). The level available P is also observed to be dependent of the duration.

Effective Cation Exchange Capacity (ECEC) in Table 2 reveals that there is a significant increase as both GB and PM were added. The increment was observed to be significantly consistence as the rates of these amendment increases. This was corroborated by Mbah and Mbagwu (2006) and Thomas and Aluko (2016) that reported an increase in ECEC after the application of PM which was further attributed to the availability and adequate supply of organic matter. The ECEC of the soil increases significantly as the duration increases.

Generally, it was observed that all the chemical parameters recorded increased as the duration increases. The increment of these chemical constituents with duration could be attributed to the fact that the nutrients contained in organic materials are slowly released over time as also reported by Onwuka and Nwangu (2016).

Table 1: Physical and chemical properties of the soil before treatment

Parameters	Values
Particle size (g kg^{-1})	
Sand	668
Silt	160
Clay	172
Textural Class	Sandy loam
pH(H_2O)	5.86
pH($CaCl_2$)	5.52
Organic Carbon (g kg^{-1})	8.24
Total Nitrogen	0.45
Avail. Phosphorus (mg kg^{-1})	8.89
Exchangeable bases (Cmol kg^{-1})	
Ca^{2+}	4.23
Mg^{2+}	1.52
Na^{+}	0.43
K^{+}	0.78
ECEC	4.77

Source: Field work, 2018

Total Nitrogen	0.45
Avail. Phosphorus (mg kg^{-1})	8.89
Exchangeable bases (Cmol kg^{-1})	
Ca^{2+}	4.23
Mg^{2+}	1.52
Na^{+}	0.43
K^{+}	0.78
ECEC	4.77

Source: Field work, 2018

Table 2: Effect of rates and durations of GB and PM on selected soil chemical properties

Rate (R) (t ha^{-1})	pH ($CaCl_2$)	Org, Carbon (g kg^{-1})	Total Nitrogen (g kg^{-1})	Available phosphorus (mg kg^{-1})	ECEC (Cmol kg^{-1})
0	5.52^{bc}	8.20^{d}	0.39^{c}	8.99^{c}	4.62^{c}
10 GB	$5,87^{b}$	10.55^{c}	0.77^{b}	10.69^{b}	6.88^{b}
10 PM	5.94^{b}	10.03^{c}	0.68^{bc}	$10,98^{b}$	6.76^{b}
20 GB	6.33^{ab}	10.98^{c}	0.74^{b}	13.75^{b}	6.97^{b}
20 PM	$6,42^{ab}$	12.45^{bc}	0.82^{ab}	13.44^{b}	7.11^{b}
30 GB	6.85^{a}	14.98^{b}	0.94^{a}	$15,58^{ab}$	13.65^{ab}
30 PM	6.72^{a}	16.66^{b}	0.95^{a}	17.32a	12.98^{ab}
40 GB	6.82^{a}	20.42^{a}	0.97^{a}	22.16^{a}	16.85^{a}
40 PM	6.85^{a}	18.87^{ab}	0.94^{a}	21.68^{a}	17.77^{a}
SE	0.61	1.19	0.17	4.24	4.34
Duration(D)					
2 Months	5.88^{b}	11.24^{b}	0.74^{b}	9.11^{c}	8.43^{b}
4 Months	6.38^{a}	18.33^{a}	0.79^{b}	14.67^{b}	16.96^{a}
6 Months	6.79^{a}	18.86^{a}	$0,96^{a}$	22.33^{a}	16.75^{a}
SE	0.27	1.62	0.11	2.01	0.35
Interaction R*D	NS	NS	NS	NS	NS

Source: Field Work, 2018

Means with the same letter in a column are not significantly different at 5%. ECEC = Effective Cations Exchange Capacity. NS = Not significant at 5%

Two kilogram of soil samples thoroughly mixed with the amendments was weighed into eighty one poly pots (drainage holes were earlier made on each of the poly pot but covered with lining materials before filling with the soil). And on weekly basis, the soil columns were wetted with 700 ml of water. Five hundred

Conclusion

The results of this study have shown that the addition of organic materials such as *Gliricidia* Biochar and Poultry Manure greatly improved the chemical properties of the soil. From the study, application of beyond 20tha^{-1} is thus recommended. It can also be concluded and recommended that farmers should apply these organic materials not less than two months before cultivation so as to achieve the full benefits of the application in terms of the release of the nutrients.

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Comparative Effects of Rice Bran Compost and Urea Fertilizer on The Growth, Yield and Nutrient Concentration of Amaranthus Cruentus

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Abstract

Pot experiment was conducted to evaluate the effects of rice bran compost (RBC) and urea (U) fertilizer on the growth and yield of *Amaranthus cruentus*. The experimental design was a completely randomized design consisting of seven treatments and four replicates. The treatments were: control, RBC at 120 kg N ha^{-1} (RBC120) and 60 kg N ha^{-1} (RBC60), urea at 120 kg N ha^{-1} (U120) and 60 kg N ha^{-1} (U60), RBC (60 kg N ha^{-1}) plus urea (60 kg N ha^{-1}), (RBC60U60) and RBC (30 kg N ha^{-1}) plus urea (30 kg N ha^{-1}), (RBC30U30) using 5 kg soil per pot. The planting was done twice. Six weeks after planting, plants treated with (RBC30U30) had 38.75 cm plant height which was significantly higher than the control (24.10 cm). However, sole application of RBC120 gave the significant plant height (20.00 cm) in the second planting while the control was (8.38 cm). The stem diameter shows similar trend. RBC60 had the highest significant fresh yield (26.35 g plant^{-1}) compared with the control (9.24 g plant^{-1}) in the first planting. However, RBC120 gave the highest yield (10.45 g plant^{-1}) in the second planting but was not significantly different from the control (4.29 g plant^{-1}). Thus, application of (RBC30U30) appeared to be the best amongst the treatments for the growth of *Amaranthus* while for the yield, sole application of RBC60 or RBC120 is enough for the production of *Amaranthus* in this area.

Keywords: : Amaranthus, rice bran compost, urea, growth and yield.

EFFETS COMPARATIFS DU COMPOST DE SON DE RIZ ET DES ENGRAIS D'URÉE SUR LA CROISSANCE, LE RENDEMENT ET LA CONCENTRATION EN NUTRIMENTS D'AMARANTHUS CRUENTUS

Résumé

L'expérience en pot a été menée afin d'évaluer les effets du compost de son de riz (RBC) et de l'urée (U) sur la croissance et le rendement d'Amaranthus cruentus. Le dispositif expérimental était un dispositif complètement aléatoire composé de sept traitements et quatre répétitions. Les traitements étaient: contrôle, RBC à 120 kg N ha-1 (RBC120) et 60 kg N ha-1 (RBC60), urée à 120 kg N ha-1 (U120) et 60 kg N ha-1 (U60), RBC (60 kg N ha-1) plus urée (60 kg N ha-1), (RBC60U60) et RBC (30 kg N ha-1) plus urée (30 kg N ha-1), (RBC30U30) en utilisant 5 kg terre par pot. La plantation a été faite deux fois. Six semaines après la plantation, les plants traités avec (RBC30U30) avaient une hauteur de 38,75 cm, significativement

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plus élevé que le témoin (24,10 cm). Cependant, seul le traitement RBC120 a donné une hauteur significative de la plante (20,00 cm) dans la deuxième plantation alors que le témoin était (8,38 cm). Le diamètre de la tige montre une tendance similaire. Le RBC60 avait le rendement frais significatif le plus élevé (26,35 g plante-1) par rapport au témoin (9,24 g plante-1) lors de la première plantation. Cependant, RBC120 a donné le rendement le plus élevé (10,45 g plante-1) dans la deuxième plantation non significativement différente du témoin (4,29 g plante-1). Ainsi, l'application de (RBC30U30) semble être le meilleur parmi les traitements pour la croissance des Amaranthus tandis que pour le rendement, la seule application de RBC60 ou RBC120 suffit pour la production d'Amaranthus dans cette zone.

Mot-clé: Amaranthus, compost de son de riz, urée, croissance et rendement.

Introduction

Amaranthus cruentus commonly known as Amaranth belongs to the family Amaranthaceaece. It is a leafy vegetable commonly cultivated in Nigeria and other part of the world. It has a short gestation period of 5-6 weeks enabling the rural and peri-urban farmers in Nigeria to cultivate it as many times as possible within the cropping season (Adewole and Igberaese, 2011).

The current high demand for vegetable in the cities and towns has stimulated the growth and market gardening along perennial rivers and streams in major towns and cities in Nigeria. Some farmers rely on irrigation water from streams, wells and borehole to cultivate vegetable all year round. Organic production of vegetables has become good source of employment for young school leavers and are also preferred in quality to conventional ones (Dipeolu, et al., 2009).

Amaranthus has received considerable research attention in many countries because of high nutritional value of some species that are important source of food as vegetable or grain (Dada et al., 2017). Thus, grain Amaranth and many other Amaranthus species show tremendous potential for human consumption and other uses and are particularly promising as a remedy for hunger and malnutrition in developing countries (Iren, et al., 2016; Dada et al., 2017).

Amaranthus species is an important vegetable in human diet as a source of nutrient such as vitamin, mineral, sugar protein and fiber needed for healthy body growth and sustenance (Bailey, 1992). It is grown as soup vegetable or for boiled as greens, (Adeyemi et al., 1987). The nutrient values of Amaranthus include its high levels of essential micro-nutrient like iron (an important element against anaemia), manganese and zinc (Mnkeni et al., 2007). It is also known to be rich in Ca, Mg, carotene, niacin as well as vitamin A and C. *Amaranth* seed is high in protein (15-18%) and contains respectable amount of lysine and methionine, two essential amino acids that are not frequently found in other grains. Lysine plays a vital role in the treatment and prevention of a disease known as "osteoporosis" that makes bones prone to fracture (Pisarikova *et al*., 2005).

Most Africans soils are inherently low in organic carbon, slightly acidic and relatively sandy. Studies by (Ayoola and Adeniyan, 2006), revealed that the use of inorganic fertilizer alone has not been helpful in Agriculture. Adeoye *et al*. (2005) had advocated the use of properly amended manures to the resource – poor – farmer for the cultivation of another popular *Amaranth* leafy vegetable in Nigeria.

The use of manure and urea fertilizer for production of *Amaranthus* has been reported to promote vegetative growth and impact the characteristic of deep green color essential for photosynthesis (Futuless and Bagale, 2007). Moreover, use of inorganic fertilizer to increase yield has been found to be effective only within few years, demanding consistent use on long term basis (Ojeniyi *et al.,* 2009). The hazardous environmental consequences and high cost of inorganic fertilizers make them not undesirable but also uneconomical and out of reach of the poor farmers (Shigam and Binang, 2013). This has led to increased use of organic manure, a readily available alternative, which proves more environmentally friendly.

In addition, complementary use of organic and in-organic fertilizers has been proved to be a sound soil fertility management strategy (Law Ogbomo *et al.,* 2011). Organic fertilizer fortified with in-organic materials may be formulated to replenish the soil and improve plant fertilization. It releases nutrients in soils in the form that plants can easily absorb and it can activate soil micro-organisms and increase microbes which will help the decomposition processes of organic matter. This will promote higher plant growth, healthier crops and better fruit yield. It reduced the use of chemical fertilizer, which will lead to lower production cost and in turn increases income (Worthington, 2011).

Therefore, the objective of this study is to evaluate the effect of rice bran compost and urea fertilizer on the growth and yield of *Amaranthus cruentus* in Igboora, Ibarapa area of Oyo State.

Materials and Methods

Location

The study was carried out in the Department of Agricultural Technology screen house of the Oyo State College of Agriculture and Technology, Igboora (Latitude 7^{0} 40 N and Longitude 3^{0} 30 E) between June and August, 2017.

Soil Sampling

Surface soil samples (0 – 15cm depth) were collected from the experimental site of Agricultural Technology department for the screen house experiment. The samples collected were bulked to form a composite sample, which was air dried and sieved. A

portion was kept for the soil analysis while the rest was weighed into buckets for the pot experiment.

Soil Analysis

Soil pH (1:2) in water was determined by glass electrode pH meter (IITA, 1982). Organic carbon was determined by chromic acid oxidation method (Walkley and Black, 1934). Total N was by the regular macro kjeldahl procedure. Available P was by Bray – 1 P method and P content determined colorimetrically from spectrophotometer using ammonium molybdate method (Bray and Kurtz, 1945). Exchangeable bases (Ca, Mg, K and Na) were extracted using 1 N neutral ammonium acetate solution. Sodium and Potassium in the extract were determined using flame photometer, while Calcium and Magnesium were determined using atomic absorption spectrophotometer (AAS). Particle size analysis was done using hydrometer method (Bouyoucos, 1945). The percent of sand, silt and clay of the soil were used to determine the textural class using USDA textural triangle.

Experimental Design

The experiment was laid out in a completely randomized design (CRD) with four replicates. The treatments include the control, rice bran compost (RBC) applied at 60 and 120 kg N ha^{-1}, urea at 60 and 120 kg N ha^{-1}, (RBC) at 30 kg N ha^{-1} plus urea at 30 kg N ha^{-1} and (RBC) at 60 kg N ha^{-1} plus urea at 60 kg N ha^{-1}. The RBC used for the experiment was a combination (ratio 2:1) of rice bran and poultry manure in order to increase the nutrient concentration of the rice bran particularly the N. The RBC compost contained 0.794 % N. Thus there were twenty eight greenhouse buckets in all. Rice bran compost was applied two weeks before sowing so as to allow mineralization to take place. The fertilizer was mixed with 5 kg soil inside the greenhouse buckets.

The *Amaranthus* seed were sown into the greenhouse buckets and later thinned to 2 plants per bucket after 10 days of sowing, the variety planted was NHAC3 – A from NIHORT, Ibadan.

The plants were watered when necessary throughout the period of experiment, and the experiment was carried out twice. Each cycle of the experiment was for a period of six weeks.

Agronomic Data Collected

The agronomic parameter taken on the plants include plant height using a meter rule and stem girth with the aid of Vernier caliper at 2, 3, 4, 5, and 6 weeks after sowing, number of leaves per plant was also taken by counting the leaves at 2, 3, 4, 5, and 6 weeks after sowing.

Fresh shoot weight was also measured using a sensitive weighing balance in the laboratory. The shoot was also oven dried at 65 ^{0}C inside the oven until it reaches constant moisture content to obtain dry shoot weight.

Data Analysis

All the data collected were subjected to analysis of variance (ANOVA) using statistical package DSAASTAT ver 1.101 (2011) and treatment means separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

Chemical and physical properties of the soil used for the experiment

The chemical properties of the soil used for the experimented is given in Table 1. The result of the analysis shows that the soil is slightly acidic with a pH value of 6.47. The exchange site of the soil is dominated by Ca ion (3.98 cmol kg^{-1}). The total nitrogen (N) and available phosphorus of the soil are also low and below the critical values (Adeoye and Agboola, 1985; Adeoye, 1986), and hence needed additional inputs of nutrients particularly N. The textural class of the soil is sand according to USDA textural triangle.

Effect of urea and rice bran compost (RBC) on the *Amaranthus* plant (cm)

The results in Table 2 show the effects of urea fertilizer and RBC on the *Amaranthus* planted. Application of urea fertilizer and RBC increased the growth of *Amaranthus* throughout the period of planting. It was observed that combined application of urea at 30 kg ha^{-1} and RBC at 30 kg ha^{-1} gave the tallest plant height of 21.05 cm after 3 weeks of planting. This value was significantly higher than that of the control (8.68 cm) at 5% level of probability. Similar trend was observed after 6 weeks of planting. The highest plant heights obtained from the treatments suggests plants from these pots received better nutrition as a result of the treatments applied compared to the control which derived its nutrients mainly from the native nutrients present in the soil used for the experiment. Similar observation have been reported by Iren *et al.* (2016) who reported positive response of Amaranthus to nutrients addition over that of the control.

The residual effects of the treatments on the growth of Amaranthus showed that application of RBC at 120 kg ha^{-1} performed better than the control throughout the period of the experiment. There was an increase in the height of the plant from week 3 up to week 6 of planting. The ability of the RBC to perform better than the control and even other treatments where urea fertilizer was applied may be due to the slow release nature of nutrients from organic materials compared to mineral source of fertilizers. The effectiveness of manure to improve the second cropping of *Amaranthus* have been reported by Adewole and Dedeke (2012).

Effects of urea fertilizer and rice bran compost (RBC) on the stem diameter of *Amaranthus* (cm)

The result in Table 3 shows the effect of urea and rice bran compost (RBC) on the stem diameter of *Amaranthus* planted. The results show that both RBC and urea fertilizer improved the plant width throughout the period of the experiment. However, application of RBC at 60 kg ha^{-1} gave the highest *Amaranthus* width of 2.66 cm which was significantly higher than the value obtained in pots with no treatment (1.76 cm) at six weeks after planting. The second planting revealed that all the treatments performed than the control. It is important to note that application of RBC at 120 kg ha^{-1} gave the highest value of stem diameter throughout the period of planting except at week four. The values for week 3, 4, 5 and 6 are in the order of 0.68, 1.18, 1.79 and 1.94 cm respectively. These values were significantly better than that of the control. The ability of the RBC to perform better than the urea fertilizer even in the second planting affirmed the residual effectiveness of compost compared to mineral fertilizers.

Effects of urea fertilizer and rice bran compost (RBC) on the number of leaves of *Amaranthus*

Table 4 shows the effect of urea fertilizer and rice bran compost (RBC) on the number of leaf. The results showed that combined application of urea at 30 kg ha^{-1} and RBC at 30 kg ha^{-1} produced

the highest number of leaf (12) and (14) for week 2 and 3, respectively. In contrast, highest number of leaf was recorded from pots that received RBC at 60 kg ha^{-1} at week 5 and 6 after planting. All these values were significantly higher that of the control throughout the first planting.

The residual effects of urea and RBC application showed that the leaf number of *Amaranthus* increased greatly with application of RBC at 60 kg ha^{-1} except at week 4 after planting in the second planting. It is important to also note that application of RBC at 60 kg ha^{-1} (15) performed significantly better than sole application of urea both at 60 and 120 kg ha^{-1} with values of 12 and 14, respectively after 6 weeks of planting.

Effects of urea fertilizer and rice bran compost (RBC) on the yield of *Amaranthus* (g plant^{-1})

The result in Table 5 shows the effects of urea fertilizer and rice bran compost on the yield of *Amaranthus* planted. The highest fresh shoot weight was obtained from pots that received application of RBC at 60 kg ha^{-1} (26.35 g plant^{-1}) while the combined application of urea at 30 kg ha^{-1} and RBC at 30 kg ha^{-1} (3.08 g plant^{-1}) gave the highest dry shoot weight. These values were significantly higher than all other treatments including the control. The effectiveness of RBC in producing the highest yield of *Amaranthus* further confirmed the potential of organic materials in soil fertility management as reported by Agboola and Obatolu (1990).

The residual effects of the treatments on the yield of *Amaranthus* showed that application of RBC at 120 kg ha^{-1} gave the highest fresh shoot yield value of 10.45 g plant^{-1} and dry yield value of 1.47 g plant^{-1}. These values were higher than all other treatments including the control though not significantly different. This trend confirmed that application of organic materials have ability to support the yield of plant up to the second planting because of the slow release nature of the materials compared to inorganic materials.

Effect of urea fertilizer and rice bran compost (RBC) on the N, P and K concentration of *Amaranthus*

The result of the nutrient concentration (N, P and K) of *Amaranthus* is shown in Table 6. The nitrogen concentration in *Amaranthus* was highest in the application of urea at 120 k gha^{-1} with a value of 0.82%. This value is significantly higher than the control and other treatments. The lowest value of 0.51% was given by the application of RBC at 120 k gha^{-1} at 5% level of probability. The highest value of N observed from plants that received inorganic urea may be due to quick release nature of the nutrient in the urea fertilizer unlike the compost.

The application of RBC 60 k gha^{-1} gave the highest potassium concentration of 6.98%. This value is significantly higher than the control (5.85%) and other treatments at 5% level of probability. However, there was no significant difference amongst the treatments in terms of P concentration.

Conclusion

The study has revealed that addition of rice bran compost and urea fertilizer could improve the *Amaranthus* growth as well as the yield of *Amaranthus*. However, RBC appeared to be more superior among all the sources of fertilizer used in this study even up to the second planting. In addition, application of urea at RBC at 60 kg ha^{-1} as well as the combined application of urea at 30 kg ha^{-1} and RBC at 30 kg ha^{-1} appeared superior in terms of fresh and dry matter yields of *Amaranthus* after the first planting while application of RBC at 120 kg ha^{-1} will give the highest yield even up to second planting. This means that application of RBC at this rate could support the yield of *Amaranthus* even up to second planting.

Table 1: Chemical and physical properties of the soil used for the experiment

Parameter	Value
pH (H_2O)	6.47
Sand (%)	93.20
Silt "	4.00
Clay "	2.80
Ca (cmol kg^{-1})	3.98
Mg "	1.24
Na "	0.61
K "	0.58
Al + H "	0.11
ECEC "	6.52
Base saturation (%)	98.31
Total N (%)	0.15
Total organic Carbon	4.03
Av. P (mg kg^{-1})	5.39
Mn "	58.10
Fe "	8.75
Cu "	1.71
Zn "	4.16
Textural class	Sand

Table 2 : Effects of urea fertilizer and rice bran compost (RBC) on the height of *Amaranthus* plant (cm)

	Weeks of Planting			
Treatments	3	4	5	6
		First Planting		
CTR	8.68b	11.45b	18.00b	24.10b
RBC60	15.40ab	20.71a	30.53a	36.56a
RBC120	18.10a	23.18a	30.10a	35.53a
U60	16.90a	20.03a	26.08ab	30.03ab
U120	16.80a	20.16a	28.08a	34.00ab
RBC30U30	21.05a	25.76a	32.94a	38.75a
RBC60U60	19.73a	23.79a	29.04a	33.73ab
		Second Planting		
CTR	3.19c	4.03c	5.63b	8.38b
RBC60	5.75ab	8.40ab	16.26a	18.81a
RBC120	7.00a	11.69a	18.00a	20.00a
U60	4.44bc	8.88ab	14.36ab	16.80a
U120	3.56bc	6.50bc	11.44ab	14.75ab
RBC30U30	5.50ab	9.44ab	16.28a	13.38a
RBC60U60	5.19abc	9.06ab	14.00a	17.13a

Means followed by the same letter are not significantly different from others at 5% level of probability using DMRT .

NOTE: CTR = Control, RBC = Rice bran compost and U = Urea

Table 3: Effects of urea fertilizer and rice bran compost (RBC) on the stem diameter of *Amaranthus* (cm)

Treatments	Weeks of Planting			
	3	4	5	6
	First Planting			
CTR	2.06a	1.20b	1.71b	1.76b
RBC60	2.21a	2.03a	2.58a	2.66a
RBC120	2.24a	1.80ab	2.20ab	2.25ab
U60	2.20a	1.80ab	1.98ab	2.14ab
U120	2.30a	1.73ab	2.00ab	2.23ab
RBC30U30	2.18a	1.86ab	2.31ab	2.40ab
RBC60U60	2.24a	2.00a	2.23ab	2.43ab
	Second Planting			
CTR	0.21c	0.23c	0.44b	0.68b
RBC60	0.51ab	0.90abc	1.49a	1.70a
RBC120	0.68a	1.18ab	1.79a	1.94a
U60	0.48abc	1.71a	1.148a	1.85a
U120	0.33bc	0.75bc	1.25a	1.63a
RBC30U30	0.56ab	0.93abc	1.48a	1.46a
RBC60U60	0.48abc	0.93abc	1.35a	1.79a

Means followed by the same letter are not significantly different from others at 5% level of probability using DMRT.
NOTE: CTR = Control, RBC = Rice bran compost and U = Urea

Table 4: Effects of urea fertilizer and rice bran compost (RBC) on the number of leaves of *Amaranthus*

Treatments (kg ha^{-1})	Weeks of Planting			
	3	4	5	6
	First Planting			
CTR	8.b	10b	13b	15c
RBC60	10ab	14ab	17a	20a
RBC120	11ab	12ab	15ab	17abc
U60	10ab	11ab	14ab	16bc
U120	10ab	11ab	15ab	17abc
RBC30U30	12a	14a	16ab	19ab
RBC60U60	11ab	13ab	15ab	18ab
	Second Planting			
CTR	4c	5c	6b	8d
RBC60	8a	12a	15a	15a
RBC120	8a	12a	13a	13abc
U60	7ab	10b	11a	12c
U120	6bc	9b	12a	14ab
RBC30U30	8a	11ab	13a	12bc
RBC60U60	7ab	11ab	12a	15a

Means followed by the same letter are not significantly different from ot hers at 5% level of probability using DMRT.
NOTE: CTR = Control, RBC = Rice bran compost and U = Urea

Table 5: Effects of urea fertilizer and rice bran compost (RBC) on the yield of *Amaranthus* (g plant^{-1})

Treatments (kg ha^{-1})	Fresh Shoot Weight	Dry Shoot Weight
	First Planting	
CTR	9.24b	0.89b
RBC60	26.35a	3.00ab
RBC120	16.70ab	2.51.ab
U60	16.18ab	2.45ab
U120	20.04ab	2.45ab
RBC30U30	19.76ab	3.08a
RBC60U60	17.75ab	2.89ab
	Second Planting	
CRT	4.29a	0.53a
RBC60	9.25a	1.43a
RBC120	10.45a	1.47a
U60	6.63a	0.92a
U120	6.41a	0.85a
RBC30U30	8.17a	1.08a
RBC60U60	8.38a	0.98a

Means followed by the same letter are not significantly different from others at 5% level of probability using DMRT.
NOTE: CTR = Control, RBC = Rice bran compost and U = Urea

Table 6: Effect of urea fertilizer and rice bran compost (RBC) on nutrient concentration of *Amaranthus* (N, P and K)

Treatments (kg ha^{-1})	N (%)	P (mg kg^{-1})	K (%)
CTR	0.66 ab	730.64 a	5.85 b
RBC60	0.69 ab	730.63 a	6.98 a
RBC120	0.51 b	383.81 a	6.20 ab
U60	0.65 ab	485.55 a	6.59 ab
U120	0.82 a	702.89 a	6.44 ab
RBC30U30	0.80 a	591.91 a	6.48 ab
RBC60U60	0.55 b	393.06 a	6.16 ab

Means followed by the same letter are not significantly different from others at 5% level of probability using DMRT.
NOTE: CTR = Control, RBC = Rice bran compost and U = Urea

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Factors affecting Land Management Practices and Soil conservation Methods among Maize Farmers in Ogun State, Nigeria

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Abstract

The study examined the determinants of various land management practices and conservation methods on maize farmers' output in Ogun state, Nigeria. Multistage sampling technique was used to select 240 maize farmers in the study area. Interview schedule was used to elicit needed information such as age, land conservative/management practice and production characteristics of maize farmers in the study area. Data were analyzed using descriptive statistic and stochastic production function (SPF). The result revealed that 70.8%, 70.5% and 89.2% were male, married and literate respectively with mean household size estimated at 4 persons. About 33.0%, 9.2% and 1.0% adopted planting cover crop, mulching and fertilizer application respectively as means of land management practices while 28.3% and 48.3% of the farmers adopted crop rotation and mixed cropping as land conservation practices. SPF showed that farm size ($p<0.01$), labour ($p<0.01$), land management practice ($p<0.01$) and land conservation practice ($p<0.01$) have a significant influence on maize production in the study area. The study concluded that land management and land conservation practices were determinant factors in maize production. The study recommended that researcher-farmer interaction be encouraged and more awareness on quality farm management practices be created to improve maize production.

Keywords: : Land Management, Stochastic Production Function, Cover crops

Facteurs affectant les pratiques de gestion des terres et les méthodes de conservation des sols chez les producteurs de maïs de l'État d'Ogun, Nigéria

Résumé

L'étude avait pour but d'examiné les déterminants de diverses pratiques de gestion des terres et méthodes de conservation de la production des producteurs de maïs dans l'État d'Ogun, au Nigéria. Une technique d'échantillonnage à plusieurs degrés a été utilisée pour sélectionner 240 producteurs de maïs dans la zone d'étude. Le calendrier des entretiens a été utilisé pour obtenir les informations nécessaires telles que l'âge, les pratiques de conservation / gestion des terres et les caractéristiques de production des producteurs de maïs dans la zone d'étude. Les données ont été analysées à l'aide des statistiques descriptives et d'une fonction de production stochastique (SPF). Le résultat a révélé que 70,8%, 70,5% et 89,2% étaient respectivement de sexe masculin, mariés et alphabétisés, la taille moyenne du ménage étant estimée à 4 personnes. Environ 33,0%, 9,2% et 1,0% ont adopté respectivement la culture de couverture végétale, le paillage et l'application d'engrais comme moyens de gestion des terres, tandis que 28,3% et 48,3% des agriculteurs ont adopté la rotation des cultures et les cultures mixtes comme pratiques de conservation des terres. Le SPF a montré que la taille de

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l'exploitation (p <0,01), la main-d'œuvre (p <0,01), les pratiques de gestion des terres (p <0,01) et les pratiques de conservation des terres (p <0,01) ont une influence significative sur la production de maïs dans la zone d'étude. L'étude a conclu que la gestion des terres et les pratiques de conservation des terres étaient des facteurs déterminants dans la production de maïs. Au regard des résultats de cette étude, il est recommandé que l'interaction chercheur-agriculteur soit encouragée et qu'une plus grande sensibilisation aux pratiques de gestion agricole de qualité soit créée pour améliorer la production de maïs.

Mots clés: Gestion des terres, Fonction de production stochastique, Cultures de couverture

Introduction

Land is the major resource for the livelihood of the poor. In Nigeria, a typical villager recognizes land in its entirety. Oluwatayo, Sekunade and Adeniji (2008) reported that land to the farmer is like home and work place and shares it with the entire biotic complex. As important as land is to farmers' livelihood, Arimi (2014) observed that subsistent farmers encounter a lot of integrating constraints on land management practices. These constraints were categorized into three; economic constraints such as capital need and financial incentives; social conditions which include land tenure, availability of infrastructures and educational level of farmers; and ecological consideration such as limited knowledge of inputs and sustainability of some systems. Land use in many African nations has been characterized by a significant amount of land degradation. Moreover, these two processes are clearly related. Many poor African pastoralists and farming household respond to declining land productivity by abandoning existing degraded pasture and cropland, and moving to new land for grazing and crop cultivation. Due to the fact that the pattern of land use will often result into depletion of soil nutrients, appropriate management practices have to be adopted. Oluwatayo *et al.*, (2008) noted the need for appropriate soil management in tropical soil to sustain increased crop yields as cultivation continues on an annual basis. This was traced to the fact that clay in most tropical soil, referred to as low activity clay (LAC) does not expand and contract readily with moisture changes and the soil becomes susceptible to soil compaction. Also, LAC soils have a low cation exchange capacity, which means that nutrients are not held by the soil, but quickly leached below the crop roots. This is due to high temperature; which makes organic matters in tropical soil to be susceptible to rapid mineralization.

Furthermore, in an imperfect market setting, the nature of poverty is also important in determining its impact on natural resources management and degradation. Households that are not poor by welfare critera such as minimum levels consumption may still encounter "investment poverty" that prevents them from making profitable investments in resource conservation and improvement.

Problem statement

The study was informed by the declining food crop production in Nigeria. Food crop production in Nigeria no longer keeps with population growth. Thus creating a wide gap between the demand and supply of food (Abdulrahman, 2013). This is evident in the observed food crop deficit and the upward trend in the price of foodstuff in the market over the years (Food and Agriculture Organisation, 2006). The growth of Nigeria economy with reference to agriculture has been import driven rather than production driven. Consequently, there is a growing advocacy for improving Nigeria agricultural production so as to achieve sustainable food security. According to Abdulrahman (2013), a lot of effort had been directed at finding appropriate institutions for organizing millions of small scale farmers towards achieving food security (through increased food crops production) and agricultural productivity. Food production could be affected by the farmers age, access to credit, gender, farm size, educational level and farming experience. It is on record that 50% of world's population is dependent on subsistence agriculture. The effect of this is high, underfeeding and malnutrition throughout the nation. Nigeria as a nation only depends on rural inhabitant who constitutes over 15% of the total population for the production of foods (FAO, 2006). These farmers are poor subsistence farmers and they spend little on food production, which lead to low productivity.

Moreover, Nigeria is witnessing an upward trend in price of foodstuff, which should not be attributed to inflationary tendencies alone. The price increase is mainly due to decrease in production coupled with rise in demand as a result of increase in population and purchasing power. For example, cassava products was reported to be declining by less than 10% for reasons connected with losses from livestock and declining soil fertility which is a result of the effect of land productivity (Amaza and Olayemi, 2000). Hence, there is every need to increase food crop production due to increase in human population so as not to cause hunger and starvation among the teeming population.

This study was therefore conceived to determine the effect of land management practices on maize production among maize farmers Ogun state, Nigeria. Hence, the specific objectives are to describe the socioeconomic characteristic of maize farmers, examine the type of land management and conservation practices adopted by maize farmers and determine the effect of land management practices on Maize production in the study area.

METHODOLOGY

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Study area

The study was carried out in Ogun State, South Western Nigeria. The state lies between longitudes $2^{0}2^{1}$ and $3^{0}55^{1}$ and latitudes $7^{0}01^{1}$ and $7^{0}18^{1}$.It has a tropical climate with rainforest vegetation on its southern part and a derived savannah on its northern end. It has an estimated land area of 16,409.26 square kilometers. The estimated human population is 3751140 (2006 population census) and it is characterized commercially by a dual economic focus, the bourgeoning industrial sector and a dominant agricultural sector. The vegetation is largely rainforest and savannah and this makes it possible to cultivate many crops ranging from tree crops to arable crops and food crops such as maize, cowpea, cassava, melons, cashew, cocoa, oil palm, garri and vegetables.

Sampling procedure and Data collection

The study populations were mainly rural farming households who engaged in maize crop production in the study area.

Multistage samplingtechnique was used to select 240 farming households from 20 communities in two Agricultural Development Programme (ADP) zones of Ogun State (Abeokuta and Ilaro).First stage involved the selection of two Zones which are Abeokuta and Ilaro randomly. Second stage involved simple random selection of three (3) and two (2) blocks from each of the two ADP zones respectively making 5 blocks respectively. Stage three involved random selection of four (4) cells from each of the 5 blocks making 20 cells. While the last stage involved random selection of twelve (12) farming households from each of the 20 cells making 240 farming households. Primary data were collected using structured interview guide. Data were analyzed using frequency count, percentage, mean and Stochastic Production Function

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The socioeconomic distributions of the respondents were presented in Table 1. Distribution of age of the food crop farmers in the study area as shown in Table 1 reveals that majority (94.17 percent) of food crop farmers were aged below 60 years with the mean age of 43 years. The result was in conformity with Adebayo (2014) who pointed out that individuals were more active under the age of 50 years. This implies that most of the respondents were in their economically active age and were expected to be energetic and productive. Also, many (72.5 percent) of the food crop farmers were married with mean household size of 4 persons. Also, based on religion distribution of the respondents, majority (60.0 percent) are Christains. Distribution of food crop farmers by educational status revealed that many (50.8 percent) had secondary school education as against 10.8 percent without formal education. The mean farming experience and farm size were estimated at 9 years and 4.1 hectares respectively. This is contrary to Dipeolu, Philip, Aiyelaagbe, Akinbode and Adedokun (2009) where majority of food crop farmers had no formal education while Arimi (2014) reported that majority of Nigeria's farmers are still subsistence in nature. Also, majority (72.5 percent) of food crop farmers had contact with extension agents once a year. This finding aligned with Fabusoro *et al.,* (2008) that shortage of extension personnel hindered the delivery of good agricultural extension services.

Table 1: Distribution of the respondents according to the socioeconomic characteristics in the study area

Socioeconomics characteristics	Frequency	Percentage	Mean
Sex			
Male	170	70.83	
Female	70	29.17	
Age			
Less than 30	52	21.67	
31-40	48	20.00	
41-50	88	36.67	43
51-60	38	15.83	
61 and above	14	5.83	
Marital status			
Married	174	72.50	
Single	52	21.67	
Divorced	10	4.17	
Widowed/widow	2	0.83	
Separated	2	0.83	
Religion			
Christianity	144	60.00	
Islam	88	36.67	
Traditional	8	3.33	
Level of education			
Non-formal	26	10.83	
Primary	40	16.67	
Secondary	122	50.83	
Tertiary	52	21.67	
Household size			
1-2	68	28.33	
3-6	142	9.17	4
7-10	28	11.67	
10 and above	2	0.83	
Farm size			
1-5 hectares	180	75.00	4.19
6-10 hectares	16	6.67	
11-15 hectares	26	10.83	
16 and above	18	7.50	
Farming experience			
1-5 years	66	27.50	
6-10 years	94	39.17	9.6
11years and above	80	33.33	
Contact with extension agent			
None	4	1.67	
Once	174	72.50	
More then once	62	25.3	
Total	**240**	**100**	

Source: Field Data, 2018

Distribution of the respondents based on the various land management practice adopted in the study area

Table 2 revealed the various land management practices adopted by maize farmers in the study area. It was revealed that 2.50% of the respondents does not engage in any form of land management practices, 3.34% of the respondents engaged in Terracing 1.67% of the respondents engaged in contour bonds, 1.67% of the respondents engaged in Ridge across slope, 5.83% of the respondents engaged in Crop rotation, 35.0% of the respondent engaged in Multiple cropping, 32.5% of the respondent engaged in Cover Cropping, 9.17% engaged in Mulching, none of the respondent were engaged in Agro-forestry, 2.50% of the respondents engaged in bush fallowing, 5.0% of the respondents engaged in compost, while 0.82% of the respondents engaged in Fertilizer Application. This implies that Majority of the respondents were engaged in various land management practices.

Table 2: Distribution of the respondents based on the various land management practice adopted in the study area

Land Management Practice	Frequency	Percentage
None	6	2.50
Terracing	8	3.34
Contour Bonds	4	1.67
Ridge Across Slope	4	1.67
Crop Rotation	14	5.83
Multiple Cropping	84	35.00
Cover Cropping	78	32.50
Mulching	22	9.17
Agro-Forestry	0	0.00
Bush Fallowing	6	2.50
Compost	12	5.00
Fertilizer Application	2	0.82
Total	**240**	**1000**

Source: Field Data, 2018

Land conservation practice adopted by maize farmers in the study area was revealed in Table 3 that 28.33% of the respondents engaged in crop rotation, 13.33% of the respondents engaged in Bush fallowing, 48.33% of the respondents engaged in Mixed cropping, 8.33% of the respondents engaged in Planting cover crop while 1.67% of the respondents engaged in Mulching. This implies that majority of the respondents were engaged in diverse land conservation practices in the study area.

Table 3: Distribution of respondents according to land conversation practices adopted in the study area

Land conservation methods	Frequency	Percentage
Crop Rotation	68	28.33
Bush Fallowing	32	13.33
Mixed Cropping	116	48.34
Planting Cover Crop	20	8.33
Mulching	4	1.67
Total	240	100

Source: Field Data, 2018

Maximum Likelihood Estimates of the Stochastic Production Function of Maize farmers

Table 4 presents the maximum likelihood estimates (MLE) o f the production function of maize farmers in Ogun state. The variance parameter for sigma-square for maize farmers was estimated at 0.467. The sigma-square attests to the goodness of fit and correctness of the distributional form of the model while the gamma revealed the systematic influences that were unexplained by the production function and the dominant sources of random error. This implies that about 47 percent of the variance in output of maize farmers in Ogun state is due to the differences in their technical inefficiency.

The result showed that hired labour and farm size in hectares have positive significant influence on maize production at 1 percent. Furthermore, the finding showed that other variables such as fertilizer, agrochemical and cost of planting materials/input didn't exert any significant influence on maize production in the study area.

The contribution of farmers' personal characteristics such as Age, Years of education, Farming experience, Household size and Sex, land management practice, land conservative practice to farm inefficiency were also examined. However, all the variables examined in the inefficiency model are not significant except land management practices and land conservative practice that have negative influence on farmers' inefficiency model. This implies that land management practices and conservations practices by farmers in are predominant factors in maize production in the study area.

Table 4: Stochastic Frontier Production Function result of Maize farmers' production

Variables	Coefficient	Standard error	t - value
Constant	0.6231***	0.2115	2.9460
Farm size	0.4510***	0.1521	2.96515
Labour (Man days)	0.7211***	0.2007	3.5929
Fertilizer (Kg)	0.2981	0.3092	0.9641
Agrochemicals (Kg)	1.0134	0.7022	1.4431
Planting material/input ( )	0.0207	0.0332	0.6234
Inefficiency Model			
Constant	2.1311**	1.0763	1.9800
Sex	0.5671	0.5231	1.0841
Age	0.0033	0.1128	0.0292
Education	-0.2091	0.3121	-0.6699
Farm Experience	-0.7711	0.9899	-0.7789
Household size	-0.2219	0.3441	-0.6448
Land Management Practice	-0.1952***	0.0522	-3.7394
Land Conservative Practice	-0.6493***	0.2316	-2.8035
Diagnostic Statistics			
Stigma - square (&)^2	0.741	1.586	0.467
Gamma (Y)	0.641	0.311	2.061
Log Likelihood	-116.21		
Chi Square	32.21***		

Source: Field Data, 2018

*** implies significant at 1 percent, ** implies significant at 5 percent

CONCLUSION AND RECOMMENDATION

The study concluded that majority of the respondents were still in their economic stage, married and expected to be productive. The result of SPF revealed that hired labour and farm size in hectares exert a positive influence on maize production in the study area. The study recommends that researchers should be result oriented, specified their researches on specific food commodity and create awareness on how to improve the quality of farm management practices currently in practice. There is need for the government to add to the present subsidy style (credit facilities support) through subsidized planting materials, inorganic fertilizers and agro-chemicals as well as provision of soft loan to farmers who were unable to benefit directly from the credit subsidies to remain in agriculture

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Growth and Yield of **Celosia Argentea** (L) as Influenced by Mineral Fertilizer and Composted Organic Residues in Ilorin Southern Guinea Savanna Zone of Nigeria

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Abstract
Crop residue is an organic material abundant in Nigeria, but which is yet to be utilized for soil improvement purposes particularly in raising *Celosia argentea.* Hence, a screen house experiment was conducted in Kwara State University, Malete, Nigeria to assess the direct and residual effect of different composted organic residues on the growth and yield of *Celosia argentea*, seven treatments were used, including the control, NPK 15-15-15 and five differently composted organic residues namely; Poultry manure+Gliricidia+Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV). The treatments except control were applied at 45 kgN/ha. The experiment was a Completely Randomized Design with three replicates. Growth and yield parameters were taken and data were analyzed using ANOVA ($p < 0.05$).The results indicated all composted organic residues significantly enhanced the growth and yield of *Celosia.* However, residual effect of *Celosia* fresh shoot yield values obtained from PGM (3.7g) was significantly ($p < 0.05$) higher than that of NPK values (1.2g).Therefore, PGM could be used as alternative to mineral fertilizer in raising *Celosia argentea*, thereby enhancing better waste management.

Keywords: : Celosia argentea, Growth, Mineral fertilizer, Organic residue, Yield.

Croissance et rendement de Celosia Argentea (L) influencés par les engrais minéraux et les résidus organiques compostés dans la zone de savane d'Ilorin au sud de la Guinée au Nigéria

Abstrait
Les résidus de culture sont une matière organique abondante au Nigéria, mais qui n'est pas encore utilisée à des fins d'amélioration des sols, en particulier pour l'élevage de Celosia argentea. Par conséquent, une expérience de criblage a été menée à l'Université d'État de Kwara, Malete, Nigéria pour évaluer l'effet direct et résiduel de différents résidus organiques compostés sur la croissance et le rendement de Celosia argentea, sept traitements ont été utilisés, dont le témoin NPK 15-15 -15 et cinq résidus organiques compostés différemment, à savoir; Fumier de volaille + Gliricidia + enveloppe de Mucuna (PGM), Fumier de volaille + Gliricidia (PG), Fumier de volaille + Gliricidia + Paille de riz (PGR), Fumier de volaille + enveloppe de Mucuna (PM) et Fumier de volaille + Herbe de vétiver (PV). Les traitements sauf le témoin ont été appliqués à 45 kgN / ha. L'expérience était une conception complètement aléatoire avec trois répliques. Les paramètres de croissance et de rendement ont été pris et les données ont été analysées à l'aide de l'ANOVA ($p < 0,05$). Les résultats ont indiqué que tous les résidus organiques compostés ont considérablement amélioré la croissance et le rendement de la célosie. Cependant, l'effet résiduel des valeurs de rendement de pousses fraîches de Celosia obtenues à partir de PGM (3,7 g) était significativement ($p < 0,05$) plus élevé que celui des valeurs de NPK (1,2 g), améliorant ainsi une meilleure gestion des déchets.

Mots clés: Celosia argentea, Croissance, Engrais minéral, Résidu organique, Rendement

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Introduction

Celosia argentea is a traditional leafy vegetable produced in Nigeria and other tropical countries of Africa by small holders' farmers; solely or intercropped with arable starchy staples to produce enough food to satisfy their dietary and cash requirements (Gbadamosi and Adeoluwa, 2014; Ayorinde et al., 2017: Onwordi et al., 2019). Celosia is an important source of protein, minerals and vitamins, especially in areas where animal protein sources are scarce (Olaniyi, and Ojetayo 2012). Continuous cropping of soils with leafy vegetables is usually associated with loss of organic matter. This is because almost all parts of the crop are harvested and crop residues are removed from the field or burned (Oroka, 2012). Inorganic fertilizer is the quickest and easiest way of increasing leafy vegetable yield per unit area (Agu et al., 2015.). It has been reported to enhanced crop growth and nutrient uptake (Sridhar and Adeoye, 2003). However, it does not improve the soil texture and microbial population. The impact of increased use of mineral fertilizers has been high but the resulting soil physical degradation, increased soil acidity level and soil nutrient imbalance have drawn the attention of researchers back to the use of organic materials as suitable soil amendment for increasing crop production (Olowoake and Adeoye, 2012). One of the most promising methods to improve soil fertility in intensified cropping systems is composting of organic residue. The most popular combination of waste for composting is mixing animal waste (cow dung, poultry litter, pig manure, fecal sludge etc.) with agro based wastes (rice straw, sawdust, wheat straw, water hyacinth, food waste etc.) (Neves et al., 2009; Khatun et al., 2020). Applications of composted organic residues have been reported to produce high yield and quality food crops (Babajide and Olayiwola, 2014). Some workers have also reported positive responses in vegetables grown under organic fertilizer management (Koura et al., 2015; Azarmi et al., 2009).

Composting of poultry manure, *Gliricidia* leaves, vetiver grass, rice straw and mucuna husk can as well provide a compostable mixture in different proportions that will reduce dependence on chemical fertilizers, increase the yield of *Celosia argentea*, and improve soil fertility as well as eliminating the problems of high rates of organic fertilizer use. In spite of the numerous benefits of compost in crop growth as evidenced from literature (Akanbi *et al.,* 2007, Olowoake and Ojo 2014), there is little or no information on the optimum composted organic residue required for growing *Celosia argentea* in Ilorin, North-central Nigeria. Therefore, this study determined the direct and residual effect of mineral fertilizer and composted organic residue on the growth and yield of *Celosia argentea*.

Materials and Methods

The study was conducted for a period of fourteen weeks in a screen-house at Kwara State University (Latitude 80 71'N and Longitude 40 44'E), Malete. Ilorin, Nigeria, which lies in the southern guinea savanna belt of Nigeria. The annual rainfall in the area is about 1200mm and temperature varies between 33^{0}C and 34^{0}C during the year, with a distinct dry season from December to March. The experiment was carried out to study the growth and yield of *Celosia argentea* as influenced by mineral fertilizer and composted organic residues in Ilorin Southern Guinea Savanna Zone of Nigeria. Twenty one pots were filled with 5.5kg of soil. The treatments used were five differently composted organic residues namely; Poultry manure+ Gliricidia +Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+ Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV); mineral fertilizer (NPK 15-15-15); and control. The Gliricidia leaves, mucuna husk and rice straw were shredded before they were composted. The compost used for this study was prepared by pit method (Olowoake and Adeoye, 2012). The constituents of the composted organic residues are as shown in Table 1. The treatments were arranged in a completely randomized design (CRD) with three replicates. The soils and compost were left to mineralize for two weeks before planting while the mineral fertilizer was applied two weeks after planting. Celosia seeds were broadcasted and thinned to two (2) seedlings. The treatments except control were applied at 45 kgN/ha (Olaniyi and Ojetayo 2012). Pre-cropping chemical analysis of the experimental soil used in the screen-house was carried out before the experiment. Soil samples were randomly collected from within the depth of 0-15cm. The soil samples were bulked together to form a composite sample. This was air-dried and pass through a 2mm sieve and taken to the laboratory for physical and chemical analysis to determine their nutrient level prior to application of compost. Representative samples were analyzed for pH, using 1:2 (soil: water) suspension, particle size (Bouyoucos, 1962), total nitrogen using the micro-kjeldahl method (Bremmner, 1966), and exchangeable cations (K, Ca, Mg and Na) after extraction with 1N NH OAC (pH 7). K in the filtered extract was determined with a flame photometer, whereas Ca, Na, and Mg were determined with an atomic absorption spectrophotometer. Available phosphorus (Bray-1-P) was determined by colorimeter using the method of Bray and Kurtz (1945) and organic carbon by method described by (Juo, 1981). The experiment was repeated without any fertilizer application at the second planting. Growth and yield parameters data collected were as follows: plant height, stem girth, number of leaves and yield components such as fresh and dry shoot weight. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan Multiple Range Test (DMRT).

Results

The results of chemical analysis of different matured composts used for the experiment are presented in Table 1. The nutrient concentration of N, P and K increased with inclusion of poultry manure in rice straw, mucuna husk and Gliricidia leaves. Generally, N ranged between 6.8 to 10.5 g kg^{-1} N. P ranged from 4.4 to 13.1 g kg^{-1} P and K ranged from 1.6 to 6.0 g kg^{-1} K. PGR had the highest nutrient concentration in g kg^{-1} N, while PGM had the highest g kg^{-1} P. However, PM had the highest nutrient concentration in g kg^{-1} K.

Table 1:Nutrient content of composts

Nutrient	Compost				
gkg^{-1}	PM	PGR	* PV	PG	PGM
N	8.1	10.5	6.8	10.4	6.9
P	4.4	6.1	5.3	5.6	13.1
K	6.0	5.7	1. 6	5.8	5.0

* Source -Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria

Legend
PGM- Poultry manure+Gliricidia+Mucuna husk, PG- Poultry manure+Gliricidia
PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk

PV- Poultry manure +Vetiver grass

The chemical properties of the soil used for the experiment are presented in Table 2. The soil was slightly acidic and low in total N, exchangeable K, Ca and Mg. Available P was fairly good for vegetable crop production (Table 2). The low soil contents for the major nutrients signify the need for improvement for optimal *Celosia argentea* performance.

Parameters	Soil test value
pH	6.9
Org. C (gkg^{-1})	11.8
Total N (gkg^{-1})	2.04
P Mehlich ($mgkg^{-1}$)	10.2
Exchangeable bases (c mol kg^{-1})	
K	0.17
Mg	0.46
Ca	2.35
Na	1.86
Extractable micronutrients (c mol kg^{-1})	
Cu	1.58
Fe	67.8
Zn	3.2
Mechanical composition (c mol kg^{-1})	
Sand	872
Silt	94
Clay	34
Textural class	Loamy sand

Table 3 shows the effect of treatments on plants height, stem girth and number of leaves of Celosia at first and second planting. Pots treated with compost and NPK significantly had higher growth parameter values than the control. At first planting, highest plant heights were recorded with NPK. Celosia plants treated with NPK had mean height of 12.8cm which was significantly higher than all other treatments. However, other compost; PGM, PM and PV performed better than the control, which had the lowest plant height of 7.9cm. Pots treated with NPK fertilizer and organic compost also show significant ($P<0.05$) increase in the number of leaves of *C. argentea* when compared with the control. The highest stem girth (3.7mm) recorded in *Celosia argentea* was from NPK. This was significantly ($p<0.05$) higher than other treatments including the control. Mean stem girth value ranged from 3.7 mm in NPK to 1.4 mm in the control. At second planting, NPK, and compost significantly ($P<0.05$) increased plant height. PGM had significantly ($P< 0.05$) highest plant height compared with the NPK treatment, PV came second and it was significantly better than other compost (PG. PGR and PM respectively). At the end of the second planting, PGM had the highest number of leaves (13.2), while the least was recorded in the control (8.5). Stem girth differed significantly across the treatments at the end of second planting. Stem girth value of Celosia amended with PGM was however higher than values obtained from NPK and other compost. Mean stem girth value ranged from 1.9 mm in PGM to 0.2 mm in the control.

Table 3: Effects of composted organic residue and inorganic fertilizer on the growth parameters of *Celosia argentea* at first and second cropping

Treatment	Plant height (cm)	Number of leaves	Stem girth (mm)
	First Planting		
Control	7.9d	8.5d	1.4d
PGM	10.6b	14.8b	2.9b
PG	9.4c	11.0c	2.4c
PGR	9.3c	11.2c	2.3c
PM	10.2b	11.6c	2.4c
PV	10.9b	11.7c	2.5c
NPK 15-15-15	12.8a	19.7a	3.7a
	Second Planting		
Control	3.2e	4.0e	0.2e
PGM	8.3a	13.2a	1.9a
PG	4.2d	9.0c	0.8c
PGR	4.5d	9.2c	0.9c
PM	5.1c	9.4c	0.9c

Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Legend
PGM- Poultry manure+Gliricidia+Mucuna husk, PG Poultry manure+Gliricidia PGR- Poultry manure +Gliricidia+Rice straw, PM-Poultry manure+Mucuna husk PV- Poultry manure +Vetiver grass

Figure 1 shows the effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea* at the end of first planting. The result of the yield parameters revealed better performances of the inorganic fertilizer (NPK) on the plant compared to the composted organic residue. At the end of the first planting, NPK produced the highest fresh shoot weight (11.8 g) and the least fresh shoot weight (4.2 g) was recorded in the control. NPK had the highest dry shoot weight (5.4 g), followed by PGM (4.0 g) while the least was recorded in the control treatment (1.8 g). However, there were no significant (P<0.05) differences between the compost treatments; PG PGR and PM from the dry shoot weight recorded.

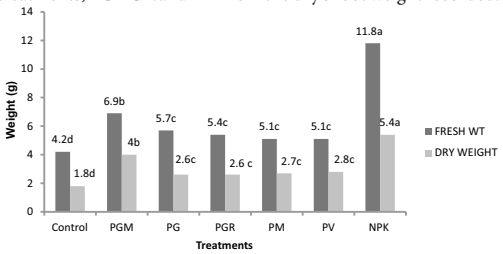

Fig. 1: Effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea* at first planting

Legend
PGM- Poultry manure+Gliricidia+ Mucuna husk, PG- Poultry manure+Gliricidia PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk PV- Poultry manure +Vetiver grass

Figure 2 shows the residual effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea*.When compared with the control, NPK fertilizer and composted organic residues significantly increased (P< 0.05) the fresh shoot and dry shoot weight of *C. argentea*. Pots applied with compost PGM recorded the highest fresh shoot weight (3.7 g) and dry shoot weights (2.7 g) respectively; it was closely followed by PV.

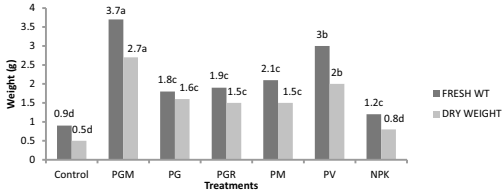

Fig. 2: Residual effects of composted organic residue and inorganic fertilizer on the fresh and dry weight of *Celosia argentea*

Legend
PGM- Poultry manure+Gliricidia+Mucuna husk, PG- Poultry manure+Gliricidia
PGR- Poultry manure +Gliricidia+Rice straw, PM- Poultry manure + Mucuna husk
PV- Poultry manure +Vetiver grass

Discussion
Based on the established critical level of 4.3 g kg-1 for total N, 10-16mg kg-1 for available P, 0.20 cmol/kg for K, 2.6 cmol/kg for exchangeable Ca recommended by (Adeoye andAgboola, 1985, Adeoye, 1986, Agboola and Corey 1972).The soil at the commencement of the experiment was deficient in N, K, Ca, and adequate in P. The low soil N and K status are expected to benefit from the application of soil amendments. The use of composted organic residues and NPK fertilizer produced significant effect on the performance of Celosia when compared with the control plants. All the growth parameters taken were positively improved by the organic and inorganic amendments. This might be due to the low nutrient status of the soil used. The higher growth and shoot yield of *Celosia argentea* obtained in pot treated with NPK fertilizer over the organic compost in the first planting could be attributed to the immediate availability of nutrients in the chemical fertilizer as previously observed by (Adeoluwa and Adeogun 2010; Bhatt *et al*., 2019). Although the result of the laboratory analysis of Poultry manure+Gliricidia (PG), Poultry manure +Gliricidia+Rice straw (PGR) showed that it has high percentage of N. The low performance of the compost on *Celosia argentea* at the end of first planting could be due to slow rate of decomposition of compost compared with NPK. The crop performance in the second planting is better with treatment that received the compost is an indication of the residual pool of the nutrients. (Eghball *et al*., 2004; Adekayode and Ogunkoya, 2011). The release of nutrients under Poultry manure+Gliricidia+Mucuna husk (PGM) and Poultry manure +Vetiver grass (PV) which enhanced better growth and yield after second planting could be attributed to the higher nitrogen availability and beneficial effects of these materials. This is similar to the results obtained by Gnansounou *et al.* (2017); Are et *al.* (2012) and Olowoake and Adeoye, (2012) and Roongtanakiat, (2000) who obtained better crop yields from PV and PGM. The values of growth and yield of *Celosia argentea* were observed to be low in the pot without any treatment. This might be as a result of low nutrients status of the soil especially N and K. Generally, from the study there was an increase in the performance of the crop on the parameters measured and overall yield. This implies that Celosia responds well to organic fertilizer as the application of Poultry manure+Gliricidia+Mucuna husk (PGM), Poultry manure+Gliricidia (PG), Poultry manure+Gliricidia+Rice straw (PGR), Poultry manure + Mucuna husk (PM) and Poultry manure +Vetiver grass (PV) influences its growth and yield. This implies that the addition of compost in *C. argentea* production is a means of improving the yield in and thus, making its cultivation productive and sustainable.

Conclusion
This study showed that composted organic residues can be used as fertilizer for production of *Celosia argentea*. The result of this experiment revealed that NPK presented good growth and yield after first planting. However, residual effect of compost (Poultry manure + Gliricidia + Mucuna husk and poultry manure +

vetiver grass) presented better yield than NPK. In summary, composted organic residues used for production of *C. argentea* could constitute an alternative to mineral fertilizer. Furthermore, application of compost PGM and PV at the rate of 45 kgN/ha led to higher *Celosia argentea* yield.

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Efficacy of Calcium Carbonate and Periwinkle Shells on Hatchability and Survival of Eggs and Fry of *Clarias gariepinus*

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Abstract
This study examined the buffering potency of calcium carbonate and periwinkle (*Tympanotonus fuscatus*) shells on water acidity and its effect on the hatchability of fish eggs and survival of the fry of *Clarias gariepinus*. Four concentrations (5.4g, 13.5g, 135g and 540g) of five treatments *viz*; calcium carbonate ($CaCO_3$) [T_1], un-burnt uncrushed periwinkle shells (UUPS) [T_2], un-burnt crushed periwinkle shells (UCPS) [T_3], burnt crushed periwinkle shells (BCPS) [T_4], burnt uncrushed periwinkle shells (BUPS) [T_5] and the control which had no form of treatment in it. Sixty-three, 20 litre shaded plastic bowls (1/2 filled, pH of 5.3) of three replicates/treatments/dosage used. *C. gariepinus* was spawned artificially and a measured quantity of the eggs and milt were stripped into each experimental bowl.T_4 effected similar changes just as T_1 (7.89) in increasing the water pH to 7.49 at 13.5g. At 135g, T_4 increased the pH to 8.30 which was higher than that of T_1 (8.01). The percentage survived fry at 5.4g and 135g, ranged from 5% in the control to 11.74% and 19.69% in T_1 respectively. At 13.5g, survival rate was from 5% in the control to 47.69% in T_3. At 540g, fry did not survive in T_2, T_3, T_4 and T_5. Fish fry survived better in T_3 (un-burnt and crushed shells) with a 47.69% survival rate, at 13.5g. This was similar to the survival rate in T_1 (47.45%) at 13.5g. Therefore, the use of un-burnt and crushed periwinkle shells at 13.5g as an organic buffer was found most suitable to replace the conventional synthetic calcium carbonate in reducing acidity in water to ensure higher hatchability and survival of *Clarias gariepinus* fry was effective in this study. Underground waters are usually acidic and so should be treated with an organic buffer (*Tympanotonus fuscatus* shells) before use in a fish hatchery.

Keywords: : Periwinkle shells, calcium carbonate, hatchery, aquaculture

Efficacité des carapaces de carbonate de calcium et de perwinkle sur l'éclosion et la survie des œufs et des alevins de Clarias gariepinus

Résumé
Cette étude a examiné le pouvoir tampon des coquilles de carbonate de calcium et de pervenche (Tympanotonus fuscatus) sur l'acidité de l'eau et son effet sur l'éclosion des œufs de poisson et la survie des alevins de Clarias gariepinus. Quatre concentrations (5,4 g, 13,5 g, 135 g et 540 g) de cinq traitements à savoir; carbonate de calcium (CaCO3) [T1], coquilles de pervenche non brûlées non écrasées (UUPS) [T2], coquilles de pervenche écrasées non brûlées (UCPS) [T3], coquilles de pervenche broyées brûlées (BCPS) [T4], coquilles de pervenche non écrasées brûlées (BUPS) [T5] et le contrôle qui ne contenait aucune forme de traitement. Soixante-trois bols en plastique ombragés de 20 litres (1/2 remplis, pH de 5,3) de trois répétitions / traitements / dosage utilisé. C. gariepinus a été engendré artificiellement et une quantité mesurée d'œufs et de laitance a été dépouillée dans chaque bol expérimental. T4 a effectué des changements similaires tout comme T1 (7,89) en augmentant le pH de l'eau à 7,49 à 13,5 g. À 135 g, la T4 a augmenté le pH à 8,30, ce qui était supérieur à celui de T1 (8,01). Le pourcentage a survécu aux alevins à 5,4 g et 135 g, variait de 5% dans le contrôle à 11,74% et 19,69% dans T1 respectivement. À 13,5 g, le taux de survie était de 5% dans le contrôle à 47,69% dans T3. À 540 g, les alevins n'ont pas survécu en T2, T3, T4 et T5. Les alevins de poisson ont mieux survécu dans T3 (coquilles non brûlées et écrasées) avec un taux de survie de 47,69%, à 13,5 g. Cela était similaire au taux de survie en T1 (47,45%) à 13,5 g. Par conséquent, l'utilisation de coquilles de pervenche non brûlées et écrasées à 13,5 g comme tampon organique s'est avérée la plus appropriée pour remplacer le carbonate de calcium synthétique conventionnel pour réduire l'acidité de l'eau afin d'assurer une plus grande éclosabilité et la survie des alevins de Clarias gariepinus était efficace dans cette étude . Les eaux souterraines sont généralement acides et doivent donc être traitées avec un tampon organique (coquilles de Tympanotonus fuscatus) avant d'être utilisées dans une écloserie.

Mots clés: coquilles de pervenche, carbonate de calcium, écloserie, aquaculture.

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Introduction

Fish growth depends on water quality in order to boost its metabolic processes (Ugumba and Ugumba, 1993). Animals can however become stressed or die when exposed to pH extremes or when pH changes rapidly even if the change occurs within a pH range that is normally tolerated. Fish fry are produced in large numbers but only a few survive due to the chemistry of the aquatic environment. The most sensitive stages of development for chronic or episodic exposure to low pH are the embryonic development and the newly hatched stages. Young fishes are extremely sensitive to pH levels below five (5) and may die at this low pH levels. Ideally, an aquaculture pond should have a pH between 6.5 and 9 (Bhatnagar *et al*., 2004). However in the case of low pH, liming materials are used to rectify the low pH of aquatic body. Calcium carbonate can maintain a near neutral pH when added to pond water to keep it safe for aquatic life. Calcium carbonate also improves the survival of fish eggs and developing embryos which are particularly sensitive to acidification (Louis *et al*., 2009). However, in recent times, organic aquaculture has been advocated. The major constituents of fish feed, fertilizers, liming materials are chemical in nature (Kiran and Thongam, 2012). As a result of this, studies are being carried out to replace inorganic inputs in aquaculture with organic inputs that are converted to organic aquaculture.

The periwinkle (*Tympanotonus fuscatus*) shell is very rich in calcium and can be manipulated to yield various calcium compounds. The shell is the hard, rigid outer calcium carbonate covering of certain animals. The blood of mollusc is rich in liquid form of calcium which concentrates out and crystallizes as calcium carbonate (Ugoeze and Chukwu, 2015). Large amounts of shells may form sediment and become compressed into limestone (Francis, 2006). They can be used to increase soil pH (Akpabio, 2006).The periwinkle shell is grounded for several purposes such as powder for pimples, cleansing, (for example vim for washing), as fertilizers and as calcium source in feed (Grolier, 1980).Other uses include building construction, ornamentals and cosmetics (Fayeofori, 2012). The properties of biomaterial of *Tympanotonus fuscatus* (periwinkle) shell as a pharmaceutical raw material has been reported (Ugoeze and Chukwu, 2015). Davies and Ogidiaka (2017) have also reported the use of periwinkle shell as a buffering material. The objective of this study is to determine the buffering efficacy of calcium carbonate and periwinkle (*T. fuscatus*) shells on water acidity and its effect on the hatchability and survival of *Clarias gariepinus* egg and fry in the different treatments at 5.4g, 13.5g, 135g and 540g.

Materials and Methods

Description of Study Area, Source of Periwinkle Shell and Calcium Carbonate

The study was conducted at the University of Benin Fish Farm located in the Department of Aquaculture and Fisheries Management, Faculty of Agriculture, University of Benin, Benin city, Edo State. The periwinkle shells were sourced from market women at Uselu market in Egor Local Government Area of Benin City, Edo State.

Preparation of Periwinkle Shells as an Organic Buffer

The collected periwinkle shells were washed in water to remove mud, stones and other materials. They were placed in a stainless tray and sun dried; after which they were oven dried using a charcoal oven for about an hour and thirty minutes. The temperature ranged from 80^{0}C to 100^{0}C. The shells were then grouped into the following: un-burnt uncrushed periwinkle shells (UUPS), un-burnt crushed periwinkle shells (UCPS), burnt crushed periwinkle shells (BCPS), and burnt uncrushed periwinkle shells (BUPS). The burnt shells were burnt using a stainless steel pot over a naked flame and then crushed using a ceramic mortar and pestle. Each category/form of periwinkle shells was used at concentration; 5.4g, 13.5g, 135g and 540g.

Calculation of the Quantity of Periwinkle Shells used

According to Davies (2012), 7200kg of organic buffer = 1×10^{7} litres (10,000 m^{3}) of water with pH 4.6-5.0. Thus 7.2g will be placed in 10 litres of water.

According to Davies and Ogidiaka (2017) factors more than one times of the normal dosage were used to speed up the process of buffering (from acidic to alkaline) while the dosage below the recommended was used for comparison. These factors include; 0.75, 1.875, 18.75 and 75. Therefore; 7.2g × 0.75 (factor) =5.4g for the first concentration, 7.2g × 1.875 (factor) = 13.5g for the second concentration, 7.2g ×18.75 (factor) = 135g for the third concentration and 7.2g × 75 (factor) = 540g for the fourth concentration. The level of concentration was used in accordance with the research performed by Davies and Ogidiaka (2017).

Source of Water and Experimental Bowls

The water used for the experiment was collected from the underground water (borehole) which is used for fish production purposes in the Department of Aquaculture and Fisheries Management experimental fish farm. The experimental bowls were obtained from the department's wet laboratory. Ten litres of water was placed in each experimental bowl. The different forms of periwinkle shells which have already been weighed were placed in sewn sieve-like materials and placed in the water in the experimental bowls 24 hours prior to the spreading of fish eggs.

Spawning

Materials used in the spawning exercise include; cotton wool, razor blade, a 2ml syringe, needle, saline water, methylated spirit, plastic bowls, detergent, a hand towel, holding trough, spawning mats, experimental bowls and dissecting table. The procedures employed in the spawning exercise include:

Selection and hormone injection of brood stock: Male and female brood stocks of specie: *Clarias gariepinus* were purchased from a private fish farm in Benin City and selected based on maturity. The selected female brood stock was injected with ovaprim using a 2ml graduated syringe and needle intramuscularly at an angle $30\text{-}45^{0}$ between the dorsal fin and the lateral line towards the head region.

Stripping and Fertilization: The latency period lasted for about eleven (11) hours after which the female brood stock was stripped. The abdomen was massaged gently and its eggs were stripped into a plastic bowl. The male brood stock was dissected using a razor blade and the sperm sac was removed and cut open to spill its milt over the eggs. The milt and the eggs were mixed together and saline water was added to facilitate fertilization.

Incubation: The eggs were then spread unto the spawning mats using the same measurement in the various experimental bowls containing the various forms and concentrations of periwinkle shells. This was done so that each experimental bowl will receive the same number of eggs. The incubation period lasted for about 24-37 hours.

Determination of Fertilization, Hatching and Survival Rate

The rate of fertilization, hatching and survival of *C.gariepinus* was calculated using the following formulas:

$$\text{Fertilization} = \frac{\text{No. of fertilized egg}}{\text{Total no of egg incubated}} \times 100$$

$$\text{Hatchability} = \frac{\text{No. of hatched egg}}{\text{Total no of egg incubated}} \times 100$$

$$\text{Survival} = \frac{\text{No. of fry}}{\text{No. of hatched egg}} \times 100$$

Measurements of Water pH

The pH was measured with the aid of a pH meter at the initial and final stages after the introduction of shells into the water medium.

Table 1: Induced Breeding with the use of Ovaprim

Date of inducement	**02-02-2018**
Species of fish used	*Clarias gariepinus*
Source of fish	A private fish farm
Weight of male	1.5kg
Weight of female before stripping	2.0kg
Weight of female after stripping	1.8kg
Weight of eggs of female	0.2 kg
Syringe type	2ml
Dosage and type of hormone	Ovaprim (0.5ml) 1 ml
Time of inducement	8:35 am
Time of stripping	7:30pm
Latency period	11 hours
Incubation period	24- 37 hours

Experimental Design and Statistical Analysis

One way Analysis of Variance (ANOVA) was carried out to determine significant differences in the buffering efficacy of the treatments and in fry hatchability and survival. In cases where there were statistical significant differences, the means were separated using Duncan's Multiple Range Test (DMRT). The level of significance was set at $P<0.05$.

The statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS) version 24.0 for windows.

Results

Buffering potency of the different concentration of periwinkle (*T. fuscatus*) shells

The highest level of pH was recorded in T_4 at 135g and the lowest in the control. Analysis of variance showed that there was a significant difference ($P<0.05$) in the pH between the treatments at the various concentrations. As revealed by Duncan Multiple Range Test at 5.4g, the treatments were significantly different ($P<0.05$) from each other. However, there was no significant difference between T_4 and T_5 (Fig. 10). The control was significantly lower than all the other treatments. At 13.5g (Fig 11) and 135g (Fig 12), there was a significant difference ($P<0.05$) in the pH between the treatments with the control being significantly lower ($P<0.05$). At 540g, the pH in T_1 and control were significantly different from each other ($P<0.05$) (Fig 13).

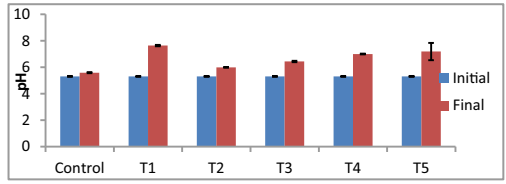

Figure 1: Initial and final pH of acidic borehole water treated with different forms of periwinkle shells and calcium carbonate using 5.4g as buffer

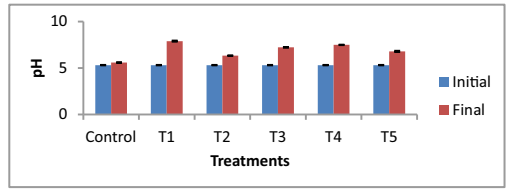

Figure 2: Initial and final pH of acidic borehole water treated with different forms of periwinkle shells and calcium carbonate using 13.5g as buffer

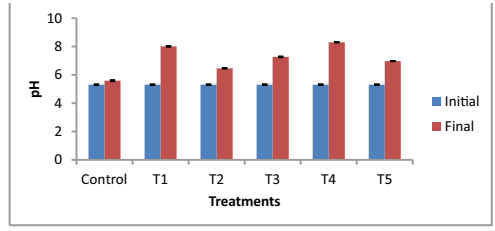

Figure 3: Initial and final pH of acidic borehole water treated with different forms of periwinkle shells and calcium carbonate using 135g as buffer

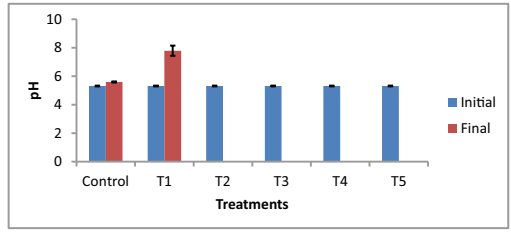

Figure 4: Initial and final pH of acidic borehole water treated with different forms of periwinkle shells and calcium carbonate using 540g as buffer

Hatchability of *Clarias gariepinus* eggs in the different treatments at the various concentrations Fertilized eggs

The highest percentage of fertilized eggs was recorded in T_3 at 5.4g and the lowest percentage in T_3 at 13.5g (Table 2). Analysis of variance showed that there was no significant difference ($P>0.05$) in the percentage fertilized eggs in the different treatments at the various concentrations. At 13.5g, the percentage fertilized in T_1

was significantly different and higher (P<0.05) than that in T_3 and in the control. Although there was no significant difference (P>0.05) between T_1 and T_3 at 135g, both were significantly different and higher from T_4 and the control. There was no significant difference (P>0.05) in the different treatment at 540g (Table 2).

Table 2: Mean comparison of the percentage fertilized eggs of *Clarias gariepinus* in the treatments at various concentrations

Concentration	Control	T1	T2	T3	T4	T5
5.4g	98.62±0.48b	99.59±0.09a	99.70±0.23a	99.89±0.09a	99.60±0.23a	99.41±0.52a
13.5g	98.62±0.48b	99.76±0.07a	99.19±0.19ab	98.60±0.38b	99.26±0.59ab	99.21±0.21ab
135g	98.62±0.48b	99.62±0.32a	99.15±0.23ab	99.68±0.18a	98.81±0.71b	99.26±0.22ab
540g	98.62±0.48a	99.23±0.42a	99.53±0.05a	99.45±0.55a	99.54±0.79a	99.42±0.52a

Means with the same letter are not significantly different @ 5% probability level

Hatched eggs

The percentage number of eggs hatched was recorded to be highest in T_1 at 540g and lowest in T_2, T_3 and T_4 at 540g where hatching did not occur (Table 3). Analysis of variance showed that there was a significant difference (P<0.05) in the percentage of eggs hatched in the different treatments. As shown by Duncan Multiple Range Test, at 5.4g, the percentage hatched in treatments were not significantly different (P>0.05) from each other. However, there was a significant difference (P<0.05) between T_2 and T_4. At 13.5g, the percentage hatched in T_3 was significantly different and higher (P<0.05) than that in T_2. At 135g, T_1 and T_3 were significantly different (P<0.05) from each other (Table 3). The eggs that hatched at 540g were significantly different (P<0.05) from each other.

Table 3: Mean comparison of the percentage hatched eggs of *Clarias gariepinus* in the treatments at various concentrations

Concentration	Control	T1	T2	T3	T4	T5
5.4g	91.45±0.23a	93.06±0.61a	87.70±2.97b	92.80±1.08a	46.25±1.35c	91.84±0.24a
13.5g	91.45±0.23bc	92.90±0.65ab	89.14±3.54c	94.68±1.14a	92.95±0.69ab	93.07±0.82ab
135g	91.45±0.23ab	95.18±0.40a	85.00±3.24bc	73.29±1.18d	79.88±10.55cd	92.59±2.65ab
540g	91.45±0.23b	95.44±0.46a	0.00±0.00	0.00±0.00	0.00±0.00	90.64±0.51c

Means with the same letter are not significantly different @ 5% probability level

Survived fry

The percentage survived fry was highest in T_3 at 13.5g (47.69%) and was lowest in T_2, T_3, T_4 and T_5 at 540g where no fry survived (Table 4). Analysis of variance showed that there was no significant difference (P>0.05) in the percentage survival in the different treatments. Duncan Multiple Range Test showed that at 5.4g, 13.5g and 135g, there was no significant difference (P>0.05) in the percentage survival rate between the treatments. At 540g, the survived fry in T_2 was significantly higher and different than that in the control (Table 4).

Table 4: Mean comparison of the percentage survived *Clarias gariepinus fry*

Concentration	Control	T1	T2	T3	T4	T5
5.4g	5.00±2.71a	11.74±1.29a	4.36±4.18a	10.80±3.53a	6.53±7.96a	8.84±12.08a
13.5g	5.00±2.71a	47.45±33.35a	29.95±22.86a	47.69±28.37a	92.95±0.69ab	37.78±25.53a
135g	5.00±2.71a	19.69±20.00a	3.27±3.88a	4.41±4.31a	9.65±7.07a	12.53±13.465a
540g	5.00±2.71b	33.20±29.76a	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00

Discussion

Extreme pH negativity affects fish growth and reproduction (Zweig *et al*., 1999) and fish shows lower tolerance to extreme pH especially at the embryonic and larvae stages (Lloyd and Jordan, 1964). *Clarias gariepinus* fish is widely cultured in Nigeria. It is acceptable among consumers and has high economic value. However, the issue is how to ensure high fry survival (Adewumi, 2015). Fish fry are produced in large numbers but only a few survived due to the chemistry of the aquatic environment (Bhatnagar *et al*., 2004). Louis *et al*., (2009) reported that liming with the use of calcium carbonate helps to neutralize acid waters and buffer them from rapid fluctuations in pH. Since the advocacy for organic aquaculture, several researches have been carried out so as to gradually replace inorganic with organic inputs. This study incorporated the use of periwinkle shells in different forms and concentrations as a buffering material in order to replace the use of the conventional synthetic calcium carbonate as lime so as to ensure a higher fry survival.

The buffering potency of the treatments except for T_5 increased with increasing concentration (Table 2). At 5.4g, the pH increased in the following order: $T_1 > T_5 > T_4 > T_3 > T_2 >$ Control.

All the treatments except T_2 and T_3 had pH above 6.5 as recommended by Ekubo and Abowei, (2011), Wurts and Durborow (1992) and Bhatnagar*et al*., (2004) and also with Santhosh and Singh, (2007). At 13.5g, the pH increased in the order: $T_1 > T_4 > T_3 > T_5 > T_2 >$ Control. When the concentration increased to 13.5g, the pH in the different treatments except in T_5 increased. At this concentration, all the treatments except T_2 and the control were within the recommended range. The order of pH at 135g was: $T_4 > T_1 > T_3 > T_5 > T_2 >$ Control. As the concentration increased to 135g, all the treatments increased in pH. In T_4, the pH increased to 8.30. However, this was still within the suitable range for fish which is in line with Santhosh and Singh, (2007) who stated that the suitable pH range for fish culture is between 6.7 and 9.5. At 540g, eggs did not hatch in T_2, T_3 and T_4. Although eggs hatched in T_5, the fry died after a short period; which proved that at this concentration the periwinkle shells may not be suitable for hatchery purposes. T_1 was the only treatment at 540g where eggs hatched and survived. The pH here was 7.79 which support fish growth and survival. In this study, the buffering efficacy increased as the concentration of the shells increased in most of the treatments. Throughout the experiment, T_2 and the control had the lowest pH at the different concentrations which were not within the recommended range. This could be due to the fact that in T_2, the shells were un-burnt and uncrushed while in the control, there was no form of treatment. T_4 (Burnt and crushed) can be said to be an effective substitute for T_1 (the conventional calcium carbonate) because they both had similar pH in most cases.

There was a high success in the percentage of eggs that fertilized in the different treatments at the various concentrations. However, not all the eggs that fertilized hatched. At 5.4g, eggs hatched in the different treatments as well as in the control. However, the lowest percentage of eggs that hatched was recorded in T_4 (46.25%). The percentage hatched eggs at 13.5g and 135g ranged from 89.14% to 94.68% and 73.29% to 95.18% respectively in the different treatments. At 540g, the fertilized eggs did not hatch in T_2, T_3 and T_4. In T_5(90.64%), where the eggs hatched, the fry died shortly afterwards. The reason for this could be due to the fact that the shells at 540g raised the pH beyond the recommended range which is required for hatchability of fish eggs and fry survival. Bhatnagar *et al.,* (2004) stated that <4 or > 10.5 is lethal to fish culture.

At the end of this study, the control recorded the lowest fish fry survival. This could be due to the fact that the control recorded the lowest pH which was not within the recommended range needed for fish survival. This is in accordance with the work carried out by Davies and Ogidiaka (2017) where the pH in the control remained unsuitable for fish culture throughout the experiment. At 5.4g, the percentage survival rates of all the treatments were very low. The survival rate in the different treatments increased as the concentration increased to 13.5g and reduced when the concentration increased to 135g. At 540g, fish fry only survived in T_1. The treatments at 13.5g recorded better survival rate than at other concentrations. This is possibly because, the pH provided at 13.5g was more suitable for fish fry survival than at the other concentrations. At 13.5g, T_3 recorded the highest fish fry survival (47.69%) which was closely followed by T_1(47.45%). Therefore, T_3 can be seen as an effective substitute to T_1 in terms of survival of fish fry. This is probably because both treatments created a pH that was more suitable for fish survival.

Conclusion and Recommendation

At the end of this study, it was discovered that *Tympanotonus fuscatus*(periwinkle) shells possess the ability to buffer water. All the treatments containing shells increased the pH of the water as did the conventional calcium carbonate. As the concentration of the treatments increased, the pH also increased. However, this was not the case in the percentage survival of fry. Although the fish fry that survived increased when the concentration increased from 5.4g to 13.5g, there was a drop at 135g and no survival (except in T_1) at 540g. T_4 (Burnt and crushed) can be said to be as effective as T_1 (the conventional calcium carbonate) because it resulted in similar changes in pH as did T_1 and at 135g. It even increased pH to a greater extent than T_1. However, for hatchery purposes, T_3 (un-burnt and crushed shells) can be seen as an effective substitute for T_1 in reducing mortality of fish fry due to acidity. The reason for this is because both treatments had better survival rates than the other treatments at 13.5g.

Therefore, the use of unburnt and crushed periwinkle shells at 13.5g as an organic buffer to replace the conventional synthetic calcium carbonate in reducing acidity in water to ensure higher hatchability and survival of *Clarias gariepinus* fry was effective in this study.

Due to the high calcium content of *T.fuscatus* shells, further studies should be carried out on this shell for aquaculture purposes.

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