PRODUCTIVITY OF CUCUMBER (*Cucumis sativus* L) AND POST-HARVEST SOIL CHEMICAL PROPERTIES IN RESPONSE TO ORGANIC FERTILIZER TYPES AND RATES IN AN ULTISOLS†

[PRODUCTIVIDAD DEL PEPINO (*Cucumis sativus* L) Y PROPIEDADES QUÍMICAS DEL SUELO POST-COSECHA EN RESPUESTA A TIPOS Y TASAS DE APLICACIÓN DE FERTILIZANTES ORGÁNICOS EN UN ULTISOL]

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SUMMARY

Cucumber productivity in Nigeria is low due to low native fertility status of the soil among other factors. This field experiment was conducted in February to June of 2015 and 2016 at the Experimental Farm, Faculty of Agriculture, University of Benin, Benin City, Nigeria to evaluate the effects of cattle and poultry manures on the productivity of cucumber (*Cucumis sativus* L.) and their post-harvest effect on the chemical properties of the soil. The experiment was in a 2 x 4 split plot arrangement fitted into a randomized complete block design with three replications with the organic fertilizers (cattle and poultry manures) as main treatments the application rates (0, 5, 10 and 15 t ha^{-1}) as sub plots. Data were collected on growth and yield variables of cucumber. The results revealed that organic fertilizer types had no effect (P>0.05) on growth, yield and post-harvest variables except vine girth. The rate of application had effect on growth, yield and post-harvest soil chemical properties (P<0.05). The highest fruit yields were 3.99 and 3.66 t ha^{-1} observed on plants treated with 15 and 10 t ha^{-1} of organic fertilizer, respectively. Based on convenience and cost, 10 t ha^{-1} of poultry manure is thereby recommended for farmers.

Keywords: Cattle and poultry manures; growth and yield parameters; soil analysis.

RESUMEN

La productividad del pepino en Nigeria es baja debido a la baja fertilidad del suelo, entre otros factores. Este experimento de campo se realizó entre febrero y junio de 2015 y 2016 en la Granja Experimental, Facultad de Agricultura, Universidad de Benin, Ciudad de Benin, Nigeria, para evaluar los efectos del estiércol de ganado y aves de corral en la productividad del pepino (*Cucumis sativus* L.) y su efecto poscosecha sobre las propiedades químicas del suelo. El experimento se realizó en una distribución de parcelas divididas de 2 x 4 en un diseño de bloques completos al azar con tres repeticiones con los fertilizantes orgánicos (estiércol de ganado y aves) como tratamientos principales, las tasas de aplicación (0, 5, 10 y 15 t ha^{-1}) como sub parcelas. Se recolectaron datos sobre las variables de crecimiento y rendimiento del pepino. Los resultados revelaron que los tipos de fertilizantes orgánicos no tuvieron un efecto (P> 0.05) en las variables de crecimiento, rendimiento y poscosecha, excepto la circunferencia de la vid. La tasa de aplicación tuvo un efecto (P <0.05) sobre el crecimiento, el rendimiento y las propiedades químicas del suelo después de la cosecha. Los rendimientos de frutos más altos fueron 3.99 y 3.66 t ha^{-1} observados en plantas tratadas con 15 y 10 t ha^{-1} de fertilizante orgánico, respectivamente. De acuerdo con la conveniencia y el costo, se recomiendan 10 t ha^{-1} de estiércol de aves para los agricultores.

Palabras clave: estiércol de ganado y aves de corral; parámetros de crecimiento y rendimiento; análisis de suelos.

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INTRODUCTION

Cucumber (*Cucmis sativus* L.) is the family of Cucurbitaceae and an important fruity vegetable with great economic potentials, as medicinal plant and source of industrial raw material. Cucumber is a dependable laxative for those who suffer constipation. The juice of cucumbers is a valuable food in the treatment of hyperacidity, gastric and duodenal ulcers (Ernestina, 2001).It is a popular fresh market vegetable for making salads. Fruits are sliced into pieces and served with groundnut, vinegar or a salad dressing, on their own or served other vegetables. Young or unripe cucumber fruits are usually used as cooked vegetables or made into Chutney (Grubben and Denton, 2004). It is a rich source of minerals and vitamins (Eifediyi and Remison, 2009). It is also used in skin and hair care.

Despite the numerous benefits and economic importance of this crop in Nigeria, its cucumber production and utilization have not been a viable option for farmers (Olawuyi *et al.;* 2011). Due to intensive cropping, imbalance use of inorganic fertilizers and continuous cropping among other factors has led to the soil nutrients depletion (Mahmood *et al.;* 2004). This necessitated the use of fertilizer input to supplement the low plant nutrient content of the soil. The yield of cucumber was increased through inorganic fertilizer application (Agba and Enya, 2005).Chemical fertilizers promote plant growth and give high yields. It is however, scarce, beyond the reach of the resource-challenged farmers and pollute the environment. This calls for development of alternative nutrient source to the use of inorganic fertilizer (Olawuyi *et al.;* 2011).This necessitated the use of organic fertilizers in the production of cucumbers. Organic fertilizers are readily available, affordable by the resource poor farmer and eco-friendly. In addition, organic fertilizers mineralize slowly, so a subsequent successive crop can as well benefit from its incorporation into the soil. Hence, the main aim of this study is to evaluate the effect of organic manures on the productivity of cucumbers with the soil sustainable for continuous production.

MATERIALS AND METHODS

Site Description

The field experiment was carried out during the early growing seasons of 2015 and 2016(February to June) at the Experimental Farm, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. This is located between latitude 6°, 44' N and 7°,34' N and longitude 5° 40' E and 6° 43'E. The elevation of the site is about 162 m above sea level. Benin City is in the rain forest agro-ecological zone of Nigeria. The study area lies within rain forest which has now degraded to secondary forest as a result of shifting cultivation. The dominant soil of the site was ultisols of Benin formation (Smith and Montgomery, 1962). Long term weather data (1970 - 2005) at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City indicated an annual rainfall of 2000mm. The rainy season occurs from March to October and maximum rain is received in the month of June, July and August. The minimum, maximum and air temperature is 22.5, 32 and 23.6 ^{0}C, respectively. The dominant plant species at the site were*Panicum maximum* and *Mimosa* spp.

Experimental Design

The field trial comprised two organic fertilizer types (cattle and poultry manures) as the main plots and four rates of application (0, 5, 10 and 15t ha^{-1}) as sub-plots laid out in a 2 x 4split plot arrangement fitted into a randomized complete block design (RCBD) with three replications, giving rise to 24 experimental units (plots). Each plot has a dimension of 1.5 x 3 m with 0.5 m space between plots and one metre between blocks.

Soil Sample Collection, Organic Fertilizers and Laboratory Analysis

Soil sampling was done at two intervals: pre-planting and post-harvest. For the pre-planting, soil samples were collected from the experimental site at a depth of 0-15 cm using auger and bulked together to form composite soil sample for the pre-planting physical and chemical analysis. After harvest, soil samples were randomly collected from each plot and analyzed for its post-harvest chemical properties. The samples were air-dried and sieved with 2 mm sieve and used for soil chemical properties determination. Before application of organic fertilizers (poultry and cattle manures), they were sub-sampled and air-dried for five days under shade and analyzed for chemical properties.

Particle size distribution was determined by the hydrometer Method (Day, 1965), soil pH at 1:1 soil to water ratio was determined using digital glass electrode pH meter. Organic carbon was determined by wet dichromate acid oxidation Method (Page, 1982). Total nitrogen was determined by Micro-Kjedahl Method (Bremmer and Mulvancy, 1982). Available phosphorus was extracted using calcium chloride extraction Method (Houba *et al.*, 2000) Exchangeable bases (Ca, K, Mg and Na) were extracted using 1N ammonium acetate solution at pH 7.0. Calcium and magnesium contents were determined volumetrically by ethylenediaminetetra-acetic acid (EDTA) titration procedure (Black, 1965) while potassium and sodium were by flame photometer. Exchangeable acidity was determined by titration Method (Anderson and Ingram, 1993).

Organic fertilizers (poultry and cattle manures) were analyzed for pH, organic carbon, total nitrogen, phosphorus, potassium, calcium, magnesium and exchangeable acidity using similar procedures as for soil sample.

Cultural Practices

The site was cleared manually using hoe and cutlasses, debris packed and mapped out to blocks. Spade was used to make beds and organic manures incorporated into the designated plots at a rate of 0, 5, 10 and 15t ha^{-1} at four weeks prior to planting to allow for equilibration. Each individual plot was mulched with dried grass (*Panicum maximum*) after incorporation of organic fertilizer.

Seeds were sown in holes two cm deep at the rate of three seeds per hole on the 28th of March, 2015 and 2016 in the field at a spacing of 70 cm within row and 90 cm between rows giving rise to 12 plants per treatment. The plants were later thinned to one plant per stand at the two - leaf stage precisely 14 days after germination. The experiment plot was weeded manually when necessary. The experimental plot was watered every other day, except when it rained. No disease infestation was recorded during the course of the experiment. Minor incidence of cucumber beetles and Lepidoptheral larval attack were controlled by spraying with 60 ml of Upper Cott insecticide per 10 liters of water 14 days after germination.

Data Collection

Within the net plot, four plants were randomly selected and tagged for data collection. Data were collected on vine length, vine girth, number of branches and leaves and leaf area index (LAI). Vine length was measured in cm from the base of the vine to tip of the vine. Vine girth was taken at 5 cm above the base on each sample plant with the use of vernier caliper. Number of branches and leaves referred to the total count of branches and leaves per plant. The leaf area (LA) involved measurement of the length and width for randomly selected leaves of each of the four sampled plants. The means were calculated and used to estimate the LA using Flavio and Marcos (2003) formula and thus:

LA = (0.859 (LW) + 2.7) x number of leaves

Where: LA = leaf area, L = length, W = width.

From the LA, LAI was computed using Remison (1997) formula:

$$LAI = \frac{Leaf\ area}{Land\ area}$$

Days to 50 % flowering were the number of days from sowing to the time of the first six plants in each plot produced visible flowers.

At harvest, data were collected on number of fruits per plants, fruit girth, fruit length, fruit size, fruit weight per plant and fruit yield. Number of fruits per plant was the total count harvested fruits per plant of all pre-tagged plants and average computed. Fruit girth referred to the average width at the widest point in the middle portion of all harvested fruits of pre-tagged plants measured with vernier caliper. Fruit length referred to fruit measurement using tape rule from the bottom to the top of all harvested fruits of pre-tagged plants and average computed. Fruit weight per plant was estimated by the summation of weight of all harvested fruits of pre-tagged plants divided by four. Fruit size was obtained by dividing the fruit weight per plant by number of harvest fruits per plant. Fruit yield was computed based on the weight of harvested fruits per plot and converted into hectare and expressed in tonnes and thus:

$$\text{Fruit yield} = [\frac{Area\ of\ an\ hectare}{Area\ of\ plot} \times wt\ of\ HA] \times \frac{1}{1000} t\ ha^{-1}$$

Where HA = weight of harvested fruits (kg ha^{-1})

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) after finding the mean of the data collected between the two cropping seasons using GENSTAT statistical package. Differences among treatment means were separated using the Least Significance Difference (LSD) test at 0.05 level of probability.

RESULTS

Pre-planting physical and chemical properties of the soil and composition of organic fertilizers

The result of the soil analysis is shown in Table 1. The soil textural class was Sandy loam, slightly acidic and low in total nitrogen, phosphorus, and organic carbon. The chemical properties of the organic manures used for the experiment is shown in Table 2. Chemical analysis showed that poultry manure was neutral (7.20), while cattle manure was alkaline (8.50). Both manures had the high organic carbon content. The results also show that all the manures used contained moderate content of total Nitrogen, Phosphorus, Potassium and Magnesium that can support cucumber production.

Table 1. Physical and chemical properties of soil of the experimental site prior to cropping with cucumber

Soil property	Value
Sand (g kg^{-1})	886.00
Silt (g kg^{-1})	50.40
Clay (g kg^{-1})	63.60
Textural Class	Sandy loam
pH	6.30
Organic carbon (g kg^{-1})	18.60
Total nitrogen (g kg^{-1})	0.86
Available phosphorus (mg kg^{-1})	8.15
Exchangeable cations (cmol kg^{-1})	
Calcium	1.27
Magnesium	0.44
Potassium	0.34
Sodium	0.28
Hydrogen	0.41
Aluminum	0.03

Growth of cucumber

Table 3, shows the effect of organic fertilizer application on vine length, vine girth, number of leaves, number of branches, leaf area index on days to 50 % flowering. There was no significant difference among the organic fertilizer types on the growth parameters except on vine girth where poultry manure had thicker vines. At 50 % flowering, all treated plants except days to 50 % flowering were significantly different from the control plants. Vine length, vine girth, number of leaves and leaf area index (LAI) increased as fertilizer rate increased ($P<0.05$). Unfertilized plots had the least values for all the parameters except days to 50 % flowering. Longest vine (120.75 cm) was observed at the application rate of 15t ha^{-1} but statistically comparable with 10 t ha^{-1} (117.58 cm) and 5t ha^{-1} (115.67 cm). This distribution pattern was repeated for number of branches and LAI. The thickest vines were observed on plots fertilized with 15t ha^{-1} (1.81 cm) and 10 t ha^{-1}(1.78 cm).This trend was repeated for number of leaves.

Table 2. Chemical composition of organic fertilizers

Parameter	Organic fertilizer	
	Poultry manure	Cattle manure
pH	7.20	8.50
Organic C (g kg^{-1})	34.40	28.73
Available P (mg kg^{-1})	9.70	6.45
Total N (g kg^{-1})	1.85	1.23
Exchangeable cations (cmol kg^{-1})		
Ca^{2+}	2.84	3.53
Mg^{2+}	0.76	0.92
K^{+}	0.72	0.42
Na^{+}	0.35	0.38
H^{+}	0.06	0.04
Al^{3+}	0.04	0.03

Table 3. Effects of different level of organic fertilizer on the growth of cucumber

Treatment	Vine length (cm)	Vine girth (cm)	No. of leaves	No. of branches	LAI	Days to 50 % flowering
Organic fertilizer type						
Cattle manure	115.92	1.61	14.42	4.07	1.28	32
Poultry manure	116.79	1.68	13.92	4.08	1.23	34
$LSD_{(0.05)}$	ns	0.054	ns	ns	ns	ns
Rate of application						
0	111.42	1.41	13.17	3.47	1.06	34
5	115.67	1.59	14.08	3.92	1.30	33
10	117.58	1.78	14.50	4.33	1.32	34
15	120.75	1.81	14.92	4.58	1.34	33
$LSD_{(0.05)}$	5.959	0.216	0.795	0.679	0.131	ns
F x R	ns	ns	ns	ns	ns	ns

Fruit yield and yield components

Table 4, shows the effect of organic fertilizer type and rate of application on number of fruits, fruit girth, fruit length, average fruit weight and fruit yield. Results showed that there was no significant difference on the fertilizer type on yield parameters. Rate of fertilizer application had significant on growth parameters except fruit size. Number of fruits per plant was highest in plots fertilized with 15t ha^{-1} (9.90) and this was statistically similar to 10 t ha^{-1} (8.10). Similar trend was observed in fruit weight and fruit yield. Fruit girth and length values observed with plots fertilized with 5, 10 and 15t ha^{-1} were statistically comparable (P>0.05) but significantly (P<0.05) than 0 t ha^{-1} (unfertilized plots). There was no significant interaction effect of fertilizer type and rate of application on the yield of cucumber.

Post-harvest soil chemical properties after cropping with cucumber

The post-harvest effect of organic fertilizer application on soil chemical properties is presented in Table 5. Organic fertilizer type had no significant effect on post-harvest soil chemical properties except on exchangeable Mg which was higher in poultry manure treated plots. The rate of application of organic fertilizer had significant effect only on organic carbon, total N, available P and exchangeable Mg .These chemical properties increased with increase in rate of fertilizer application. However, 5 – 15 t ha^{-1},were not significantly different for total N and available P. Plot fertilized with 15 t ha^{-1}organic fertilizer had the highest organic carbon (21.21 g kg^{-1}) and exchangeable Mg^{2+} (4.01). There was no significant interaction effect of organic fertilizer and rate of fertilizer application on any of the post-harvest soil chemical property.

Table 4. Effects of different level of organic fertilizer on the yield and yield components of cucumber

Treatment	No of fruits plant^{-1}	Fruit girth (cm)	Fruit length (cm)	Fruit size (g)	Fruit weight kg plant^{-1}	Fruit yield t ha^{-1}
Organic fertilizer type						
Cattle manure	7.62	16.49	16.48	181.10	1.40	3.13
Poultry manure	7.10	15.48	15.36	197.40	1.35	3.03
$LSD_{(0.05)}$	ns	ns	ns	ns	ns	ns
Rate of application						
0	4.93	15.25	14.75	183.40	0.86	1.93
5	6.50	15.94	16.79	185.80	1.20	2.69
10	8.10	16.47	16.53	205.20	1.65	3.66
15	9.90	16.29	15.62	182.40	1.80	3.99
$LSD_{(0.05)}$	2.606	0.628	1.295	ns	0.366	0.790
F x R	ns	ns	ns	ns	ns	ns

DISCUSSION

The general fertility status of the soil was low since it contained low amount of total N, available P and organic Carbon. This could be due to leaching, erosion and loss of organic matter (Duran and Smith, 1987).This observation corresponded with Agboola (1982), who reported that soils in Nigeria are generally low in inherent fertility. Consequently, the use of organic fertilizers is most effective means in improving soil fertility in order to boost crop productivity.

Cattle and poultry manure on analysis contained essential plant nutrients required for proper growth of plants. This is in agreement with Moral *et al* (2005), who reported that organic fertilizers were as good as inorganic fertilizer for improving crop production. They contained high amount of organic carbon. This emphasized the manures can improve the soil physical, chemical and biological properties. Since organic carbon is a reservoir of plant nutrients, on mineralization, it would release more nutrients to the soil. These nutritious qualities of the manures may then be utilized for the growth and development of the crop. The tested crop benefited from organic fertilizer application as its growth was enhanced compared to unfertilized plants, through their superior growth. This is in agreement with Agba and Enya (2005) and Eifediyi and Remison (2009), who had reported increase in growth and yield components of cucumber in response to fertilizer application. Similarly, Ndaeyo *et al* (2005) also reported the crop response to fertilizer application. The response to fertilizer application is affected by nutrient reserve in the soil. According to Ndaeyo *et al* (2005), crops respond more to fertilizer application in soils with low nutrient reserve, than soils with high nutrient reserve. Superior performance of poultry manure in thickening vine girth can be attributed to high total N and available P in poultry manures compared to cattle manure. This observation is in agreement with Ewulo (2008) who reported that poultry manure contain high percentage of N and P for healthy growth of plants. This also suggests that more assimilates were produced in poultry manure treated plants which enhanced thicker vine production. Since Mg played an active in photosynthesis, higher Mg content available to poultry manure treated plants is an indication of higher production of assimilates resulting in secondary growth of the plant, hence thicker vines.

Increase in the number of leaves of fertilized plants compared to unfertilized plants indicated that increased nutrients in the soil increase number of leaves per plant. This was similar to findings by Law-Ogbomo and Remison (2009), who observed highest number of leaves in yam plants treated with the highest rate of fertilizer, while the least number was recorded in those treated with 0 t ha^{-1} (control). Higher number of leaves corresponding give rise to higher leaf area index (LAI) due to adequate supply of nutrients from applied manures, led to better utilization of nutrients for the production of assimilates resulted in higher values for these characters. Increased LAI was more pronounced in plants treated with fertilizers. This could be due to higher leaf area and number of leaves observed with fertilized plants. High LAI associated with fertilized plants signify greater leaf product rates, leaf area expansion and leaf area duration (Law-Ogbomo and Remison, 2009).

After cropping with cucumber, fertility status of the soil was improved. The higher exchangeable Mg observed in poultry manure treated plots implies higher rate of mineralization of Mg. The higher organic content of the poultry manure could have probably accounted for the residual exchangeable Mg content of the soil The reduction in the pH level of the soil could be attributed to crop removal. The rate of fertilizer application had significant effect on organic Carbon, total N available P and exchangeable Mg^{2+} and increased up to300 kg Nha^{-1}. This agreed with Dinesh *et al* (2012) who observed significant increase in soil properties in the short term following application of organic and bio-fertilizers. Similarly, Mbagwu and Ekwealor (1990) reported that organic fertilizers apart from releasing nutrient elements to the soil, improves other soil chemical and physical properties, which enhances crop growth and development.

Table 5. Some post-harvest soil chemical properties after cropping with cucumber as influenced by different level of organic fertilizer application

Treatment	pH	Organic C	Available P	Total N	Exchangeable cations (cmol kg^{-1})					
		(g kg^{-1})	(mg kg^{-1})	(g kg^{-1})	Ca^{2+}	Mg^{2+}	K^+	Na^+	H^+	Al^{3+}
Organic fertilizer type										
Cattle manure	5.44	18.49	8.45	0.81	0.63	0.24	0.29	0.20	0.44	0.06
Poultry manure	5.17	18.38	8.50	0.84	0.51	2.08	0.29	0.14	0.48	0.07
$LSD_{(0.05)}$	ns	ns	ns	ns	ns	1.356	ns	ns	ns	ns
Rate of application (t ha^{-1})										
0	5.22	16.32	7.90	0.81	0.51	0.19	0.28	0.16	0.50	0.07
5	5.23	16.84	8.44	0.82	0.52	0.23	0.29	0.16	0.49	0.06
10	5.37	19.37	8.64	0.83	0.59	0.22	0.29	0.18	0.44	0.06
15	5.40	21.21	8.91	0.84	0.68	4.01	0.29	0.18	0.42	0.06
$LSD_{(0.05)}$	ns	0.883	0.565	0.023	ns	1.901	ns	ns	ns	ns
F x R	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

CONCLUSION

Application of cattle and poultry manure enhanced the growth and productivity of cucumber. However, poultry manure treated plants had thicker vines. The highest yield was obtained from 15 t ha^{-1}, which was statistically comparable to 10 t ha^{-1}. Soil chemical properties were enhanced by organic fertilizer application. But poultry manure left more exchangeable Mg to the soil and also contained more organic carbon, total N and available P than cattle manure. Therefore, it is suggested that farmers in the ultisols location use 10 t ha^{-1} of poultry manure in place of inorganic fertilizer to boost production, based on convenience and cost.

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