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Original Research Article

Effect of organic and inorganic fertilizers on the growth and yield of cucumber (*Cucumis sativa L.*) in South-South Nigeria

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The experiment was conducted at the University of Port Harcourt Teaching and Research farm, Port Harcourt, Rivers State, Nigeria from April to August, 2019 on the effects of organic and inorganic fertilizers on the growth and yield of cucumber (*Cucumis sativus* L). The research was done in a randomized complete block design with four treatments and replicated four times. The treatments include control (no application), NPK 15:15:15, spent mushroom substrate, and poultry manure. Data collected were, vine length (plant height), number of leaves, stem girth, leaf area, length of pod, weight of pod. Results showed that plots with poultry manure had significant effect on vine length, number of leaves, leaf area at 6 weeks after planting (WAP) and 8WAP. The highest number of fruits was 9.0 per plot or 15,000 per hectare and highest fruit weight was 1.59kg/plot (2,650kg/ha) which were higher than NPK 15:15:15 (0.47kg/plot or 783.33kg/ha) and spent mushroom substrate (0.19kg/plot or 316.67kg/ha). Hence, the use of poultry manure as organic source for the cultivation of cucumber in the study area would be recommended.

Keywords: NPK 15:15:15, poultry manure, spent mushroom substrate, cucumber.

INTRODUCTION

Cucumber fruit (*Cucumis sativus* L.) belongs to the Cucurbitaceae plant family that can be cultivated in subtropical and tropical environments; therefore, they are native to many countries of the world (Gross et al., 2014; Ismail et al., 2010). It is an important fruit vegetable that is cultivated in most parts of Nigeria. This plant is a versatile vegetable because of various uses ranging from salads, pickles, beauty products and digestive aids.

Cucumber serves as a major source of vitamins but is still low in productivity owing to several factors, with nutrient/water observed to be the limiting factors (Ayotamuno et al., 2007). Fresh consumption of this crop provides a variety of health benefits including valuable antioxidant, anti-inflammatory and anti-cancer benefits (Mukherjee et al., 2013). In the global market, about 80% of the world production of cucumber is in Asia with China leading production (60%) followed by Turkey, Russia, Iran and the United States of America in that order. The global production of cucumber was 65 million tonnes in 2012 grown in an area of 2,109,650 ha (FAOSTAT, 2013).

Cucumbers help eliminate uric acid which is mostly beneficial to those who have arthritis, and its fiber-rich skin and high levels of potassium and magnesium helps regulate blood pressure and promote nutrient functions. The magnesium content in cucumbers also relaxes nerves and muscles and aids blood circulation.

Cucumber production is fast becoming popular in most part of Nigeria probably because of its high nutritional and economical value (Nweke et al., 2013). In South Eastern Nigeria, cucumber farming is hardly practiced because of its ecological requirement of high temperature, rainfall and relative humidity. Successful cultivation of any crop depends on several factors. Fertilizer is one of the important factors of a successful cucumber cultivation. Fertilizers are substances which when added to the soil supply one or more plant nutrients. It can be organic or inorganic.

Inorganic fertilizers are chemical compounds made in

factory or obtained from mining while organic fertilizer is composed mainly of waste and residues from plants and animal life (Cooke, 1982). Organic fertilizers are derived from animal matter, animal excreta (manure), human excreta and vegetable matter. Examples are compost and crop residues (Heinrich et al., 2009). Organic fertilizers are used to augment the concentrations of plant nutrients and organic substances. They can restore soil fertilities and enhance the crop yield, in quantity and quality.

The use of inorganic fertilizer has not been helpful under intensive agriculture because of its high cost and its association with reduced crop yield, soil degradation, nutrient imbalance and acidity (Kang and Juo, 1980; Obi and Ebo, 1995). The complementary use of organic and inorganic fertilizers has been recommended for sustenance of long-term cropping in the tropics (Ipimoroti et al., 2002). Aliyu (2000) also reported that vegetables grown on plots treated with organic manure are always larger than those grown on plots treated with inorganic fertilizers, because organic manure improves the soil structure, increases aeration, water retentions as well as nutrient ions retentions and adsorptions for effective crop growth.

In spite of the increasing relevance of cucumber in Nigeria where it is widely consumed, low yields are obtained in farmers' field because of declining soil fertility as a result of continuous cropping and poor knowledge to soil amendment practices, which has led to several nutrients becoming deficient.

It is in attempt to fill the gap in our present knowledge that this research was carried out to evolve a package for the optimization of the production of cucumber in Nigeria through fertilizer especially the poultry manure and spent mushroom substrate.

The objective of this study was to investigate the effects of organic fertilizers: poultry dropping, spent mushroom substrate comparing with inorganic fertilizer (N.P.K. 15:15:15) on the growth and yield of cucumber in Port Harcourt, Rivers State.

MATERIALS AND METHODS

Experimental Site

In order to study the effect of organic and inorganic fertilizer on growth and yield of cucumber, a field experiment was conducted during the 2019 growing season at the Teaching and Research Farm of Faculty of Agriculture, University of Port Harcourt, Rivers State. The University of Port Harcourt lies on latitude 04^{o} 54^{1} 538^{1}N and 006^{o} 55^{1} 329^{1} E with an average temperature of 27^{o}C, relative humidity of 78% and average rainfall that ranges from 2500-4000mm (Nwankwo and Ehirim, 2010).

Experimental Design and Field Preparation

Soil sample were collected with an auger from the experimental field before clearing of the site at a depth of 0-15 cm for analysis. The samples were taken at different points of the experimental site and bulked together to get a composite sample and air dried for analysis. The air-dried samples were passed through a 2mm mesh sieve before analysing for physico-chemical properties at Zetta Allied Digital Energy Limited, Port Harcourt, Rivers State, Nigeria. The particle size analysis was done by using hydrometer method (Gee and Bauder, 1986). Soil pH was determined using 1:2 soil distilled water suspension using a pH meter (Maclean, 1982). Available phosphorus was estimated by the Bray and Kurtz No.1 method as modified by Olsen and Sommers (1994). Percentage organic matter was derived by multiplying % organic carbon by Broadbent factor of 1.72. Total N was determined by Macro-Kjeldahl method of Bremner and Mulvaney (1982), organic carbon was determined by Walkley and Black (1934) while exchangeable bases (Na, K, Ca, Mg) were extracted with 1N solution of NH_4OA buffered at pH 7.0 and read directly using a flame photometer (Thomas, 1982). Also analyzed was organic fertilizers (poultry manure and spent mushroom substrate). They were analyzed to determine their nutrient contents before application.

The conventional land preparation which was manual clearing and preparation of beds were carried out to conserve the soil and its nutrient. A total land area of 17 m x 10 m (0.017 ha) was used for the experiment with a bed size of 2 m x 3 m given a total of 16 beds (4 blocks) and alley way of 0.5 m. The experiment was laid out in a randomized complete block design (RCBD) with four treatments and was replicated four times. The experimental treatments were: organic manure [poultry manure (PM) and spent mushroom substrate (SMS)], inorganic fertilizer (NPK 15:15:15) and control (no application). Poultry manure was sourced from a middle scale poultry farm at Alakahia in Port Harcourt, Rivers State, the spent mushroom substrate was gotten from mushroom unit of Faculty of Agriculture, University of Port Harcourt. NPK 15:15:15 was sourced from Oil-mill market, Eleme in Rivers State. The hybrid F1 seed was bought from Agri-tropic vegetable seeds in Port Harcourt.

Application of poultry manure and spent mushroom substrate was carried out 9 days before planting, for proper decomposition. Quantity used was 6kg per bed in each case, giving a total of 96kg per 0.017ha or 5,648kg/ha. It was spread evenly and mixed up with soil using shovel. N.P.K 15:15:15 was applied 3weeks after planting at the rate of 3g/plant and was applied using ring method. Planting was done in May 2019. Two seeds were sown per hole at a spacing of 60 cm x 50 cm given a total of 40 seeds per bed and total population of 640 seeds per 0.017ha at a depth of 2 cm. Manual weeding was done at 3, 6, and 9 weeks after planting using hand hoe and hand picking. Staking of the vines were also done 5 weeks after planting, when the vines were long enough to climb the stick. A height of 1m staking was maintained on all the beds. Staking of the plants is important so as to reduce infection that may lead to rotting of the fruits as a result of contact with soil.

Data Collection

Data collection was done with respect to growth and yield parameters. On growth parameters the followings were

Table 1. Chemical analysis of soil, poultry manure and spent mushroom substrate

Chemical properties	Soil sample Value	Poultry manure	Spent mushroom substrate
pH	5.9	7.1	6.4
Total Nitrogen (%)	0.14	4.8	1.74
Available P (mg/kg)	14	9.7	1.73
Ca (cmol/kg)	1.03	2.31	1.95
Mg (cmol/ kg)	1.27	2.01	1.94
Available K (cmol/kg)	0.083	1.8	2.26
Sand (%)	16.00		
Silt (%)	19.00		
Clay (%)	63.00		
Organic carbon (%)	0.60		
Organic matter (%)	1.032		
Textural Class	Sandy loam		

Fertilizers Effects on Growth Parameter

taken: vine length (plant height), numbers of leaves, leaf area, leaf area index and plant girth. These parameters were taken at interval of 4th, 6th and 8th weeks after planting. A sample of three plants were randomly selected from the inner rows of each experimental unit and marked with plastic spoon, to measure the growth parameter.

On vine length of the plant, it was measured from the ground level to the tip of the plant, using a meter rule. The number of leaves per plant was taken by counting the number of leaves on the plant, while on leaf area, three leaves were selected randomly, the length and its width were taken with a transparent meter rule. The plant girth was measured using caliper.

On yield parameter, the data collected after fruit harvest (produce of cucumber) includes; fruit length, which was measured using a transparent meter rule, the length taking from the top to the end. Fruit weight from each sub plot was weighed and recorded using weighing balance.

Statistical Analysis

The data generated from this experiment were subjected to Analysis of variance (ANOVA) using the computer software SAS (2010) and the treatment means were separated using the Least Significant difference (LSD) at 5% probability.

RESULTS

Chemical properties of Soil and the Treatments

The results of the chemical composition of the soil, poultry manure (PM) and spent mushroom substrate (SMS) before planting and before applications is in Table 1. The results showed that soil was sandy loam by texture and moderately acidic with pH value of 5.9, while nitrogen was low, calcium and potassium were very low. Phosphorus and magnesium were moderately low. Poultry manure showed a pH value of 7.1 (neutral), but had very high nitrogen, medium calcium, moderate magnesium and very high potassium. Spent mushroom substrate is slightly acidic with pH value of 6.4, very high nitrogen, medium phosphorus, very low calcium, moderate magnesium and very high potassium.

The effects of poultry manure (PM), spent mushroom substrate (SMS) and NPK 15:15:15 on plant height, number of leaves, leaf area, leaf area index, and stem girth of cucumber are presented in Tables 2 and 3 below.

On Plant height (cm), the means from Table 2 shows that at 4 WAP spent mushroom substrate had the lowest mean, but no significant difference between NPK and Control, and at 8 WAP there was no significant difference between SMS and Control. Poultry manure maintained the highest mean value from 4 – 8 WAP. There were significant differences among treatments at 4, 6 and 8 WAP. On the number of leaves as indicated in Table 2, there were significance difference among the various treatments throughout the 4, 6 and 8 WAP, with poultry having the highest mean (16.0; 29.00; 21.0 respectively) followed by NPK 15:15:15 at 4 WAP, 6 WAP and 8 WAP then spent mushroom substrate while control had the least mean.

Fertilizers Effects on Leaf Area (cm^2)

The leaf area as indicated in Table 3 differs significantly ($p = 0.05$) as shown below. There was significance difference among the various treatments as observed in 4, 6 and 8 WAP, with poultry manure having the highest leaf area (360.7, 449 and 382 cm^2 respectively) followed by NPK 15:15:15, Spent Mushroom Substrate at 6 and 8 WAP compared to Control which is the least. Although there was no significant difference between SMS, NPK and Control at 4 and 6 WAP compared to poultry manure. At 8 WAP the lowest mean was observed in control, while there was no significant difference between SMS and NPK. The highest effect value was obtained at 6 WAP while the lowest was seen at 4 WAP.

The fertilizer effect on leaf area index in Table 3 shows that poultry manure at 4WAP was significantly higher compared with other treatments used at this stage. There was no significance difference between NPK and Spent mushroom substrate on the leaf area Index at 4WAP. Furthermore, the result reveals that poultry manure is still significantly higher than all other treatments at 6 WAP. It also reveals that there were no significance differences

Table 2. Effect of Fertilizers on Plant height (cm) and Number of leaves

	Plant	Height	(cm)	Number	Of	Leaves
	4WAP	6WAP	8WAP	4WAP	6WAP	8WAP
Control	14.58 b	45.3 b	58.8 c	8.0 b	14.0 c	12.0 a
NPK 15:15:15	14.87 b	59.2 b	78.2 b	9.0 b	19.0 b	19.0 a
PM	38.49 a	106.5 a	109.8 a	16.0 a	29.0 a	21.0 a
SMS	13.82 a	47.8 b	46.5 c	8.0 b	15.0 c	17.0 a
LSD 5%	5.87	17.17	45.81	2.499	4.438	14.31

Means with the same letter down the column were not significantly different at 5% probability
NOTE: WAP (weeks after planting); PM (poultry manure); SMS (spent mushroom substrate)

Table 3. Effect of fertilizers on Leaf Area (cm^2), Leaf Area Index and Stem Girths (cm^2)

	Leaf	Area	(cm^2)	Leaf	Area	Index	Stem	Girths	(cm^2)
Treatments	4 WAP	6 WAP	8 WAP	4WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP
Control	148.6 b	214 b	200 c	0.427 b	1.06 b	1.24 a	2.83 b	3.26 b	3.44 a
NPK 15:15:15	156.5 b	276 b	298 b	0.443 b	1.78 b	1.89 a	2.75 b	3.28 b	3.60 a
PM	360.7 a	449 a	382 a	1.833 a	4.40 a	2.89 a	4.00 a	4.54 a	4.68 a
SMS	184.8 b	241 b	247 b	0.524 b	1.13 b	1.19 a	2.76 b	3.16 b	3.65 a
LSD 5%	45.26	72.3	140.7	0.366	0.956	1.852	0.41	0.39	1.29

Means with the same letter down the column were not significantly different at 5% probability

Table 4. Effect of Fertilizers on the Number of fruits and Fruits weight (kg/plot)

	Number	of	Fruits			Fruit			Weight	
Treatments	6WAP	7 WAP	8 WAP	9 WAP	10 WAP	6 WAP	7 WAP	8 WAP	9 WAP	10 WAP
Control	0.0 a	1.0 b	0.0 b	2.0 b	1.0 b	0.00a	0.02 a	0.01 b	0.18 b	0.7 b
NPK 15:15:15	1.0 a	2.0 bc	3.0 b	4.0 b	7.0 b	0.02 a	0.03 a	0.47 b	0.51 b	0.56 b
PM	2.0 a	4.0 a	9.0 a	8.0 a	8.0 a	0.35 a	0.55 a	1.59 a	1.27 a	1.25a
SMS	2.0 a	2.0 bc	2.0 b	4.0 b	3.0 b	0.19 a	0.25 a	0.19 b	0.27 b	0.23 b
LSD 5%	2.46	3.46	3.62	4.22	5. 09	0.41	0.55	1.15	0.980	0.71

Means with the same letter down the column were not significantly different at 5% probability

between NPK and SMS on the leaf area index of cucumber. At 8WAP, poultry manure maintains the highest mean among the treatments with a value of 2.89cm^2 compared to spent mushroom substrate: 1.19cm^2 and NPK: 1.89cm^2, but there was no significance difference. The effect of fertilizer on stem girth in Table 3 shows that the poultry manure is significantly different with a value of 4.0cm^2 at 4WAP compared with spent mushroom substrate and NPK.

This result also shows that there is no significant difference between NPK and spent mushroom substrate. However, there was no significant difference between Control (3.26 cm^2), NPK (3.28 cm^2) and Spent mushroom substrate (3.16 cm^2) at 6 WAP as compared to poultry manure at 4.54cm^2.

Fertilizer Effect on Yield Parameters

Number of fruits

In Table 4, poultry manure from the first harvest (6 WAP) to the last harvest (10 WAP), had increase in number of fruits, having a mean of 2.0, 4.0, 9.0, 8.0 and 8.0 respectively compared to other treatments. A significant difference at 5% probability was observed at 7, 8, 9 and 10 WAP of harvest with the application of poultry manure.

Fertilizer Effects on Fruit Weight per Plot (kg/ha)

From Table 4, the highest fruit weight of 1.59 kg/plot (2,650kg/ha) was obtained with the application of poultry manure compared to 0.19 kg/plot (316.67kg/ha) of spent mushroom substrate, 0.47 kg/plot (783.33kg/ha) in NPK and 0.01kg/plot (16.67kg/ha) in control at 8WAP.

Fertilizer Effects on Fruit Length (cm) and Fruit Diameter (cm^2)

From the result in Table 5, the fruit length and diameter were significantly enhanced by poultry manure, the means at 7 WAP and 8 WAP was observed to be significant with

Table 5. Effect of Fertilizers on Fruit length (cm) and Fruit diameter (cm^2)

	Fruit Length					Fruit Diameter				
Treatments	**6WAP**	**7 WAP**	**8WAP**	**9 WAP**	**10 WAP**	**6WAP**	**7WAP**	**8 WAP**	**9 WAP**	**10WP**
Control	0.00 a	5.8 b	3.1 c	9.7 a	7.6 a	0.00a	6.9 b	3.8 b	10.4 a	6.9 a
NPK 15:15:15	0.25 a	6.8 b	7.1 b	11.9 a	13.6 a	0.42 a	6.8 b	7.4 bc	11.5 a	11.4 a
PM	1.15 a	16.8 a	16.7 a	15.9 a	15.7 a	1.67 a	16.2 a	15.6 a	14.5 a	14.0 a
SMS	1.12 a	4.0 b	10.1 b	11.2 a	10.3 a	1.21 a	3.7 b	11.2 bc	13.4 a	10.0 a
LSD 5%	1.92	10.24	7.94	9.25	7.57	1.99	10.66	8.98	9.63	10.22

Means with the same letter down the column were not significantly different at 5% probability

poultry manure having the highest mean 16.8, 16.5 and 16.2, 15.6 respectively. At 6 WAP (1st Harvest), 9WAP and 10 WAP, there was no significant difference although poultry manure had the highest mean. At 6WAP, there was no harvest recorded in control, few in NPK (0.25; 0.42) and poultry manure (1.15; 1.67) was higher.

DISCUSSION

The result of the soil analysis was in accordance to the criteria for soil fertility classes of Ibedu et al., (1988). The low fertility of the soil was as a result of continuous cropping in the experimental area over the years. The analysis of poultry manure and spent mushroom substrate was to have an idea of its nutrients statues and the quantity to apply.

The highest number of leaves was observed at 6 WAP. This was as a result of nutrient in the enriched soil from application of organic fertilizers. This confirms the findings of Poswal and Akpal (1991) who reported that organic amendments such as green manure, crop residues, and poultry manure are used in improving soil fertility, hence the performance in plant height and number of leaves. It also confirms the work of Garg and Bahla *(*2008), that reported poultry manure supplies more nitrogen and phosphorus to the plants as compare to other organic fertilizers.

The vigorous growth and leaf formation observed in the treated plots suggests that poultry manure has positive effect on the leaf formation and growth due to the high nitrogen content of the poultry manure. This agrees with Ridge (1991), who observed that the number of leaves produced by a plant, its leaf area and leaf area index are directly proportional to the photosynthates produced. Poultry manure contains essential elements associated with high photosynthetic activities and thus promoted roots and vegetative growths (Hochmuth et al*.,* 1993; Opara and Asiegbu, 1996; Ajari et al., 2003; John et al., 2004; Rayeswari et al., 2007).

On the number of fruits, the results were similar with maize plant fertilized with poultry manure which produced higher grains probably due to reasonable and sufficient supply of nutrients from the manure. Similar results were achieved by Ezeibekwe et al. (2009) where he had highest flowering, fruiting and fruit biomass with poultry manure.

The results obtained on fruits weight is in accordance with Schjegel (1992) who observed that the need and utilization of poultry manure has overtaken the use of other animal manure, because of its high content of nitrogen, phosphorous and potassium. It also agrees with the previous studies by Warman (1986), Duncan (2005), Oagile and Namasiku (2010), that observed poultry manure was preferred amongst other organic animal wastes because of its high concentration of macro-nutrients. Uwah and Iwo (2011) reported an increase in fresh pod weight of okro by 94 and 57% while mean fresh pod yield by 160 and 115% when 10t ha^{-1} poultry manure and 4t ha^{-1} mulch rates were used respectively compared to the unamended control plots. The effects on fruits length agreed with (Dauda et al*.,* 2005) who reported positive effects of poultry manure on plant growth and development as well as its nutrient content.

Conclusion

This field trial experiment indicates clearly the effect of application of organic (poultry manure, and spent mushroom substrate) and inorganic (NPK 15:15:15) fertilizers as soil enrichment materials which resulted in the better performance of cucumber in terms of growth and yield compared to the control. The experiment shows that the soil enriched with poultry manure gave more productive yield and growth than spent mushroom substrate, NPK 15:15:15 and control. Therefore, poultry manure should be used for cucumber production in the study area for better yield. Further trials are required in order to determine the effects of the amendment materials on the nutritional value of cucumber.

Conflict of interests

The authors declare that they have no conflicting interests.

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