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Profitability of the use of poultry manure for cucumber (*Cucumis sativus* L.) production in Iwollo, Southeastern Nigeria

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ABSTRACT: A field experiment was conducted at the Teaching and Research Farm of Enugu state polytechnic, Iwollo, Southeastern Nigeria in 2020 to evaluate the profitability of the use of poultry manure for cucumber production in the area. The study was carried out in a randomized complete block design (RCBD) with four replications. The treatment comprised different rates of poultry manure viz; 0 (control), 5, 10, 15 and 20 t ha^{-1}. The growth and yield parameters investigated were vine length, number of branches per plant, number of leaves per plant, leaf area index, number of fruits per plant, fruit yield per plant and fruit yield per hectare. The data collected on growth and yield parameters were subjected to analysis of variance (ANOVA) and treatment means were separated using Fisher's least significant difference (F-LSD) at 5% level of probability. Gross margin (GM) as well Return on Investment (RoI) was calculated to determine the profitability. The results showed that poultry manure significantly ($p<0.05$) induced higher vine length, number of branches per plant, number of leaves per plant, leave area index, number of fruits per plant, fruit yield per plant and fruit yield per hectare compared to control (0 t/ha) with optimum values obtained in 20 t ha^{-1}. The profitability of the use of poultry manure increased with increase in the rate of poultry manure. The highest gross margin (₦ 3,233,860) was obtained from 20 t ha^{-1} of poultry manure followed by 15 t ha^{-1} (₦ 2,021,020), 10 t ha^{-1} (₦ 1,381,748), 5 t ha^{-1} (₦ 588,300) and 0 t ha^{-1}(₦14,660). Similarly, the highest RoI was obtained in 20 t ha^{-1} of poultry manure (325.95%) followed by 15 t ha^{-1} (237.49%); 10 t ha^{-1} (185%); 5 t ha^{-1} (93%) and the lowest was in 0 t ha^{-1} (2.76%). It could be concluded from the study that the use of poultry manure for cucumber production in Iwollo is profitable and most profitable when 20 t ha^{-1} is used.

Keywords: Cucumber, gross margin, growth, profitability, return on investment, yield.

INTRODUCTION

Cucumber (*Cucumis Sativus* L.) is a monoecious annual horticultural crop that belongs to the Cucurbitaceae family (Rolnik and Olas, 2020). It is believed to have been cultivated by man for over 3,000 years (Adetula and Denton, 2003; Okonmah, 2011). Cucumber is a creeping vine that roots in the ground and can grow through supporting frames, wrapping around supports with its thin tendrils. It is believed to have been first domesticated in India and later in Iran and China (Golabadi et al., 2012) and it is grown all around the world (Pal et al., 2017). Cucumber is grown for its tender fruits, which are consumed either raw as salad, cooked as vegetable or as pickling in its immature stage (Khan et al., 2015). The fresh cucumber fruits are good source of vitamin C, vitamin K, vitamin A, vitamin B6 and thiamin (Adinde et al., 2016). It helps in healing diseases of urinary bladder and kidney, digestive problems like heart burn, acidity, gastritis and ulcer (García-Closas et al., 2004).

In Nigeria, cucumber is widely grown in the northern part of the country where there is favourable weather conditions for the crop in contrast to the extreme temperature, heavy rainfall and high humid condition in the Southern part which does not favour cucumber production. Nevertheless, the crop is presently been cultivated in some parts of southeastern Nigeria under moderate rainfall and controlled environment. In Iwollo, its production and utilization is gradually increasing with prevailing market price of ₦250 ($0.61) per kilogram of fresh cucumber fruits for 2020 production season. Farmers in the area still lack technical knowhow required for the production coupled with declining soil fertility due to continuous cropping among other factors which often lead to low yield per unit area of the crop. Application of organic and inorganic fertilizer has been established as effectively way of improving growth and yield of crops (Iken and Amusa, 2004; Dauda et al., 2008; Kroma et al., 2016; Khan et al., 2017; Ogunniyi et al., 2019). Inorganic fertilizers are often expensive, unaffordable, inaccessible and unavailable to small-holders farmers in Nigeria. Organic manure serves as a good alternative to inorganic fertilizer (Naeem et al., 2006) and improves soil structure (Dauda et al., 2008) and microbial biomass (Suresh et al., 2004). Organic manure plays a direct role in plant growth as a source of all necessary macro and micro nutrients in available forms during mineralization and improves physical and chemical properties of soils (Chatejee et al., 2005). According to Kaith et al. (2009), organic manure repairs infertile soil by improving the soil texture, colour, mineral availability to plant, water retention ability and survival of micro organisms. Mangila et al. (2007) and Enujeke et al. (2013) noted that poultry manure is not only cheap and effective but also essential for establishing and maintaining the optimum soil physical conditions for plant growth and yield. Adesina et al. (2014), Alabi (2006) and Aliyu (2003) also noted that application of poultry manure is one of the ways of improving soil fertility and final yield of crops. Mangila et al. (2007) and Enujeke (2013) reported that poultry manure contained nutrients which improve the physical condition of soil for plant growth and development. Ewulo et al. (2008) also reported that high concentration of nitrogen present in poultry manure is easily available to plants and released slowly to the soil. Agu et al. (2015) reported increased vine length and number of leaves per plant of cucumber as a result of poultry manure application and stated that it could be due to improvement in the nutrient status and physicochemical properties of the soil. Dauda et al. (2008) reported that poultry manure increased fruit weight of cucumber and attributed it to the ability of poultry manure to increase soil fertility.

Most of the researches on the use of poultry manure for cucumber production were centered on evaluating the optimum level of poultry manure for growth and yield of the crop. Agu et al. (2015) reported significant higher performance of cucumber crop in Iwollo, Southeastern Nigeria as a result of the application of poultry manure at 40 t ha^{-1}. Oke et al. (2020) recommended 15 t ha^{-1} of poultry manure for commercial production of cucumber in Ibadan, Nigeria for rapid growth and yield. Enujeke (2013) recommended 20 t $ha^{-1}$of poultry manure to farmers in Asaba, Nigeria for increase in growth and yield of cucumber. There is dearth of information on the profitability of the use of poultry manure for cucumber production in Iwollo, Southeastern Nigeria. Poultry manure, though cheaper than inorganic fertilizer is no longer seen as just pollutant in Iwollo, Southeastern Nigeria. Available findings on its relevance in soil amendment and as good alternative source of plant nutrients have increased its value and demand. Poultry manure serves as additional source of revenue to poultry farmers in the study area who bag it and sell to crop farmers. Presently, poultry manure is sold at ₦10,000 ($24.34) per ton in Iwollo, Southern Nigeria. The application of poultry manure or increase in the rate of poultry manure leads to increase in the total variable cost of the production which can result to economic loss if there is no marginal return. It is imperative to do economic analysis of cucumber grown under different rates of poultry manure to determine the profitability of the use of poultry manure for cucumber production in the study area. The finding will guide the farmers on the best way to maximize profit from cucumber production and sustain the gradually increasing production of the horticultural crop in the locality. This study was therefore aimed to evaluate the profitability of the use of poultry manure for cucumber production in Iwollo, Southeastern Nigeria.

MATERIALS AND METHODS

Description of the experimental site

The study was carried out at the teaching and research farm of the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo, Nigeria during the rainy season of 2020. The study area is located in the southeast agro-ecological zone of Nigeria with geographical co-ordinate of 6° 27^1 North; 7° 17^1 East (Maplandia, 2021). The rainfall pattern is bimodal between April to July and September to November with short spell in August. The soil where the experiment was conducted was sandy loam and slightly acidic with 5.5 pH value.

Field preparation and cultural operations

The experiment was carried out in a randomized complete block design (RCBD) with five treatments and four replications. The experimental site was cleared using cutlass and land size of 9 m x 9.5 m (0.00855 ha) was marked out and tilled to fine tilt using hoe. The piece of land was marked into four blocks each measuring 1.5 m x

9.5 m. The blocks were further divided into five plots each measuring 1.5 m x 1.5 m giving a total of 20 plots. In-between the blocks and plots were 1 m and 0.5 m pathways. The treatments were 0, 5, 10, 15 and 20 t ha^{-1} of poultry manure. The treatments were randomly assigned to the experimental units using table of random number. The poultry manure was incorporated into the soil using hoe after plot formation. The poultry manure used was from layers and was sourced from the deep litter poultry house of the Poultry Unit of Enugu State Polytechnic, Iwollo Southeastern Nigeria. F1 hybrid cucumber variety African Giant (Cu999) was used for the study. Two seeds per hill were planted at a depth of about 2.5 cm using a spacing of 50 cm x 50 cm. The cucumber stands were later thinned down to 1 stand per hill at two weeks after planting giving a plant density of 40,000 stands per hectare. Weeding was done manually using weeding hoe as at when due. Insect pests were controlled using lambda cyalothrin insecticide while fungi diseases were controlled using copper (II) oxide fungicide.

Data collection

Data were collected from 5 tagged plants used as sample plants. Data were collected on vine length, number of leaves per plant, number of branches per plant, leaf area index (LAI), number of fruits per plant, fruit yield per plant (kg) and fruits yield per hectare (tons). All the data were collected at 6 weeks after planting (at full flowering) except yield parameters which were collected at harvest.

Vine length (cm): Vine length was measured from the base of the plant to the tip of the vine using measuring tape.

Number of branches per plant: The number of branches per plant was determined by direct counting of the branches in the sample plants and the average was taken. Thus;

$$\text{Number of branches per plant} = \frac{\text{TNB}}{\text{NSP}}$$

Where: TNB = Total number of branches from the sample plants and NSP = Number of sample plants

Number of leaves per plant: The number of leaves per plant was determined by direct counting of the leaves in the sample plants and the average was taken. Thus;

$$\text{Number of leaves per plant} = \frac{\text{TNL}}{\text{NSP}}$$

Where: TNL = Total number of leaves from the sample plants and NSP = Number of sample plants

Leaf area index (LAI): The length and width of three full leaves from each sample plants were measured with a simple ruler and the average length and width were determined. The leaf length was measured starting from the tip of the lamina to the petiole and the width was measured starting from one end of the widest lamina lobe to the other end. Thus, the leaf area index (LAI) was determined as follows;

$$\text{LAI} = \frac{\text{LL (cm)x LW (cm)x NL x PD}}{\text{A (cm}^2\text{)}}$$

Where: LL = leaf length (cm), LW = leaf width (cm), NL = number of leaves per plant, PD = plant density per plot and A = Area of the plot (cm^2)

Number of fruits per plant: Number of fruits per plant was determined by counting the total number of fruits harvested from sample plants per plot and dividing it by the number of sample plants. Thus;

$$\text{Number of fruits per plant} = \frac{\text{TNFH}}{\text{NSP}}$$

Where: TNFH = Total number of fruits harvested from the sample plants and NSP = Number of sample plants.

Fruit yield per plant (kg): Fruit yield per plant was determined by dividing the total weight of all the harvested fruits from sample plants by the number of sample plants per plot. Thus;

$$\text{Fruit yield per plant (kg)} = \frac{\text{TWFH}}{\text{NSP}}$$

Where: TWFH = Total weight of fruits harvested from the sample plants and NSP = Number of sample plants.

Fruits yield per hectare (tons): Fruit yield per hectare was determined by multiplying the fruit yield per plant with the plant density per hectare and dividing the product by 1000 to convert it to ton. Thus;

$$\text{Fruit yield per hectare (tons)} = \frac{\text{FY x PD}}{1000}$$

FY = Fruit yield per plant (kg) and PD = Plant density per hectare

Statistical analysis

All the data collected were subjected to analysis of variance (ANOVA) for randomized complete block design (RCBD) using Genstat Release 10.3DE software (GenStat, 2011). The treatment means were separated using least significant difference (LSD) at 0.05 probability level as described by Obi (2002).

Economic analysis

The cost of production and the revenue accrued from the enterprise under 0, 5, 10, 15 and 20 t ha^{-1} of poultry manure application was calculated. Gross margin analysis as well as the return on investment (RoI) was used to determine the profitability level of the production.

Gross margin was calculated as thus;

GM (₦) = TR (₦) – TVC (₦)

Where: GM = Gross margin, TR = Total revenue and TVC = Total variable cost

The Return on Investment (RoI) was calculated as thus;

RoI (%) = (GM (₦)/TVC (₦)) x100

The Total Variable Cost (TVC) included costs of items such as poultry manure, cucumber seeds, insecticide, fungicide, bags and labour for land preparation, poultry manure application, planting, weeding, spraying of the agro chemicals (insecticide and fungicide), cleaning and bagging of cucumber fruits. The Total Revenue (TR) was calculated by multiplying the yield (kg/ha) from the treatments by ₦200/kg which was the prevailing farm gate unit price of cucumber produce for 2020 production season.

RESULTS

Vine length (cm)

The growth parameters as influenced by different rates of poultry manure were shown in Table 1. There was significant difference ($p<0.05$) among the treatments in vine length. The plants that received 20 t ha^{-1} of poultry manure produced the highest mean vine length (184.1 cm) however; it was statistically at par with the mean vine length produced by plants that received 15 t ha^{-1} of poultry manure (173.7 cm). They were followed by plants that received 10 t ha^{-1} of poultry manure which produced mean vine length of 136.6 cm while the least mean vine length (101.6 cm) among the poultry manure treated plants was obtained in plants that received 5 t ha^{-1} of poultry manure. All the poultry manure treated plants performed significantly better than plants that did not receive poultry manure (0 t ha^{-1}) (control) which produced mean vine length of 63.3 cm.

Number of branches per plant

There was significant difference (($p<05$) among the treatments in number of branches per plant (Table 1). The highest mean number of branches per plant was obtained in 20 t ha^{-1} of poultry manure (5.44) followed by 15 t ha^{-1} (4.94); 10 t ha^{-1} (4.44) while the least was in 5 t ha^{-1} (3.06) among the poultry manure treated plants. All the poultry manure treated plants performed significantly better than plants that did not receive poultry manure (0 t ha^{-1}) (control) which produced mean number of branches per plant of 2.44.

Number of leaves per plant

The number of leaves per plant varied significantly ($p<05$) among the treatments (Table 1). The highest mean number of leaves per plant (45.3) was obtained in 20 t ha^{-1} of poultry manure application while the least (23.3) was obtained in 5 t ha^{-1} among the poultry manure treatments. The mean number of leaves per plant obtained in 15 t ha^{-1} of poultry manure (33.3) was statically at par with 28.9 obtained in 10 t ha^{-1}. All the poultry manure treatments differed statistically with control (0 t ha^{-1}) which produced mean number of leaves of 14.8.

Leaf area index (LAI)

The result of the analysis of variance on leaf area index (LAI) presented in Table 1 showed that there was significant difference ($p<0.05$) among the treatments. The highest LAI (5.06) was recorded in 20 t ha^{-1} of poultry manure while the least (1.94) was obtained in 5t ha^{-1} although it was statistically at par with 2.61 LAI obtained in 10 t ha^{-1}. 3.33 LAI obtained from plants that received 15 t ha^{-1} was statistically at par with 2.61 LAI obtained from plants that received 10 t ha^{-1} of poultry manure. All the poultry manure treatments recorded statistically higher LAI compared to control which had 0.85 LAI.

Number of fruits per plant

The result of the analysis of variance presented in Table 2 revealed that the number of fruits per plant varied significantly ($p<0.05$) among the treatments. The highest mean number of fruits per plant among the plants that received poultry manure was obtained from 20 t ha^{-1} of poultry manure (5.12 fruits) followed by 15 t ha^{-1} (3.88 fruits) and; 10 t ha^{-1} (3.06 fruits) while the least was from 5 t ha^{-1} (2.31 fruits). All the plants that received poultry manure produced significantly higher number of fruits compared to those that did not receive poultry manure (0 t ha^{-1} of poultry manure) (control) which produced mean number of 1.56 fruits.

Fruit yield per plant (kg)

The fruit yield per plant varied significantly ($p<0.05$) among the treatments. The highest fruit yield per plant among the plants that received poultry manure was obtained from 20 t ha^{-1} of poultry manure (0.528 kg) followed by 15 t ha^{-1} (0.359 kg); 10 t ha^{-1} (0.266 kg) while the least was from 5

Table 1. Vine length, number of branches per plant, number of leaves per plant and leaf area index of cucumber as influenced by different rates of poultry manure.

Treatments (t ha^{-1})	Vine length (cm)	Number of branches per plant	Number of leaves per plant	Leaf area index (LAI)
0 (control)	63.3	2.44	14.8	0.90
5	101.6	3.06	23.3	1.92
10	136.6	4.44	28.9	2.61
15	173.7	4.94	33.3	3.33
20	184.1	5.44	45.3	5.06
$LSD_{0.05}$	30.96	0.445	8.03	0.905
Grand mean	131.9	4.06	29.1	2.77
S.E	20.09	0.289	5.21	0.587
C.V (%)	15.2	7.1	17.9	21.2

$LSD_{0.05}$ = Least significant difference at 0.05 probability level; S.E. = Standard errors; C. V. = Coefficient of variations.

Table 2. Yield of cucumber as influenced by different rates of poultry manure.

Treatments (t ha^{-1})	Number of fruits per plant	Fruit yield per plant (kg)	Fruit yield per hectare (tons)
0 (control)	1.56	0.068	2.73
5	2.31	0.152	6.10
10	3.06	0.266	10.64
15	3.88	0.359	14.36
20	5.12	0.528	21.13
$LSD_{0.05}$	0.715	0.0713	2.852
Grand mean	3.19	0.275	10.99
S.E	0.464	0.0463	1.851
C.V (%)	14.6	16.8	16.8

$LSD_{0.05}$ = Least significant difference at 0.05 probability level; S.E. = Standard errors; C. V. = Coefficient of variations.

t ha^{-1} (0.152 kg). All the plants that received poultry manure produced significantly higher fruit yield per plant compared to those that did not receive poultry manure (control) which produced 0.068 kg of fruits.

Fruit yield per hectare (tons)

The result of the analysis of variance showed that fruit yield per hectare varied significantly ($p<0.05$) among the treatments (Table 2). The highest fruit yield per hectare among the plants that received poultry manure was obtained from 20 t ha^{-1} of poultry manure (21.13 tons) followed by 15 t ha^{-1} (14.36 tons); 10 t ha^{-1} (10.64 tons) while the least was from 5 t ha^{-1} (6.10 tons). All the plants that received poultry manure produced significantly higher fruit yield per hectare compared to those that did not receive poultry manure (control) which produced 2.73 tons of fruits per hectare. The performance of the treatments in terms of fruit yield per hectare was in this order; 20>15>10>5>0 t ha^{-1}.

Gross margin (GM)

The result of the gross margin analysis was presented in Table 3. The total variable cost for the use of 0, 5, 10, 15 and 20 t ha^{-1} of poultry manure for cucumber production was ₦531,340, ₦631,700, ₦746,252, ₦850,980 and ₦992,140, respectively. The use of 20 t ha^{-1}of poultry manure incurred the most total variable cost among all the treatments followed by 15, 10, 5 and 0 t ha^{-1}in that order. Similarly, 20 t ha^{-1} of poultry manure generated the highest revenue (₦4,226,000) among all the treatments followed by 15 t ha^{-1} (₦2,872,000), 10 t ha^{-1} (₦2,128,000), 5 t ha^{-1} (₦1,220,000) and 0 t ha^{-1}of poultry manure (₦546,000) in that order. Consequently, the highest gross margin (₦3,233,860) was obtained from 20 t ha^{-1} of poultry manure among all the treatments followed by 15 t ha^{-1} (₦2,021,020), 10 t ha^{-1} (₦ 1,381,748), 5 t ha^{-1} (₦ 588,300) and 0 t ha^{-1} of poultry manure (₦14,660) in that order.

Return on investment (RoI)

The return on investment (RoI) for using different rates of poultry manure for cucumber production was presented in Table 4. The result showed that the highest RoI was obtained in 20 t ha^{-1} of poultry manure (325.95%) followed by 15 t ha^{-1} (237.49%); 10 t ha^{-1} (185%); 5 t ha^{-1}(93%) and the lowest was in 0 t ha^{-1} (no poultry manure) (2.76%).

Table 3. Gross margin analysis for the cucumber produce of 2.73 t ha^{-1} (2,730kg), 6.10 t ha^{-1} (6,100kg), 10.64 t ha^{-1} (10,640kg), 14.36 t ha^{-1} (14,360kg) and 21.13 t ha^{-1} (21,130kg) from the use of 0, 5, 10, 15 and 20 t ha^{-1} of poultry manure, respectively.

Variables	Quantity	Unit cost (₦)	Amount per hectare for the poultry manure treatments (₦)				
			0 t ha^{-1}	5 t ha^{-1}	10 t ha^{-1}	15 t ha^{-1}	20 t ha^{-1}
Variable cost							
Cucumber seeds	1500g	240/g	360,000	360,000	360,000	360,000	360,000
Poultry manure	Varied according to the treatments	10/kg	0.00	50,000	100,000	150,000	200,000
Insecticide	2 litres	2500	5000	5000	5000	5000	5000
Fungicide	15 sachets	500	7500	7500	7500	7500	7500
Bag	Varied according to yield	200	11,000	24,400	42,600	57,600	84,600
Labour for stumping	3 MD	2000	6000	6000	6000	6000	6000
Labour for land preparation	20 MD	2000	40000	40000	40000	40000	40000
Labour for poultry manure application	1MD /ton	2000	0.00	10,000	20,000	30,000	40,000
Labour for planting	12 MD	2000	24000	24000	24000	24000	24000
Labour for weeding	20 MD	2000	40000	40000	40000	40000	40000
Labour for spraying of agro-chemicals	8 MD	2000	16,000	16,000	16,000	16,000	16,000
Labour for harvesting	2 MD /ton	2,000	10,920	24,400	42,576	57,440	84,520
Labour for sorting, cleaning and bagging	2 MD/ton	2000	10,920	24,400	42,576	57,440	84,520
Total variable cost (TVC)			531,340	631,700	746,252	850,980	992,140
Total Revenue (TR)		200/kg	546,000	1,220,000	2,128,000	2,872,000	4,226,000
Gross margin (GM) = TR – TVC			14,660	588,300	1,381,748	2,021,020	3,233,860

MD = Man days

Table 4. Return on Investment (RoI) from the use of 0, 5, 10, 15 and 20 t ha^{-1} of poultry manure for cucumber production.

Rates of poultry manure	0 t ha^{-1}	5 t ha^{-1}	10 t ha^{-1}	15 t ha^{-1}	20 t ha^{-1}
Yield (kg ha^{-1})	2,730	6,100	10,640	14,360	21,130
Unit price per kg (₦)	200.00	200.00	200.00	200.00	200.00
Total Revenue (TR) (₦)	546,000.00	1,220,000.00	2,128,000.00	2,872,000.00	4,226,000.00
Total variable cost (TVC) (₦)	531,340.00	631,700.00	746,252.00	850,980.00	992,140.00
Gross margin (GM) (₦) = TR – TVC	14,660.00	588,300.00	1,381,748.00	2,021,020.00	3,233,860.00
Return on investment (RoI) (%) = (GM/TVC)100	2.76	93	185.16	237.49	325.95

DISCUSSION

Influence of poultry manure on vegetative growth of cucumber

The findings of the study showed that poultry manure improved vegetative growth of cucumber as indicated by significant improvement in vine length, number of leaves per plant, number of branches per plant and leaf area index obtained in the plants that received poultry manure over those that did not receive (control). The findings were in agreement with the findings of Agu et al. (2015) and Enujeke (2013) who reported similar results as a result of poultry manure application. They were also in conformity with the findings of Adesina et al. (2014), Aliyu (2002), Aliyu (2003) and Alabi (2006) who reported that poultry manure improved the

vegetative growth of crops they studied. The improved vegetative growth observed in this study could be due to more organic matter and required nutrient provided by the poultry manure. The findings of Mbah and Mbagwu (2006) and Adekiya (2018) showed that animal manures increased soil organic matter, N, P and CEC and they attributed it to the availability and adequate supply of organic matter. Poultry manure contains nitrogen which boosts growth of plants. Mangila et al. (2007) and Enujeke (2013) reported that poultry manure contains nutrients which improve physical condition of soil for plant growth and development. Ewulo et al. (2008) also reported that high concentration of nitrogen present in poultry manure is easily available to crops and released slowly to the soil throughout the stages of the crops. Agu et al. (2015) reported that increase in vine length and number of leaves per plant as was also observed in this study could be due to improvement in the nutrient status and physicochemical properties of the soil. The increase in vine length, number of branches, number of leaves and leaf area index was an indication of vigourous vegetative growth of cucumber plants that received poultry manure. 20 t ha^{-1} of poultry manure produced the most vigourous vegetative growth followed by 15 t ha^{-1}, 10 t ha^{-1} and the least was 5 t ha^{-1}. The progressive vegetative performance of the crop with increase in the rate of poultry manure might be due to increase in nitrogen concentration and improvement in soil chemical and physical properties which in turn may have enabled the plants to take up more nutrients from the soil easily. Omeje et al. (2018) observed that all the vegetative parameters evaluated in cocoyam cultivar (*Colocasia esculenta* L.) in Iwollo, Southeastern Nigeria increased with increase in the level of poultry manure applied with the highest mean values obtained in 30 t ha^{-1}.

Influence of poultry manure on yield of cucumber

The results of the yield parameter evaluated in the study showed that poultry manure amendment significantly improved the yield of cucumber in the study area. Number of fruits per plant, fruit yield per plant and fruit yield per hectare were significantly improved by the application of poultry manure compared to no manure application. These findings were in conformity with the findings of Mangila et al. (2007), Enujeke (2013), Agu et al. (2015) and Oke et al. (2020) who reported similar results. The increased yield of cucumber observed in the study as a result of poultry manure application could be due to vigourous vegetative growth observed in plants that received poultry manure. According to Oke et al. (2020), poultry manure improves the availability of nutrients to plants, bulk density and the water holding capacity of the soil which in turn, increases the vegetative growth, accelerate the division of meristematic tissue and metabolic reactions and the plants take more food as a result of which increase in the number of fruits per plant will occur. O'Hare (2001) in his study reported that high yield of cucumber was observed due to the vigorous vegetative growth of the plants. Oke et al. (2020) also noted that the background of high yield was more number of leaves per plant, which capture more sun light to promote photosynthesis and respiration. More number of leaves observed in this study by cucumber plants that received poultry manure may have contributed to the higher yield. The significant increase in the number of fruits per plant obtained in this study as a result of poultry manure application was similar to the findings of Agu et al. (2015) who reported that the significant increase in the number of cucumber fruits could be attributed to improvement in soil physical and chemical properties and abundance of different nutrients as a result of addition of poultry manure. The increase in fruit yield per plant may be due to high concentration of nutrients provided by the poultry manure which boosted the growth over no manure application (control). The fruit yield per hectare is a product of fruit yield per plant and plant density thus, the improved fruit yield per plant observed in this study as a result of poultry manure application translated to the improved fruit yield per hectare recorded. Agu et al. (2015) opined that the significant increase in fruit yield of cucumber may have been possible due to the availability of better nutrients and improved development of the plants, along with greater proliferation of leaves due to the favourable effects of poultry manure on soil physical characteristics. 20 t ha^{-1} of poultry manure produced the highest yield followed by 15 t ha^{-1}, 10 t ha^{-1} and the least was 5 t ha^{-1}. The progressive yield performance of the crop with increase in the rate of poultry manure might be due to the progressive vegetative growth performance observed in the study. Dauda et al. (2008) reported that high poultry manure level which is a rich source of nitrogen, phosphorus, magnesium and calcium increased the fertility of the soil and led to increase in yield.

Profitability of the poultry manure in cucumber production

The economic analysis revealed that the use of poultry manure in cucumber production in the study area is profitable. The increase in the rates of poultry manure per hectare resulted to increase in the total variable cost and which in turn resulted to marginal return. The result of the return on investment (RoI) showed that for every one naira (₦1) invested in cucumber production in Iwollo, Southeastern Nigeria, 2.76; 93.00; 185.16; 237.49 and; 325.95 percent return on invested (RoI) is expected using 0 (no poultry manure); 5; 10; 15 and; 20 t ha^{-1} of poultry manure, respectively. In other words, for every one naira (₦1) invested in cucumber production in Iwollo, Southeastern Nigeria, ₦ 0.0276; ₦ 0.93; ₦ 1.85; ₦2.37 and; ₦3.26 is expected using 0 (no poultry manure); 5; 10; 15 and; 20 t ha^{-1} of poultry manure, respectively. The positive RoI obtained in all the treatments is an indication that cucumber production in Iwollo, Southeastern Nigeria is profitable and even more profitable when poultry manure

is used especially when 20 t ha^{-1} is used. Low RoI (2.76%) was obtained from no poultry manure application indicating non viability of the production. The findings were in conformity with the findings of Kroma et al. (2016) and Bamire and Amujoyegbe (2004). Bamire and Amujoyegbe (2004) in their study to determine the economics of poultry manure utilization in land quality improvement among maize farmers in southwestern Nigeria reported that yield levels (kg/ha) and mean net income earnings (N/ha) per annum were significantly higher for users of poultry manure and that users recorded 1.35 times and 1.45 times earnings more than non-users in the savannah zone and forest zone, respectively.

Conclusions

The findings of the study showed that poultry manure improved the growth and yield of cucumber and consequently the profit. All the poultry manure treatments produced significant increase in growth and yield of cucumber compared to control with optimum performance observed in 20 t ha^{-1}. The profitability level of the use of poultry manure increased with increase in the rate of poultry manure with the highest return on investment obtained in 20 t ha^{-1}. It could therefore be concluded that the use of poultry manure for cucumber production in Iwollo, Southeastern Nigeria is profitable especially when 20 t ha^{-1} is used.

Recommendations

Base on the findings of the study, the following recommendations were put forward:

1. The use 5 to 20 t ha^{-1} of poultry manure is recommended for cucumber production in Iwollo, Southeastern Nigeria.
2. For optimum growth and yield of cucumber and for maximum return on investment (RoI), 20 t ha^{-1} of poultry manure is recommended for farmers in the study area.
3. The government and non-governmental agencies (NGOs) should mobilize extension agents to conduct extension service in the study area to educate farmers on the benefits of the use of poultry manure for cucumber production in order to sustain the gradually increasing cultivation of the crop in the area thereby improving the socio-economic development of the community through the cultivation of the highly profitable horticultural crop.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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