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Effects of Poultry Manure and NPK Fertilizer on Infestation of Musk Pumpkin (*Cucurbita maxima*) by Insect Pests

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted during the 2013 growing season at the Teaching and Research Farm, University of Port Harcourt Nigeria, to evaluate the effect of poultry manure on the infestation of Musk pumpkin (*Cucurbita maxima*) by insect pests in the humid ecological zone of Nigeria. The study was laid out in a Randomized Complete Block Design (RCBD) with 5 treatments: Poultry manure (1.25 tons/ha, 2.5 tons/ha, 5.0 tons/ha), NPK (15:15:15), (300 kg/ha) and control (no treatment) and each treatment was replicated three times. Data on days to 50% germination, leaf damage, days to 50% flowering, fruit weight, number of fruits, number of insects and types of insect, were collected. The poultry manure and inorganic fertilizer reduced the number and weight of fruit, increased leaf damage (taken three times at the 3rd, 6th and 9th week after germination) and incidence of pests. The number of fruits was between 1.33 and 2.00 with fertilizer treatment and 2.33 in the control. The number of leaves damaged ranged from 1.76 to 1.98 with fertilizer treatment and 1.55 in the control at the 3rd week while at the 6th and 9th weeks there was no significant difference. The fruit weight ranged from 1.03 to 1.90 kg with fertilizer treatment and

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2.37 kg in the control. Days to 50% flowering were not significantly affected. The growth and yield of *C. maxima* in terms of quality, market value and quantity were higher in control plots. The number of insect pests was not significantly affected by the treatments. Insects collected during the study comprised hymenopterans, coleopterans and hemipterans. Application of organic and inorganic fertilizer intensified insect pest infestation and decreased fruit yield. It is recommended that fertilizer application may not be necessary in well managed soils, but where necessary, 2.5 tons/ha poultry manure may be a safer recommendation for the cultivation of *C. maxima.*

Keywords: Musk pumpkin; Cucurbita maxima; manure application; insect pest infestation; fruit yield.

1. INTRODUCTION

Musk pumpkin (*Cucurbita maxima),* a species in the gourd family (Cucurbitaceae), is normally cultivated commercially in warm areas. It is also grown in home gardens worldwide as food and animal fodder and for oil from the seeds [1]. Fruits vary in size, colour, shape and weight and have a naturally hard rind, with a thick edible flesh and numerous seeds [2]. The seed is high in protein (25-37%) and minerals and is eaten raw, toasted or pressed to make oil (37.8-45.4%) as rich as that from soybean and cottonseed [3,4].

The complementary use of organic and inorganic fertilizers has been recommended for sustenance of heavy term cropping in the tropics [5]. One of the ways of increasing the soil nutrient status is by applying either organic materials such as poultry manure, animal waste and composts or inorganic fertilizers [6]. Soil fertilization is one of the main factors increasing the yield of plants [7]. It affects the accumulation, mineralization and humification of organic matter in the soil and determines plant production potential [8]. The amount of fertilizer added to the soil, like mineral fertilizers affects the amount of mineral nitrogen available to the plants and the organic carbon content of the soil.

As organic fertilizer increases soil fertility, maintains and improves the physical and biological properties of the soil [9], poultry manure increases the availability of P, K and Mg in the soil besides the solubility of Ca and Mg and NO as a result of continued lowering of the pH (especially nitrogenous manures); it also increases electrical conductivity in the soil [10].

Inorganic fertilizers require high purchasing power; availability is an obstacle, especially in remote areas, and constitutes a high risk in low rainfall and very high rainfall areas [11]. They are also potential heavy metal contaminants (Cadmium), having acidifying effect – particularly nitrogen fertilizers – they have no direct benefit to soil biology [12].

Thus, an integral use of both organic and inorganic fertilizer to ensure adequate supply of plant nutrients and sustain maximum crop yield and profitability has been advocated [13]. However, inorganic fertilizer is expensive and may be largely unaffordable and not available to the resource-poor farmers in Nigeria. The most available alternative is currently poultry manure. Though usually bulky and expensive to transport it remains the safest source of nutrition as it is environmentally friendly, releases nutrients in a slow and steady manner to crops in the field thereby activating soil microbial activities [14]. This practice has long been used by ancient farmers as a major source of plant nutrition [15]. The dearth of knowledge on the effect of poultry manure on the infestation of *C. maxima* by insect pests necessitated this study. The aim of this study was to evaluate the effect of poultry manure and NPK fertilizer on the infestation of musk pumpkin (*C. maxima*) by insect pests in the forest zone of Nigeria. It is hoped that the outcome of this study would encourage the production and cultivation of cucurbits in this area.

2. MATERIALS AND METHODS

2.1 Study Location

The study was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Port Harcourt, Nigeria. The study area falls within the rainforest zone of south-south Nigeria and is located on latitude 04.5°N and longitude 07.01°E with mean daily temperatures varying from 25.6 to 29.1°C and relative humidity of 78%, with an elevation of 18 M above sea level; it has a bimodal rainfall pattern with peaks in June and September which range from 2,400 to 3,600 mm per annum.

2.2 Materials

Musk melon (*C. maxima*) used for the experiment was obtained from Jos main market in Nigeria and poultry manure (organic fertilizer) was obtained from the Teaching and Research

Farm, Faculty of Agriculture, University of Port Harcourt, Port Harcourt, Nigeria and NPK 15:15:15 (inorganic fertilizer) was obtained from a commercial source in Port Harcourt.

2.3 Poultry Manure Processing

The poultry manure (PM) was left to cure for 21 days, later sun dried in the open before pulverizing. It was applied at three rates as: treatment 1 (1.25 /ha), treatment 2 (2.5t ha) and treatment 3 (5.0 /ha) while NPK 15:15:15 was applied at the recommended rate of 300 kg/ha. A control (no treatment) was included in each treatment. The fertilizers were broadcast and mixed thoroughly with soil to ensure even distribution as soon as the beds were ready and *C. maxima* was sown 14 days after to enable the soil to absorb the fertilizers.

2.4 Experimental Layout

The experiment was laid out in a randomized complete block design (RCBD) and each treatment was replicated three times. The treatment plots measured 2 m x 2 m each with a 1 m alley to separate the blocks and treatment plots. A 2.0 m distance was used to separate replications in order to minimize overlapping by the trailing vines. There were 5 plots for each treatment combination giving a total of 15 treatment plots.

2.5 Sowing, Cultural Practice and Harvesting

A 100 cm x100 cm planting space at a depth of 2-3 cm was adopted with 9 plants per plot. Sowing was done manually and two seeds of *C. maxima* per hill were sown and this was later thinned down to one plant per hole after 2 weeks. Weeding was done fortnightly using a hoe until the plant canopy was well established and thus able to suppress weeds. Subsequently, weeding was done by hand pulling. Musk melon was harvested when fruits turned from dark green to yellow.

2.6 Data Collection

Days to 50% germination and flowering were determined and leaf damage was scored using a visual scale of 0-6: According to the method by [16].

0-1 hole no damage
2-4 holes slightly damaged
5-6 holes moderately damage
>6 holes highly damaged

2.7 Insect Collection

Insects were sampled in the mornings between 06:00 and 07:00 am and were collected from plants at different stages (seedling, vegetative and flowering) of growth. Numbers and identities of the infesting pests were determined. Insects found on the plants and in plots were collected, recorded and preserved in 75% ethanol. Insect samples were then sent to the Insect Museum of the Ahmadu Bello University, Zaria, Nigeria for proper identification.

2.8 Analysis

Soil samples (0-15 cm depth) were collected randomly before treatment using a core sampler. Both soil and manure samples were transferred to the laboratory for analysis. Soil pH was determined in a 1:1 soil to water suspension using a pH meter. Total nitrogen was determined by Makcro-kjedahl method [17]. Available phosphorus was determined by Bray-P.I method [18]. Potassium (K) was determined by flame photometry [17].

All data collected were transformed using square root and differences between means were determined at the 5% level of probability using the least significant difference technique.

3. RESULTS

3.1 Physicochemical Properties of soil and Poultry Manure used to Cultivate Musk Melon

Soil pH was 6.0 with a total nitrogen content of 0.17%, available phosphorus 3.33 mg /kg, exchangeable potassium 3.27 mg/kg and total organic matter (TOM) was 3.45%. Poultry manure had a pH of 7.8 with a total nitrogen content of 0.48%, 109.8 mg/kg available P, 3.27 mg/kg exchangeable K and TOM 9.14%.

3.2 Effect of Poultry Manure and Inorganic Fertilizer on Days to 50% Germination, Flowering and the Number of Fruits of *C. maxima*

The number of days it took *C. maxima* to attain 50% germination and flowering did not differ significantly among the various treatments; however, it took *C. maxima* an average of 9.33 days in plots treated with 2.5 tons/ha PM to 15.0 days in plots treated with 1.25 tons/ha PM to

attain 50% germination. It took *C. maxima* an average of 29.0 days in control plots to 39.0 days in plots treated with 5 tons/ha PM to attain 50% flowering.

Number of harvestable fruits of *C. maxima* grown with different rates of PM and 300 kg NPK shows that significantly higher numbers of fruits were harvested in control plots compared to plots that were applied with fertilizer except for plots treated with 300 kg NPK and 1.25 tons/ha PM. The least number of fruits was harvested in plots treated with 2.5 tons/ha PM (Table 1).

3.3 Effect of Poultry Manure and Fertilizer on Leaf Damage Due to Insect Infestation in *C. maxima* Collected at 3 - Weekly Intervals

Leaf damage due to insect pests in *C. maxima* (Table 2) shows that in the first collection there was significantly higher (P=0.05) leaf damage in plots treated with 5 tons/ha PM though it did not differ significantly from the levels of damage in plots treated with 1.25 tons/ha PM and 2.5 tons/ha PM; the lowest level of leaf damage was recorded in control plots.Leaf damage in subsequent collections did not differ among the treatments.

3.4 Effect of Poultry Manure on *C. maxima* Fruit Weight, Number of Insect Larvae, Exit Holes and Adults

Table 3 presents data on effect of organic and inorganic fertilizer application on fruit weight, number of larvae, exit holes and adult insects in *C. maxima*. Fruit weight was higher in control plots than in plots treated with 2.5 tons/ha PM. Numbers of larvae and exit holes did not differ among the treatments, but a relatively higher number of larvae and exit holes were recorded in plots treated with 2.5 tons/ha PM and the least was in NPK-treated plots for all the parameters. The number of adult insects collected was significantly higher in plots treated with 2.5 tons/ha PM. In the second collection there was no significant difference among the treatments in respect of fruit weight, exit holes and number of adult insects.

3.5 Effect of Fertilizer on the Incidence of Insect Pests on *C. maxima*

Table 4 shows that the number of insect pests collected in *C. maxima* under different rates of PM and inorganic fertilizer application did not differ significantly among the treatments although higher numbers of insects were recorded in plots treated with 5 tons/ha PM. There was a progressive increase in the numbers of insects up to the 7th week and then a decline as the plants were reaching maturity.

3.6 Insect Species Associated with *Cucurbita maxima*

A total of 12 insect species belonging to eight families in three orders were collected on *C. maxima* at different stages of growth. Three beneficial species from the families of Apidae, Coccinellidae and Braconidae were collected and identified as pollinators, predators and parasitoids, respectively. *Aulocophora vinula*, a coleopteran of the family Chrysomelidae, was the most abundant insect pest species while *Apis melifera* L., a pollinator, was the most abundant beneficial species (Table 5).

4. DISCUSSION

Days to 50% germination and flowering of *C. maxima* did not differ significantly in all the treatments; however, plants in plots applied with fertilizer took longer days to flower.

Table 1. Effect of poultry manure and fertilizer on days to 50% germination, flowering and number of fruits

Treatments	Days to 50% germination	Days to 50% flowering	Number of fruits
1.25 tons/ha PM	15.0	34.7	2.00^{ab}
2.5 tons/ha PM	9.33	30.3	1.33^{b}
5.0 tons/ha PM	14.3	39.3	2.00^{ab}
NPK kg/ha	11.3	31.7	1.67^{ab}
Control	13.3	29.0	2.33^{a}
	NS	NS	
S.E	2.74	6.25	1.00

Means with the same letters within a column are not significantly different (P=0.05): NS= Not Significant, S.E. = Standard Error

Table 2. Effect of poultry manure and fertilizer on leaf damage due to insect infestation in *C. maxima* collected at 3-weekly interval

Treatment	Leaf damage week 3	Leaf damage week 6	Leaf damage week 9
1.25 tons/ha PM	1.77[ab]	1.72	1.89
2.5 tons/ha PM	1.93[ab]	2.21	1.84
5.0 tons/ha PM	1.98[a]	1.78	1.76
NPK kg/ha	1.76[b]	1.77	1.78
Control	1.55[c]	1.78	1.85
		NS	NS
S.E.	0.25	0.86	0.25

Means with the same letters within a column are not significantly different (P=0.05): NS= Not Significant, S.E. = Standard Error

Table 3. Effect of poultry manure and fertilizer on fruit weight, number of insects' larva, exit hole and adults in *C. maxima*

Treatment	Fruit weight (kg/ha)	Larvae	Adult	Exit hole
		1st collection		
1.25 tons/ha PM	1.83[a]	2.90[a]	0.70[b]	0.87
2.5 tons/ha PM	1.03[b]	3.50[a]	2.77[a]	1.03
5.0 tons/ha PM	1.90[a]	0.70[b]	0.70[b]	1.00
NPK kg/PM	1.60[ab]	0.70[b]	0.70[b]	0.70
Control	2.37[a]	0.70[b]	0.70[b]	0.70
				NS
S.E.	0.30	1.43	0.57	0.21
		2nd collection		
1.25 tons/ha PM	1.90	0.70[b]	0.70[b]	0.70
2.5 tons/ha PM	1.90	0.70[b]	0.70[b]	0.70
5.0 tons/ha PM	1.37	2.33[a]	1.50[a]	1.00
NPK kg/ha	1.93	0.70[b]	0.70[b]	0.70
Control	1.93	0.70[b]	0.70[b]	0.70
	NS			NS
S.E.	0.23	0.95	0.44	0.16

Means with the same letters within a column are not significantly different (P=0.05). NS= Not Significant, S.E. = Standard Error

Table 4. Number of insect pests collected on *C. maxima* under different poultry manure (PM) t/ha and inorganic fertilizer (NPK) kg/ha at different growth stages

Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
1.25 tons/ha PM	1.40	1.63	1.63	1.80	1.47	3.10	4.00	2.23	3.00
2.5 tons/ha PM	0.70	2.13	0.70	1.50	1.17	3.47	4.47	2.37	1.73
5.0 tons/ha PM	1.70	1.77	1.47	2.40	1.60	3.57	4.03	2.43	1.97
NPK kg/ha	0.70	1.40	1.10	1.97	2.43	3.50	3.23	2.37	1.53
Control	1.30	1.70	1.80	2.00	1.77	2.37	3.93	2.83	1.87
	NS	NS	NS	NS	NS	NS	NS	NS	NS
S. E.	0.50	0.38	0.56	0.66	0.57	0.75	0.66	0.49	1.27

Means with the same letters within a column are not significantly different (P= 0.05). NS= Not Significant, S.E. = Standard Error

This observation is consistent with the report by [19] on cucumber when they evaluated the effects of levels of NPK fertilizer and PM on cucumber growth and performance in the same agro-ecological zone. This observation could be attributed to the influence of the rich nutrients especially nitrogen on vegetative growth and this may have resulted in depressed growth and development of yield forming organs. The maximum period of 39.3 days it took *C. maxima* treated with 5 tons/ha PM to flower probably corroborates this assertion.

Table 5. Insect species complex on *C. maxima*

Order	Family	Species	Part of plant attacked/visited	Status	Number
Coleoptera	*Chrysomelidae*	*Aulocophora vinula* eric	Leaf	Pest	92
Coleoptera	*Chrysomelidae*	*Altica nigrita* lab	Leaf	Pest	6
Coleoptera	*Chrysomelidae*	*Aulocophora africana* weise	Leaf	Pest	18
Coleoptera	*Chrysomelidae*	*Chrysolagria nairobana* barch	Leaf	Pest	9
Coleoptera	*Nitidulidae*	*Carpophilus sp*	Fruit	Pest	52
Coleoptera	*Coccinellidae*	*Ephilachna chrysomelina* Var	Leaf	Pest	18
Hemiptera	*Carabidae*	*Egadroma sp*	Leaf	Pest	20
Hemiptera	*Coreidae*	*Leptoglossus membranaceus* F.	Leaf	Pest	3
Hemiptera	*Pentatomidae*	*Aspavia armigera* F.	Leaf	Pest	4
Hymenoptera	*Apidae*	*Apis melifera* L.	Flower	Pollinator	414
Hymenoptera	*Coccinellidae*	*Cheilomenses sulhurea*	-	Predator	30
Coleoptera	*Braconidae*	*Iphiaulax sp*	-	Parasitoid	1

There were no significant differences between treatments on the number of fruits, except between 2.5 tons/ha PM and the control. This may be as a result of the nitrogen in the poultry manure which promotes vegetative growth and prolongs the vegetative period resulting in fewer fruits being produced.

The higher leaf damage (1.98) recorded in week 3 in plots treated with 5 tons/ha PM and the least damage recorded in control plots in weeks 6 and 9 supports the report of [20] who observed significant increase in dry matter accumulation in maize with successive increase in organic matter content which increases herbivory; it however contradicts the proposition by [21] that organic farming has the likelihood of reducing pest outbreak.

In this study, significantly higher numbers of insect pests, damaged fruits and leaves were observed in plots treated with organic fertilizer. In earlier studies, [22,23] reported that greater numbers of arthropods occurred on plants grown with organic amendments. Additionally, in the second collection, increasing quantity of PM to 5.0 tons/ha^{-1} slightly increased pest infestation. In contrast, [19,24,25] and [26] reported that application of organic amendments significantly lowered aphid population in other vegetable crops. The observation therefore could be attributed to other factors reported by [27] and [23] such as allelochemics, trichomes, weather, and natural enemies influencing pest populations. They further argued that it is necessary to understand the factors that predispose vegetable species to pests and the role of polyculture, crop rotation, and neighbouring plants in determining pest population in a vegetable farm.

Twelve insect species belonging to eight families in three orders including beneficial species were identified in *C. maxima*. Earlier, [19] identified 21 insect species including two beneficial species on cucumber in the same region. Similar insect species as shown in this study were reported by [28] who identified species of Chrysomelidae and *Diabrotica speciosa* (Germ.) as the major defoliators in pumpkin grown with other vegetables.

5. CONCLUSION

From the foregoing, it could be concluded that fertilizer application (both inorganic and organic) intensifies pest colonization and damage of *C. maxima.* As a result, fertilizer application appears to depress fruit yield in curcubits. Fertilizer application may not be necessary in the cultivation of *C. maxima* especially in well managed soils. The insect pests associated with *C. maxima* were mostly from two orders - Coleoptera and Hemiptera. The beneficial species comprised the orders Hymenoptera (parasitoids and pollinators) and Coleoptera (predators). It would seem that 2.5 tons/ha poultry manure may be a safer recommendation for the cultivation of *C. maxima* especially in well managed soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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