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Effects of Poultry Manure on Watermelon (*Citrullus lanatus*) Production and Insect Infestation in a Humid Ecological Zone

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ABSTRACT

A field trial was conducted to evaluate the effect of poultry manure (PM) on the growth, yield, and infestation of insect pests of watermelon. There were five treatments namely; 1.25 tons of PM ha^{-1}, 2.5 tons of PM ha^{-1}, 5 tons of PM ha^{-1}, 300kg of NPK ha^{-1}, and an untreated control with three replications, which were laid out in a Randomized Complete Block Design. Data on vine length, stem girth, number of leaves, fruit weight, days to 50% emergence, days to 50% flowering, and number of insects were recorded. The results showed that there were no significant differences in the vine length, stem girth, number of leaves, fruit weight, and 50% emergence. However, there were significant differences in vine length at week 3 and week 4, stem girth at week 3, 50% days to flowering, and week 1 for insect population between the 1.25 tons of PM ha^{-1} and control. The study showed that *C. lanatus* can be economically grown in the humid ecological zone (October-January) and poultry manure at the rate of 1.25 tons of PM ha^{-1} was optimal for its cultivation.

Keywords: Poultry manure, insect pests, watermelon(Citrullus lanatus), production, Infestation.

INTRODUCTION

Watermelon (*Citrullus lanatus*) belongs to the family Cucurbitaceae (Schippers, 2000). It is a warm, long-season, trailing, prostate, annual with a monoecious and/or andro-monoecious sexuality (Boualem *et al.*, 2016). The crop can survive the desert climate when groundwater is not available and the fruit sometimes serves as a source of water for human consumption (FAO, 2013). The fruit of watermelon has a thick exocarp that has variable pigmentation with a solid or striped appearance, a fleshy mesocarp, and an endocarp that varies in color from white to yellow or red (Bahari *et al.*, 2012; Munisse *et al.*, 2013; Dube *et al.*, 2020). Apart from its many uses as a fruit vegetable, it is a source of carotenoids, Vitamins A, B6, C, lycopene, and antioxidants (Dube *et al.*, 2020). Watermelon is an important crop with a world production of 99,957,595 metric tons, while the average amount of watermelon from Africa stood at 7,187,997 metric tons (FAO, 2022). Currently, Africa, as a whole, is the third producer of watermelon in the world (Anonymous, 2019).

In Nigeria, though there are no official figures recorded for its production, the crop has a wide distribution as a garden crop, while as a commercial vegetable production, its cultivation is confined to the drier savannah region of Nigeria (Dauda *et al.*, 2008). Studies in Nigeria and elsewhere confirm poultry manure as an effective nutrient source for increasing yield and nutrient status for crops such as maize, amaranth, sorghum, and pepper (Aliyu *et al.*, 1992; Babatola *et al.*,

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2002; Adeniyan & Ojeniyi, 2005). To obtain a high yield of watermelon, there is a need to augment the nutrient status of the soil to meet the crop's needs, while maintaining soil fertility. One of the ways of increasing the soil's nutrient status is by boosting its content either with the use of organic materials such as poultry manure, animal waste, and the use of compost or with the use of inorganic fertilizers (Dauda *et al.,* 2005).

Although the ability of organic manures and organo-mineral fertilizers to compete favorably with chemical fertilizers has no doubt been established for an array of tropical crops, it is still highly imperative to test their efficacies in deep nitrogen feeder crops like watermelon (Okunlola *et al.,* 2011). Soil fertility depletion in small-holder farms is the fundamental cause of declining per capita food production (Sanchez *et al.,* 1996). The shortage and high cost of inorganic fertilizers have limited their use for crop production among the peasant farmers in Nigeria (Tanimu *et al.,* 2007). There is, therefore, the tendency for increased dependency on the use of organic waste such as farmyard manure, crop residues, and poultry manure for crop production. Poultry manure was adjudged to be the most valuable of all manures produced by livestock (Omisore *et al.,* 2009). Moreover, the nutrient content of poultry manure is among the highest of all animal manures (Davies *et al.,* 2013) and its use as a soil amendment for crops will provide appreciable quantities of all the major plant nutrients. It also improves biological activities, soil tilt, and soil chemical properties (Schmitt & Rehm, 1992). Poultry manure's relative resistance to microbial degradation is essential for establishing and maintaining optimum soil physical condition and is important for plant growth as it induces life into soils and promotes biological activities (Chandra, 2005). It is also very cheap, costing about $24.34/ton in Nigeria (Adinde *et al.,* 2021), and effective as a good source of nitrogen for sustainable crop production (Dauda *et al.,* 2005).

Surekha and Rao (2001) and Prakash *et al*. (2002) have earlier explored the use of organic manures for managing the pests of okra. Research has shown that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to the optimal physical, chemical, and biological properties of the soil (Patriquin *et al.,* 1995). Reduced susceptibility to insect pests may be a reflection of differences in plant health as mediated by soil fertility (Altieri, 1999). The rationale for this study was to compare the impact of poultry manure on growth, yield, and its potential in managing insect pests of watermelon in the humid tropics.

Materials and Methods

Study site

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Port Harcourt, Rivers State, Nigeria. The study area falls within the rainforest zone of south-south Nigeria and is located on latitude 04°54 N and longitude 06°55 E, with a mean temperature of 27ºC, relative humidity of 78%, and rainfall of between 2500-4000mm per annum (Atijegbe *et al.,* 2013). The area has a bimodal rainfall pattern with a long rainy season (March-July) and a short rainy season (September-November) preceded by a short dry spell in August and a longer period from December to February (Akande *et al.,* 2010).

Experimental design

The experiment was laid out in a randomized completed block design with 15 plots. The plot size was 2m x 2m = 4 m2. Five treatments with three replicates were applied: untreated (control), 1.25 tons of poultry manure ha^{-1}, 2.50 tons of poultry manure ha^{-1}, 5.00 tons of poultry manure ha^{-1}, and 300kg of NPK ha^{-1}. The number of stands per plot was 9 with a spacing of 1m. The cultivar "Sugar Baby" obtained from Jo's main market in Plateau State, Nigeria was used. Poultry manure sourced from the deep litter poultry pen of the University of Port-Harcourt Demonstration Farm was sun-dried for two weeks, pulverized, applied as per treatments, and incorporated two weeks before sowing. No insecticides were used during the duration of the experiment. Normal cultural practices (weeding) were maintained throughout the experiment.

Soil and poultry manure analysis

Chemical analysis of poultry manure and soil was conducted before planting. The experimental site was plowed and samples were collected at random from six representative locations of the field with a core sampler at a depth of 0-15cm and bulked into a composite sample and a sub-sample was taken to the laboratory for analysis. The poultry manure was air-dried for two weeks to reduce the moisture content, and foul odor, allow for easy handling and field application, and pulverized before laboratory analysis.

Insect Collection

Insect collection was done using the collecting jars (alcohol vials). Insects were sampled into alcohol vials in the morning hours between 6.00 am and 7.00 am. Insect collection was done using a sweep net and a fine camel hair brush, and preserved in vials containing 90% ethanol and taken to the laboratory for sorting. Representative insect samples were then sent to the insect museum of the Ahmadu Bello University Zaria, Kaduna State, Nigeria for identification.

Data collection and statistical analysis

Data on vine length, stem girth, number of leaves, and fruit weight for the sampled stands were recorded for 6 weeks. Stem girth and vine length were measured weekly for two weeks after planting at the growth stage using a string and meter rule. Days to 50% emergence and 50% flowering were also recorded. Data were transformed using the square root transformation before analysis. Data were analyzed using ANOVA and means separated using the least significant difference (LSD) at a 5% probability level (Judd et al., 2017).

Results

Chemical analysis of soil and poultry manure

Analysis of the soil and poultry manure revealed that the soil had a pH value of 6.00 with 3.45% total organic matter while the poultry manure had a pH value of 7.48 and higher content of nitrogen (N), phosphorus (P) and organic matter (Table 1).

Table (1): Physio-chemical properties of soil and poultry manure

Parameter	Soil	Poultry manure
pH	6.00	7.48
N	0.17%	0.48%
P	3.33mgkg^{-1}	109.89mgkg^{-1}
K	3.27mgkg^{-1}	3.27mgkg^{-1}
Organic matter	3.45%	9.14%

Effects of soil amendment on growth parameters

There was no significant difference between treatments in vine length at 2 weeks after planting (WAP) and 3WAP, however, at 4WAP and 5WAP there was a significant difference between untreated and 1.25 tons of PM ha^{-1} (Table 2). The highest vine lengths of 56.37cm, 80.57cm, 90.00cm, and 101.87cm were recorded on 1.25 tons of PM ha^{-1} at 2WAP, 3WAP, 4WAP, and 5WAP, respectively (Table 2).

For stem girth, there was no significant difference among treatments at 2WAP, 3WAP, and 5WAP, except at 4WAP where there were significant differences ($p \leq 0.05$) among untreated, 1.25 tons of PM ha^{-1} and 300kg NPK ha^{-1}. The highest stem girth of 2.73cm, 3.23cm, 4.07cm, and 4.57cm were recorded on 1.25 tons of PM ha^{-1} at 2WAP, 3WAP, 4WAP and 5WAP, respectively. There were no significant differences between the treatments for the number of leaves on watermelon (Table 2).

Table (2): Effect of soil amendment on vine length, stem girth, and number of leaves of watermelon.

Treatments	2WAP	3WAP	4WAP	5WAP
Vine length (cm)				
Untreated	20.40^{a}	21.83^{a}	25.50^{b}	27.87^{b}
1.25 tons PM ha^{-1}	56.37^{a}	80.57^{a}	90.00^{a}	101.87^{a}
2.50 tons PM ha^{-1}	38.27^{a}	42.27^{a}	49.37^{ab}	72.30^{ab}
5.00 tons PM ha^{-1}	35.30^{a}	40.87^{a}	50.67^{ab}	58.90^{ab}
300kg NPK ha^{-1}	15.50^{a}	30.03^{a}	34.23^{ab}	38.77^{ab}
	Stem girth (cm)			
Untreated	2.47^{a}	2.40^{a}	2.30^{b}	2.80^{a}
1.25 tons PM ha^{-1}	2.73^{a}	3.23^{a}	4.07^{a}	4.57^{a}
2.50 tons PM ha^{-1}	1.70^{a}	2.30^{a}	2.77^{ab}	3.57^{a}
5.00 tons PM ha^{-1}	1.97^{a}	2.43^{a}	3.07^{ab}	3.53^{a}

300kg NPK ha-1	1.50 a	2.27 a	2.17 b	2.57 a
	Number of leaves			
Untreated	3.50 a	3.40 a	3.67 a	3.97 a
1.25 tons PM ha-1	5.77 a	7.33 a	7.77 a	8.00 a
2.50 tons PM ha-1	5.40 a	5.60 a	5.87 a	5.73 a
5.00 tons PM ha-1	5.23 a	5.43 a	5.80 a	6.60 a
300kg NPK ha-1	3.03 a	4.23 a	5.70 a	4.47 a

This means in the same column with the same letters are not significantly different (P≥0.05)

Effects of soil amendments on insect pests, exit holes, and fruit weight

There were no significant differences between treatments on the number of larvae in the fruits, number of adult insects found on the fruits, and weight of fruits. The maximum fruit weights of 12.17 g and 5.68 g were recorded on 2.50 tons PM ha^{-1} at harvest 1 and harvest 2, respectively (Table 3).

Table (3): Effect of amendments on exit holes, larvae, adult insects, and fruit weight of watermelon**.**

Treatments	Exit holes	Larvae in fruit	Adult insects	Fruit Weight (g)
Harvest 1				
Untreated	1.30 a	1.00 a	0.70 a	8.87 a
1.25 tons PM ha-1	0.87 a	0.70 a	0.70 a	3.80 a
2.50 tons PM ha-1	1.03 a	0.87 a	0.70 a	12.17 a
5.00 tons PM ha-1	0.87 a	0.70 a	0.70 a	5.77 a
300kg NPK ha-1	0.87 a	0.70 a	0.70 a	3.90 a
Harvest 2				
Untreated	0.74 a	0.64 a	0.64 a	2.20 a
1.25 tons PM ha-1	0.80 a	0.78 a	0.70 a	2.08 a
2.50 tons PM ha-1	0.96 a	0.70 a	0.70 a	5.68 a
5.00 tons PM ha-1	0.74 a	0.70 a	0.70 a	1.67 a
300kg NPK ha-1	0.90 a	0.70 a	0.70 a	4.85 a

This means in the same column with the same letters are not significantly different (P≥0.05)

Days to 50% germination and flowering

There was no significant difference between treatments in the number of days to 50% germination of watermelon. However, there was a significant difference in the number of days to 50% flowering between the untreated plots and all other treatments. The untreated plots took a much longer time (54.67 days) to flower (Table 4).

Table (4): Effect of amendment on days to 50% germination and 50% flowering of watermelon.

Treatments	Growth stage (days)	
	50% germination	50% flowering
Untreated	5.67 a	54.67 a
1.25 tons PM ha-1	5.67 a	47.33 b
2.50 tons PM ha-1	5.00 a	45.00 b
5.00 tons PM ha-1	5.33 a	46.67 b
300kg NPK ha-1	5.00 a	46.67 b

This means in the same column with the same letters are not significantly different (P≥0.05)

Effect of soil amendment on insect population

The results showed significant differences in insect population for the first week between 2.50 tons PM ha^{-1} and 1.25 tons PM ha^{-1}, 5.00 tons PM ha^{-1}, 300kg of NPK ha$^{-1,}$ and control. However, there were no significant differences among the treatments from weeks 2 to 6. (Table 5)

Table (5): Effect of soil amendment on insect population of watermelon.

Treatments	Growth Stage					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Untreated	0.70 [b]	1.00 [a]	1.63 [a]	1.60 [a]	1.20 [a]	0.70 [a]
1.25 tons PM ha^{-1}	0.70 [b]	1.30 [a]	0.87 [a]	1.80 [a]	1.63 [a]	1.00 [a]
2.50 tons PM ha^{-1}	1.30 [a]	1.80 [a]	1.40 [a]	2.30 [a]	1.73 [a]	1.10 [a]
5.00 tons PM ha^{-1}	0.70 [b]	1.03 [a]	1.83 [a]	1.77 [a]	1.80 [a]	1.33 [a]
300kg NPK ha^{-1}	0.87 [ab]	1.23 [a]	1.33 [a]	1.93 [a]	1.57 [a]	1.17 [a]

This means in the same column with the same letters are not significantly different (P≥0.05)

Effect of soil amendment on insect species complex

Nineteen species of insects from 4 orders and 11 families were collected; of these 12 were identified as insect pests of watermelon, while three were identified as beneficial insects (Table 6).

Table (6): Insect orders, families, species, and pest status of watermelon.

Species	Order	Family	Status
Epilachana chrysomelina. F.	Coleoptera	Coccinellidae	Pest
Aulacophora vinula. Eric.	Coleoptera	Chrysomelidae	Pest
Aulacophora africana. Weise	Coleoptera	Chrysomelidae	Pest
Aulacoryssus aciculatus Dej.	Coleoptera	Carabidae	Pest
Monolepta elegans. Allards.	Coleoptera	Chrysomelidae	Pest
Hypocacculus buqueti Mars.	Coleoptera	Histeridae	Pest
Platysoma castanipes Mars.	Coleoptera	Histeridae	Pest
Lixus camerunus Kib.	Coleoptera	Curculionidae	Pest
Asbecesta cyanipennis Hat.	Coleoptera	Chrysomelidae	Pest
Nagosta sp.	Hemiptera	Reduviidae	Pest
Dysdercus sp.	Hemiptera	Pyrrhocoridae	Pest
Atherigona sp.	Diptera	Muscidae	Pest
Stenus furcifer Puthz.	Coleoptera	Staphilinidae	Pest
Platymetopus vestities Dej	Coleoptera	Carabidae	Pest
Aulacophora africana Weise.	Coleoptera	Chrysomelidae	Pest
Acridid (nymph)	Orthoptera	Acrididae	Pest
Cheilomenes sulphurea Oliv.	Coleoptera	Coccinellidae	Beneficial insect
Cheilomenes virina Muls.	Coleoptera	Coccinellidae	Beneficial insect
Apis mellifera L	Hymenoptera	Apidae	Beneficial insect

Discussion

Soil pH (6.00) was ideal for watermelon cultivation, because it falls within the 5.5-7.0 range, which is best for most vegetable plants (Hudson *et al.*, 1990). Acidic soils especially in Sub-Saharan Africa inhibit the availability of essential elements and reduce the activities of micro-organisms (Agegnehu *et al.*, 2021). Application of poultry manure increased *C. lanatus* vine lengths, stem girth, and leaf numbers compared to the untreated control. This concurs with the work of Adenawoola and Adejoro

(2005) who found poultry manure to increase the growth and yield of *Corchorus olitorius*. However, increasing application rates of poultry manure did not lead to an increase in the growth of *C. lanatus*, an observation that agrees with the report by Graham and Gratte (2005) that watermelons do not have a large fertilizer requirement and that the crop can be grown with little or no fertilizer or on fertile lands. However, they recommended that heavy soils are preferred, as fertilizer costs are reduced when watermelon is grown on heavy soil, but to obtain a good yield of watermelon, fertilizer application is imperative.

Dauda *et al.* (2008) reported that poultry manure promotes vigorous growth, and increases meristematic and physiological activities in the plant due to the supply of plant nutrients and improvement in soil conditioning. Thus, improving the structure and texture of the soil, enhancing the soil water holding capacity and aeration, essential for healthy plant, nutrient release (Badu Brempong & Addo-Danso, 2022). Poultry manure is rich in nitrogen, phosphorous, calcium, and micronutrients which are released to the plants (Parker *et al.,* 1959), and organic matter decomposition contributes to the organic matter content of the soil, decomposes with time releasing organic compounds that benefit to soil microorganism and promote long-term soil health (Wang *et al.*, 2023). These often result in the synthesis of more photo-assimilates which are used in producing fruits. Although there was not much difference in the fruit weight of watermelon among all the treatments, the result showed that an increase in application rate led to a corresponding increase in weight. This finding agrees with Havlin *et al.* (2013) who reported that poultry manure had positive effects on the growth and yield of watermelon which they attributed to the fact that poultry manure contained essential nutrient elements that favor high photosynthetic activities to promote prolific root and vegetative growth.

The study suggests that *C. lanatus* attained 50% germination in 5-6 days in all treatments. This could mean that fertilizer application in the form of either organic or inorganic is not a major factor for its germination but rather suitable factors like soil moisture, temperature, and other basic environmental requirement. This assertion agrees with the earlier report by Theodora *et al.* (2003) that the application of farmyard manure does not affect germination. Similarly, Loecke *et al*. (2004) also concurred that plant emergence was not affected by manure treatments. The shorter time it took for plants in plots treated with PM to flower could be a result of the high amount of phosphorus contained in PM. Phosphorus is a vital nutrient involved in stimulating and enhancing bud development, fruit set and seed formation, and blooming. The delay in *C. lanatus* flowering as observed in untreated plots with a significantly higher number of days to 50% flowering conforms with the works earlier reported by Jimin *et al*. (2013) that higher application of PM significantly delayed days to 50% flowering stage.

Insect species complex on watermelon was relatively higher in plots treated with poultry manure but was not statistically significant (Table 5). This could be attributed to the high rate of nitrogen and organic matter which possibly led to a luxuriant growth making it possible for the proliferation of insects. This observation supports the earlier reports by Phelan *et al.* (1996), Morales *et al.* (1997), Leal and Sanchez (1996), Myers and Stolton (1999), and Altieri and Nicholls (2018) who reported that the population of sucking and lepidopteran insect pests were significantly high on crops grown with synthetic or inorganic fertilizer.

Conclusion

The results of this research show that poultry manure at 1.25 tons PM ha^{-1} is optimal for the cultivation of watermelon in the humid ecological zone of Nigeria. This study also shows that watermelon can be economically cultivated in the humid ecological zone.

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آثار سماد الدواجن على إنتاج البطيخ (Citrullus lanatus) والإصابة بالحشرات في منطقة بيئية رطبة.

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ملخص

أجريت تجربة ميدانية لتقييم تأثير روث الدواجن (PM) على نمو وإنتاجية و حدوث الاصـــابه بالآفات الحشـــرية للبطيخ. كـان هنـاك خمســـة علاجـات وهي؛ 1.25 طن/هكتـار من (PM) OR روث الـدواجن و2.5 طن/هكتـار من (PM) ORروث الدواجن و5 طن/هكتار من (PM) OR روث الدواجن و300 كغ/هكتار من سماد NPK وعينة ضابطة غير معالجة بثلاث مكررات، والتي تم إجراؤها بنظام تصـــميم القطاعات العشـــوائية الكاملة. تم تســـجيل بيانات طول الكرمة ومحيط الســـاق وعدد الأوراق ووزن الثمار وعدد أيام البزوغ بنســـبة 50٪ وعدد الأيام حتى 50٪ من التزهير وعدد الحشـرات. أظهرت النتائج عدم وجود فروق جوهرية في طول الكرمة ومحيط السـاق وعدد الأوراق ووزن الثمرة ونسبة 50٪ من البزوغ. لكن كانت هناك فروق جوهرية في طول الكرمة في الأســـبوعين الثالث والرابع ومحيط الســـاق في الأسبوع الثالث ونسبة 50٪ من عدد أيام التزهير والأسبوع الأول لتعداد الآفات الحشرية بين 1.25 طن/هكتار من روث الدواجن والمجموعة الضـــابطة. أوضـــحت الدراســـة أن نبات *C. lanatus* يمكن زراعته اقتصـــادياً في المنطقة البيئية الرطبة (أكتوبر- يناير) وأن روث الدواجن بمعدل 1.25 طن/هكتار هو الأمثل لزراعته.

الكلمات الدالة: روث الدواجن، الافات الحشرية، البطيخ (سترولاس لاناتوس)، الاصابة.

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