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RESEARCH ARTICLE
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Effect of Pig manure rates on performance of okra (*Abelmoschus esculentus* L. Moench) and *Podagrica uniforma* Jacq. Infestation in South Western Nigeria

Efecto de las dosis de estiércol de cerdo sobre el rendimiento de la okra (*Abelmoschus esculentus* L. Moench) y *Podagrica uniforma* Jacq. Infestación en el South Western Nigeria

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Abstract

Insect infestation and low soil fertility are the major constrictions in okra production and various tactics have been recommended for increased production. An experiment was conceived to explore the effects of different levels of pig manure on the performances and severity of damage caused by *Podagrica uniforma* Jacq. infestation on okra in South Western, Nigeria. The research was arranged in Randomized Complete Block Design (RCBD) with four treatments (0 $t.ha^{-1}$, 5 $t.ha^{-1}$, 10 $t.ha^{-1}$, 15 $t.ha^{-1}$ and 20 $t.ha^{-1}$) replicated thrice. Okra growth, fruit yield, insect population and severity of damaged leaves were assessed and exposed to the Analysis of Variance, and Duncan Multiple Range Test (DMRT) at a 5 % level of significance was used to separate significant treatment means. The study outcomes revealed that okra growth and yield parameters were directly proportional as the pig manure rates increase. A similar trend was equally recorded for *P. uniforma* population in okra plants enriched with variable rates of pig manure, okra supplied with 20 $t.ha^{-1}$ of pig manure exhibited the highest growth, yield performance and *P. uniforma* population. While the severity of leaf damage caused by *P. uniforma* was in descending order, very low in okra enriched with varying levels of pig manure as compared to the damage recorded in control. The trial showed that okra growth and yield was significantly ($p<0.05$) enhanced by the application of 20 $t.ha^{-1}$ pig manure with a resultant reduction in the severity of damaged leaves caused by *P. uniforma* infestation.

Key words: *Insect population; Okra; pig manure; Podagrica; severity; variable rates*

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Resumen

La infestación de insectos y la baja fertilidad del suelo son las principales limitaciones en la producción de okra, a pesar de existir diversas estrategias para incrementar la producción. El objetivo fue evaluar los efectos de diferentes niveles de estiércol de cerdo sobre los rendimientos y la gravedad de los daños causados por la infestación de *Podagrica uniforma* Jacq. en Okra in South Western, Nigeria. Se estableció un diseño de bloque completo aleatorizado (RCBD) con cuatro tratamientos (0 $t.ha^{-1}$, 5 $t.ha^{-1}$, 10 $t.ha^{-1}$, 15 $t.ha^{-1}$ y 20 $t.ha^{-1}$) y tres repeticiones. Se evaluaron el crecimiento de la okra, el rendimiento de los frutos, la población de insectos y la gravedad de las hojas dañadas mediante el análisis de la varianza, para separar las medias significativas de los tratamientos se utilizó la prueba de rangos múltiples de Duncan (DMRT) a un nivel de significación del 5 %. Los parámetros de crecimiento y rendimiento del quimbombó fueron directamente proporcionales a medida que aumentaban las tasas de estiércol porcino. Similar tendencia se registró para la población de *P. uniforma* en plantas de okra enriquecidas con tasas variables de estiércol de cerdo. La okra suministrada con 20 $t.ha^{-1}$ de estiércol de cerdo presentó el mayor crecimiento, rendimiento y población de *P. uniforma*, mientras que la severidad del daño foliar causado por *P. uniforma*. fue en orden descendente, en comparación con el daño registrado en el control. Los resultados mostraron que el crecimiento y el rendimiento de la okra mejoran significativamente ($p<0.05$) con la aplicación de 20 $t.ha^{-1}$ de estiércol de cerdo, reduciendo la severidad de las hojas dañadas debido a la infestación de *P. uniforma.*

Palabras clave: *Población de insectos; okra; estiércol de cerdo; Podagrica; severidad; tasas variables.*

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is a widespread fruit vegetable crop in many humid and sub-humid countries for its stretching features which play a vital role in improving the palatability of many starchy dishes or bulky main foods like pounded yam, gari, fufu etc (Akinyele & Osekita, 2006; Adesina & Afolabi, 2014). In spite of Nigeria being ranked the world's second-largest okra producer with 15.4 % production after India with 67.1 % (Food and Agricultural Organization of the United Nations [FAOSTAT], 2023; Varmudy, 2011) okra production in Nigeria habitually recorded low yield, ascribed to insect pest infestation and deficient in essential soil nutrients. One of the restrictions against profitable okra cultivation is damage and injury caused by insect pest infestation (Praveen & Dhandapan, 2001). It has become a common scenario to discover copious holes on okra leaves usually caused by herbivorous insects, which is practically being acknowledged as a typical feature of the crop (Egwuatu, 1982). Different pests attacked the plant, practically at all phenological stages. Though, only a few of these are regarded to be economically important among which are flea beetles, shoot and fruit borers, whitefly, jassid, aphid, spotted bollworms, American bollworms, cotton stainer (Youdeowei, 2002; Rao & Rajendra, 2003).

Largely, apart from insect invasion; low soil fertility is also part of the most important constraints in okra production and various approaches have been suggested for providing good soil conditions for increased production.

Since okra is a low-worth crop in Nigeria, chemical control of insect pests is scarcely adopted in okra cultivation, as it may be loss-making (Olotuah, 2003). Apart from the unprofitability of synthetic insecticide usage, worry about human and environmental well-being is of pronounced concern to researchers and scientists worldwide (Banjo & Oduala, 1996) hence working against the use of conventional insecticide application globally (Akingbohungbe, 2007). Moreover, consciousness concerning food security has enlarged the call for naturally cultivated food crops, necessitating an assessment of the influence of cultural practices as safer alternatives to the use of orthodox pesticides. Farmers can employ some cultural operations to minimize insect infestation and injury to plants. This can be achieved by guaranteeing that plants are grown in a favourable condition, such as with appropriate water and fertilizer applications. Plants grown in mineral-nutrient-deficient soil were less resistant to disease infection and insect pest infestation (Huber & Graham, 1999; Huber & Thompson, 2007).

In numerous aspects, the flourishing of both plants and insects is symbiotic (Panda & Khuh, 1995). The availability of nutrients affects the growth and development of plants, whereas the quality of the food provided by their host plants determines the growth and development of insects (McGuinness, 1987; Gogi et al., 2012). Saumya et al. (2007) opined that when organic manures are used in crop cultivation; they are known to encourage resistance in plants against insect pest invasion or feeding activities thereby reducing damages and crop loss. |

Hence, the studies on animal droppings for crop nutrition and management of insect pests of crops in agriculture and horticultural agro-ecosystems could lead to the invention of an integrated management strategy, therefore giving room for a decline in pesticide load and inorganic fertilizer usage, thereby improving soil health and reducing environmental pollution (Meenatchi et al., 2011).

Therefore, in this study, the objectives were: 1) to evaluate the levels of pig manure on insect pest populations, 2) to mitigate the impact of insect infestation and crop damage, and 3) to improve yield of Okra. all of them will contribute to build in the future Okra sustainably production in Nigeria.

Materials and methods

Experimental site

The research was carried out on a plot of land measuring 24 m x 19 m (456 m^2) at the Faculty of Agricultural Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria, experimental farms during the wet seasons of 2020 and 2021. The study region is situated at latitude 7011 North and longitude 5035 East in the south-west Nigerian rainforest agroecological zone. With a mean temperature of 28 °C and precipitation ranging from 900 mm to 1800 mm, the study region has two fundamental climates: the rainy season, which happens between March and September, and the dry season, which takes place between October and February. The soil at the test site belongs to the Okemesi Series, and according to Alfisol's classification, it is either Oxic Tropuldalf or Luvisol.

Determination of soil physio-chemical properties

Prior to the clearing of the field, mixed soil samples were at random taken at three distinct spots using a soil auger in a depth range of 0 cm to 15 cm from the centre point of each plot at five locations per plot. To pass through a 2 mm sieve, soil samples were bulked, dried by air, pulverized, and sieved. Afterward, the soil sample undergone routine analysis adopting conventional laboratory protocols as specified by Carter & Gregorich (2008). Using an electronic pH meter, overall pH of the soil was determined electrometrically in a 1:2 suspension of soil 0.1 M KCl (Thomas, 1996). The hydrometer method was employed to assess the particle size distribution, and a textural triangle was employed to establish the textural classification. Organic carbon was estimated using the following dichromate wet oxidation Walkey/Black technique (Nelson & Sommers, 1982) and organic matter calculated by multiplying carbon by 1.724 to obtain an approximation. The micro Kjeldahai decomposition mechanism as well as distillation process produce a total nitrogen content (Bremner & Mulvaney, 1982). Exchangeable bases (Na, K, Ca, and Mg) were detected using an atomic absorption spectrophotometer after being leached with 1 N ammonium acetate (NH_4OAC), whereas K and Na were detected using a flame photometer (International Institute of Tropical Agriculture [IITA, 1989]). By using the Bray 1 method (Bray & Kurtz, 1945), available phosphorus was determined, and exchangeable acidity was estimated utilizing KCl extraction method (Mclean, 1982).

Pig Manure and Okra Seed Source

The National Horticultural Research Institute (NIHORT), Ibadan, Nigeria provided the seeds of an early maturing okra variety NH-47-H that was used in the study. The piggery unit at Rufus Giwa Polytechnic in Owo, Ondo State, provided the pig excrement. The manure was pulverized and shade dried, and a sample was taken for standard laboratory testing to ascertain its nutrient makeup. (Sanni & Adesina, 2012). Pig manure was lightly worked into the experimental soil one week before sowing to allow for proper and adequate decomposition, mineralization and release of nutrients into the soil for plant use (Adesina et al., 2018).

Land Preparation and Experimental design

After manually clearing the site and parked the trash, the land was subdivided into three blocks measuring 7 m x 5.9 m (41.3 m^2) each, with a discard of between 0.5 m and 1 m resulting in 12 experimental plots. Five treatments were used in the experiment, which was set up using a Randomized Complete Block Design (RCBD), replicated three times (Tswanya et al., 2017): T1 = control (no pig manure), T2 = 4.5 kg in 2 m x 2 m bed (corresponding to 5.0 $t.ha^{-1}$), T3 is a 9 kg in 2 m x 2 m bed (corresponding to 10.0 $t.ha^{-1}$), T4 is a 13.5 kg in 2 m x 2 m bed (corresponding to 15.0 $t.ha^{-1}$), and T5 is an 18 kg in 2 m x 2 m bed (corresponding to 20.0 $t.ha^{-1}$).

Cultural Operations and Treatment Application

Using a dibber, okra seeds were planted at a density of two seeds per hole, at a depth of 0.5 cm, at a spacing of 60.0 cm between rows, and 50.0 cm within rows. At the two seed-leaf stages, one week following emergence, they were later thinned to one healthy seedling per stand. The supply for the missing stand was accomplished seven days following emergence. Okra seeds were soaked in water for 10 to 15 minutes prior to sowing in order to speed up germination; viable seeds (seeds that sank) were chosen for sowing, while non-viable seeds were thrown away. Neither pesticides nor herbicides were used. At 14, 28, and 42 days following okra emergence, weeds were manually managed. Okra water requirement was met through rainfed as the study was conducted during the rainfall peak in the study area.

Data Collection

Five randomly selected plants from the inner rows were tagged to obtain data on plant growth and yield characteristics, insect infestation, and leaves damage. A measuring tape was used to measure the height of the plants from their bases to their terminal points, and the results were recorded. The tagged plants' leaves were counted physically, and the stem girth was measured with a digital Vernier calliper. Fresh fruit harvesting began seven weeks after the sprouting of the seedlings and was conducted five days apart for four consecutive weeks

Fruits were handpicked based on how easily they broke when pressed with the tips of the fingers. A weighing scale, metre rule, and digital calliper were used to measure the total weight, length, and diameters of harvested fruits, respectively.

In the centre row of each plot, the insect population was observed and counted visually between the hours of 6 a. m. and 7 a. m. in the morning, when the insects are still dormant and immobile (Adesina & Enudeme, 2018). A 0–5 rating scale per plant was used to visually evaluate the extent of the leaf damage, with 1 denoting 0 % – 20 % of the leaf eaten, 2 denoting 21 % – 60 % of the leaf eaten, 4 denoting 61 % – 80 % of the leaf eaten, and 5 denoting 81 % – 100 % (Anjorin et al., 2013).

Data Analysis

The Statistics for Agricultural Scientist (SAS) package was used to perform analysis of variance (ANOVA) on all data obtained, and statistically significant means were differentiated using the Duncan Multiple Range Test (DMRT) at a 5 % level of confidence. Prior to performing an ANOVA, insect counts were square root converted to homogenize the variance and normal data distribution.

Results

Chemical characteristic of the experimental soil and pig manure

Table 1 lists the chemical characteristics of the pig dung and experimental soil utilized in the experiment. Sandy loam was the soil's texture categorization, and it had a mild acidity (pH

6.31). Low levels of total nitrogen (0.14 %), organic carbon (1.39 %), and available P were found in the soil (27 $mg.kg^{-1}$). While Ca and Mg concentrations were significant, exchangeable K and Na concentrations were low. The pig manure, was alkaline in nature, with high organic matter content, an appreciable amount of total nitrogen, available phosphorus and exchangeable cations.

Table 1: The chemical properties of the experimental soil and pig manure used for the experiment

Property	Soil sample	Pig manure
Sand (%)	80	
Silt (%)	9	
Clay (%)	11	
Textural class	Sandy loam	
Organic matter (%)	1.39	54.81
Total N (%)	0.14	4.03
Available P (mg kg^{-1})	27.00	5.81
Exchangeable cations (cmol kg^{-1}) K^+	0.16	5.06
Na^+	0.04	3.62
Ca^{++}	3.60	3.02
Mg^{++}	1.90	2.95
pH (in 0.01 M $CaCl_2$)	6.31	7.36

Impact of varying pig manure rates on okra agronomic factors

The study's findings demonstrate that various quantities of pig manure had a substantial impact on okra vegetative characteristics (Table 2). With an increase in the pig manure rates and okra plant age, the vegetative parameters grew more quickly. At 4, 6, and 8 weeks after planting (WAP), okra plants in control plots had the fewest leaves, the lowest plant height, and the smallest stem girth growth compared to okra plants in plots treated with varied quantities of pig manure, which showed noticeable treatment effects. In plots where 20 $t.ha^{-1}$ (PM) was applied, the highest vegetative growth was observed. However, in okra planted in plots treated with 15 $t.ha^{-1}$ and 20 $t.ha^{-1}$ pig manure at 4, 6 and 8 WAP, plant height, leaf count and stem girth were not substantially significantly different. Similar patterns were observed between control, 5 $t.ha^{-1}$ and 10 $t.ha^{-1}$ in terms of the number of leaves produced and stem girth development respectively.

Effects of a variable rate of pig manure on okra yield attributes

Okra fruit length, fruit diameter and weight were markedly influenced by the application of pig manure at different levels compared to the yield attributes obtained from control plots. The pig manure effect increases as the rate of application increases. The best yield characteristics were recorded under 20 $t.ha^{-1}$ and the least yield was recorded in the plot with no addition of manure (Table 3).

Effects of varying pig manure rates on *Podagrica* spp population

Podagrica spp. population were moderately affected by different levels of pig manure. (Figure 1) with the highest population recorded at 20 $t.ha^{-1}$ (5.89) followed by 15 $t.ha^{-1}$ (4.72) and the effect decreases with decreases in the application rates. The lowest insect population was observed in the control (1.87).

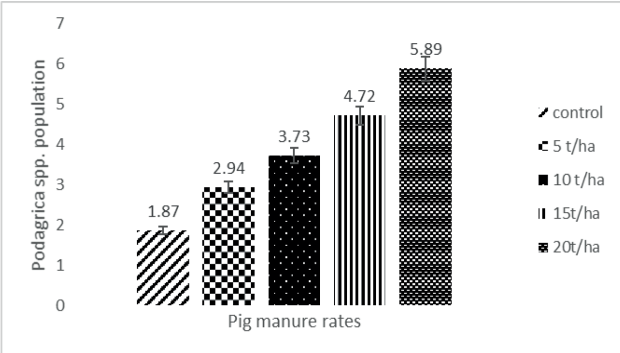

Figure 1. Effects of variable rates of pig manure on *Podagrica* spp. population of okra.

Effects of varying pig manure rates on the degree of damaged okra leaves

The level of damage done to okra leaves was in descending order very low in okra enriched with varying levels of pig manure as compared to leaf damage recorded in control (Table 3). The level of damage done was highest in okra planted on plots with no addition of manure (10.58) and lowest damage in plots fertilized with 20 $t.ha^{-1}$ However, non-significant leaf damage was recorded in okra planted on plots enriched with

Table 2: Effects of variable rate of pig manure on okra agronomic parameters.

Parameters	Treatments ($t.ha^{-1}$)	Week after planting (WAP) 4	6	8
Height (cm)	Control	16.58±0.22a	17.75±0.5a	18.25±0.86a
	5	21.73±3.91b	25.67±5.94b	28.67±6.30b
	10	23.00±7.09bc	29.76±4.08c	33.00±3.30c
	15	29.00±1.04d	34.42±2.58d	48.25±5.87d
	20	30.00±0.75d	36.50±2.41d	46.75±2.08d
No of Leaves	Control	4.25±0.14a	3.08±8.8 a	4.25±2.7a
	5	5.33±0.44a	4.83±0.0a	5.33±0.0a
	10	5.58±0.46a	6.17±9.6ab	5.58±4.9a
	15	6.08±6.08ab	7.33±7.8ab	7.58±4.2b
	20	6.67±0.16ab	8.5±8.8 ab	7.17±7.8b
Stem girth (cm)	Control	1.45±0.71a	1.20±2.7a	1.21±0.0a
	5	1.73±0.33a	1.73±6.1a	1.73±2.2a
	10	1.68±7.55a	2.22±8.8ab	2.30±0.0b
	15	2.60±0.33ab	3.20±7.8ab	3.39±4.9b
	20	2.95±0.12ab	3.51±6.1ab	3.25±0.0b

Values followed by the same letters in each column are not significantly different (Duncan Test, $p \leq 0.05$).

Table 3: Effects of variable rates of pig manure on okra yield attributes.

Treatments ($t.ha^{-1}$)	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)
Control	1.20±2.7a	0.97±7.8a	1.86±0.0a
5	3.93±1.3b	1.40±2.2b	3.69±2.2b
10	4.83±4.2c	2.30±2.7bc	9.30±0.0c
15	5.33±2.7d	3.87±4.5bc	12.49±4.9d
20	6.56±4.2d	4.60±9.3c	14.22±0.0e

Values followed by the same letters in each column are not significantly different (Duncan Test, $p \leq 0.05$).

5 $t.ha^{-1}$ and 10 $t.ha^{-1}$, 15 $t.ha^{-1}$ and 20 $t.ha^{-1}$ pig manure when compared respectively.

Discussion

Notwithstanding, Nigeria is ranked the second largest producer of okra and the great demand due to its economic and nutritional benefits, okra cultivation consistently recorded low yield, attributed to an array of insect pest infestation and poor soil fertility, resulting in poor yield and low market value.

The soil analysis results show that the experimental site is well-suitable for growing okra. However, the soil is deficient in basic soil nutrients which is below the critical level (Akinrinde & Obigbesan, 2000) required for optimum crop performance. The low soil fertility observed in the experimental site might be due to the continual cropping of the land without the application of soil amendment practice (Sanchez, 2002; Sanni et al., 2016). Therefore, for viable cultivation of okra, performance and optimum yield to be realized from the experimental soil, there is a need for soil enrichment with either organic or inorganic fertilizers and is envisaged to confidently affect okra production and growth.

The increase vegetative growth with pig manure was mainly due to the adequate organic matter with mineralised N, P and K content of the treated experimental plot, which made available to the growing okra seedlings, was primarily responsible for the increase in vegetative growth with pig manure. These outcomes are consistent with those of Frank (2000) who reported that significant crop vegetative growth was obtained with soil amended with organic manure.

The increase in yield could be due to the application of pig manure, thus confirming the role of organic manure in promoting vigorous vegetative growth in crops and in turn increasing yield. The yield increased with an increase in pig manure rates could be a result of the variable level of NPK content of the pig manure and suggest that it supplies nutrients which enhance physiological and metabolic functions in plant tissues thus culminating in strong growth which are significant indicators that boost fruit yield. This outcome is in line with reported of yield responses to various types of manure rate treatments from Dauda et al. (2005); Sanni & Adesina (2012) Adesina & Sanni (2013).

The severe damage caused by *Podagrica* infestation on okra leaves as witnessed in control plots in this study might be a result of the low fertility level of the experimental soil that predisposed okra to insect infestation. This aligned with the findings of Luna (1988) who opined that the capability of plants to repel or endure pest infestation is grounded, to some extent, on favourable soil physical, chemical and biological properties. While Magdoff & Van-Es (2000) stated that, any cultural practices that lead to the depletion of soil fertility can result in lowering plant resistance or tolerance to insect pest infestation. The lessening degree of damaged leaves in okra enriched with the application of pig manure might be owing to the obtainability of continuous slow release of essential nutrients needed by the plant, which guarantees improvement of plant vigour to develop a tolerance level to the insect attack (Adesina et al., 2018).

Okra plants in the study witnessed an increased *Podagrica* population as the level of pig manure increased. The reason for this could be nutrient absorption by plants enhanced normal physiological function and photosynthetic processes, thereby influencing vegetative growth, which made okra plants, produce vigorous and succulent leaves that are attractive to insects. The increase in the insect population seen in this study negates the conclusions of Adilakshmi et al. (2007); Atijegbe et al. (2014) and Adesina et al. (2018) who reported that the enrichment of soil with organic manure suggestively has a subduing effect on the prevalence of fruit borer, aphid, *Podagrica* spp. and other insect pest infestation on okra.

Conclusion

The utilization of pig manure as an agent of soil amendment would eliminate the menace of indiscriminate disposal of pig droppings in developing countries which constitute environmental pollution. This investigation shows that variable rates of pig manure significantly improved okra performances in terms of growth and yield and significantly play a compensatory role in okra yield in spite of the insect population increase on okra enriched with pig manure as evident in the reduction in the severity of damaged leaves. Thus, it is recommended that the application of 20 $t.ha^{-1}$ of pig manure will be appropriate to improve okra yield and suppress the damaging effect caused to okra growth by *Podagrica* spp. Also, the study should be replicated in other agroecological zones of Nigeria in order to come up with universal application rate.

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Conflicts of Interests

The authors declare no competing interests.

Authors contribution

JMA, conceived and designed the experiment and proofread manuscript; NSO, supervised the experiment and proofread the manuscript; OOIA, carry out data analysis and result interpretation; GAB, prepared the draft manuscript; AMA, sourced for relevant literature; ASB, conduct the field layout. TAJ, source for okra seeds and pig manure, ROO, carry out the entomological survey, OAO, carry out data analysis and result interpretation, AMS carry out the entomological data collection and SOO, carry out agronomic data collection. All authors have read and approved the manuscript.

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