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Effect of Organo-mineral fertilizer application on insect pests' population on garden eggplant in Obio Akpa, Akwa Ibom State

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Abstract
Field study was conducted in the Teaching and Research Farm of Akwa Ibom State University, Obio Akpa Campus during the early planting season of 2021 to study the effect of Organo-mineral fertilizer application on insect pests on garden eggplant in Obio Akpa, Akwa Ibom State. The experiment was laid out in a Randomized Complete Block Design with three levels of fertilizer application (0, 2 and 4 t/ha) which served as treatments and were replicated three times. Eggplant seedlings were raised in a nursery and transplanted in the field when they were five weeks old. Observations were taken on general insect population, major insect pests, and effect of the level of fertilizer application on insect infestation from 2 to 12 weeks after transplanting (WAT). The major insect pests identified were *Zonocerus variegatus*, *Ootheca mutabilis*, *Acrae aegina*, *Epilachna* beetle and *Anoplocnemis curvipes*. Generally, all the major insects collected had their highest number in 4 t/h organo-mineral fertilizer treated plot. The study also showed a significant negative correlation with T= - 0.512, - 0.546 and - 0.508 for 2t/h, 4 t/h and the control respectively, between the number of fruits and pest frequency under different rates of fertilizer application. Although insect population increased as a result of organo-mineral fertilizer application, it had no negative effect in the performance of garden egg.

Keywords: Garden eggplant, fruit yield, Organo-mineral fertilizer, major insect pests

Introduction
Garden egg, also known as African eggplant *Solanum melongena* (L.) is a herbaceous, perennial plant that is extensively cultivated throughout the tropics (Daunay and Itazra, 2012) [8]. Eggplant is one of the most eaten fruit vegetable crop in West Africa (Owusu *et al*. 2001; Itanson *et al.*, 2006; Obeng-Oferi *et al*., 2007) [31, 27]. The crop is a sun loving fruit that is a large, fleshy, ovoid berry which can reach 40 cm in length. Different local varieties are in existence and grown by different ethnic groups. In Nigeria, the Hausa's call it Yalo, Anara by Igbo's and Igbagba by Yoruba's (Schippers, 2000) [34]. The plant is highly cherished in the South-Eastern and South-South regions of the country where they serve different purpose in ceremonies. In some traditional cultures, the crop represents fruitfulness and blessings, and often offered at various festivities, ceremonies, religions rites and as acceptance of a visitor (Igwe *et al.*, 2003, Emma-Okafor, 2017) [19, 39]. Eggplants are eaten raw alone as vegetable snacks, or in combination with fried groundnut, boiled or fried for making sauce for unripe plantain, cocoyam or yam porridge (Emeasor and Uwalaka, 2018) [11]. In some parts of northern Nigeria, both the young green leaves and fruits are used for soup, stew or sauce or in preparing African salad (Abubakar, 2017) [1].
The nutritive value of eggplant is highly appreciated as they provide important protein, vitamins (A, B, & C), and minerals such as potassium, magnesium and calcium (Dupriez and Deleener, 1989) [10]. Apart from its nutritional importance, eggplant has medicinal values that cut across different ecological/ethnic zones. Guiama (2010) [17] reported that the roots are traditional medium to treat bronchitis asthma, wound, stomach disorders and various ailments. Chadma and Oluocha (2003) [6] earlier reported that consumption of eggplant has been recommended to fight malnutrition problems among African women and children. In addition, the plant contributes to the sustainability of cropping system and soil fertility improvement as well as helping in stabilizing soil, using its root system (Duke, 1990) [9]. Despite eggplant significance, there is an increasing concern about its yield as a result of field insect pests' infestation (Emeasor and Uwalaka, 2018) [11]. The insect pests are reported to account for reduced yield and losses of between 75-90% of the crop (Mckinlay, 1992) [21]. Damage caused by defoliators, fruit, flower and stem borers reduces yield quality of the

produce and consequently impact negatively on their market prices (Onekutu *et al*., 2010) [29]. The control of these insect and pest, generally has centered mainly on use of synthetic insecticides such as karate, cyperforce etc. that are hampered by many attendant problems such as environmental concerns and toxicity to humans that consume the product. There have been increasing research efforts to understand a more sustainable pest control strategies, including the use of fertilizers (Moursy *et al*., 2021) [24]. This work focuses on the study of the effect of organo-mineral fertilizer application on eggplant performance and the associated insect pests in Obio Akpa, Akwa Ibom State.

Materials and methods

The study area

The work was carried out at the experimental farm of the Department of crop science of Akwa Ibom State University, Obio Akpa, during the early planting season (April/May). The community, Obio Akpa is on altitude 40.00 m/131.23 ft, located within the tropical rainforest belt and geographically lies between latitude 4^0 30^1, and 5^0 30^1, N and Longitude 7^0 30^1 and 8^0 30^1 E. A bimodal rainfall pattern (wet and dry seasons) characterizes the area; the wet season gives rise to two maxima rainfall regimes, with the heaviest rainfall in June for the first rainfall and September for the second maximum, which is interrupted by a short dry spell, traditionally referred to as "August break". The mean annual rainfall in the wet season ranges from 2500-3000 mm. Dry seasons starts from November and lasts till February and with mean annual temperature between 26 ^{0}c and 28 ^{0}c. Highest temperatures are experienced between January and February while relative humidity is between 75-90% (Slus, Ak 1989) [35].

Land preparation

The experimental plot was prepared manually by clearing the bush and shades. Trashes were packed to the sites of the field, and the land tilled and leveled manually. It was thereafter marked and pegged for planting. Before planting, the seedling and organic manure were incorporated into the soil two weeks prior to planting.

Soil analysis

In determining the physico-chemical properties of the soil before the experiment, soil samples (surface soil, 0-15cm) were collected from each plot. The samples were bulk and air-dried for routine analysis as described by Carter (1993) [4]. Soil pH was determined in a 1:2:5 soil/water ratio using a pH meter with a glass electrode. Organic matter was determined by Walkley- Black dichromate digestion method (Nelson and Sommers, 1982) [26], while total nitrogen was determined by the Kjeldahl method (Bremner and Mulvancy, 1982) [3]. Phosphorous was determined using Bray-1 method (Murphy and Riley, 1962) [25]. Exchangeable Ca, Mg, K, Na were extracted using ammonia acetate while potassium was determined using the flame photo meter.

Field layout and experimental design

The experiment was laid out in a Randomized Complete Block Design with three blocks which served as replicates. The total area of land for the experiment was 14 m x 14 m (196 m^2). Each block consisted of three (3) sub-plots, each measuring 4 m x 4 m (16 m^2) giving a total of 9 sub-plots for the three blocks. Each block was demarcated from one another with 1m path. They were in all three treatments in the experiment. Treatment consisted of different doses of organo-mineral fertilizer with three levels namely 0, 2 and 4 tha^{-1} application and with each treatment replicated three times.

Nursery preparation

Nursery preparation, the garden egg variety ("Nnya use") a local variety used for the study was collected from Cross River Basin Authority in Abak Local Government Area of Akwa Ibom State. Nursery beds measuring 2 m long and 1.2 m wide were prepared and nursery raised in June. Seeds were sown thinly in rows of 10 cm apart, while seed beds were regularly watered and covered with mulch after sowing. The mulch was removed after germination and shade erected to protect the young seedlings against sunshine. Seeding's were pricked out to avoid over growing and watered until they reached transplanting stage.

Transplanting/cultural practices

Seedings were transplanted when they were about five weeks old. The seedlings were watered before uprooting for transplanting to soften the soil for easy lifting. Seedings were then taken to the experimental site for transplanting late in the evening, and planted at a spacing of 90 cm. Plots were weeded manually using hoe and hand at 2, 4 and 6 WAT. Thereafter, subsequent weeding was done when necessary to prevent weeds from competing with the crop for nutrients, sunlight and water.

Data collection

Soil physico-chemical properties of the field before planting

Data collection focused on the determination of the following: soil particle sizes, textual class, exchange bases and acidity as well as test for exchangeable aluminum.

Sampling of insects

Four (4) garden eggplants were randomly selected and tagged for data collection. Biweekly inspection of sampled plants was carried out and insects found on leaves, flowers and fruits of the randomly selected plants per plot, counted and recorded throughout the growing period of the crop. Insects were counted and recorded during morning hours (6-7 am). Collected insects were preserved in 70% alcohol or pinned and preserved in insect boxes for identification. Immature stages were collected and reared in the laboratory until adult stage emerged for proper identification. Direct visual count of all insects according to Pedigo (1989) and Mohammad (2013) [23] on each tagged plant was adopted. Insects collected, were identified using key by Critchley (2001) [7] and photographic atlas of entomology (Castner, 2000) [5]. The experimental site was exposed to natural infestation by insect pests; no control measure was applied throughout the life of the garden eggplant in the field.

Data analysis

All data collected were subjected to analysis of variance (ANOVA) while the Duncan Multiple Range Test was used to compare treatment means at 0.05 level of significance.

Results

The initial chemical properties of the experimental plot before treatment application is presented in table 1.The soil

were dominated by high sand with loamy clay and silt fraction. Organic matter recorded 2.79% while total Nitrogen and Phosphorous were 0.07% and available phosphorous 6.93 mg/kg^{-1} Electrical conductivity of soil (EO) was 0.09 ds/m and pH 5.80. Effective cation exchange capacity (ECEC) was 6.78 cmol/kg while there was high content of base saturation 73.01% attributed to high level of Ca, Mg.

Table 1: Soil physico-chemical properties of the field before planting

Particle size analysis soil properties	Values
Sand	87.60
Silt (%)	3.88
Clay (%)	8.52
Textural class	
pH (%)	5.80
EC (%)	0.09
Organic mater	2.79%
Total N	0.07%
Available P	6.93 mgkg-^{1}
Exchange bases	
Ca	3.20 cmol/kg
Mg	1.60 cmol/kg
Na	0.05 cmol/kg
K	0.10 cmol/kg
Exchange acidity	1.0 cmol/kg
Exchangeable aluminium	0.83cmol/kg
ECEC	6.78 cmol/kg
B/salt	73.01%

Table 2: Insect pests associated with garden eggplant at the study site in Obio Akpa.

S/N	Scientific Name	Common Name	Parts of Plant Attacked	Type of Damage Caused
1.	*Callichroma sp* (Coleoptera: Chrysomelidae)	Longhorn beetle	Attacked leaves and stems	Adults feed on leaf and stem
2.	*Ootheca mutabilis* (Sah) (Coleoptera: Chrysomelidae)	Leaf-eating beetle	Leaves	Adults feed on leaves (defoliators)
3.	*Epilachna* beetle (Coleoptera: Cocinellidae)	Leaf beetle	Leave	Adults and larva feed on leave lamina, leaving the veins causing skeletonized patches (plate 3).
4.	Unidentified large beetle (Coleoptera: Scarabacidae)	-	Stem	Adults scraped the bark of garden stem exposing the wood (plate 2).
5.	*Anoplocnmis curvipes* (Fab) Hemiptera: Coreidae	Leaf-footed bugs	Shoots and fruits	Adults and nymphs pierced and suck sap from the shoots and developing fruits causing distortion of leaves and poor fruit development (plate 1.)
6.	Helopeltis *spp* (Hemiptera: Miridae)	Plant/leaf bugs	Leaves	Adult and nymphs are sap suckers. They cause affected leaves to distort.
7.	*Aspavia spp* (Hemiptera: Pentatomidae)	Shield/Sting bug	Leaves	Adults and nymphs suck sap from the leaves
8.	*Leucinodes orbonalis* Lepidoptera: Pyralidae	Shoot/fruit borer	Shoot stem and fruits	Larvae bore into the stem through the shoots and into young fruits, causing wilting of the shoot and holes in mature fruits (plate 6).
9.	*Acrae aegina* (Lepidoptera: Nymphalidae)	-	Leaves	Larvae feed and skeletonized leaves (plate 4).
10.	*Zonocerus variegatus* (L.) Orthoptera: Pyrgomorphidae	Variegated grasshopper	Leaves and other green parts	It is polyphagous attack on many plant parts.
11.	Formicidae	Red ants	Stem and fruits	Built cast on stem and fruit of garden egg (plate 5).

Insect pests' complex found in the study site or field (Table 1) comprised of four (4) orders and ten (10) families among whom were defoliators, sap suckers, shoot, stem and fruit borers. Majority of these insect orders were coleopterans and hemipterans such as leaf eating beetles, longhorn beetles, and shied/sting bugs. Leaves, stems and shoots/fruits were parts of the plant mostly attacked. The nature of attack showed that adults and larvae of most of the insects feed on leaves and stems. Most coleopterans feed on leave lamina, leaving the veins and causing skeletonized patches (plates 3). Scarabaecidae adults, scrap bark of the garden eggplant stem exposing the wood (plate 2). Hemipterans such as *Anoplocnemis curvipes* (fab) adults pierce and suck sap from the shoots and developing fruits, causing distortion of leaves and poor fruits development (plate 1). The result also showed that larvae of *Acrae aegina*, a Lepidopteran feed and skeletonize leaves (plate 4) while the red ants were found building cast on stem and fruits of the plant (plate 5). (Plate 6) shows garden eggplant and fruits attacked by shoot and fruit borers.

Plate 1: Adult *Anoplocnemis curvipes*

Plate 2: Scarabaecidae beetle

Plate 3: Larvae of *Epilachna*

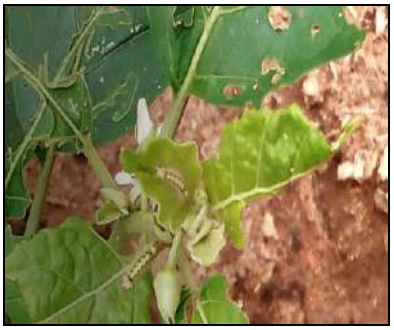

Plate 4: Larvae of *Acrae aegina* feeding on garden egg leave

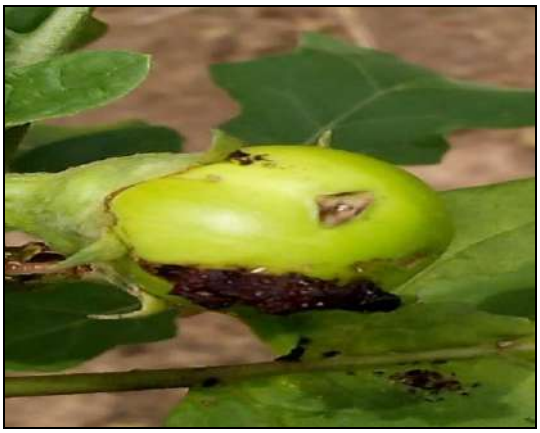

Plate 5: Ant cast mound on garden egg fruit

Plate 6: Garden eggplant and fruits attacked by shoot and fruit borer

Table 3: Major insect pests of garden eggplant and their frequency in Obio Akpa

Treatment	*Ootheca mutabilis* (Sah)	*Epilachna* beetle	*Anoplocnemis curvipes* (Fab)	*Acrae aegina*	*Zonocerus variegatus*	Total
2 tha $^{-1}$	3^{b}	3^{ab}	2^{b}	4^{a}	3^{b}	15^{b}
4 tha $^{-1}$	5^{a}	4^{a}	4^{a}	3^{b}	6^{a}	22^{a}
Control	2^{c}	1^{c}	1^{c}	2^{c}	3^{b}	9^{c}
Total	10	8	7	9	12	46

Mean with the same superscript along the same column are not significantly different (p>0.05).

Table 3 shows the five most important and commonest insects in the study in terms of number and damage done.

These included *O. mutabilis* (Sah), Larvae of *Ephilachna* beetle (plate 3), *A. curvipes* (Fab.) (Plate 1), *A. aegina* (plate 4) and *Z. variegatus* (plate 2). In terms of their frequency (number of weeks observed from date of transplanting), the result showed that *Z. variegatus* had the highest (12 weeks), followed by *O. mutabilis* (Sah.) with 10 weeks, *A. aegina* with 9 weeks and *Epilachna* beetle with 8 weeks, while *A. curvipes* (Fab) occurred in 7 weeks only. It was observed that *Z. variegatus* was found in the farm right from the nursery stage and may imply that same insect attacked garden egg from the seedling stage. The mean major insect pests and their level of severity in the study area are in the following increasing order; *Z. variegatus*, *O. mutabilis* (Sah) > *A. aegina* > *Epilachna* beetle > *A. curvipes* Fab.

Table 4 shows the effect of the fertilizer level on number of insect on garden eggplant. Generally, there was significant difference (P> 0.05) in number of insects among the three levels of fertilizer application throughout the growth period. At 2-6 WAT, the highest number of insects was obtained in 4 tha^{-1} followed by 2 tha^{-1} while the control had the least. At 8 WAT, 4 tha^{-1} had the highest number of insect (4 insects) for 2 tha^{-1} and the control had the least (3 insects respectively). Also, 4 tha^{-1} recorded the highest number of insect at 10 WAT (6 insects) followed by 2 tha^{-1} (3 insects) while the control had the least (1insect). At the last growth stage (12 WAT), the highest number of insects was recorded in 4 tha^{-1} (5 insects) followed by 2 tha^{-1} with a mean of 3 insects, while the control had the least (2 insects). The result showed that the level of application of organo-mineral fertilizer had significant (P>0.05) effect on severity of insect pest on garden eggplant, that is, pest infestation on garden eggplant increased with increasing level of fertilizer application.

Table 4: Effect of fertilizer level on number of insect on garden eggplant

Treatment	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	Total
2 tha^{-1}	3^{b}	3^{ab}	2^{b}	4^{a}	3^{b}	3^{b}	15^{b}
4 tha^{-1}	5^{a}	4^{a}	4^{a}	3^{b}	6^{a}	5^{a}	22^{a}
0 tha^{-1}	1^{c}	1^{c}	1^{b}	3^{c}	1^{b}	2^{c}	9^{c}

Mean with the same superscript along the same column are not significantly different (p.0.05)

The elemental analysis of the organo-mineral fertilizer applied is presented in Table 5. Nitrogen had the highest percentage 2.8, followed by potassium with 2.2, moisture content 1.4, while the least was phosphorous with 1.2.

Table 4: Chemical properties of organo-mineral fertilizer used in the study

Properties	Values (%)
Nitrogen (N)	2.8
Phosphorous (P)	1.2
Potassium (K)	2.2
Moisture	1.4
Total	4.0

Discussion

The results show that the soil was dominated by high said with loamy clay and silt fraction. Organic matter content was low (2.79%), this value was lower than the 10% given for soils in south eastern Nigeria (Esu, 2010) [13]. This low organic matter content suggests that the soil lacks ability to adequately supply essential nutrients and maintain good structure needed for plant growth. The management of this soil therefore required adequate fertilizer and organic matter application to improve soil condition that can give good yield capable of resisting insect infestation. Total nitrogen was 0.07%, below the limit of 0.5% considered as medium range for crop growth. There was high level of available phosphorous 6.03 mk/kg which was above the critical value of 0.05 cm01/kg (FAO, 1976). Electrical conductivity (Ec) of the soil was low 0.09 ds/m which was much lower than 2 ds/m reported by FAO (1990) [40] for classifying soil as saline. Effective cation exchange capacity CEO was t6.78 cmol/kg below the critical value of 20 cmol/kg regarded as suitable for crop production (FAO, 2014) [15].

Numerous insect pests were found in association with garden eggplant in the field. These consisted mainly of *O. mutabilis*, *Epilachna* beetle, *A. curvipes* (Fab), *A. aegina* and *Z. variegatus*. This present result is consistent with the report of Folorunso *et al*., (2020) [16] while working on the population density of insect pests associated with eggplant varieties and found 4 major pests *Z variegatus*, *Spodoptera litoralis*, *L. orbonalis* and *Epilachna* spp). Similarly Olaniran *et al*., (2021) [28] in Ogbomoso identified the major insects of eggplant to be *Z. variegatus*, *S. litoralis*, *L. orbonalis* and *Epilachna* spp. Also in this study, in terms of abundance, *Z. variegatus* was most predominant in number and further constituted the greater number eggplant pests. There were found in the farm right from the nursery stage. The result is in agreement with the findings of Folorunso *et al*., (2020) [16] and Olaniran *et al*., (2020) who stated that by far, the most economically important insect species of garden egg palnt in West Africa is *Z. variegatus*. Similarly Ugwu *et al*., (2021) [36] and Oso and Borisade () listed a number of the most economically important insect species of eggplant in Nigeria and noted that grasshoppers, crickets (Orthopterans) and beetles (Coleopterans) were among the notorious insects feeding on the foliage. According to him, the adults and nymphs of grasshoppers as well as adults of the beetles caused appreciable damage by feeding on cotyledon, stems and foliage of young plants. The large numbers of *Z. variegatus* sampled in this study may be attributed to adaptation to their environment in terms of sufficient food for growth and reproduction.

The mean major insect pest and their level of severity in the study area which showed the following increasing order, *Z. variegatus* > *O. muttabolis* (Sah) > *A. aegina*> *Epilachna* beetle > *A. curvipes* (Fab) could imply that some insect pest attacked the plant from the seedling stage to maturity. It could be deduced that damage done by insect pests on garden eggplant depends on growth period of the plant. This is demonstrated by the fact that the some of the insects recorded their peak and worst attack on the crop at either vegetative, flowering or fruiting stages. Most of these insects attacked the crops at vegetative stage, implying that defoliators may have dominated the major insect pests. Generally, there was a significant difference (p>0.05) in number of insect among the three levels of fertilizer application throughout the growth period. It can be deduced from this result that the levels of application of the organo-mineral fertilizer had significant (p>0.05) effect on severity of insect pest on the plant. Pest infestation on eggplant increased with increasing level of fertilizer application. This result is in line with the findings of Sylvester *et al*., (2013)

who recorded higher number of insect pests on NPK fertilizer and poultry manure treated plots.

Results from this present work also confirm reports of Pimetel *et al*., (1986) and Yardim and Edwards (2003) [37] who observed that an unusual great number of arthropods occur on plants grown with inorganic fertilizer. The reason according to them being that fertilizer application influences the nutritional elements in plants and if in excess reduces resistant to insect pest. On the contrary, the present result is not in congruent with similar past work by Mishra and Sahu (2019) [22] who in their work on effect of organic and in organic fertilizers on pest incidence and yield of Okra reported that a particular treatment, T_7 (RDF 75-25% neem oil cake) has significant effect in disease incidence and pest population by reducing their population. Similar study earlier by Joshi (2011) showed how the application of chemical fertilizer lowered significantly white fly and mite populations. It can therefore be deduced from this study and past works that both organically and inorganically treated plants can attract increased or decreased insect pest. The reason for such results could be the presence of certain phytochemicals in the organic-treated fertilizers that attracts the insect populations. More so, excess nitrogen is well documented to correlate to increased pest prevalence.

Conclusion

The study has shown that the levels of application of organo-mineral fertilizer increased populations of insect pest on garden eggplant. It further revealed that the relationship between the number of insect pests observed and growth, as well as yield parameters of the crop are mostly negative under the three levels of fertilizer application, implying that the sole economic importance of pests on garden eggplant is reduction in growth and yield of the crop. However, plots amended with organo-mineral fertilizer increased the vegetative growth of the plant as well as yield.

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