Journal of Agriculture, Environmental Resources and Management
ISSN2245-1800(paper) ISSN 2245-2943(online)
7(12)1-800;**January**.2026; pp112- 117

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Influence of Biopesticides on the Yield and Pest Incidence of Bell Pepper (*Capsicum annum* L.) in Owerri.

Anah, Chinweizu O.[1]; Abana, Peace C.[1]

[1]Agricultural Technology Department, Federal Polytechnic Nekede Owerri.

cobinna@fpno.edu.ng

Abstract: The excessive reliance on synthetic pesticides in vegetable production has raised concerns regarding environmental pollution, pest resistance, and food safety, thereby necessitating the evaluation of safer and sustainable pest management alternatives. This study investigated the influence of selected biopesticides on pest incidence and yield performance of bell pepper (*Capsicum annuum* L.) in Owerri, Southeastern Nigeria. Field experiments were conducted during the cropping season using a randomized complete block design with four treatments and three replications. The treatments consisted of neem (*Azadirachta indica*) leaves extract, tobacco (*Nicotiana tabacum*) leaves extract, *Imidacloprid is a systemic insecticide*, and an untreated control. Data were collected on major insect pest incidence, severity of damage, plant growth parameters, number of fruits per plant, fruit weight, and total marketable yield. The study revealed that all tested biopesticides significantly ($p \leq 0.05$) outperformed the control group and synthetic insecticide in reducing pest pressure. Neem leaf extract emerged as the most effective treatment, maintaining the lowest pest populations and minimal crop damage. Tobacco leaf extract followed as a strong secondary option, showing moderate but consistent effectiveness. Beyond pest suppression, these natural alternatives directly improved harvest quality: plots treated with Neem and tobacco produced more fruits, and superior overall yields compared to untreated plots and plots treated with synthetic insecticide. These findings suggest that for bell pepper farmers in the Owerri agro-ecological zone, biopesticides offer a viable, high-performing alternative to conventional chemicals for both crop protection and yield enhancement. Adoption of these eco-friendly pest management options can contribute to sustainable vegetable production, improved food safety, and reduced dependence on synthetic pesticides.

Keywords: Biopesticides, Bell pepper, Pest incidence, Yield, Owerri.

Introduction: Bell pepper (Capsicum annuum L.) is an economically important vegetable crop in Nigeria and across tropical Africa, valued for its nutritional content, culinary versatility, and market demand. However, production is severely constrained by insect pests including fruit flies (Bactrocera spp., Ceratitis spp.), thrips (Scirtothrips dorsalis, Frankliniella spp.), whiteflies (Bemisia tabaci), aphids (Myzus persicae, Aphis gossypii), and lepidopteran borers such as false codling moth (Thaumatotibia leucotreta) and Helicoverpa armigera (Adom et al., 2023; Pathan et al., 2023). These pests cause direct fruit damage, transmit viral diseases, and reduce marketable yields by 30–70% in unprotected fields (Rahman et al., 2022). Recent surveys in West Africa indicate that viral diseases, often transmitted by these insect vectors, are the primary constraint to pepper production, with farmers reporting significant yield losses (Zohoungbogbo et al., 2024). While synthetic insecticides are the standard response, their use in Nigeria is increasingly scrutinized due to environmental degradation and the emergence of resistant pest populations (Acheuk et al., 2022). Consequently, modern agricultural research has pivoted toward "botanicals"—bioinsecticides derived from plant extracts—as biodegradable and cost-effective alternatives (Tavares, 2021). Recent longitudinal studies (2022–2024) have mapped the overwhelming presence of viral pathogens in pepper fields across West Africa. Specifically, the *Pepper veinal mottle virus* (PVMV) and *Cucumber mosaic virus* (CMV) have been identified as the most prevalent threats, with incidence rates reaching as high as 80–90% in some regions (Zohoungbogbo et al., 2022). These viruses are directly linked to the density of aphid and whitefly populations. Farmers in neighbouring regions have shown a growing but still limited awareness of these connections, with approximately 17% now adopting homemade biopesticides to manage vector pressure (Zohoungbogbo et al., 2024).

Contemporary research has categorized over 112 native plant species with insecticidal properties suitable for sustainable crop protection (Dougoud et al., 2019). Neem (*Azadirachta indica*): Remains the most widely recommended botanical due to its multi-modal action, acting as both a repellent and an antifeedant that disrupts larval molting (Acheuk et al., 2022). Recent trials show that neem-based formulations can reduce aphid populations by over 50% within 96 hours of application (Dougoud et al., 2019).

Chili and Garlic Extracts: Applications of garlic (*Allium sativum*) and chili pepper botanicals have demonstrated high efficacy, especially when used in mixtures. Combined applications of chili, garlic, and neem oil have been shown to achieve over 70% pest mortality in controlled settings (Dougoud et al., 2019).

The shift toward bioinsecticides is supported by measurable gains in horticultural performance. In West African pepper trials, the use of integrated pest management (IPM) strategies, including botanicals, has been correlated with significantly higher total yields—sometimes reaching 30 t/ha depending on the cultivar (Zohoungbogbo et al., 2022). Furthermore, these natural extracts are cited as a "cheap, accessible, and biodegradable" alternative for farmers in regions where synthetic products are either unaffordable or unavailable (Tavares, 2021). Conventional pest management in Nigeria and tropical Africa has relied heavily on synthetic chemical pesticides, which pose risks including pesticide resistance, environmental contamination, harm to non-target organisms, and health hazards to farmers and consumers (Ratto et al., 2022). Growing awareness of these challenges has spurred interest in biopesticides—pest control agents derived from natural materials including plants, microorganisms, and naturally occurring biochemicals—as sustainable alternatives or complements to synthetic chemicals (Md et al., 2024; Ratto et al., 2022). This study investigates the impact of some selected bioinsecticides on pest population dynamics and the resulting fruit yield of bell peppers in the ecological context of Owerri, Nigeria.

Materials and methods.: Location of study.: This research was carried out at the Teaching and Research Farm of the Department of Agricultural Technology, Federal Polytechnic, Nekede, Owerri, Imo state between April to August 2025. Owerri, lies between latitudes 5°41' N and longitudes 7° 34' N of the Greenwich (Prime) Meridian (Enyioko *et al*., 2019) and is characterized by a natural rainforest turned derived savannah agro-ecology with mean annual atmospheric temperature ranges from 25 ± 6 0C, mean annual rainfall range from 1800 ± 250 mm and annual relative humidity of 85 ± 10 % (NIMET, 2017). The soil type is utisols and has a sandy-loam texture. The experiment was laid out in an RCBD with 3 replications. The treatments were T1 = Tobacco extracts (*Nicotiana tobacum*), T2 = Neem extracts (*Azadirachta indica*), T3 = Chemical insecticide (Imadaspring Insecticide), T4 = Control (no application).

Treatment Preparation: Tobacco extract**;** 40g of tobacco leaves were crushed, and soaked in 2 liters of hot water over night. The liquid was strained into plastic storage containers and sprayed directly on the crops weekly. (Leaf Only.n.d.). Neem extract**;** Extract was obtained by soaking 1 kg of crushed fresh leaves in 2 L of water overnight then strained through a fine cloth. A teaspoon of dishwater was added to the solution, to act as surfactant. 1 liter of the concentrated extract was mixed with 10 liters of water and applied on the crops weekly (Muhammad, & Kashere, 2020).

Planting and transplanting: Bell pepper seeds were planted in nursery trays and transplanted 5 weeks after germination to the main field. Seed beds measured 2m x 2m, and seedlings were spaced at 50cm x 60cm.

Data were collected in the following parameters:

Plant height: The height of the sampled plants was measured using a meter tape, measurement was taken on four randomly selected plants from the base to the top of the leaf.

Number of Leaves: The number of leaves were counted, the average taken and recorded at 2,4,6 and 8 weeks after transplanting.

Leaf Area: The leaf area was calculated thus: LA = 0.57 (L.W) (Pardon et al., 2016) at 2,4,6, and 8 weeks after transplanting. Where L = maximum length of terminal leaflet; W= maximum width of the terminal leaflet.

Leaf damage: The number of leaf damage per plant was recorded. This was done as

% of leaf damage = Total number of leaves - undamaged leaves x 100

Total number of leaves produced 1

Insect population count: Assessment of the insect pest population was done by visually counting 10 randomly selected plants per plot in the middle row. Sampling commenced at 2 weeks after transplanting and at biweekly intervals between 7:30am to 9:30 am.

Pest incidence was calculated using**:**

Pest incidence = number of infected plants x 100

total number of plants assessed 1

Weight of harvested fruits: Mature bell peppers were harvested weekly. Harvested fruits of each selected plants were placed in a labeled polythene bag and taken to the laboratory where they were weighed.
Number of harvested fruits: Number of harvested fruits were counted and recorded.
Number of damaged fruits: **N**umber of damaged fruits were counted and recorded.
Data collected were subjected to analysis of variance (ANOVA) and the treatment means were separated by Duncan multiple range test DMRT at 5% level of probability using R studio version 1.4.1106.

Results and Discussion: Plant Height: The effect of the biopesticides on plant height of bell pepper is shown in table 1. At 2,4,6 and 8 weeks after transplanting, the T.L.E (Tobacco leaf extract) gave the highest plant heights (4.35cm, 10.14cm, 11.11cm and 13.37cm respectively), though not statistically different from the plant height of other plants as a result of the other treatments while the Control gave the lowest plant height (3.59cm, 5.82cm, 7.42cm, 9.11cm respectively).

This result supports the report of Ratto et al. (2022) who claimed that tobacco as a bio insecticide enables plants achieve greater height due to reduced tissue damage.

Number of Leaves: The influence of bio-insecticide on number of leaves of bell pepper is presented in table 2. Bell pepper plants treated with T.L.E (Tobacco leaf extract) throughout the different weeks after transplanting had the highest number of leaves, but was not significantly different in other treatments except in at 8 WAT. The lowest number of leaves were obtained from Control, which was significantly from other treatments at 8 WAT only.

This result is in line with that of Arya et al. (2016) who reported that tobacco extract reduces pest pressure leading to less leaf damage thereby allowing bell pepper plants to retain more leaves.

Leaf Area: The leaf area as influenced by the application of biopesticides is presented in table 3. T.L.E treated bell peppers had significantly the largest leaf area at 2 and 8 WAT with control plant having the smallest. However, at 4 and 6 WAT, bell pepper plants treated with N.L.E (neem leaf extract) showed a significantly higher leaf area than the control. This is supported by the work of Dorm and Raffa (2014) who reported that reduced pest population through bio-insecticides can positively influence the leaf area as the bell pepper plants are able to allocate resources to leaf expansion rather than repair.

Number of Damaged Leaves: The Control from the results gave significantly higher number of damaged leaves when compared with the Neem leaf extract and the tobacco leaf extract as well as the chemical insecticide at 4 6 and 8 WAT (table 4). N.L.E treated plants showed the lowest leaf damage. This result is in line with the observation made by Isman (2012) which reported that Neem treated plants often exhibit lower leaf damage compared to untreated plants, as insects avoid feeding on treated leaves due to the bitter compounds in neem.

Insect Count: The different treatments did not have any significant effect on the insect population at 4 WAT until the 6 WAT. Plant treated with N.L.E had significantly lower insect population count compared to the chemical and non-treated control (Table 5). This result aligns with the observation of Yusof et al. (2022) and Koul & Walia, (2009) that Neem interferes with the feeding, growth and reproductive cycles of insects, disrupt molting and inhibit insect development reducing insect count over time.

Number of Harvested Fruits and Damaged Fruits: Table 6 shows that, the neem leaf extract had the highest number of fruits harvested followed by the tobacco leaf extract which were significantly different from control, the chemical insecticide with the control gave the least number of harvest fruits. However, the highest number of damaged fruits were expectedly seen with the control, while the least number of damaged fruits were from the chemical treated plants. This report aligns with the report conducted by Isman (2016) who showed that reduction in pest stress minimizes fruit loss due to pest damage and improves overall number of fruits harvested.

Fruit weight: The evaluation of the influence of biopesticides on the weight of fruits (Table 7) showed that the mean weight of fruits of all the treated plants with NLE significantly weighed more than the control, but significantly not higher than TLE and chemical treated plants.

This result is consistent with the report of Adom et al., (2023) who reported increased yields of pepper due to biopesticide application and highlights the importance of using appropriate concentrations of botanical insecticides like Neem extract to avoid phytotoxic effects and promote effective pest control without negatively impacting fruit yield and quality.

Pest incidence in the field: In this study, 3 insect pests were identified on the bell pepper plants (Aphids, Flea Beetles, and Leaf-Footed Bug) (Table 8). The control plots were severely attacked by these different kinds of insect pests throughout the study period as compared to the plots that were treated with leaf extracts and the chemical insecticide. These high percentage pest incidences indicate that the control plots did not have any form of protection from insect pest attack. This is in conformity with a report by Adom et al. (2023), who were of the view that a number of insect pests infest the bell pepper plants which reduced yield. These activities of the insects led to wilting of young shoots, followed by drying and drop off, which slowed plant growth (Cisse et al.,2025).

The flee beetle and the aphids were generally found on the entire study field. Both the adults and nymphs of the aphids drew the plant sap and decreased the plant vigor. According to Ratto et al. (2022), in severe infestations, the leaves turned yellow and dropped off.

Conclusion: The potential of using neem leaf extract as a bio-insecticide against insect pests of bell peppers was established in this study. Out of the three treatments the neem leaf extract showed great potential in improving bell pepper yield, reduced insect pest incidence even better than a synthetic chemical. The neem extract enhanced normal plant growth and reduced high fruit loss. Thus, higher production was found in the plots treated with neem leaf extract. Some insect pests such as aphids, flea beetle, and leaf-footed bug were identified to attack bell pepper in the farm at the specific location. The use of leaf extracts such as neem is therefore recommended as a viable insect pest management strategy to improve performance and reduce cost of production of horticultural crops.

Acknowledgment: The Authors wish to thank the Tertiary Education Trust Fund (TETFund) for providing the sponsorship for this research through the Institutional Based Research Grant.

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Table 1. Influence of Bio-insecticide on plant height of bell pepper (cm).

Treatment	Weeks After Transplanting			
	2	4	6	8
T.L.E	4.35a	10.14a	11.11a	13.37a
N.L.E	3.93a	6.97b	9.30a	12.95a
CHM	3.78a	6.73b	9.54a	10.13a
CONT	3.59a	5.82b	7.42a	9.11a

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)

- CONT Control

Table 2. Influence of Bio-insecticide on number of leaves of bell pepper.

Treatment	Weeks After Transplanting			
	2	4	6	8
T.L.E	4.51a	14.16a	60.66a	85.32a
N.L.E	4.29a	16.00a	58.33a	72.41ab
CHM	3.91a	14.67a	60.75a	69.16ab
CONT	4.33a	12.11a	48.32a	51.41b

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table 3. Influence of bio-insecticides on leaf area of bell pepper $(cm)^2$.

Treatment	Weeks After Transplanting			
		4	6	8
T.L.E	5.90a	22.79b	40.13b	63.64a
N.L.E	5.62b	24.42a	44.63a	64.93a
CHM	5.33c	21.80b	39.40b	60.81b
CONT	5.30c	20.52c	37.00c	58.83c

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table 4. Influence of bio-insecticide on the number of damaged leaves per plant.

Treatment	Weeks After Transplanting		
	4	6	8
T.L.E	2.25b	1.26b	1.57bc
N.L.E	1.95c	1.13b	1.26c
CHM	2.29b	1.33b	1.71b
CONT	2.73a	1.77a	2.10a

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table: 5. Influence of bio-insecticide on the insect count of bell pepper per plant.

Treatment	Weeks After Transplanting		
	4	6	8
T.L.E	6.66a	4.33ab	3.00bc
N.L.E	6.00a	3.33b	2.00c
CHM	7.33a	5.66a	4.56b
CONT	8.66a	5.66a	8.52a

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract

- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table: 6. Influence of bio-insecticide on the number of harvested/damaged fruits of bell pepper.

Treatment	No of harvested fruits/Ha	No of damaged/Ha
T.L.E	25,000.00a	5,000.00a
N.L.E	28,250.00a	5,000.00a
CHM	18,325.00ab	3,325.00a
CONT	11,650.00b	6,650.00a

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table: 7. Influence of bio-insecticide on the fruit weight of bell pepper per plant (kg).

Treatment	Fruit weight (kg)
T.L.E	0.23ab
N.L.E	0.30a
CHM	0.17ab
CONT	0.12b

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control

Table 8. Influence of bio-insecticides on the incidence of Aphids (*Aplua gossypii*), Flea beetles (*Epitrix cucumeris*), and Leaf-Footed Bug (*Acanthocoris Scaber*) on bell pepper (*Capsicum annum*)

Treatment	Incidence (%)		
	Aphids	Flee Beetle	Leaf-Footed Bug
T.L.E	18.70b	20.00b	15.60b
N.L.E	14.00b	18.70b	12.50b
CHM	21.80b	25.60b	19.13b
CONT.	51.50a	44.30a	51.80a
Mean	26.50%	27.15%	24.75%

Numbers with the same letters are not statistically different according to DMRT ($p<0.05$).

- T.L.E Tobacco leaf extract
- N.L.E Neem leaf extract
- CHM Chemical insecticide (Imidacloprid)
- CONT Control