

Effect of Seed Extract of *Piper nigrum* (Black Pepper) in the Control of Maize Stem Borer (Army Worm) (*Busseola fusca*) in Maize Plant

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ABSTRACT

This experiment was conducted in the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri, Nigeria between September and November in 2020. The experiment investigated the use of seed extract of *Piper nigrum* (Black pepper) in the control of maize stem borer (*Busseola fusca*) in the maize plant. The experiment was arranged in a randomized complete block design (RCBD) with four treatments and four replications, giving a total of 16 treatment units. In this trial various levels of treatments of *Piper nigrum* were used (0.0, 50, 75, 100) mls for crude extracts. Soil analyses before and after treatment application were determined. The proximate analyses were carried out on *Piper nigrum* which revealed the nutritional contents in percentages. Phytochemical analyses were carried out which revealed the presence of bioactive constituents. Infrared spectroscopy (FTIR) revealed the various functional groups or organic compounds absorbed at different wavelengths. Data were collected on plant height, stem girth, number of leaves, leaf area, number of insects, number of plants infested, weight of cobs at harvest (kg/ha), weight of biomass after harvest and subjected to analysis of variance (ANOVA) at 0.05 % level of significance. The result of the trials revealed that plots that received (100 and 75) mls were the best in all the parameters tested. Plant heights were significantly ($p \leq 0.05$) different over 0.0ml, the control. The number of leaves per plant, stem girth, leaf area, number of insects, number of plants infested, weight of Biomass, were all significant at ($p \leq 0.05$). Finally, weight of cobs at harvest was ($p \leq 0.05$) over (0.0 and 50) mls, measuring 3231.3kg/ha, the ability of *Piper nigrum* to perform all these could be likened to the presence of phytochemical constituents and other bioactive compounds, inherent in the botanical plant material.

Keywords: Maize stem borer (*Busseola fusca*), *Piper nigrum*, Phytochemicals, Stem girth, Soil and Proximate analyses, Insects



Article information

Received 10 March 2025

Accepted 28 May 2025

Published 25 June 2025

<https://doi.org/10.26765/DRJBB164951201>

Citation: Emeribe, E. O. (2025). Effect of Seed Extract of *Piper nigrum* (Black Pepper) in the Control of Maize Stem Borer (Army Worm) (*Busseola fusca*) in Maize Plant. *Direct Research Journal of Biology and Biotechnology*. Vol. 9(8), Pp. 24-33.

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INTRODUCTION

Maize is an important cereal crop in Nigeria and the most consumed cereal (Falusi *et al.*, 1988). Maize otherwise known as corn is important to the economy due to its wide range of uses. Maize is used as feed for livestock. It is used to create a variety of food and non-food products such as corn oil, starch corn meal and sweeteners, ethanol which is used as a cleaner burning alternative to gasoline (Emeribe and Mavis, 2018). Green maize, fresh on the cob is eaten baked, roasted or boiled (IITA, 2009).

Maize belongs to the family *Gramineae*. It is widely cultivated throughout the world. According to FAO, 2000, Africa produced 7% of the 59 million tons produced worldwide from 138 million hectares in the year 2000. Many factors limit maize production, insects and mites (Patricio *et al.*, 2024) being among the most important (Emeribe and Mavis, 2018; Bosque-Perze, 1995). The major insect pests of maize include, stem borers, African stalk borer (*Busseola fusca fuller*, the pink stem borer

(*Sesamia calamists*) stem borers interfere with the movement of water metabolized through the plant vascular system, which stunts its growth during development. Attacks during the first eight weeks after sowing results in "dead heart" and let damage (beyond 8 weeks after sowing) lead to stem lodging. Both types of damage to the crop cause drastic damage in maize yield (Emeribe and Mavis, 2018).

The larvae of stem borer usually cause the damage. The natural larvae bore into the maize stem of the plant and later into the tassels and cobs (Tetera *et al.*, 2011). Estimated yield stem losses caused by stem borer in West Africa ranged from 10-100% (Emeribe and Mavis, 2018). The potential yield of maize within the environment could be realized when pests are managed by scouting fields regularly and applying treatment when necessary. Stem borers are among the most important insect pest of maize, they reduce maize yield that varies between 10-70% (www.infor-net-biovision, 2021).

Therefore, efforts should be made to manage pests to increase maize production. Furthermore, maize stem borer (Army worm) is difficult to control with synthetic insecticides (Vitale *et al.*, 2007), the reason presumably being that existing spray based-practice have been found ineffective, more so, they are costly and hazardous (Clive, 2003; Hulme, 2005; Ohazuruike and Obi, 2000). Pests are also increasingly developing resistance to conventional chemical insecticides and outbreaks are expected to worsen through climatic change (Ahaotu *et al.*, 2019, Ahaotu and Akagha, 2020).

However, instances of affirmed natural products (phytochemical) used in insect pest control include, garlic, (*Allium sativum*) (Ahaotu *et al.*, 2024), Onion, (*Allium cepa*), *Piper nigrum* Uziza (Asika *et al.*, 2019), *Moringa oleifera* (Ihezuo *et al.*, 2013), Neem, *Azadirachta indica* (Ahaotu, 2024), Turmeric, *Curcuma longa* (Ahaotu and Lawal, 2019), Scent leaf (*Ocimum gratissimum*), Alligator pepper (*Aframomum melegueta*), Chilli pepper (*Capsicum annum*), Lemon grass, (*Cymbopogon citrate*) (Ajari *et al.*, 1987; Echereobia *et al.*, 2009; Emeribe *et al.*, 2016). Studies in some African countries suggested that extracts of locally available plants can be effective as crop protectants (Isman, 2008, Ahaotu *et al.*, 2013, Emeribe and Mavis, 2018). Among the botanicals used are natural pyrethrins, Neem extracts, Senegalensis against cotton boll worms in Benin and extracts from Marigold against *bruchids* in cowpea storage in Uganda among others. Recent studies demonstrated that, stabilized natural pyrethrins have shown contact and systemic toxicity against maize weevil *Sitophilus Zea Mays*.

Therefore, these necessitate further research work to develop other methods of controlling maize stem borer-army worm. In Nigeria, extracts of locally available plants have been traditionally used as a mixture (Emeribe *et al.*, 2016). Indigenous knowledge and traditional practice can make valuable contributions to domestic food production in countries where strict enforcement is not applied. (Isman, 2003).

Hence, it becomes necessary to find out the effects of black pepper (*Piper nigrum*) extract in the control of maize stem borer (Army worm). However, the use of black pepper as a better alternative to synthetic insecticide to control maize stem borer is economic, safe, eco-friendly, bio-degradable and have no harmful effect on non-target organisms, human beings inclusive. Therefore, the main objective of this study is to evaluate the potentials of *Piper nigrum* extract in the control of Army worm (*Busseola fusca*) on *Zea mays*. Also, the specific objectives were to evaluate the pesticidal activity of *Piper nigrum* seed extract on some parameters in the control of army worm in maize plants, determine the best concentration level of *Piper nigrum* in the control of army worm on yield qualities and to evaluate the phytochemicals and other organic compounds inherent in the plant extract.

The larvae of stem borer usually cause the damage. The natural larvae bore into the maize stem of the plant and later into the tassels and cobs (Tetera *et al.*, 2011). Estimated yield stem losses caused by stem borer in West Africa ranged from 10-100% (Emeribe and Mavis, 2018). The potential yield of maize within the environment could be realized when pests are managed by scouting fields regularly and applying treatment when necessary. *Piper nigrum* has stimulating and carminative properties of the volatile oils causing a reflex flow of saliva with increased secretion of gastric juice and improved appetite (Emeribe *et al.*, 2016). Gastro intestinal movements are augmented with consequent eructation of gas and relief of colic. In sufficient doses, the peppers dilate the superficial vessels of the skin causing a feeling of warmth followed by diaphoresis and some reduction of temperature. On account of these properties, they are much employed as condiments, especially in hot countries. The therapeutic properties of *Piper nigrum* oil include the following as in analgesic, antiseptic, antispasmodic, antitoxic, aphrodisiac, digestive, diuretic, febrifuge laxative, rubefacient and tonic. Piperine extracted from *Piper nigrum* also possesses chemical properties (Emeribe *et al.*, 2016).

Piperine, (C₁₇H₁₉N₀₃), primarily comes from the Asian vine, *Piper nigrum*. Piperine can be used as pesticides and also for medical treatments (Emeribe *et al.*, 2015). Piperine are very effective in the control of insect-pest because they possess repellent, knockdown, anti-feedant, broad spectrum properties and also, they are important because they are less hazardous, biodegradable and maintain balanced biodiversity on insect pest (Emeribe *et al.*, 2016). Neem dust is used to control the stored grain pest, use of various plant extracts like *Acorus spp*, *Melia spp* and *Acacia spp* plant-based insecticides (Emeribe and Mavis, 2018).

Nicotine, rotenone and pyrethrum were popular among the (plant-based insecticides) PBIs used to some extent for storage pest control and other pest in green house (Schumtterer, 1981). Some of these plant species possess one or more useful properties such as repellence, anti-feedant, fast knockdown, flushing action, biodegradability,

broad-spectrum of activity and ability to reduce insect resistance (Olaifa *et al.*, 1987). However, most of them are either weak insecticide or may require other plant species with different mode of action to increase their potency (Oparaeke, 2004). *Xylopi aethiopica* is found to be weak insecticide for control of *Callosobruchus maculatus* (Oparaeke and Bunmi, 2004) and in the field pest of cowpea (Oparaeke, 2004). However, ground, dried fruits of *Xylopi aethiopica* (African or Ethiopian pepper) mixed with chillies (*Capsicum spp*) are applied to kola nut was found to have repellent properties against kola weevils (Burkill, 1985) and bitter leaf (*Vernonia amygdalina*) has shown potency against "tailor ants" infesting local pear fruits and leaves in Eastern Nigeria (Stoll, 1988).

Ogah *et al.*, (2011) reported that Neem seed kernel (*Azadirachta indica*) extract significantly reduced stem borers damage (number of dried hearts, white heads) compared to untreated chuck, and also significantly increase number of productive fillers with resultant increase in grain yield than the control plots. Tadele, (2013) reported that among the botanical powder application *Chrysarthemum cinerariaefolium*, *Cymbopogon citrates* and *Nicotiana spp* were recorded to have higher efficacy against *Busseola fusca* by having 100%, 83.3% and 75% mean mortality, respectively within three days. Ogendo *et al.* (2013) reported that results from the field bioassay traits showed that the application of crude powder of *Tephrosia vogelli*, *Tegates minuta* and *Lantana camara* general plant ash at 15-30kg/ha reduced stem borer population by 18-63% and increased the maize grain yield by 30-70% compared to the intricate control plots.

Extracts of chilli pepper in mixtures with garlic (*Allium sativum* L) onion (*Allium cepa*. L) bulbs extract and lemon grass (*Cymbopogon citrates*), leaf extract were found very effective against some leaf creating insect pest of crops (Ubasineke, 2021 and Stoll, 1988). In South East Nigeria, rural farmers mix chilli pepper and wood ash of *Parkia spp*, *Elaeis guineensis*, *Eucalyptus spp* or *Azadirachta indica* to control *Podgorica spp* on okra plants, *Abelmoschus esculentus* L. (Amadi, 1993). The natives of this also use the mixture of Siam weed and *Ocimum gratissium* L. leaf extracts to repel termites, "tailor ants" and "soldier ants" around their houses similarly, a mixture of water from fermented cassava (*Manihot esculenta*) tubers and bitter leaf (*Vernonia amygdalina*) has shown potency against "Tailor ants".

MATERIALS AND METHODS

Study Location and Description

This study evaluated the use of seed extract of *Piper nigrum* (black pepper) in the control of maize stem borer (army worm) in maize plant. The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri, Nigeria. The site lies between latitude 5° and 6°N and longitude 6°N and 7°E having an altitude of 91m above

sea level with the South-East agricultural zone of Nigeria (Metrological unit, Ministry of Lands and Survey, 2006). Previous study showed that the soil is sandy loam with pH value of 5.2. The average temperature, annual rainfall and relative humidity of Owerri, Imo State, Nigeria are 27°C, 2500mm and 75% respectively. (Metrological Unit, Ministry of land and Survey, 2006). The region has a tropical humid climatic with distinct wet and dry season. The wet season is from late March to October with little dry season in July and August.

Source and Preparation of Planting Materials

An improved variety of maize seed (Oba 6) and the black pepper were purchased from a commercial market at Imo State, Nigeria. The black pepper seeds were sundried, grounded, 500g of the grounded black pepper was soaked with 1 litre distilled water for 24hrs, sieved with 0.3 0.2mm mesh to get the crude liquid. The grounded black pepper and its aqueous solution was measured in the following levels, 0.0ml (control), 50ml, 75ml and 100ml.

Methods Adopted

The liquid extracts were applied as sprays with hand sprayers on the maize plants according to levels of concentration.

Experimental Design

The experiment was laid out in Randomized Complete Block Design (RCBD) with four blocks and four treatments replicated four times = (4x4 = 16). The experimental site was manually cleared, packed and the seed beds were prepared before planting on the 1st of September 2020. The size of the experimental plot was 7m x 7m making it an area of 49m². The planting space was 50cm x 50cm each bed measuring 1m x1m and distance between each bed was 0.25m x 0.5m. Weeding was done as need arose.

Data Collection

In this study different data were collected to evaluate the effect of different treatments used.

Number of insects

This was determined by counting the number of insects on 3 plants selected at random before and after application of treatments.

Number of plants infested

In this study the number of plants infested by army worm were counted in 3 different plants randomly selected

Leaf Area (Cm)

Leaf area was measured and calculated using the

formulae $LA = L \times B \times 0.75$

Where L = the leaf length

B = leaf breadth

0.75 Correction factor (Ogoke *et al.*, 2015).

Plant growth

The growths of the plant were determined by measuring its height, number of leaves per plant, number of fruits and stem girth.

Plant height (Cm)

The height of 3 selected plants upon each treatment levels were measured from the base to the tips of the plants.

Number of leaves per plant

This was done by counting the number of leaves per plant on 3 selected plants from each treatment levels.

Stem girth (cm)

The girths of 3 selected plants were measured using veneer calliper. The average was determined and recorded.

Fruit yield (kg/ha)

This was done at the end of the growing season of maize; the weight of the harvested fruits in each plot was weighed, calculated and subjected to statistical analysis.

Data Analysis

Data collected were subjected to statistical analysis using Analysis of Variance technique (ANOVA) SAS/STAT software appropriate to randomized complete block design (RCBD) and mean separation was done using the least significant difference (LSD) at 0.05% level of significance (Onuh and Igwemma, 2001).

RESULTS

Result on soil analyses before application of treatments revealed the presence of P^H in H_2O , % organic carbon, % organic matter, % Nitrogen, % Phosphorus, % Sand, % Clay, % Silt, Exchangeable acidity (Cmol/kg) as shown in (Table 1). Results on soil analyses after harvest revealed the presence of % sand, % silt, % clay, P^H in H_2O , total nitrogen(mg/kg), exchangeable acidity (cmol/kg), CEC (cmol/kg), calcium (mg/kg), magnesium (mg/kg), sodium (mg/kg), potassium (mg/kg), zinc (mg/kg), copper (mg/kg), iron (mg/kg) as shown in (Table 2). Results on proximate analyses of *Piper nigrum* revealed the presence of the

following in percentages, Fat, Protein, Ash, Fibre, Moisture content, CHO, Ca, Mg, Mg/kg or P(ppm), K, Na (Table 3). On the other hand, phytochemical analyses of *Piper nigrum* revealed the presence of % phytate, % phenol, % oxalate, % alkaloid, % flavonoid, % tannin, % HCN (Table 4).

From Figure 1 showed the result of infrared spectroscopy of *Piper nigrum* at different wave numbers at which different organic compounds were absorbed. Besides, (Table 5) revealed the infrared spectroscopy of *Piper nigrum* showing functional groups, bond position (cm^{-1}) and intensity of absorption at which functional groups or organic compounds were absorbed. On plant height, from (Table 6), at 2, 4, 6 and 8WAT showed that at 2, 4, and 8WAT, all the treatments (0.0, 50, 75, 100) mls were not significantly ($P \leq 0.05$) different. At 6WAT, treatments (50, 75, 100) mls were significantly ($P \leq 0.05$) different over 0.0mls. On the stem Girth 2, 4, 6, 8WAT, at 2WAT (50, 75, 100) mls differed significantly ($P \leq 0.05$) over 0.0mls. At 6 and 8 WAT each of the treatments differed significantly ($P \leq 0.05$) over other treatments as shown in (Table 7).

On number of leaves 2, 4, 6, 8 WAT, at 2 WAT, there were no significant ($P \leq 0.05$) differences between 0.0ml over 50mls but (75 and 100) mls differed significantly over 0.0ml. At 4 WAT, (50, 75, 100) mls differed significantly ($P \leq 0.05$) over treatment 0.0ml. At 6 and 8 WAT, there were no significant ($P \leq 0.05$) differences over all the treatments (0.0, 50, 75, 100) mls (Table 8). On leaf area of maize at (2, 4, 6, 8) WAT revealed that at 2 WAT, there was no significant ($P \leq 0.05$) difference between (0.0, 50 and 75) mls, likewise in treatments (75 and 100) mls. But treatment 100ml differed significantly ($P \leq 0.05$) over (0.0 and 50) mls. At 4 WAT, there was no significant ($P \leq 0.05$) difference between treatments (0.0 and 50) mls, likewise between (50, 75, 100) mls. Furthermore, treatments (75 and 100) mls differed significantly ($P \leq 0.05$) over 0.0ml. At 6 WAT, there was no significant ($P \leq 0.05$) difference between treatments (50 and 75) mls, but treatments (100, 75 and 50) mls differed significantly ($P \leq 0.05$) over treatment 0.0ml. At 8 WAT, significant ($P \leq 0.05$) difference existed in all the treatments (0.0, 50, 75, 100) mls (Table 9). On number of insects 2, 4, 6, 8 WAT, at 2 WAT there were no significant ($P \leq 0.05$) differences over all the treatments (0.0, 50, 75, 100) mls.

At 4 WAT 50ml differed significantly ($P \leq 0.05$) over 0.0ml. Also, 0.0ml differed significantly ($P \leq 0.05$) over treatment 75ml. No significant ($P \leq 0.05$) difference existed between treatments (75 and 100) mls. At 6 and 8 WAT, treatments (50, 75, 100) mls differed significantly ($P \leq 0.05$) over treatment 0.0ml (Table 10). On the number of plants infested (2, 4, 6, 8) WAT, at 2 WAT there was significant ($P \leq 0.05$) difference between (0.0 and 50) mls. There were no significant ($P \leq 0.05$) differences between (0.0, 75 and 100) mls.

Furthermore, there were no significant ($P \leq 0.05$) differences between (50, 75, 100) mls.

At (4, 6, 8) WAT treatment 0.0ml differed significantly

Table 1: Soil Analyses Before Treatments Application

P ^H in H ₂ O (1:25)	6.28
% organic carbon	0.698
% organic matter	1.204
% Nitrogen	0.129
Phosphorus (ppmP/g)	6.65
% sand	94.24
% clay	1.76
% silt	4.00
Exchangeable acidity cmol/kg	0.234
Exchangeable Aluminium cmol/kg	Trace
Calcium cmol/kg	2.40
Magnesium cmol/kg	1.80
Sodium cmol/kg	0.034
Potassium cmol/kg	0.021

Table 2: Soil Analyses After Treatments Application

Property	Unit	Value
Sand	%	89.4
Silt	%	3.40
Clay	%	7.20
P ^H	H ₂ O	6.80
Total nitrogen	Mg/kg	2.58
Organic carbon	%	4.82
Phosphorus	Mg/kg	0.62
Exchangeable acidity	cmol/kg	0.05
Cation exchange capacity	cmol/kg	6.36
Calcium	Mg/kg	2.23
Magnesium	Mg/kg	2.87
Sodium	Mg/kg	0.56
Potassium	Mg/kg	0.698
Zinc	Mg/kg	13.45
Copper	Mg/kg	0.59
Iron	Mg/kg	9.40

Table 3: Proximate analyses of Piper nigrum.

Parameters	Value
% Fat	27.30
% protein	11.91
% Ash	6.44
% Fibre	6.55
% Moisture Content	22.72
% CHO	25.08
% Ca	0.232
% Mg	0.285
Mg/kg or P (ppm)	8.992
% K	2.10
% Na	0.98

Table 4: Phytochemical Analyses of Piper nigrum

Parameters	Values
Phytate (%)	0.824
Phenol (%)	1.0423
Oxalate (%)	0.854
Alkaloid (%)	4.61
Flavonoid (%)	11.58
Tannin (%)	0.607
HCN (%)	283.5

($P \leq 0.05$) over treatments (50, 75, 100) mls (Table 11). On weight of cobs at harvest there was no significant ($P \leq 0.05$) difference between (0.0 and 50) mls. Also, there was no significant ($P \leq 0.05$) difference on the weight of

cobs between treatment (50 and 75) mls and also between (75 and 100) mls. Also, treatment 100ml differed significantly ($P \leq 0.05$) over treatments (0.0 and 50) mls. Besides treatment 75ml differed significantly ($P \leq 0.05$) over

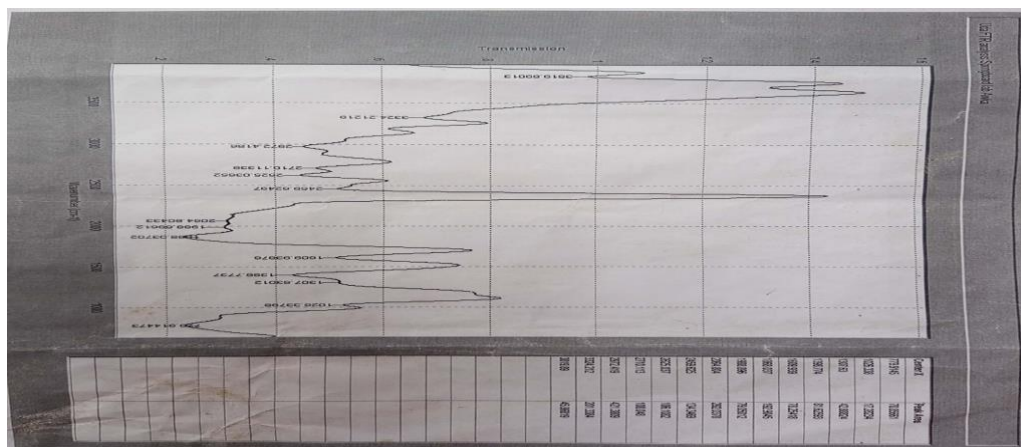


Figure 2: Infrared spectroscopy (FTIR) of *Piper nigrum* at different wave numbers.

Table 5: Infrared spectroscopy of *Piper nigrum* showing the functional groups, the bond position (cm^{-1}) and intensity of absorption.

Functional Group	Bond Positions Cm^{-1}	Intensity of absorption
Alkanes		
C – H	2850 – 2960	Medium to strong
Alkenes		
= C – H	3020 – 3100	Medium
C = H	1650 – 1670	Medium
Alkynes		
$\equiv$ C – H	3300	Strong
– C $\equiv$ C –	2100 – 2260	Medium
Alkyl halides C – C	600 – 800	Strong
Alcohols	3400 – 3640	Strong
Amines: N – H	3310 – 3500	Medium
Carboxylic acids: C = O	2500 – 3100	Strong
Nitrites: C $\equiv$ N	2210 – 2260	Medium

Table 6: Plant height of maize 2, 4, 6, 8 WAP

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	4.38 ^a	17.38 ^a	19.13 ^b	36.25 ^a
50ml	5.00 ^a	16.75 ^a	25.75 ^a	39.38 ^a
75ml	4.63 ^a	17.25 ^a	25.75 ^a	39.75 ^a
100ml	4.75 ^a	16.88 ^a	25.12 ^a	39.75 ^a
LSD	0.832	0.77	3.50	9.79

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table 7: Stem girth of maize 2, 4, 6, 8 WAT

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	4.40 ^b	5.50 ^d	5.80 ^d	5.90 ^d
50ml	5.03 ^a	6.05 ^c	6.10 ^c	6.20 ^c
75ml	5.22 ^a	6.68 ^b	6.80 ^b	6.70 ^b
100ml	5.25 ^a	9.95 ^a	7.00 ^a	7.00 ^a
LSD	0.36	0.19	0.11	0

*Means on the same column having the same superscript letter(s) were not significantly different at ($p \leq 0.05$) using LSD.

0.0ml (Table 12). On weight of biomass after harvest, there were no significant ($P \leq 0.05$) difference between treatments (0.0 and 50) mls and same applies between treatments (50 and 75) mls. But significant ($P \leq 0.05$) difference existed between 100ml over all the treatments (0.0, 50 and 75) mls (Table 13).

DISCUSSION

The pH before and after treatment were 6.28 and 6.80

respectively. This is in line with <http://www.uaex.edu> (2021) that soil P^H for maize ranges from 5.8 to 7.0, % organic carbon before and after treatment were 0.698 and 4.82 respectively. This result showed an increase in organic carbon after treatment. % organic matter before treatment was 1.204 while organic matter was not dictated after treatment. This is in consonance with <http://www.farmer.gov.in> (2021) that maize grows well with good organic content having high water capacity with neutral pH which are considered good for higher

Table 8. Number of leaves 2, 4, 6, 8 WAT.

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	7.63 ^b	8.38 ^b	9.25 ^a	11.00 ^a
50ml	9.00 ^{ab}	9.75 ^a	10.25 ^a	11.50 ^a
75ml	9.25 ^a	9.50 ^a	10.00 ^a	11.50 ^a
100ml	9.63 ^a	9.75 ^a	10.00 ^a	11.25 ^a
LSD	1.60	0.66	1.05	1.80

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table 9: Leaf area of maize 2, 4, 6, 8 WAT.

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	39.60 ^b	110.45 ^b	223.10 ^c	268.75 ^d
50ml	48.10 ^b	161.13 ^{ab}	284.75 ^b	328.00 ^b
75ml	58.18 ^{ab}	163.65 ^a	291.30 ^b	353.33 ^a
100ml	68.55 ^a	210.48 ^a	319.48 ^a	314.48 ^c
LSD	19.20	51.38	16.84	8.60

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table10: Number of insects 2, 4, 6, 8 WAT

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	3.50 ^a	4.25 ^a	3.75 ^a	2.75 ^a
50ml	3.75 ^a	2.00 ^b	1.25 ^b	0.50 ^b
75ml	4.75 ^a	2.75 ^{ab}	1.25 ^b	0.50 ^b
100ml	3.00 ^a	1.50 ^b	0.25 ^b	0.00 ^b
LSD	1.81	1.33	1.39	1.07

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table 11: Number of plants infested 2, 4, 6, 8 WAT.

Treatment	2WAT	4WAT	6WAT	8WAT
0.0ml	5.00 ^a	4.50 ^a	4.00 ^a	3.50 ^a
50ml	3.00 ^b	1.75 ^b	1.00 ^b	0.25 ^b
75ml	4.00 ^{ab}	1.50 ^b	0.50 ^b	0.25 ^b
100ml	3.25 ^{ab}	0.75 ^b	0.25 ^b	0.00 ^b
LSD	1.93	1.62	0.85	1.00

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table 12: Weight of cobs at harvest.

Treatment	Values
0.0ml	1445.5 ^c
50ml	2002.3 ^{bc}
75ml	2578.5 ^{ab}
100ml	3231.3 ^a
LSD	816.14

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

Table 13: Weight of biomass after harvest.

Treatment	Values
0.0ml	388.3 ^c
50ml	623.8 ^{bc}
75ml	895.3 ^b
100ml	1430.0 ^a
LSD	300.89

*Means on the same column having the same superscript letter(s) were not significantly different at ($P \leq 0.05$) using LSD.

productivity. % Nitrogen before and after treatment was 0.129 and 2.58 mg/kg respectively. This implies increase in total Nitrogen after treatment application which means,

the treatment applied may have increased the total Nitrogen of the soil. Phosphorus (ppm/Pg) was 6.65 before treatment and 0.62mg/kg after treatment. This implies that

phosphorus may have been taken up by the maize plants during their growth and fruition. % sand, clay and silt before and after treatments were 94.24, 1.76, 4.00 and 89.4, 7.20, 3.40 respectively. This result showed a decrease in % sand and % silt after treatment and an increase in % clay after treatment.

Exchangeable acidity (cmol/kg) of the soil before and after treatment was 0.234 and 0.5 respectively. Here, there was a reduction in exchangeable acidity because of the treatment applied. Exchangeable Aluminium was in trace amount before treatment while after treatment it was not found which was good for the soil as this may increase soil acidity. Calcium before and after treatment were 2.40 and 2.23 respectively, there were also a reduction in calcium level after treatment. Magnesium, sodium and potassium were 1.80, 0.034 and 0.021 before treatment while after treatment were 2.87, 0.56 and 0.698 respectively, all these elements increased after treatment. Zinc (13.45 mg/kg), copper (0.59mg/kg) and Iron (9.4mg/kg) were revealed after treatment in the soil while before treatment they were absent. Cations exchange capacity was revealed after treatment at 6.36 while it was not present before treatment (Tables 1 and 2). The result of the study of proximate analyses revealed the percentage nutritive constituents of *Piper nigrum* such as fat, protein, ash, fibre, moisture content, CHO, calcium, magnesium, Mg/kg or P(ppm), potassium and sodium (Table 3).

Phytochemical screening also revealed the presence of bioactive compounds in percentages comprising phytate, phenol, oxalate, alkaloid, flavonoid, tannin and HCN (Table 4). The presence of these phyto-nutrients is in consonance with Emeribe *et al.*, (2015) that *Piper nigrum* contains piperine which can be used for pesticides and medicaments. On infrared spectroscopy of *Piper nigrum*, some functional groups like alkanes, alkenes, alkynes, alkyl halides, alcohols, amines, carboxylic acids and nitrites were identified at different wavelengths 2850 – 2960, 3020 – 3100/1650 – 1690, 3300/2100 – 2260, 600 – 800, 3400 – 3640, 3310 – 3500, 2500 – 3100, 2210 – 2260 respectively. These showed that apart from phytochemical compounds, *Piper nigrum* still contained other bioactive compounds as enumerated. This is in line with (Emeribe *et al.*, 2016) which revealed the presence of organic compounds like -OH, -COOH and CO, (Table 5) being absorbed at different wave-lengths.

Based on the data collected, the results of the study revealed that the crude liquid extract of *Piper nigrum* showed significant ($P \leq 0.05$) differences in most of the parameters tested. On plant height there was significant ($P \leq 0.05$) difference at 6 WAT while no significant ($P \leq 0.05$) difference was observed at 2, 4 and 8 WAT (Table 6). This result is in line with the works of Emeribe and Mavis, (2018) that *Vernonia amygdalina* as a botanical in the control of stem borer of maize never affected plant height. On stem girth, significant ($P \leq 0.05$) differences were observed in all treatment levels at 2, 4, 6 and 8 WAT (Table 7). This observation was in tandem with the works of Emeribe and Mavis, (2018) that in their work using bitter

leaf, never affected stem girth except in the control. Also, in the work of Ogah *et al.*, (2011) reported that Neem seed kernel (*Azadirachta indica*) extract significantly ($P \leq 0.05$) reduced stem borer damage, compared to untreated check and also significantly ($P \leq 0.05$) increased number of productive fillers. On number of leaves, significant ($P \leq 0.05$) differences existed among 2, 4 WAT. There were no significant ($P \leq 0.05$) differences among treatments at 6 and 8 WAT. This result tallied with the work of Emeribe and Mavis (2018) that the application of *Vernonia amygdalina* on maize never affected maize plant on the production of number of leaves. It is also in consonance with Stoll, (1988) that extracts of chilli pepper in mixtures with garlic (*Allium sativum*.L) (Ahaotu *et al.*, 2024); onion (*Allium cepa*) bulbs extracts and lemon grass *Cymbopogon citrates* leaf extracts were found very effective among some leaf creating insects' pests of crop (Table 8). On leaf area, various levels of treatments were significant ($P \leq 0.05$) at 2, 4, 6, 8 WAT (Table 9).

This discovery is in line with the works of Stoll, (1988) that botanical products like chilli pepper lemon grass mixed with *Allium sativum* were found to be active against some leaf insect of crop. This is also in line with Ogendo *et al.*, (2013), which reported that results from the field bioassay traits showed that the application of crude powder of *Tephrosia vogelli*, *Tegates minuta* and *lantana camara* at 15-30kg/ha reduced stem borer population by 18-63% and increase the maize grain yield by 30-70% (Ahaotu *et al.*, 2025). On number of insects, no significant ($P \leq 0.05$) difference was observed at 2 WAT, but at 4, 6, 8 WAT, significant ($P \leq 0.05$) differences were observed (Table 10).

The result tallied with the works of Burkill, (1895) that ground dried fruits of *Xylopia aethiopica* (African pepper) mixed with *Capsicum spp* applied to kola, was found to have repellent properties. Jacobson, (1953), opined that bitter leaf (*Vernonia amygdalina*) has showed potency against tailor ants infesting local pear fruits and leaves in eastern Nigeria. On number of plants infested there were significant ($P \leq 0.05$) difference among treatments at 2, 4, 6 and 8 WAT (Table 11). The different levels of treatments were able to control and repel stem borer from attacking the maize plants except in the control plots. This could be drawn from the presence of phytochemicals and other bioactive compounds inherent in *Piper nigrum*. Furthermore, this result was in line with the works of Emeribe and Mavis, (2018) in their work with *Vernonia amygdalina* which controlled stem borer infestation in maize field. It also tallies with the works of (Ahaotu *et al.*, 2025a; Ogendo *et al.*, 2013 and Ahaotu *et al.*, 2025b), that application of crude powder of *Tephrosia vogelli*, *Tegates minuta* and *lantana camara* at 15-30kg/hectare reduce stem borer population by 18-63% and increase the maize grain yield by 30-70%. Amadi, (1993) stated that in South East Nigeria, rural farmers mix chilli pepper and wood ash of *Parkia spp*, *Elaeis guineensis* (Frederic *et al.*, 2024), *Eucalyptus spp* to control *Podagrica spp* on okra plants. On weight of cobs at harvest, significant ($P \leq 0.05$)

differences were observed using different treatment levels, example 100ml over 50ml and 0.0ml (Table 12). This result is in tandem with Ogendo *et al.*, (2013) that the use of botanicals like *Tephrosia vogelli*, *Tegates minuta* and *lantana camara* increased the maize grain yield by 30-70% compared to intricate control plots. The result further corresponded with the findings of Emeribe and Mavis (2018) that application of different levels of *Vernonia amygdalina* improved the yield of maize because the application repelled and also destroyed the stem borers that would have attacked the maize in the field. On weight of biomass after harvest, significant ($P \leq 0.05$) difference existed between 100ml over all other treatments (Table 13). This result confirmed the works of Emeribe and Mavis (2018) that *Vernonia amygdalina* controlled stem borer in maize field. Tadele, (2013) reported that botanical products from *Chrysanthemum cineraria folium* and *Nicotiana spp* were recorded to have higher efficacy against *Busseola Fusca* of maize in the field.

Conclusion

The foregoing discussion above therefore revealed that the application of *Piper nigrum* extracts contained some promising phytochemicals and other bioactive compound, it revealed significant ($P \leq 0.05$) differences on plant height, stem girth, number of leaves, leaf area, number of insects, number of plants infested, weight of cobs and weight of biomass. There was successful improvement on the reduction of attack by the stem borer in the maize field. Based on these trial treatment levels (100 and 75) mls were promising in the control of *Busseola Fusca Fuller*. But 10.0mls showed more potency and repellency at different weeks after treatment. Besides, there is need to carry out other analyses such as High-Pressure Liquid Chromatography (HPLC) Gas Chromatography Mass Spectrometer (GCMS) and Nuclear Molecular Resonance (NMR) to find out the active principles and structure inherent in *Piper nigrum* that controlled the pest (stem borer) using crude extracts of *Piper nigrum*.

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