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Effect of Ginger (*Zingiber officinale Roscoe*) Extracts in the Control of Fruit and Shoot Borer (*Leucinodes orbonalis Guenee*) in Garden Egg (*Solanum melongena L.*) in Owerri, Imo State, Nigeria.

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ABSTRACT

This experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri, Nigeria between July and September 2019. The experiment investigated the effect of ginger (Zingiber officinale. Roscoe) extracts in the control of fruit and shoot borer (Leucinodes orbonalis. Guenee). The experiment was arranged in a Randomised Complete Block Design (RCBD) with four treatments and three replications. In the trial various levels of treatment were used (0ml, 50ml, 100ml, 150ml) and (0g, 50g, 100g, 150g) for crude liquid and powder extract respectively. The proximate analysis revealed the nutritional contents Ash (0.5), Moisture (58.2), Fat (0.9), Protein (2.7) and Fibre (1.2) in percentages. Phytochemical analysis revealed the presence of bioactive constituents Tannin (0.7), Phenol (0.2), Alkaloid (0.6), Flavonoid (2.0) Saponin (2.0), Oxalate (0.9), HCN (0.03) and Phytate (0.1) in percentages. Infrared spectroscopy also revealed various functional groups of organic compounds absorbed at different wave-lengths were Akylhalide (466.37, 540.29, 682.73 and 762.12), Alcohol (1032.76, 3440.00, 3768), Amines (1032.76, 3440.00), Aromatic Secondary and Primary Amine (1256.00 and 1422.42), Alkene (1641.77), Nitrite (2370.00) Alkyne (2370.00) and Alkane and Alkyl group (2933.00). Data were collected on number of fruits infested, fruit yield (kg/ha), number of leaves per plant, plant height, stem girth, leaf area, leaf area index and subjected to analysis of variance at (P≤0.05%) level of significance. The result of the trials revealed that plot that received 150ml of crude liquid extract suppressed number of fruit infested after harvest (1.333) than the crude powder extract of 150g (2.333) and were significantly different (P≤0.05). From the fruit yields (kg/ha), there were no significant differences between the crude and the liquid extracts. In other parameters collected, plant heights were significantly different from crude powder extract but not significantly different for crude liquid extract (P≤0.05). The numbers of leaves per plant were both significantly different in crude powder and liquid extract. In stem girth the crude powder extract showed significant difference but showed no significant different in crude liquid extract (P≤0.05). Zingiber officinale reduced the number of fruit infested with Leucinodes orbonalis on garden egg plants. This action might be due to the anti-nutritional or bioactive components contained in the extracts.

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INTRODUCTION

Vegetables are widely produced in many parts of Sub-Saharan African particularly, in the urban zones as they make up the nutrients in diets (Chen *et al.,2001).* Garden egg (*Solanum spp*) is a vegetable with expanding prominence on earth (Pessarakli and Dris.,2003) and originated from tropical Africa (Norman.,1992). Blay, (1991) reported that among the *Solanum spp* are two African egg plants; *S. aethiopiaim L*. (Ethiopian egg plant-green) and *S. marcocarpon L*.(Gboma egg plant-white). Among members of the *Solanaceae* family, *Solanum melongena* is one of the most important fruit and leafy vegetable of great significance in West, Central and East Africa and other regions of the world (Blay and Oakes, 1996).

Globally, Garden egg-plant (*Solanum melongena)* is one of the ten (10) major vegetables (Lester and Seek, 2004). Garden egg is widely consumed on a daily basis especially in South-East Nigeria and the crop represents a very important source of income for many rural and urban households involved in the cultivation (Danquah, 2000). The crop is largely produced for the local market and also small amount is exported to Europe (Horna and Gruere, 2006). This has helped to reduce poverty and livelihood diversification of poor rural and some urban household who are involved in the cultivation and marketing of garden egg.

Furthermore, garden egg contains 92.5% water,6% sugars,0.3% fat and 1% protein as its nutrient composition. It also contains between 30% and 50% of Potassium, Iron, Copper, Fibre and Manganese, Vitamins, Thiamine (Vitamin B_1,B_6), Niacin, Folate and Manganese (Sabo and Dia.,2009). It is also valuable for canning industries for garden egg paste. It is low in fat, protein and carbohydrates (Chinedu *et al,* 2011). Gisbert *et al,* (2006).found that garden egg substantially reduce aortic cholesterol content, plasma cholesterol level and weight in hyper-

Insect pests retard the growth and development of this crop. Some of these pests includes; Budworms (*Scrobipalpa blasigona),* the egg fruit and shoot borer(*Leucinodes orbanalis),* whiteflies(*Bemisia tabacigennadius),* Epilachna beetles (*Epilachna choysomelina),* Thrips (*Thrips tabaci)* and the Aphids (*Aphis gossypii)* (Sirinivasen, 2009 and MoFA., 2011). Infestation by whiteflies and aphids can cause transmission of viral diseases and reduction of photosynthetic efficiency through the production of sooty mould, but fruit and shoot borer can result in significant decrease in crop output. Patnaik, (2002) reported that L.*orbanalis* destruction to fruit in the field ranges from 47.6% to 85.8% of harvest.

Horna *et al, (2008)*, stated that infestation by some of these pests significantly increase the probability that farmers would apply pesticides. Pesticide are substance intended for controlling, destroying and preventing any pest interfering with the production, processing, storage or marketing of agricultural commodities (Horna and Gruere, 2006). Presently, pesticide application is the primary means used in cutting down these important insects-pests. Non-optimal utilization of these chemical substance leads to a series of issues identified with both loss of effectiveness in the long-run and certain externalities, for examples, contamination and endangerment of the wellbeing of organisms (AVRDC, 2003). Due to the monetary value of acquiring pesticide and its harmful effects on most humans and environment, most farmers abstain from cultivating garden eggs (Gupud and Canapi.,1994). It then means that, there is a need for environmentally friendly pesticides for plants and mammals. Efforts to substitute synthetic pesticides with less costly, topically usable eco-friendly secure, dependable and socio-friendly options including botanicals have been attempted (Rechcigl and Rechcigl, 2000). This can help garden egg producers to reduce their reliance on chemical pesticides.

Plant derived extracts are broad spectrum substances used in controlling insects-pest and are known to be safe to human, animals and environment. The main benefits of plant extracts are that they can easily be developed by farmers hazard free and cheaper, compared to chemical insecticides. Plant extracts have protective substances which make it impossible for insect to feed on the plant. Attempts are therefore being made in many countries to decrease the utilization of dangerous and destructive pesticides synthetic by employing native plant materials and the application of material of biodegradable nature to protect the garden egg plant.

One of such plant that possesses insecticidal properties is ginger, *Zingiber officinale*. It is highly medicinal, and are used to prepare many delicacies in Africa. This work was designed to use ginger in the control of *Leucinodes orbonalis* in egg plants. Specifically ginger extracts was evaluated while phyto-chemical content of ginger and other bioactive compounds were evaluated to ascertain the control of *Leucinodes orbonalis* in egg plants.

Garden egg is a delicate tropical perennial plant often cultivated as a tender or half hardy annual in temperate climates. It grows up at about 40 to 150cm in height with large coarsely lobed leaves that are 10 to 20cm long and 5 to 10cm broad. Botanically, garden egg are classified as a berry and it contains numerous small, soft, edible seed that taste bitter because they contain or are covered in nicotinoid and alkaloids. The fruit turn red or yellow when ripe but still green when immature and the flowers are bisexual flowers which are sometimes white, yellow or purple in color.

The garden egg plant is a warm season crop which prefers relatively high temperature for optimum day temperature of 25-35^{0}C and optimum night temperature of 20-27^{0}C (Norman., 1992; Obeng-Ofori *et al.,* 2007). High soil temperatures are injurious to the root system and can be reduced by mulching. It requires well drained soil with good moisture retaining properties. Soil rich in organic matter and pH ranging from 5.5 to 6.5 is suitable for its production (Rice *et*

Eggplant fruit and shoot borer(EFSB) damage is caused by the larva which feeds inside the fruit and at the same time leave large exist holes when leaving to pupate, reducing the market value of the fruits and rendering them unfit for human consumption(Alam *et al.,*2003). The damage by this borer start at seedling stage and continues till the next harvest of fruits. At the early stage of plant growth, the larva bores into petioles and midribs of large leaves and young shoots, sealing the entry points with their frass, continues to feed within the stem*(*Butani and Jolwani*.,*1984), eventually leading to dropping and withering of the shoot (Alam et al., 2006). At a later stage, the larva bores into the flower buds and fruits through the calyx, leaving no visible sign of infestation(Butani and Jolwani.,1984). This leads to secondary infection by certain bacteria causing further deterioration of the fruits and making them unfit for human consumption(Islam and Karim.,1994).The biology of *Leucinodes orbanalis* has been widely studied on the eggplant in different parts of the world and has been found to be highly varied.

Ginger is in the family *Zingiberaceae* to which belongs turmeric *(Cucuma longa),* Cardmon *(Eletheria cardamonium)* and galangal. It is a herbaceous perennial which grows annual pseudo stems (table stems made of the rolled bases of leaves) at about 1m tall bearing a narrow leaf blades. The inflorescence bears a pale yellow with purple flower and arise directly from the rhizome on separate shoots (Sutarno *et al.,*1999). Ginger is the underground root of the ginger plant with a firm striated texture. It has a brownish skin which could be either thin or thick depending on when it is harvested. The ginger flesh is most times yellow in color and in some cases white or red. It is widely used as a spice or herbal medicine because of its aromatic pungent and hot taste. Ginger can be used fresh in dishes or in its processed forms such as dry ginger rhizomes, powder ginger, pickled ginger, ginger crystals paste. It is also an important export crop valued for its powder, oil and oleoresin (Anandaraj *et al.,* 2001).

The characteristics fragrance and flavour of ginger results from volatile oils that compose of 1-3% of the weight of fresh ginger, primarily consisting of zingerone, shagols and gingerol with [6] gingerols(1-[4^1-hydroxyl-3'-methoxy phenyl)-5-hydroxyl-3-decanone) as the major pungent compound. Zingerone is produced from gingerols during drying, having lower pungently and a spicy sweet aroma (Zhao *et al., 2016*).

MATERIALS AND METHOD

Study Location And Description

This study was aimed at evaluating the effect of ginger (crude liquid and powder extracts) in the control of fruit and shoot borer (*Leucinodes orbanalis)* in Owerri. The experiment was carried out at Imo State University Teaching And Demostration Farm, Imo State University Campus Owerri. The site lies at latitude 5^0 and 6^{0}N and longitude 6^{0}N and 7^{0}E having an altitude of 91m above the sea level within the South-East agricultural zone of Nigeria *(*Metrological Unit, Ministry of Lands and Survey,2006*)*. Previous study showed that soil is Sandy - Loam with pH value of 5.2. The average temperature, annual rainfall and relative humidity of Owerri was 27^{0}C, 2500mm and 75% respectively (Metrological Unit, Ministry of Lands and Survey, 2006). The region has a tropical humid climate with distinct wet and dry seasons. The wet season is from March to October with little dry season from November to February.

Experimental Material

Experimental materials used were garden egg seeds, ginger root extracts (powder and liquid), a piece of land (12 x 10m), hand sprayer, graduated syringe, sensitive weighing balance, spatula sieve (0.4, 0.3, 0.2 mm mersh).

Source and Preparation of Planting Materials

The garden egg seedlings were bought from Imo State Agricultural Development Project, Owerri and the ginger rhizomes were bought from the local relief market Owerri. The ginger rhizomes were fresh and grounded with a grinding machine to extract the liquid component of the ginger to get the liquid extract while the crude powder ginger extract was gotten by oven-drying and crushing to get the powder extracts. The ginger extracts were measured in 0ml, 50ml, 100ml, 150ml, 0g, 50g, 100g and 150g. This represented the treatment levels as;

L_0 = 0ml (control), L_1 = 50ml, L_2 = 100ml, L_3 = 150ml and P_0 = 0g (control), P_1 = 50g, P_2 = 100g, P_3 = 150g

Methods Adopted

The liquid extracts of ginger was applied as sprays with hand sprayer on the garden egg-plant according to the levels of treatment while the powder of ginger was applied as dust with a mouth of a perforated object such as mouth of a watering can.

Experimental Design and Layout

The experiment was laid out in Randomized Complete Block Design (RCBD), with 4 treatment levels replicated 3 times making it 24 experimental units (beds). The experimental site was manually cleared, path and seed bed were prepared before planting. The size of the experimental plot was 12m X 10m making it an area of 120m². The planting space was 90cm by 60cm, each bed was measured 3m X 1m and the distance between each bed was 0.5m by 0.5m.

Experimental Plot Preparation

The experiment was conducted in the rainy season at the Imo State University Teaching and Demonstration Farm. The shrubs grasses and weeds on the experimental plot were removed and the soil was ploughed manually with spade. The field was fenced to prevent human and animal interfering with growth of the plants. The individual plots were labeled according to the treatments.

Experimental Plot/ Layout

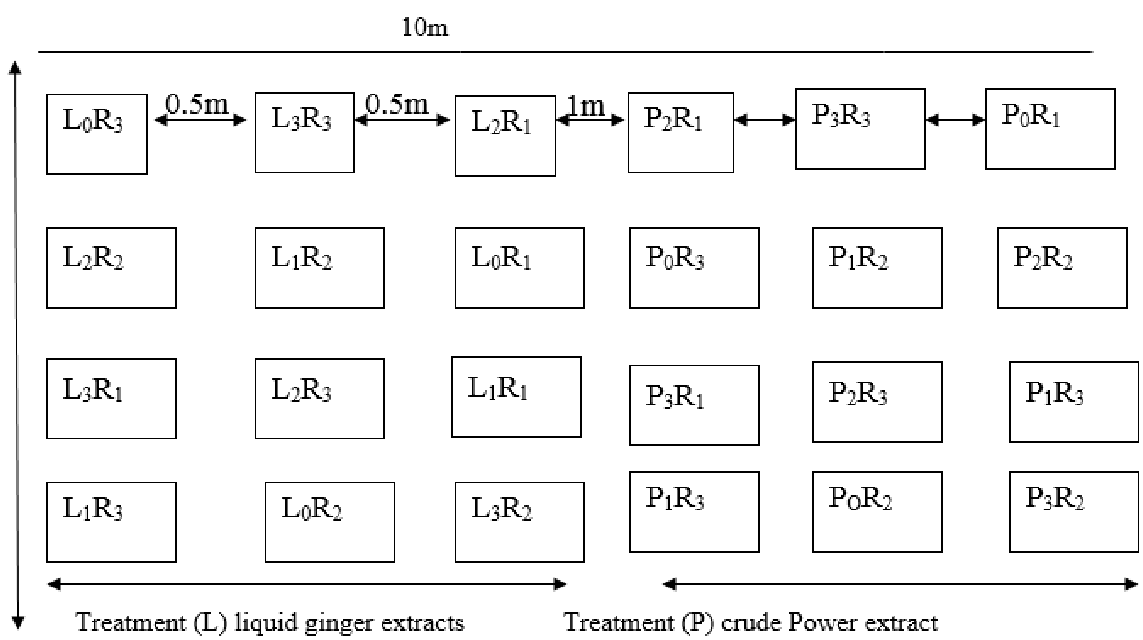

Fig 1. The experimental layout showing the randomization of treatments

Nursing of Seed

Clean healthy seeds of *S. melongena* were obtained from the Imo State Agricultural Development Project, Owerri. The soil for the nursing of the seeds were mixed with well decomposed organic manure before plating seeding emerged at regular intervals starting from the 8th day till the 20th day of planting.

Transplanting

The seedlings were transplanted onto the field after 28 days emergence when the plants had 5 to 7 leaves. Planting distances of 60 by 90 with 8 seedling bed were used in the design. There were a total of 192 plants in the experimental plot. A compound fertilizer N.P.K (15-15-15) was applied at the rate 23g/ plant at 3 weeks after transplant to boost the fertility of the soil. Watering was done immediately after transplanting when there was no rainfall till the root were established.

Data Collection

In this study, different data were collected and evaluated on the effect of treatment used.

Number Of Fruits Infested: In this study, the number of fruits infested with *Leucinodes orbonalis* were counted according to levels of treatment

Leaf Area:- This was measured and calculated using;

LA = L X B X 0.75
where, L = Length of leaf,
B = Leaf breath
0.75 = correction factor (Ogoke *et al*, 2015)

Leaf Area Index:- This is the total area occupied by plant in a plot dividing the spacing each plant occupied. It was measured from each treatment levels on six different plant selected at random.

$$LAI = \frac{Total\ area\ occupied\ byplant}{Plant\ spacing}$$

Plant Growth: The growth of the plant was determined by measuring its height, number of leaves per plant, number of fruits per plant, stem girth, etc.

Plant Height (Cm):- The height of 6 selected plants from the 6 selected plant treatment levels was measured from the base to the top.

Number Of Leaves Per Plant.- This will be done by counting the leaves of 6 selected plants.

Stem Girth (cm):- The girth of the 6 selected plants was measured using a veneer caliper. The average was determined and recorded.

Fruit Yield (kg/ha).- This was done at the end of the growing season of garden egg. The weight of the harvested fruits in each plant was weighed and subjected to statistical analysis. It was calculated using the formula below;

$\frac{Fresh\ weight(kg)}{Land\ area\ (m^2)}\ X\ 10{,}000$ (kg/ha). (*Onuh et al, 2008)*

Data Analysis

Data collected were subjected to statistical analysis using variance appropriate to RCBD and the mean separation was done using LSD at 0.05% level of significance (Onuh and Igwemma, 2001).

RESULT

Results on proximate analysis of ginger revealed the presence of % moisture content, % ash content, % fibre content, % protein and % fat content. On the other hand, phytochemical analysis of ginger revealed the presence of % tannin, % phenol, % alkaloid, % flavonoid, % saponin, % oxalate, % HCN and % phytate see table 1-2. From table 3 below, showed the results of infrared spectroscopy of *Zingiber officinale* at different wavelengths at which different organic compounds were absorbed. These organic compounds are contained in the ginger rhizome.

Results of this experiment showed that the treatment (Crude Liquid and Crude power) extracts of ginger (*Zingiber officinale*) controlled the level of *Leucinodens orbonalis* infestation when the fruits were harvested from the field after treatment applications, other insect pest like variegated grasshoppers, grasshopper caterpillars etc were observed in the field but they were also controlled by the treatments (crude liquid and crude powder) after application. But due to the main aim of this work was majored on *Leucinodes orbonalis* data were not collected on other insect ports therefore, effect of ginger extracts of *Zingiber officinal*e (crude liquid and crude power) in the control of *Leucinodes orbonalis* were represented in table 4a- 10b.

4.1 Table 1: Proximate analysis of Ginger (*Zingiber officinale*) extract in percentages

Different Compounds	Value in Percentages
Ash	0.5
Moisture	58.2
Fat	9.0
Protein	2.7
Fibre	1.2

From table 1 above, the proximate analysis result showed nutritive values of *Zingiber officinal*e. It contained high percentage composition of moisture (58.2) followed by percentage protein content (2.7), percentage fibre content (1.2), percentage fat content, (0.9) and percentage ash content (0.5) which had the lowest composition value.

Table 2: Phytochemical constituents of Ginger (*Zingiber officinale*) extract expressed in percentages).

Phytochemicals	Values in Percentages
Tannin	0.7
Phenol	0.2
Alkaloid	0.6
Flavonoid	2.0
Saponin	2.0
Oxalate	0.9
HCN	0.03
Phytate	0.1

From table 2 above, the phytochemical analysis showed the anti-nutritive bioactive components of *Zingiber officinale.* It contained high content of flavonoid and saponin (2.0), followed by oxalate (0.9), tannin (0.7), alkaloid (0.6), phenol (0.2), phytate (0.1) and then HCN (0.03) which has the lowest composition.

Table 3. Infrared spectroscopy of ginger showing the functional groups, the bond position (cm^{-1}) and the intensity of absorption at which each functional groups of organic compounds were absorbed.

Functional group	Bond position (cm^{-1})	Intensity of absorption
Akylhalide (C-I)	466.37	Strong
Akylhalide -C-Br	540.29	Strong
Akylhalide -C-Cl	682.73/762.12	Strong
Alcohol, Amines R-OH, RNH_2	1032.76	Strong, broad and medium
Aromatic secondary Amine $R-NH_2$	1256.00	Strong
Primary amine R - NH_2	1422.42	Medium
Alkenes C = C	1641.77	Medium to strong
Nitrite, Alkynes C ≡ N, - C= C	2370.00	Medium and strong
Alkane, alkylgroup -C-, -C	2933.00	Medium and strong
Alcohols, amines R – OH, R – NH_2	3440.00	Strong, broad and medium
Alcohols R-OH	3768	Strong and broad

Table 4a. Plant height per plant before and after application of crude powder extract of *Zingiber officinale* at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Po – 0g control	29.617^{a}	47.153^{c}	36.333^{b}
P_1 – 50 gP_3 – 150 g	22.193^{b}	50.857^{bc}	43.000^{b}
P_2 – 100 g	23.827^{ab}	57.857^{a}	75.000^{a}
P_3 – 150 g	21.820^{b}	53.270^{ab}	52.667^{ab}
LSD	6.6628	5.5504	24.152
CV (%)	2.44	2.44	2.44

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

Table 4b: Plant height per plant before and after application of crude liquid extracts of *Z. officinale* at 4WBT, 1WAT, 3WAT

Treatment	4 WBT	1 WAT	3 WAT
L_0 – 0ml control	22.297^{a}	51.420^{a}	73.450^{a}
L_1 – 50 ml	21.590^{a}	52.333^{a}	78.240^{a}
L_2 – 100ml	19.033^{a}	43.507^{a}	73.733^{a}
L_3 – 150ml	18.593^{a}	43.573^{a}	74.947^{a}
LSD	9.3466	11.7900	12.126
CV (%)	2.44	2.44	2.44

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

From table 4a above, there were significant differences (P≤0.05) in plant height before and after treatment of crude powder extracts of *Officinale* at 4WBT, I WAT and 3WAT.

At 4WBT, Po gave the highest mean (29.617) and was significantly different from other treatments (P_1, P_2, P_3) and the lowest mean (21.820) recorded from P_3 was significantly difference from other treatments (P_o and P_2) but was not significantly different from treatment P_2. At I WAT, treatment P_2 (57.857) recorded the highest mean and was significantly different (P≤0.05) from other treatments. The lowest treatment mean was recorded from P_0 (47.153) and was significantly different from their treatment (P≤0.05). The means were all significantly different from each other (P≤0.05). At 3WAT, treatment P_O, P_1 were not significantly different (P≤0.05) from each other but were significantly different from other treatments with a mean recording of 36.33 and 43.00 respectively.

From table 4b above, there were no significant difference ($P \leq 0.05$) in plant height of *Officinale* at 4WBT, 1 WAT and 3WAT. At 4WBT, there no significant difference between the treatment but L_0 (22.297) gave the highest mean than other treatment means. So also at 1WAT, there were no significant difference between the treatment means but the highest mean was recorded from L_1(52.33) more than any other treatment means. Similarly at 3WAT, all the treatment means are the same. They are not significantly different from each other.

Hence, only the crude powder extracts before and after application showed significant difference ($P \leq 0.05$) in the plant height.

Table 5a. Number of leaves per plant before and after application of crude powder extract of *Z. officinale* at 4WBT, 1 WAT and 3 WAT

Treatments	4WBT	IWAT	3WAT
Po – 0g control	23.333^{b}	28.667^{b}	36.333^{b}
P_1 – 50 g	24.667^{b}	30.667^{b}	43.000^{b}
P_2 – 100 g	40.667^{a}	54.667^{a}	75.000^{a}
P_3 – 150 g	26.333^{b}	36.333^{b}	52.667^{ab}
LSD	10.948	18.027	24.152
CV (%)	2.45	2.45	2.45

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

Table 5b: Number of leaves per for plant before and after application of crude liquid extract of *Z. officinale* at 4WBT, 1 WAT and 3 WAT

Treatments	4WBT	1 WAT	2 WAT
L_0 – 0ml Control	23.333^{a}	34.333^{a}	50.333^{b}
L_1 – 50 ml	27.000^{a}	45.333^{a}	68.667^{a}
L_2 – 100 ml	22.333^{a}	40.333^{a}	58.333^{ab}
L_3 – 150ml	24.333^{a}	39.333^{a}	56.333^{a}
LSD	7.1106	11.777	15.994
CV (100%)	2.45	2.45	2.45

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

From table 5a, there were significant differences ($P \leq 0.05$) in number of leaves before and after treatment of crude powder extract of *Z. officinale* at 4WBT, 1 WAT and 3 WAT.

At 4WBT, there were no significance difference between treatments P_0, P_1, P_3 (23.33, 24.67 and 26.33) at $P \leq 0.05$. But were significantly different from treatment P_0 (40.67), At 1 WAT, there were also no significance difference between treatment P_0, P_1, and P_3 (28.67, 30.67 and 36.33) at $P \leq 0.05$. Treatment P_2 (54.67) recorded the highest mean and was significantly different from other treatment means (P60.05)

At 3 WAT, treatment P_2 recorded the highest mean and was significantly different from other treatment (P_1, P_2 and P_3) (36.33, 43.00 and 52.67 respectively).

From table 5b, there were no significant difference in the treatment means but there were significant difference after treatment ($P \leq 0.05$) of crude liquid extract of *Z. officinal*e at 4WBT, 1WAT and 3WAT.

At 3WAT, treatment L_1 significantly different from other treatment means gave the highest mean (68.67) and was significantly different from L_2, L_3, L_0 respectively. Treatment L_2 and L_3 were not significantly different from each other but were significantly different from other treatments L_0 and L_1 ($P \leq 0.05$).

Hence, the were significant difference in the number of leaves for crude liquid extract and powder before and after treatment at ($P \leq 0.05$).

Table 6a. Stem girth per plant before and after application of crude powder extracts of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Po – 0g control	2.9767^{a}	3.1467^{b}	3.5567^{b}
P_1 – 50 g	2.9967^{a}	3.5467^{ab}	3.9933^{ab}
P_2 – 100 g	2.9933^{a}	3.8200^{a}	4.1100^{a}
P_3 – 150 g	2.6867^{a}	3.6333^{ab}	4.0333^{a}
LSD	0.08561	2.4469	0.4741
CV (%)	2.45	2.45	2.45

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

Table 6b. Stem girth per plant before and after application of crude liquid extracts of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Lo – 0ml control	2.7400[a]	3.5533[a]	4.0700[a]
L_1 – 50 ml	2.8433[a]	3.5700[a]	4.1200[a]
L_2 – 100 ml	2.5033[a]	3.2567[a]	3.9267[a]
L_3 – 150 ml	2.6700[a]	3.3500[a]	4.1533[a]
LSD	0.5877	0.4819	0.3791
CV (%)	2.45	2.45	2.45

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

From table 6a, above there were no significant difference ($P \leq 0.05$) in stem girth before treatment but were significant difference after treatment of crude powder extract of *Z. officinale* at 4WBT, IWAT and 3WAT. At 4 WBT, there was no significant difference between the means ($P \leq 0.05$). But P_1(2.997) recorded more than other treatment means. At 1WAT P_2 recorded the highest means (3.82) and was significantly different more than other treatments but P_1 and P_3 were not significantly, different at ($P \leq 0.05$). At 3WAT, treatment P_0 was significantly different from P_1, P_2, P_3 but treatment P_2 recorded the highest mean more other treatment mean (4.11).

From table 6b above, there were no significant differences ($P \leq 0.05$) in stem girth before and after treatment of crude liquid extracts of *Z. officinale* at 4WBT, 1WAT and 3 WAT. At 4WBT, there were no significant difference ($P \leq 0.05$) but L_1 (2.84) recorded the highest mean more than other treatments (L_0, L_2, L_3). At 1WAT, there were no significant different between treatments but L_1 (3.57) recorded the highest mean among the treatments at 3WAT, L_3 (4.15) was the highest mean more than other mean. There were significant difference in the stem girth for crude powder extract but there were no significant difference from crude liquid extract before and after treatment ($P \leq 0.05$).

Table 7a. Leaf area per plant before and after application of crude powder extracts of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Po – 0g control	122.93[a]	134.07[a]	155.03[a]
P_1 – 50 g	114.46[a]	152.30[a]	185.80[a]
P_2 – 100 g	101.28[a]	133.32[a]	177.50[a]
P_3 – 150 g	121.09[a]	163.00[a]	189.19[a]
LSD	80.705	43.194	53.365
CV (%)	121.09	2.45	2.45

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

Table 7b. Leaf area per plant before and after application of crude liquid extract of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
L_0- 0ml control	105.91[a]	140.73[a]	187.78[a]
L_1- 50ml	115.05[a]	144.43[a]	187.01[a]
L_2 – 100 ml	85.61[a]	124.57[a]	167.13[a]
L_3 – 150 ml	94.69[a]	138.79[a]	177.69[a]
LSD	72.862	84.901	95.701
CV (%)	2.45	2.45	2.45

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

From table 7a above, there were no significant differences ($P \leq 0.05$) in the leaf area before and after treatment of crude powder extract of *Z. officinale* ***at*** 4WBT, 1WAT and 3 WAT.

At 4WBT, the highest mean (122.93) in leaf area was recorded from treatment P_0, showed no significance ($P \leq 0.05$) with treatment P_2 which has the lowest mean (101.28) and in other treatments (P_1, P_3). At 1 WAT, the highest mean in leaf area (163.00) was recorded from treatment P_3 was not significantly different ($P \leq 0.05$) in other treatment (P_O , P_1) and P_2 which recorded the lowest mean (133.32). At 3WAT, the highest mean in leaf area (139.19) show no significant difference ($P \leq 0.05$) from P_3 to untreated plot P_0 which has the lowest mean (155.03) than other treatments (P_1, P_2).

From table 7b above, there were no significant differences ($P \leq 0.05$) in the leaf area before and after treatment of crude liquid extract of *Z. officinale* at 4WBT, 1WAT and 3 WAT. Hence the treatments (crude liquid and crude power) of *Z. officinale* had no significant effect ($P \leq 0.05$) on leaf area before and after application.

TABLE 8a. Leaf area index per plant before and after application of crude powder extracts of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Po –0g control	0.1677[a]	0.1597[a]	16.3300[a]
P_1 – 50 g	0.1850[a]	0.1683[a]	0.1663[a]
P_2 – 100 g	0.2690[a]	0.2950[a]	0.2997[a]
P_3 – 150 g	0.1860[a]	0.2037[a]	0.2057[a]
LSD	0.1763	0.1582	0.1657
CV (%)	2.45	2.45	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

TABLE 8b. Leaf area index per plant before and after application of crude liquid extracts of *Zingiber officinal*e at 4WBT, IWAT, 3WAT

Treatments	4WBT	IWAT	3WAT
Lo – 0ml control	0.2343[a]	0.2297[a]	0.2320[a]
L_1 – 50 ml	0.2330[a]	0.2520[a]	0.2523[a]
L_2 – 100 ml	0.2587[a]	0.3273[a]	0.3293[a]
L_3 – 150 ml	0.2980[a]	0.3067[a]	0.2057[a]
LSD	0.1753	0.1698	0.1735
CV (%)	2.45	2.45	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

From table 8a above, there were no significant differences (P≤0.05) in the leaf area index before and after treatment of crude powder extract of *Z. officinale* at 4WBT, 1 WAT and 3WAT.

At 4WBT, the highest mean (0.269) in leaf area index was recorded from treatment P_2 showed no significance (P≤0.05) in treatment plot P_0 which has the lowest mean (0.168) and in other treatments (P_1, P_2). At 1 WAT, P_2 (0.295) also recorded the highest mean more than the untreated plot P_O (0.159) and other treatments (P_1, P_3). Similarly, at 3WAT there were no significant difference between the treatments but P_2 recorded the highest mean (0.299).

From table 8b above, there were no significant difference (P≤0.05) in the leaf area index before and after treatment of crude liquid extract of *Z.officinale* at 4WBT, 1 WAT and 3 WAT.

Hence, the treatments (crude liquid and crude powder) of *Z.offinale* had no significant effect (P≤0.05) on leaf area index before and after treatment.

Table 9a. Fruit Yield (kg/ha) For Power Extracts of *Z. officinale*

Treatments	Mean
Po – 0g control	98.19[a]
P_1 – 50 g	118.34[a]
P_2 – 100 g	16.39[a]
P_3 – 150 g	128.92[a]
LSD	76.534
CV (%)	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

Table 9b. Fruit Yield (kg/ha) for Liquid Extract of *Z. officinale*

Treatments	Mean
Lo – 0ml control	57.45[a]
L_1 – 50 ml	80.81[a]
L_2 – 100 ml	85.94[a]
L_3 – 150 ml	62.06[a]
LSD	49.329
CV (%)	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

From table 9a above, there were no significant difference (P≤0.05) in fruit yield (kg/ha) for crude powder extract of *Z. officinale* after treatment but mean of P_3 recorded the highest yield (128.92) and the untreated plot recorded the least yield (kg/ha) (98.19)

On table 9b, above there were no significant difference (P≤0.05) between the treatment (L_0, L_1, L_2, L_3) in fruit weight crude liquid extract of *Z. officinale* treatment L_2 (85.94) gave the highest yield and the untreated plot recorded the lowest yield (57.45) (kg/ha).

Hence in both crude powder extracts and crude liquid extracts of ginger were not significantly different (P≤0.05).

Table 10a. Number of Fruits Infested by *Leucinodes orbonalis* for Powder Extracts of Ginger

Treatments	Mean
Po – 0g control	9.333[a]
P_1 – 50 g	5.667[b]
P_2 – 100 g	6.000[a]
P_3 – 150 g	2.333[a]
LSD	3.1939
CV (%)	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

TABLE 10b. Number of fruits infested by *Leuicinodes orbonalis* for liquid extracts of ginger

Treatments	Mean
L_0 – 0ml control	5.333^{a}
L_1 – 50ml	3.000^{a}
L_2 – 100ml	1.667^{ab}
L_3 – 150ml	1.333^{b}
LSD	2.6846
CV (%)	2.45

* Means on the same column having superscript letter (s) were not significantly different at (P≤ 0.05) Using LSD

From table 10a above, there were significant difference (P≤0.05) in the number of fruit infested by *Leucinodes Orbonalis* by crude powder extract after treatment. Treatment P_3 was significantly different (P≤0.05) from other treatment (P_0, P_1, P_2) and was recorded the lowest mean in the number of fruits infested but the untreated plot (P_0) recorded the highest mean of infested fruits (9.333). Treatments P_1, P_2 were not significantly different from each other (5.67 and 6.00) but were significant different from other treatment (P_0 ,P_1).

From 10b above, there were significant differences in the number of fruits infested by *Leucinodes orbonalis* by crude liquid extract after treatment. Treatment L_0 recorded highest mean of infested fruit (5.33) and was significantly different from L_3 which recorded the lowest mean of infested fruit (1.33) and other treatments P_1, P_2 were significant from each other (3.00, 1.67).

Hence, there were significant differences (P≤0.05) between the crude powders extract and crude liquid extract in the control of *Leucinodes orbonalin.*

DISCUSSION

Results of the study on proximate analysis revealed the percentage nutritive constituents of *Z. officinale* were ash content 0.5%, moisture content 58.2%, fat content 0.9%and fibre content1.2%. Proximate analysis revealed the presence of bioactive compounds comprising tannin 0.7%, alkaloid 0.6%, flavonoid 2.0%, saponin 2.0%, oxalate0.9%, HCN 0.03% and phytate 0.1%. Also infrared spectroscopy revealed different organic compounds and their absorption. These organic compounds are alkyl halide, alcohol, amine, alkenes, alkyne, nitrate and alkane and their wavelengths were (466.37, 540.29, 682.73/ 762.12), (1032.76, 3440.00), (1032.76, 3440.00, 1256.00, 1422.42), (1641.77), 2370.00) ,(2933.00) respectively. The revelation of the nutritional contents ,phytochemicals and infrared spectroscopy were in line with the works of Emeribe and Mavis., (2018) that natural products contain organic ,nutritive constituents , phytochemicals and bioactive compounds.

Based on the data collected, the results of the study revealed that the extracts (crude liquid and powder) of *Zingiber officinale.* Roscoe (ginger) showed significant difference (P≤0.05) in most of the parameters mostly in crude powder extract. On the number of fruits infested, table (10_a and 10_b), crude liquid and crude powder extracts of *Z. officinale* recorded the highest and lowest *L orbonalis* infestation on garden egg fruit in P_0, P_3 and L_o, L_3 (9.33, 2.33 and 5.33, 1.33 respectively). This may indicate that ginger extract of P (150g) and L_3 (150ml) is effective in reducing the fruit infestation due to the chemical composition of ginger. In addition, the P_3 and L_3 (150g, 150ml) produced stronger repelling scent from the ginger extract decreased the feeding activity and therefore, the damaged caused by the *L. orbonalis* on the garden egg fruit was low. This result similarly, agrees with the outcome of Mavis, (2018) that *Vernonia amygdalina. Del* (bitter leaf) extracts reduced the presence of insect pest on maize plant. Also Amuji *et al* ., (2012) reported that populations of *Podagrica uniform* and *Nisotra sjostedti* on plots treated with ginger extracts were appreciably reduced compared with the untreated .

On the height of plant, there was significant difference at 4WBT and also there were significant difference at WAT and 3WAT for crude powder extract but no significant difference at 4WBT, 1WAT and 3WAT for crude liquid extract. This is in line with the work done by Esanem ,(2015) that neem extracts protects the plant from insect attack that will suppress the growth of the plant. From the number of leaves per plant for crude powder extract, there were significant different before and after treatment i.e. 4WBT, 1WAT and 3WAT but for crude liquid extract there were no significant difference at 4WBT and 1WAT but there was significant difference at 3WAT. The stem girth of the crude powder extract, there was no significant difference in 4WAT but there were significant difference at 1WAT and 3WAT and from the crude liquid extract, there were no significant difference at 4WBT, 1WAT and 3WAT. The leaf areas of crude powder and liquid extracts has no significant difference before and after treatment. Similarly, the leaf area index (LAI) for crude liquid and power extracts has no significant different at 4WBT, 1WAT, and 3WAT.The results from stem girth , no of leaves, leaf area and LAI were in alignment with the work(s) done by Marvis,(2018) which stated that there were no effect on these growth parameters before and after application

Also from the fruit yield (kg/ha) from crude powder and liquid extracts, there were no significant difference before and after treatment application. These results were with a report by Horna and Gruere, (2006), who were that a number of insect particularly *L. orbonalis* attack the garden egg plant in the field and the damage caused reduces yield as well as affect the quality and quality of the produce. Sosan and Akingbohungbe, (2009), also indicated that the egg fruit and shoot borer (*Leucinodes orbonalis)* is one of the destructive insect part on garden egg plant in Africa and some parts of Asia where it reduces yield much as 70%.

CONCLUSION

The application of *Zingiber officinale* extracts reduced the level of fruit and short borer (*Leucinodes orbonalis Gueene*) infestation in the field but did not add to other growth parameters such as no of leaves, leaf areas and LAI. This experiment should further be tried using higher concentration of the extracts to obtain higher repellency and mortality rate of crude liquid and powder extracts. Based on this trial, 50mls, and 150g respectively be used by farmers to control *L. orbonalis.* The powder extract, showed more potency in controlling the *L. orbonalis* than the crude liquid extract. There is need to carry out analysis such as High Pressure Liquid Chromatography (HPLC), Gas Chromatography Mass Spectrometer (GCMS) and Nuclear Molecular Resonance (NMR) to find out the active ingredient and structure that controlled the pest using ginger crude extracts.

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