Field Screening of Five Varieties of Eggplant, *Solanum* spp. for Susceptibility to Eggplant Shoot and Fruit Borer, *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae) Infestation in Okigwe, Southeastern Nigeria

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Abstract
Five varieties of eggplant; Solanum aethiopicum, Solanum ex-lantan, Solanum gilo, Solanum macrocarpon and Solanum melogena were screened for their susceptibility to Eggplant Shoot and Fruit Borer (EFSB), Leucinodes orbonalis Guenee infestation between May – September 2017. The treatments were arranged in Randomized Complete Block Design (RCBD) with four replications. Each experimental unit measured 9 m^2 with 16 plant stands respectively. Data on adult moth population, larval infestation, length of larval feeding tunnel, number of holes on fruits and shoots were collected from four tagged plants in the middle rows. Results of Analysis of Variance (ANOVA) revealed that the least population of adult moths of L. orbonalis, 0.79 was recorded in May, however, there was a steady increase in adult moths as the months progressed, which peaked in September with 16.15 ESFB adult moths population. This represents 41.98% of the total larval infestation across the months. S. gilo had the highest percentage larval infestation of 32.10%, while the least larval infestation, 9.59% was recorded with S. melogena. Length of feeding tunnel ranged from 0.60±0.01 – 2.76±0.20 cm, with S. gilo recording the longest feeding tunnel of 2.76 cm. Number of holes on fruits and shoots were highest with S. gilo, 2.56±0.05 holes per fruit per plant and 2.75±0.20 holes per shoot per plant. Significant differences ($P<0.05$) existed amongst the varieties screened on percentage infested and uninfested fruits with S. gilo recording significantly ($P<0.05$) higher percentage infested fruits of 70.68% and least, 29.32% of uninfested fruits. Varieties screened did not show significant differences ($P>0.05$) on damaged yield but exhibited significant differences ($P<0.05$) on marketable yield; S. melogena recording the highest (1.32±1.30 tha^{-1}) and S. gilo, the least with 0.53±1.50 tha^{-1}. The screening revealed that the varieties exhibited varying levels of susceptibility to ESFB infestation with S. gilo the most susceptible, followed by S. aethiopicum, S. ex-lantan, S. macrocarpon and S. melogena in that order, respectively.
Keywords: *Eggplant, ESFB, Leucinodes orbonalis, infestation, screening*

INTRODUCTION

Eggplants contain flavonoids, such as anthocyanins. Anthocyanins are water-soluble pigments that have many health benefits (Megan, 2017). The skin of the eggplant is rich in antioxidants, fiber, potassium, and magnesium. The phenolic content of eggplant makes it such a potent free radical scavenger that this vegetable is ranked among the top 10 vegetables in terms of oxygen radical absorbance capacity. The fiber, potassium, vitamin C, vitamin B6, and phytonutrient content in eggplants all support heart health. In addition, eating foods containing certain flavonoids, including anthocyanins, may be associated with a lower risk of mortality from heart disease, according to a Hooper *et al.* (2008).

In one study, those who consumed more than three servings of fruits and vegetables per week containing anthocyanins had a 34-percent lower risk of heart disease than those who consumed less (Jennings *et al.,*

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THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

2012). In another, an increased intake of anthocyanins was associated with significantly lower blood pressure (Cassidy *et al.,* 2013). Research has shown that when rabbits with high cholesterol consumed eggplant juice, this led to significantly lower weight and blood cholesterol levels (Tempest, 2012). Chlorogenic acid contained in eggplants has been shown to decrease low-density lipid (LDL) levels. It also acts as an antimicrobial, antiviral, and anticarcinogenic agent (Jorge *et al.,* 2008).

Polyphenols in eggplant have been shown to have anti-cancer effects (Stommel and Whitaker, 2003). Anthocyanins and chlorogenic acid protect cells from damage caused by free radicals and, in turn, prevent tumor growth and the invasion and spread of cancer cells (Wang and Stoner, 2008). The anticancer action of anthocyanins appears to include preventing new blood vessels from forming in the tumor, reducing inflammation, and blocking the enzymes that help cancer cells to spread.

Findings from animal studies suggest that nasunin, an anthocyanin in the eggplant skin, is a powerful antioxidant that protects brain cell membranes from free radical damage (Nado *et al.,* 2000). It also assists in the transport of nutrients into the cell and moving waste out. Research has also shown that anthocyanins help prevent neuro inflammation and facilitate blood flow to the brain. This could help improve memory and prevent age-related mental disorders. Dietary fibers are commonly recognized as important factors in weight management and loss, because they act as "bulking agents" in the digestive system. These compounds increase satiety and reduce appetite. They help reduce calorie intake by making a person feel fuller for longer. Eggplant is already low in calories, so it can contribute to a healthful, low-calorie diet. Research has suggested that the antioxidants in eggplant may help protect the liver from certain toxins.

Leucinodes orbonalis, the eggplant shoot and fruit borer or brinjal fruit and shoot borer, is a moth species in the genus *Leucinodes*. It is found throughout the tropics in Asia and Africa and is a minor pest in the Americas. The species was first described by Achille Guenée in 1854 (https://en.wikipedia.org/wiki/Leucinodes_orbonalis). Larvae bore inside eggplant fruits and feed until they pupate. Fruit feeding by *L. orbonalis* larvae is the major cause of damage, leaving frass as it tunnels through the fruit, thereby rendering the fruits unfit for consumption (Emeasor and Uwalaka, 2018). The larvae also bore into tender shoots causing wilting and dieback of the branch terminals. This reduces the fruit-bearing capacity of the plant (Emeasor and Uwalaka, 2018).

This insect pest has been categorized in 2014 as a major pest of eggplant in Nigeria having been found to be widely distributed and infesting the plants throughout the country (CIE, 1976; EPPO, 2014). Its infestation on eggplants has been reported to have resulted in over 75 – 90 % reduction in fruit yield of eggplants in Nigeria (Onekutu, 2011). These reports informed our resolve to carry out this study, to screen five varieties of eggplant in this region for their susceptibility to Eggplant shoot and Fruit Borer, *Leucinodes orbonalis* Guen. The outcome of this study would give an insight on the most susceptible varieties; hence the control and management of the pest in future studies.

MATERIALS AND METHODS

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THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

The study was conducted in 2017 cropping season at the Vegetable Research Farm of National Horticultural Research Institute (NIHORT) Mbato Outstation, Okigwe, Southeastern Nigeria. The institute lies on latitude 05° 33′ N and longitude 07° 23′ E with an altitude of 130 m above sea level.

Seeds of *Solanum aethiopicum, Solanum ex-lantan, Solanum gilo, Solanum macrocarpon* and *Solanum melogena* were raised in the nursery following standard agronomic practices and transplanted to the experimental plots which measured 9 m^2 each. The five varieties of eggplant were used as the experimental treatments and were laid out in Randomized Complete Block Design (RCBD) with four replications.

Assessment of susceptibility of *Solanum* varieties to the Eggplant Shoot and Fruit Borer was done on four selected tagged plants from the middle row of the plots on a fortnight basis. Data was also collected on number of holes on shoot and fruit by visual observation and counting, population of *L. orbonalis* larvae by cutting open sampled fruits to check for their presence, length of feeding tunnel by using measuring tape, fruit length and fruit diameter was determined with vernier caliper, number of fruits by counting, damage and marketable yields were determined using a weighing balance. Percent infested and uninfested fruits were also determined. Analysis of variance was conducted on all means of the parameters assessed and significant means were compared using Least Significant Difference (LSD) at significance level of 5%.

RESULTS AND DISCUSSION

Field observations showed that *L. orbonalis* infested all the eggplant varieties screened throughout the period of this study (Tables 1, 2 and 3). Farman *et al.* (2016) and Purohit and Khatri, (1973) had reported that all stages of eggplant are attacked by *L. orbonalis* as the insect is regarded as one of its major insect pests.

Suresh *et al.* (1996) and Singh *et al.* (2000) in their separate studies on *L. orbonalis* destructive activities on eggplants reported that the insect pest is the most destructive insect pest of eggplant at various physiological growth of the plant. EPPO (2015) had declared *L. orbonalis* infestation as having attained the category of a severe pest for eggplants.

During the early stages of vegetative growth of the eggplants, there was a minimal population of *L. orbonalis* adult moth especially in the months of May and June, but in later months of July, August and September, from the data collected and analyzed, the results showed that there was a consistent build up in the number of adult moth of *L. orbonalis* found on the plants (Tables 1 and 2). This finding is in line with the reports of Farman *et al.* (2016) who recorded an initial 18.68% infestation of *L. orbonalis* in the month of May and observed a higher infestation rate of up to 75.50% from the month of August in India. Obodji *et al.* (2015) also reported that *L. orbonalis* infestations increased progressively from early growth stage to fruiting stage in the South of Ivory Coast. Monitoring of the population trend and seasonal abundance of *L. orbonalis* in this present study revealed that the peak infestation of 41.98% occurred in the month of September (Table 2). This finding is also in agreement with the account of Farman *et al.* (2016) who recorded percent infestation of 42.64% during the last picking in September.

In terms of varietal infestation, *S. gilo* was the most infested eggplant variety with 32.10% infestation level (Table 3). This finding corroborates the earlier findings of Uwalaka *et al.* (2012) and Emeasor *et al.* (2016) whose reports found that *S. gilo* as the most attacked eggplant variety by *L. orbonalis* in Southeastern Nigeria as the variety is also considered to be indigenous to the region and locally known as Ngwa large (Emeasor *et al.,* 2016).

There was more damage in terms of numbers of hole per shoots and fruits on *S. gilo* than in other varieties of eggplant screened (Table 5). The eggplant variety, *S. gilo* had significantly (P<0.05) more holes on shoots and fruits compared to other four varieties, these findings may however explain for the longest feeding tunnel of 2.76±0.20 cm recorded in *S. gilo* (Table 5). This result differed significantly (P<0.05) when compared with mean length of feeding tunnel obtained from *S. melogena* (0.60±0.01 cm), *S. aethiopicum* (1.53±0.09 cm), *S. ex-lantan* (1.38±1.00 cm) and *S. macrocarpon* (1.32±0.05 cm) (Table 5). Sudarshan and Pijush (2011) also reported similar results. One interesting observation in this study is that all the eggplant varieties screened showed no absolute immunity or resistance to the infestation by *L. orbonalis*, although they exhibited varying levels of susceptibility to the insect pest with *S. gilo* and *S. aethiopicum* having very high susceptibility. Emeasor and Uwalaka (2018) reported that eggplants are susceptible to *L. orbonalis* infestation. Their report validates the findings of this present study.

This study on the screening of five varieties of eggplant for their susceptibility to *L. orbonalis* showed that percent fruit infested and uninfested fruits varied according to varieties (Table 6). The highest percent infested fruits of 70.68% were obtained in plots planted *S. gilo,* followed by 67.88% infested fruits recorded for *S. aethiopicum* while the lowest percent infested fruits of 50.44% was achieved by *S. melogena* (Table 6). Results of analysis of variance showed that *L. orbonalis* significantly (P<0.05) infested the fruits of eggplant varieties screened. Similar results were reported by Obodji *et al.* (2015) who recorded 56.67% and 77.61% fruit infestation at 159 and 166 days after transplanting (DAT) with Djamba F_1 eggplant variety.

There was no varietal differences (P>0.05) on percent uninfested fruits (Table 6). *L. orbonalis* larval infestation affected and reduced significantly the production of uninfested fruits irrespective of variety. All the varieties screened recorded below 50% of wholesome (uninfested) fruits (Table 6). This reduction in percent uninfested fruits recorded by the eggplant varieties could be justified by the fact that the plants fruits were available for *L. orbonalis* larvae to feed on and provided a favourable abode for them to thrive which may also account for their high infestation level since no insecticidal treatment was applied for their control. Similar observations were made by Oboji *et al.* (2015) and Shukla and Khatri (2010) who also mentioned that the highest infestations were recorded at the beginning of fruiting when uncontrolled. Haseeb *et al.* (2009) and Saeed and Khan, (1997) also reported fruit losses of between 20 – 60%.

Analysis of variance revealed that there was no varietal differences on damage yield as influenced by *L. orbonalis* (Table 6). Generally, all the five varieties recorded low marketable yield largely due to the devastating activities of *L. orbonalis* larvae. Results also revealed that *L. orbonalis* significantly (P<0.05) affected the marketable yield of the eggplants. The lowest marketable yield of 0.53±1.50 t/ha

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18th – 22nd November, 2018

was recorded on *S. gilo* and *S. aethiopicum* each respectively (Table 6).

Observations of some morphological characters of the eggplant varieties such as fruit diameter, fruit length and shoot girth were also assayed. Significant differences (P<0.05) existed between the varieties on these morphological parameters assessed. *S. melogena* has distinctive longer fruit length of up to 19.76±0.68 cm and the highest mean value of 2.48±0.37 cm for shoot girth. *S. macrocarpon* had the highest value (5.04±0.40 cm) for fruit diameter, followed by *S. gilo* with 4.86±0.58 cm (Table 4).

On number of fruits, *S. aethiopicum* produced the highest with 128.50±1.20 fruits per plant per plot. The study revealed that *S. aethiopicum* fruits profusely, producing smaller fruits. *S. gilo* ranked second in terms of fruit production with 107.10±0.88 fruits per plant per plot (Table 4).

CONCLUSION

L. orbonalis incidence occur at all phonological stages of the eggplant varieties screened, with peak infestation occurring at the fruiting stage. The results from this study has shown that the five eggplant varieties screened varied in their susceptibility to *L. orbonalis* with the following ranking of susceptibilities: *S. gilo* > *S. aethiopicum* > *S. ex-lantan*; *S. macrocarpon* > while *S. melogena* was found to be fairly resistant to *L. orbonalis.* Results also indicated that *L. orbonalis* infestation significantly affected some growth and yield parameters of the eggplants assessed.

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ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

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THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

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Table 1: Monthly abundance of *L. orbonalis* adult moth

Variety	Month				
	May	June	July	Aug.	Sept.
S. aethiopicum	0.24 ± 0.01	1.13 ± 0.06	1.61 ± 0.13	2.92 ± 0.68	3.78 ±0.24
S. ex-lantan	0.00 ± 0.00	0.56 ± 0.36	1.05 ± 0.70	2.06 ± 0.24	2.92 ±0.87
S. gilo	0.50 ± 0.05	1.61 ± 0.04	1.91 ± 0.40	3.59 ± 0.13	4.73 ±1.20
S. macrocarpon	0.05 ± 0.08	0.49 ± 0.13	0.94 ± 0.58	1.79 ± 0.40	2.90 ±0.05
S. melogena	0.00 ± 0.01	0.05 ± 1.10	0.64 ± 0.53	1.18 ± 0.79	1.82 ±0.11
$LSD_{0.05}$	NS	0.41	0.46	0.31	0.61

NS – Not significant

Table 2: Population of *L. orbonalis* adult moth and percent larval infestation per month

Month	No. of *L. orbonalis* adult moth	% Larval infestation
May	0.79	2.06
June	3.84	9.98
July	6.15	15.99
August	11.54	29.99
September	16.15	41.98
Total	38.47	100

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THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

Table 3: Population of *L. orbonalis* and percent larval infestation per variety

Variety	No. of *L. orbonalis*	% larval infestation
S. aethiopicum	9.67	25.14
S. ex-lantan	6.60	17.16
S. gilo	12.35	32.10
S. macrocarpon	6.16	16.01
S. melogena	3.69	9.59
Total	38.47	100

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THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

Table 4: Effect of *L. orbonalis* larval infestation on some agronomic parameters of five varieties of eggplants

Variety	No. of fruits per plot	Fruit weight (t/ha)	Fruit diameter (cm)	Fruit length (cm)	Shoot girth (cm)
S. aethiopicum	128.50±1.20	2.39±0.50	1.96±1.77	1.99±0.53	1.68±1.42
S. ex-lantan	56.60±1.00	1.30±0.23	4.41±0.13	5.94±0.79	2.30±0.86
S. gilo	107.10±0.88	3.82±1.40	4.86±0.70	4.81±1.20	2.38±1.06
S. macrocarpon	50.80±1.20	1.69±0.08	5.04±0.40	6.18±0.47	2.39±0.66
S. melogena	33.20±0.79	1.99±1.00	4.58±0.58	19.76±0.68	2.48±0.37
$LSD_{0.05}$	33.57	0.69	0.25	1.73	0.33

Table 5: *L. orbonalis* larval damage on shoots and fruits

Variety	Length of feeding tunnel	No. of holes per fruit	No. of holes per shoot
S. aethiopicum	1.53±0.09	2.06±0.37	2.13±0.03
S. ex-lantan	1.38±1.00	1.06±0.10	1.00±0.20
S. gilo	2.76±0.20	2.56±0.05	2.75±0.20
S. macrocarpon	1.32±0.05	1.38±0.11	1.06±0.05
S. melogena	0.60±0.01	0.81±0.27	0.48±0.20
$LSD_{0.05}$	0.51	0.34	0.47

ISSN 978-978-54729-6-7
THEME: "Horticulture for Improved Food Security, Sustainable Environment and National Economic Growth
18th – 22nd November, 2018

Table 6: Effect of *L. orbonalis* larval infestation on eggplant fruit and fruit related parameters

Variety	% infested fruits	% uninfested fruits	Damage yield (t/ha)	Marketable yield (t/ha)
S. aethiopicum	67.88±1.55	32.12±0.41	2.52±1.00	0.53±1.50
S. ex-lantan	58.58±0.78	41.42±0.58	1.79±0.57	0.58±1.20
S. gilo	70.68±1.20	29.32±1.68	4.51±0.66	0.53±1.50
S. macrocarpon	57.88±1.31	42.12±1.63	1.63±1.00	0.87±0.93
S. melogena	50.44±0.40	46.98±1.44	0.83±0.80	1.32±1.30
$LSD_{0.05}$	23.11	11.30	Ns	0.28

Ns – Not significant

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