Assessing the Potential Impact of Garden Egg Germplasm on Egg Fruit and Shoot Borer (*Leucinodes orbonalis*) Infestation in Umudike

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Abstract: The present investigation is carried out to study the performance of five garden egg cultivars against *Leucinodes orbonalis* Guenee in South-eastern agroecology of Nigeria in 2014 and 2015 cropping seasons at the National Root Crops Research Institute (NRCRI) Umudike, Research Farm. The trials were arranged in the Randomized Complete Block Design with five replicates and analyses were done by pooling over two years due to insignificant genotype X year interactions. Results of the study indicate significant variations amongst the cultivars for the agronomic and damage attributes. Lowest number of fruits (4.47) was damaged in Ngwa large (V_5). However, highest number of damaged fruits (10.30) was recorded in Sweet white (V_3). With respect to yield parameters, highest; fruit weight per plant and fruit yield were observed in Sweet white (V_3) with values of 1.19kg and 14.28t/ha respectively. Results from rank summation index (RSI) shows that Ngwa large (V_5) is the best performer with RSI value of 17. Fruit yield was significantly and positively correlated with number of branches per plant ($r = 0.40^*$), number of fruit per plant ($r = 1.00^{**}$), Plant height ($r = 0.60^*$) and fruit weight per plant ($r = 1.00^{**}$) and recorded negatively and non- significant relationships with number of damage fruit per plant ($r = -0.30$) and Percentage fruit damage per plant ($r = -0.50$).

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1. Introduction

Eggplant (*Solanum melongena* (Linnaeus)) is one of the most important fruit and leafy vegetable widely cultivated in tropical Africa; probably the third after tomato and onion, and before okra (Grubben and Denton, 2004; Hanson *et al*., 2006). It belongs to the Solanaceae family, which includes crops such as tomatoes, potatoes and capsicums. Owing to the fact that eggplant is widely consumed on a daily basis especially in the forest zone, the crop represents a very important source of income for many rural and urban households (Danquah, 2000; Owusu- Ansah *et al*., 2001). It is known for its ability to provide large amounts of food from a small space. Also, the fruits have a storage life up to three months and can be dried and stored for later use, when the growing season is over and nothing fresh is available (NRC, 2006; Stone et al., 2011; National Research Council, 2006). The fruit is primarily used as a cooking vegetable for various dishes in different regions of the world. It has taken firm hold as a meat substitute and popular vegetarian dishes. The leaves and flowers of some varieties of eggplant are edible and may be added to soups and sauces. The fruits of eggplant can be eaten raw, cooked or fried (Tindal, 1992). Eggplant fruits provide protein, vitamins, and minerals but low in sodium, calories and fat. It contains a large quantity of water and good for balancing diets that are heavy in protein and starches. It is high in fibre and provides additional nutrients such as potassium, magnesium, folic acid, vitamin B6 and A (NRC, 2006). It is rich in reducing sugars, anthocyanin, phenols, glycoalkaloids, dry matter, and amide proteins (Bajaj *et al.,* 1979). Eggplant is good for diabetic patients and can be used to cure toothache. It has also been recommended as an excellent remedy for people suffering from liver complaints (Chen and Li, 1996).

All these benefits, coupled with higher yield and longer fruiting and harvesting period lure the farmer on eggplant production (Ghimire et al., 2007). However, eggplant production is under threat in recent years due to increased cost of production on management of insect pest complex. Eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis*

(Lepidoptera: Pyralidse) Guenee, is the key pest of eggplant (Chakraborti and Sarkar, 2011; Saimandir and Gopal, 2012) inflicting sizeable damage in almost all the eggplant growing areas (Dutta *et al.,* 2011) and is most destructive, especially in south Asia and Africa (Thapa, 2010) (Figure A - F). Patnaik (2000) for instance reported that *L. orbonalis* damage to fruit in the field ranges from 47.6 % to 85.8 % of harvest. As a result of its feeding inside fruit, the fruits become unmarketable and yield losses up to 90 percent (Baral, et al., 2006). If the caterpillars bore into shoots and stems, or there is a heavy infestation, this will weaken the host plant and cause yield loss in unaffected fruits. Hence, many farmers leaving growing eggplant because of this pest (Gapud and Canapi, 1994). The very high damage potential attributed to this pest is owed to its high reproductive capacity and rapid turnover of generations. It is also very difficult to control since it feeds inside the shoot and fruit. Synthetic chemicals have overtime provided competitive and effective tool in the battle against this pest.

Figure (A). *Leucinodes orbonalis*, live adult moth showing a typical resting posture with the abdomen curled up

Figure (B). Damage caused by *Leucinodes orbonalis* caterpillars boring into fruit

Figure (C). The larva/ Caterpillar of *L. orbonalis* causing shoot damage to garden egg stem

Figure (D). The larvae/ Caterpillar on garden egg leaf

Figure (E). Caterpillar of *Leucinodes orbonalis* on garden egg

Figure (F). Larvae of *L. orbonalis*

Their environmental and health hazards they constitute has been pointed out repeatedly. According to Horna et al. (2008), infestation by some of these pests significantly increases the probability that farmers would apply insecticides. Botwe et al. (2011) observed that some of these applications are done a day prior to harvest in order to obtain a good looking vegetable. Repeated application of insecticides at short intervals in disregard of pre-harvest intervals however, exposes the environment, consumers and farmers to toxic residues that can persist even after processing (Bull, 1992) and also increases production costs and consequently, reduces profits from sale of produce. There is every possibility also that the frequent spraying and harvesting of the fruits does not consider the half-life. This makes it expedient to explore control measures that are safe, cheap and effective. The use of resistant cultivars is perhaps the most desirable method of controlling pests in this crop (Than *et al*., 2008).

This approach, according to Voorrips *et al.* (2004), has been less exploited in fruit and vegetable crops mainly due to the longer time required for breeding and selecting for resistance and the short term advantage of chemical control. In spite of this, host resistance is considered the most prudent means of pest control because of its effectiveness, ease of use, and lack of potential negative effects on the environment (Phoulivong, 2011). According to Chandha (1993), resistant varieties showed low fruit infestation. He believed that long narrow fruited variety suffered less because of low egg laying preference compared to short and wide fruited. Similarly, genotypes bearing thin fruits with short calyx and lower number of calyx with lower diameter and thin shoot are being considered tolerant to *L. orbonalis* attack (Malik et al., 1986). The anatomical characters such as more lignified hypodermis, compact vascular bundles and narrow shoot pith were less susceptible cultivars. Borer doesn't prefer light green fruits as they had narrow pericarp and mesocarp with compact seedlings and seeds closely arranged. Knowledge of varietal preference of eggplant shoot and fruit borer can play a significant role in the successful eggplant production and will provide information that might promote minimal use of insecticides and eventually lead to pesticide free production. Unfortunately, very limited efforts were given in this regards. Considering the above situation, the present research was conducted to screen out and identify insect pest resistant/tolerant eggplant variety for exploitation in crop improvement and which might also be an important tool for the management of this pest.

2. Materials and Methods:

The experiment was conducted at the National Root Crops Research Institute (NRCRI), Umudike situated at Latitude 05°28' N, Longitude 06°52'E and Altitude 122m above sea level in 2014 and 2015 cropping season. Umudike has a total rainfall of about 2000-2500mm per annum with annual average temperature of about 26^{0}C. The predominant vegetative type is rain forest (NEST, 1991). However, the soil was classified as sandy loam ultisol. The cultivars which were obtained from different localities in Southeastern Nigeria were raised in the nursery for 4weeks, and later transplanted and watered heavily in a plot area of 2m × 3m and replicated 5 times using a randomized complete block design. They include; Gauta Bello (V_1), Large green (V_2), Sweet white (V_3), Leafy eggplant (V_4) and Ngwa large (V_5). To raise the seedlings, clean healthy seeds of local variety were sown 3 cm apart and 1 cm deep in plastic trays (34 x 24 x 4 cm), giving a total of 60 seeds per tray. They were maintained following normal agronomic practices. A space of 0.5m was allowed between treatment plots and 1.0m was spaced between blocks. The seedlings were transplanted at 1 seedling per hill with spacing of 1 × 1m which gave plant population density of 10,000plants/ha. Weeding was done regularly and manually to reduce inter-species competition.

2.1. Insect sampling and scouting: Foliage insect pests sampling commenced two weeks after transplanting of seedlings and was undertaken between 7:00 and 10:00 am.

2.2. Assessment of percent shoot damage

Assessment of shoot damage by *L. orbonalis* was undertaken by closely examining four randomly selected plants in each genotype in each block for signs of *L. orbonalis* infestation (presence of frass or emergent holes on shoots as well as signs of drooping). The extent of damage both on shoot and fruit of different genotypes were calculated and expressed in percentage (Rahman *et al*., 2012). Data were collected at every 3 weeks interval started at 2 weeks after transplanting (WAT) and continued to till maturity. Percent shoot and fruit damage were calculated using following formulae;

$$\%\ \text{Shoot damage} = \frac{\text{Number of damaged shoot}}{\text{Total number of shoot}} \times \frac{100\%}{1}$$

$$\%\ \text{Fruit damage} = \frac{\text{Number of damaged fruit}}{\text{Total number of fruit}} \times \frac{100\%}{1}$$

2.3. Assessment of percent fruit infestation by L. orbonalis:

Mature fruits were harvested per plot and the fruits were sampled for EFSB infestation. All the fruits were examined by careful dissection and the infested ones separated from the un-infested ones. The number of infested fruits were counted and expressed as percentage of total number of fruits collected per plot per week. A hand lens and diagnostic manual for the identification of insect pathogens published by Poinar and Thomas (1978) was used for confirmation of insect identity.

3. Results and Discussion:

The classification of a range of genetic variability among cultivars is pivotal to the maintenance and further acquisition of germplasm resources even as accessions from diverse origins are needed as parents stocks for the development of improved varieties (Aremu *et al*., 2007). The mean plant height, number of leaves, number of branches at 12 weeks after planting (WAP) and days to 50% flowering among the five cultivars differed significantly (Table 1). The tallest variety, Leafy eggplant (V_4) which was 80.4cm tall also had the highest number of leaves (131.7). However, Sweet white (V_3) which was the shortest variety (46.4 cm) had the highest number of branches (12.03). Gauta Bello (V_1) and Ngwa large (V_5) flowered on the 34.89th day after planting while leafy eggplant (V_4) flowered last (in 37.22 days).

This morphological variation may be due to genetic basis. The variation obtained on the days to 50% flowering is in agreement with Thomas and Vince-Prue (1997) who reported that many plants flower in response to seasonal changes in day length and that this response often varies between accessions of a single species base on their genetic constitution. According to Alejandro *et al*. (1998) this observation, along with the fact that these characteristics are expressed differently in individuals of different origin cultivated within the same home garden, suggests that such characteristics have an important genetic component. This would indicate then that changes in morphological characters may be inherited. The existence of high variability for different characters among garden egg varieties had been earlier reported by Ariyo (1993); Adeniji (2003) and Kale *et al*., (1986).

Table 1: *Agronomic traits variations of 5 garden egg cultivars*.

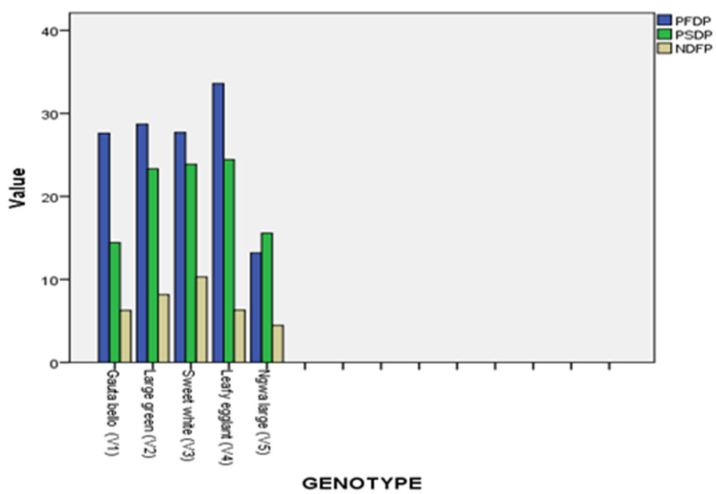
GENOTYPE	PH @ 12WAP	NL@ 12WAP	NB@ 12WAP	D50%F
Gauta bello (V1)	50.8	69.7	8.20	34.89
Large green (V2)	58.1	92.9	8.50	35.22
Sweet white (V3)	46.4	85.0	12.03	35.67
Leafy eggplant (V4)	80.4	131.7	9.80	37.22
Ngwa large (V5)	64.5	105.0	9.17	34.89
Mean	60.1	96.9	9.54	35.58
LSD $_{(0.05)}$	8.72	19.79	2.181	NS
CV (%)	2.1	6.0	9.2	10.5

PH = Plant height (cm), NL = Number of leaves,
NB= Number of branches, D50%F = Days to 50% flowering.

With respect to damage parameters, significant differences existed among the cultivars in their susceptibility to fruit borer attack (Table. 2). Shoot damage per plot was observed to be lowest (14.43%) in Gauta Bello (V_1) while the highest incidence (24.43%) was recorded in leafy eggplant (V_4). The results obtained from the number of damaged fruits per plant indicated that the lowest number of fruits (4.47) was damaged in Ngwa large (V_5). This was followed by Gauta Bello (V_1) that had 6.27 of its fruits damaged. However, highest number of damaged fruits (10.30) was recorded in Sweet white (V_3). With respect to percentage fruit damage per plant, least damage (13.2%) was observed in Ngwa large (V_5) while severe damage was recorded in leafy eggplant (V_4) which had 33.6% of its fruits damaged by *L. orbonalis*. In all, Ngwa large (V_5) was least affected by the three damage parameters (Figure. 1).

Figure (1). PFDP, PSDP, and NDFP of the five garden egg genotypes.
PFDP = Percentage fruit damage per plant (%),
PSDP = Percentage shoot damage (%) per plot, NDF/P = Number of damage fruit per plant.

The variations observed in relative susceptibility of different cultivars against *L.*



orbonalis may be attributed to multiplicity of mechanisms which influence the ultimate degree of plant damage by insect pests. Presence or absence of special substances and differing amounts of nutrients affects various gustatory responses of the insects. This view is in support of Kennedy (1995), who reported that nutrients may act as feeding stimulants or as co-factors and synergists to more specific stimulants and can play a dominant role in host selection, feeding and colonization by various insect species.

Table 2: *Yield and damage traits variations of 5 garden egg cultivars.*

GENOTYPE	NF/P	NDF/P	PFD/P (%)	PSD/P (%)	FW/P (kg)	FY(t/ha)
Gauta bello (V1)	23.10	6.27	27.6	14.43	0.633	7.60
Large green (V2)	28.03	8.17	28.7	23.33	0.797	9.56
Sweet white (V3)	37.23	10.30	27.7	23.87	1.190	14.28
Leafy eggplant (V4)	18.80	6.30	33.6	24.43	0.367	4.40
Ngwa large (V5)	33.77	4.47	13.2	15.57	0.900	10.80
Mean	28.19	7.10	26.2	20.33	0.777	9.33
LSD $_{(0.05)}$	3.974	2.524	8.05	4.601	0.2464	2.957
CV (%)	4.9	25.6	25.7	7.2	7.2	7.2

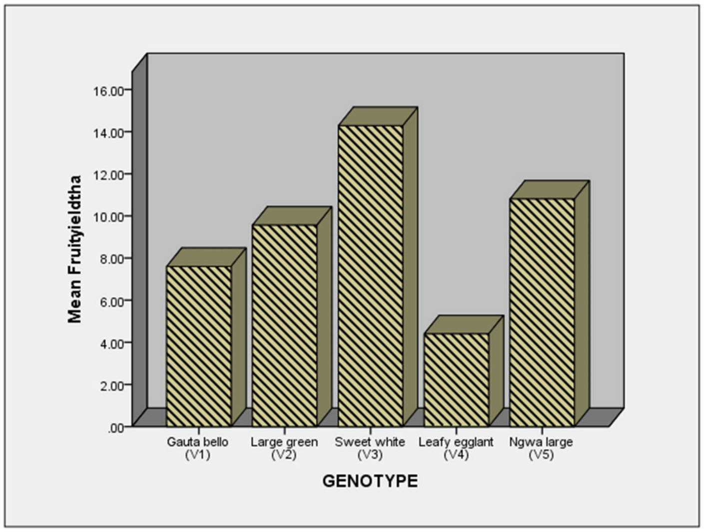
NF/P = Number of fruit per plant, NDF/P = Number of damage fruit per plant, PFD/P = Percentage fruit damage per plant (%), PSD/P = Percentage shoot damage (%) per plot, FW/P = Fruit weight per plant (kg), FY = Fruit yield per hectare (t/ha).

Martin (2004) in his study obtained the highest lignin content coupled with lowest shoot and fruit infestation in wild relatives of S. melongena. The anatomical characters such as more lignified hypodermis, compact vascular bundles tightly arranged seeds and narrow shoot pith were less susceptible cultivars. Lignin is a phenolic compound, which increases un-palatability of the food materials. Painter (1951) believed that relative susceptibility of different cultivars against *L. orbonalis* depends upon two factors, softness of shoot and fruit pulp and different intrinsic characters of tolerances.

It was reported that thick pubescence on the leaves made them least attractive to the adult moth (*L. orbonalis*) to deposit their eggs; also the newly hatched larvae cannot bore early in their fruit (Dadmal, 2004). On their studies Panda and Khush (1995) observed that varieties with characteristics like hair and prickle on stems, leaves and fruit stalks result in lowest percentage of fruit infestation as compared to those without hair and prickles. Harriman et al. (2014) argued that research of some morphic characters carried out with varieties with loose parenchyma cells in cortical region and thin cuticle collenchymatous area, with large spaces between vascular bundles were responsible for susceptibility of maize cultivars to stem borer.

With respect to yield parameters which recorded significant difference, highest; number of fruit per plant, fruit weight per plant and fruit yield were observed in Sweet white (V_3) with values of 37.23, 1.19kg and 14.28t/ha respectively. While the lowest value of 18.80, 0.367 kg and 4.40t/ha respectively was obtained in leafy eggplant (V4) (Figure. 2).

Figure (2). Fruit yield (t/ha) variation among the five evaluated garden egg cultivars.



This variation in yield could be attributed to genetic endowment of individual crop specie. Yield basically, it is determined by the expression and interaction of numerous genes which affect vital processes within the plant such as nutrition, photosynthesis, transpiration, translocation and storage of food materials. This observation is supported by Kumar (1999) who stated that yield is determined directly or indirectly by genes affecting maturity, disease and pest resistance. He maintained that variation within a crop specie are variation due to hereditary (genetic). Abdullah et al. (2003) reported that crop genotypes produce fruits of various sizes as dictated by the genetic constitution. According to Owusu-Ansah et al. (2001), major factors like diameter, number, size and length of fruit with yield potential were highly genetic variations.

Coefficient of variation (CV): The results obtained from coefficient of variation (CV) which represents a useful statistic for comparing the degree of variation from one data series to another showed that all the parameters had low to high CV. Plant height had the lowest CV (2.1%) while the highest CV was recorded in percentage fruit damage per plant (25.7%).

Rank summation index (RSI): All the parameters were used in constructing a selection index for selecting insect pest tolerant and best performing garden egg cultivars. The rankings of the 5 garden egg cultivars (Table. 4) using agronomic and insect pest damage parameters showed that Ngwa large (V_5) is the best performer with a rank summation index (RSI) value of 17. This was followed by Sweet white (V_3) with RSI values of 23. Cultivar Leafy eggplant (V_4) is the least of all the cultivars studied with the RSI value of 33.

Correlation: Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through suitable breeding programme. Correlations between yield and yield components were computed separately for garden egg cultivars. The correlation studies of Pearson correlation coefficient (r) disclosed significant (p = 0.05) to highly significant (p = 0.01) level of probability among the traits studied (Table 3). Number of damaged fruits per plant was negatively correlated with Plant height (r = -0.50), fruit weight per plant (r = -0.30) and fruit yield per hectare (r = -0.30) and positively correlated with Percentage fruit damage per plant (r = 0.60) and percentage shoot damage per plot (r = 0.60). However, significant and positive correlation were found between fruit weight per plant and number of branches per plant (r = 0.40*) and number of fruit per plant (r = 1.00**). Similarly, Fruit yield was significantly and positively correlated with number of branches per plant (r = 0.40*), number of fruit per plant (r = 1.00**), Plant height (r = 0.60*) and fruit weight per plant (r = 1.00**) and recorded negatively and non- significant relationships with number of damage fruit per plant (r = -0.30), Percentage fruit damage per plant (r = -0.50) and percentage shoot damage per plot (r = -0.10). Darekar *et al*. (1991) got similar results in their studies. These results were also supported by Shukla et al. (1998).

Table 3: *Correlation matrix of some agronomic and damage parameters of 5 garden egg cultivars.*

Agronomic and Damage Traits	1	2	3	4	5	6	7
1.Number of branches per plant	-						
2.Number of fruit per plant	0.40	-					
3.Number of damage fruit per plant	0.50	0.30	-				
4.Percentage fruit damage per plant (%)	0.30	0.50*	0.60	-			
5.percentage shoot damage (%) per plot	0.80	-0.10	0.60	0.80	-		
6.Plant height (cm)	0.10	0.60	-0.50	0.30	0.30	-	
7.fruit weight per plant (kg)	0.40*	1.00**	-0.30	-0.50	-0.10	0.60	-
8.fruit yield per hectare (t/ha)	0.40*	1.00**	-0.30	-0.50	-0.10	0.60*	1.00**

* Correlation is significant at the 0.05 level (2-tailed),
** Correlation is significant at the 0.01 level (2-tailed).

4. Conclusion:

There exist significant variations in the different garden egg cultivars studied with respect to agronomic and pest damage traits. The cultivar Sweet white (V_3) had the best rating when yield fruit was accessed as a single attribute. However when all the agronomic and pest damage attributes were subjected to rank summation index analysis, Ngwa large (V_5) emerged as the best cultivar in terms of L. orbonalis tolerance and agronomic yields. Furthermore, correlation results showed significant and positive relationship between fruit yield and number of branches per plant, number of fruit per plant, Plant height and fruit weight per plant. Ngwa large (V_5) and Sweet white (V_3) therefore could be recommended for testing on farmer's field since they could be used to overcome the challenges faced by garden egg farmers in the zone.

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