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Screening of Different Aubergine Cultivars against Infestation of Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee)

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ABSTRACT

In the present study, response of five aubergine cultivars was evaluated against Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee) under field conditions. The cultivar Round White Brinjal showed maximum fruit infestation (54.44%) followed by Singhnath 666 (53.19%) while the minimum fruit infestation was observed on Round Brinjal 86602 (42.39%). Contrarily, Short Purple cultivar showed maximum larval population (0.43) followed by Round White Brinjal (0.39) while the minimum larval population was observed on Round Brinjal 86602 (0.27) and was found comparatively resistant against the pest. The correlation between fruit infestation and larval population and different environmental factors was also studied. Average relative humidity was found positive and significantly correlated with fruit infestation. Average precipitation showed positive but non-significant correlation in case of all the cultivars except Singhnath 666 which was positive and significant. On the other hand, average temperature was found non-significant and negatively correlated in case of Brinjal Long 6275, Round Brinjal 86602 and Singhnath 666 while significant but negatively correlated in case of Short Purple and Round White Brinjal. Maximum temperature also showed significant and negative correlation for all the cultivars. Minimum temperature was observed negative but non-significantly correlated for all the cultivars. As Round Brinjal 86602 suffered less damage by the borer and therefore, is recommended for cultivation in arid and semi-arid regions.

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Authors' Contribution
AKK, HJ and TM designed the study and executed the experimental work. TM analyzed the data. HJ and TM supervised the work and helped in preparation of the manuscript.

Key words
***Leucinodes orbonalis*, Brinjal, *Solanum melongena*, Cultivars, Screening, Morphological characteristics.**

INTRODUCTION

Aubergine (*Solanum melongena* L.) also known as eggplant and brinjal, belongs to family Solanaceae. It is a good source of nutrients, minerals, antioxidants, vitamins, dietary fibers and body building proteins (Matsubara *et al*., 2005). It is extensively grown in Pakistan, Bangladesh and India on an area of more than 0.678 million hectares (FAO, 2007). It is often known as cash crop for farmers, cultivated in kitchen and commercial gardens during both Rabi and Kharif seasons. Aubergine is always available to poor community in rainy days when other vegetables are short in supply (Javed *et al*., 2017a, b). The lucrative production of aubergine is threatened by scores of biotic factors including diseases (Hussain *et al*., 2016; Ashfaq *et al*., 2017; Aslam *et al*., 2017a, b; Fateh *et al*., 2017; Kayani *et al*., 2017, 2018; Khan *et al*., 2017; Mukhtar *et al*., 2017a, b, 2018; Tariq-Khan *et al*., 2017) and particularly the insect pests (Kassi *et al*., 2018; Nabeel *et al*., 2018). Among insect pests, Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee) (BFSB) is one of the most important and serious pests of aubergine (Alam and Sana, 1964; Tewary and Sardana, 1990).

Severe damage to fruits and shoots is caused by the larvae of the pest. The petioles, midribs of large leaves and young tender shoots are bored by newly hatched larvae. Due to larval activity, translocation of nutrients towards shoots is affected. This causes withering and drooping of shoots, resultantly the growth of eggplant and size and number of fruits are significantly reduced. The larvae then enter into young fruits, make tunnels and start feeding on internal tissues. The tunnels are clogged with frass and render the fruits unmarketable (Alam *et al*., 2003; Mainali, 2014). Sometimes, secondary infection by bacteria causes rotting of fruits and further deteriorates the quality of fruits.

The pest is a serious threat due to its high reproduction, fast turnover of generations and tremendous damage. A single larva is enough to damage 4-6 healthy fruits (Jayaraj and Manisegaran, 2010). The infestations and losses caused by the pest vary from location to location and season to season depending upon environmental factors, cultivars sown and plant age. In Bangladesh, the fruit infestation ranged from 31 to 90% (Rahman, 1997), in India 37–63% (Dhankar, 1988), and in Pakistan 50-70% (Saeed and Khan, 1997). The pest is responsible for

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reducing crop yield up to 90% (Misra, 2008; Jagginavar *et al*., 2009).

The pest is mainly controlled by synthetic pesticides which cause serious health hazards. Alternatively, it can be controlled by adopting cultural practices, crop hygiene, fallow, crop rotation, ploughing, removing crop residues, change in planting time, use of resistant varieties, biological control (Iftikhar *et al*., 2018; Rahoo *et al*., 2017, 2018a, b) and sex pheromone. Use of resistant cultivars is the most productive and cheapest way to manage the pest which is environmentally safe (Kayani and Mukhtar, 2018). Therefore, in the present study, different aubergine cultivars have been assessed for their comparative response to infestation of *L. orbonalis* on the basis of different morphological characters.

MATERIALS AND METHODS

Plant material

Five aubergine cultivars *viz*. Short Purple, Singhnath 666, Brinjal Long 6275, Round Brinjal 86602 and Round Eggplant White were assessed for their relative infestation against the pest.

Research area

The comparative infestation of BFSB on five aubergine cultivars was studied at University Research Area PMAS, Arid Agriculture University, Rawalpindi. Randomized Complete Block design (RCBD) with four replications was used. In the research area, summer is hot and rainy while winter is very cold and dry. The temperature in summer is about 34.2°C while in winter it is about 24.4°C. The mean maximum and minimum temperature is 16.6°C and 3.4°C in winter, respectively. The average annually rainfall and humidity is 1143 mm and 55%, respectively.

Evaluation of aubergine cultivars for resistance

The nursery was raised in the green house in germination trays. The land was prepared by ploughing, laddering and was fertilized with farmyard manure. The total area of research plot was 40 × 40 feet. The seedlings of five aubergine cultivars were transplanted on 15 May, 2013 with plant to plant and row to row distance of 60 and 75 cm respectively. Irrigation was done whenever required. The BFSB larval infestation was recorded from 24 June, 2013. The number of infected and healthy plants was recorded at each harvesting. The percentage of infestation of BFSB on five different plants in each replication was calculated by using the following formula:

$$\text{Infestation (\%)} = \frac{\text{No. of damaged fruits}}{\text{Total No. of fruits}} \times 100$$

Brinjal fruit and shoot borer larval infestation

The BFSB larval population was recorded from top, middle and lower leaves after one week interval from five randomly selected aubergine plants from each experimental unit. The average larval population per leaf was calculated by the following formula:

$$\text{Avg. population} = \frac{\text{Total No. of larvae counted}}{\text{Total No. of leaves observed}}$$

Table I.- Morphological characteristics and methodologies for their determination.

Morphological characteristic	Methodology
Hair density on fruit crown /cm²	Fruits were collected from the randomly selected five plants. From the crown of each fruit three pieces were cut from crown of one cm² and hairs were counted under microscope and counted hair density/cm².
Hair density of leaf lamina/cm²	Three leaves were randomly selected from upper, middle and lower portion of the plants. In leaf lamina number of hair/cm² from each three pieces from each leaf was counted under microscope and their average was worked out.
Hair density on leaf midrib/cm	Three leaves were randomly selected from upper, middle and lower part of plants. In the leaf midrib number of hair/cm were counted under microscope and average was worked out.
Plant height (cm)	Five plants were randomly selected to measure the plant height from each plot. The height was measured by the help of measuring tap 100 days after transplanting.
Stem girth (mm)	Five plants were randomly selected to measure the plant stem girth from each plot. The stem girth was measured by the help of measuring tape 100 days after transplanting.
Number of holes on the infested fruit	The five different plants were randomly selected from each plot. The infested fruits were collected from the plants and counted the number of holes on infested fruit and their averages were worked out.
Infested fruit holes length (cm)	The infested fruit were collected from the brinjal plants and counted the number of holes on infested fruit. The length of infested holes were measured in (cm) by measuring tape and their averages were worked out.

Relationship between morphological characteristics and resistance

The relationship between level of resistance and different morphological characters of five aubergine cultivars was studied to evaluate the resistant of aubergine cultivars against BFSB. The morphological characters analyzed are given in Table I.

Yield

The yield of each aubergine cultivar (kg/plant) from each plot was recorded from first picking up to final picking and total yield per plant was calculated.

Correlation between environmental factors and infestation

For this purpose weather data was collected from Meteorological Research Station Rawalpindi and the larval population of BFSB and the fruit infestation was correlated with different environmental factors.

Statistical analysis

All the data were analyzed by using Co-STAT version 6.311 software package and mean values were compared by using Duncan's Multiple Range -Test at 5%.

RESULTS

Larval population of BFSB on aubergine cultivars

Significant variations in larval population of BFSB were observed among five aubergine cultivars. Minimum larval population (0.27 per leaf) was observed in case of While Round Brinjal 86602 followed by Brinjal Long 6275 (0.34) which was at par with the former and statistically different from the rest of three and were found comparatively resistant among all the cultivars (Table II). The larval population on other three cultivars was statistically similar and is given in Table II.

Table II.- Larval population and fruit infestation of BFSB on five aubergine cultivars.

Cultivars	Larval population (Leaf)	Fruit infestation (%)
Short Purple	0.43 a	51.27 ab
Round White Brinjal	0.39 a	54.44 a
Singhnath 666	0.37 a	53.19 ab
Brinjal Long 6275	0.34 ab	48.64 b
Round Brinjal 86602	0.27 b	42.39 c
LSD	0.094	4.6706

Mean sharing similar letters in each column are not significantly different by LSD Test at p=0.05.

Fruit infestation of BFSB on aubergine cultivars

The maximum fruit infestation of 54.44 % was observed on Round White Brinjal followed by Singhnath 666 (53.19%) and Short Purple (51.27%) which was statistically at par with the former while minimum fruit infestation was observed on Round Brinjal 86602 (42.39 %) followed by Brinjal Long 6275 (48.64%) and did not show significant difference with each other (Table II).

Hair density on leaf lamina (cm²)

Maximum hair density (279.0/cm²) on leaf lamina was observed on Round Brinjal 86602 followed by Brinjal Long 6275 (264.5/cm²) and Singhnath 666 (220.5/cm²) (Table III). The lowest hair density was found in case of Short Purple (186.7/cm²) which was statistically similar with Round White Brinjal (199.5/cm²).

Table III.- Hair density on leaf midrib, fruit crown and leaf lamina on five aubergine cultivars.

Cultivar	Hair density		
	Leaf midrib/cm	Fruit crown/cm²	Leaf lamina/cm²
Brinjal Long 6275	44.75b	4.16c	264.5b
Round White Brinjal	29.32bc	11.31b	199.5d
Short Purple	23.00c	12.50b	186.7e
Singhnath 666	27.57bc	12.58b	220.5c
Round Brinjal 86602	72.25a	14.25a	279.0a
LSD	14.275	1.03	4.896

Mean sharing similar letters in each column are not significantly different by LSD Test at p=0.05.

Hair density on leaf midrib/cm

The cultivar Round Brinjal 86602 had the maximum number of hairs on leaf midrib (72.25/cm) followed by Brinjal Long 6275 (44.75/cm) showing significant difference, while the minimum number of hairs on leaf midrib was recorded on Short Purple (23.00/cm) followed by Singhnath 666 and Round White Brinjal with hair densities of 27.57/cm and 29.32/cm respectively and were statistically similar with each other's as shown in Table III.

Hair density on fruit crown (cm²)

The maximum number of hairs on crown was observed on Round Brinjal 86602 (14.25/cm²) followed by Singhnath 666 (12.58/cm²) and Short Purple (12.50/cm²), while the minimum number of hairs on crown were recorded on Brinjal Long 6275 (4.16/cm²) showing significant difference from other cultivars (Table III).

Stem girth (mm)

Maximum stem girth was found on Singhnath 666 (59.21 mm) cultivar followed by Brinjal Long 6275 (50.17 mm) while the minimum stem girth (42.27 mm) was recorded in case of Round White Brinjal. Cultivars Round Brinjal 86602, Short Purple and Round White Brinjal showed statistically similar stem girths (Table IV).

Plant height (cm)

Brinjal Long 6275 had shown the maximum plant height (59.39 cm) which was found statistically similar with Singhnath 666 and Round Brinjal 86602 (53.72 and 53.26 cm respectively). On the other hand the minimum plant height was recorded in case of Short Purple (38.75 cm) and was statistically similar with Round White Brinjal (42.66 cm) (Table IV).

Number of holes on infested fruit

The Round Brinjal 86602 had minimum average number of holes (1.95) on the infested fruits which was statistically different with others while Brinjal Long 6275 showed the maximum average number of holes (2.35) followed by Round White Brinjal, Short Purple and Singhnath 666 which were statistically same with each other (Table IV).

Length of holes on infested fruit

The minimum length of holes (1.37 cm) was noticed on Round Brinjal 86602 which was statistically less than Singhnath 666 and Short Purple with 1.46 and 1.52 cm length of holes on infested fruits respectively. Contrarily, the maximum length of holes was recorded on infested fruits of Round White Brinjal (1.67 cm) (Table IV).

Table IV.- Stem girth (mm), plant height (cm), and number (n) and length of holes (cm) on the infested fruit of five aubergine cultivars.

Cultivar	Stem girth	Plant height	Number of holes	Length of holes
Brinjal Long 6275	50.17b	59.39a	2.35a	1.60a
Round White Brinjal	42.27d	42.66c	2.25ab	1.67a
Short Purple	44.41cd	38.75c	2.25ab	1.52a
Singhnath 666	59.21a	53.72b	2.25ab	1.46a
Round Brinjal 86602	46.27c	53.26b	1.95b	1.37a
LSD	2.300	4.622	0.263	0.26

Fruit yield kg per plant

The mean data regarding fruit yields of five aubergine cultivars are presented in Figure 1. Round Brinjal 86602 showed the maximum fruit yield (0.944 kg) per plant followed by Short Purple (0.655 kg) while the minimum fruit yield was observed in case of Brinjal Long 6275 (0.497 kg). The cultivars Round White Brinjal, Singhnath 666 and Brinjal Long 6275 were statistically different with each other (0.581, 0.538 and 0.497) regarding fruit yield per plant.

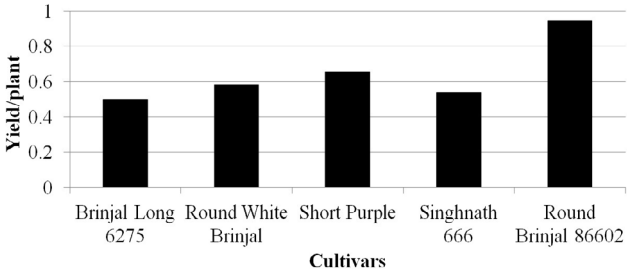

Fig. 1. Yield of five aubergine cultivars affected by Brinjal Fruit and Shoot Borer infestation.

Table V.- Correlation between fruit infestation caused by BFSB and different environmental factors.

Cultivar	Temperature (°C)			Avg R.H. (%)	Avg. rainfall (mm)
	Min	Max	Avg.		
Brinjal Long 6275	-0.25^{ns}	-0.81*	-0.64^{ns}	0.768*	0.33^{ns}
Round Brinjal 86602	-0.25^{ns}	-0.809*	-0.64^{ns}	0.768*	0.33^{ns}
Short Purple	-0.355^{ns}	-0.876**	-0.727*	0.92**	0.63^{ns}
Round White Brinjal	-0.596^{ns}	-0.93***	-0.86**	0.81*	0.70^{ns}
Singhnath 666	-0.37^{ns}	-0.82*	-0.70^{ns}	0.80*	0.79*

*, significant at 0.05; ns, non-significant.

Correlation between fruit infestation and environmental factors

The data regarding correlation of weather factors with fruit infestation on five aubergine cultivars have been shown in Table V. The average relative humidity showed positive and significant correlation with fruit infestation on Brinjal Long 6275 while the average precipitation showed positive but non-significant correlation in case of all the cultivars except Singhnath 666 which was significant. The average temperature showed negative but non-significant correlation for three of the cultivars while the rest of two cultivars showed negative but significant correlation with fruit infestation. The maximum temperature also showed the negative but significant correlation for all the aubergine cultivars. The minimum temperature showed the negative and non-significant correlation for all the cultivars with fruit infestation by BFSB, respectively. Similarly, the effect of average relative humidity and maximum temperature was found highly significant for all the aubergine cultivars

while the minimum temperature and average precipitation showed the negative correlation for all the cultivars except Singhnath 666.

DISCUSSION

In the present study, five aubergine cultivars were assessed for their susceptibility or resistance against BFSB on the basis of larval population and fruit infestation under field conditions. The cultivars showed significant variations in these parameters. The results of the current study are similar to those of Javed *et al*. (2011) who reported that BFSB larval population varied from 0.29 to 1.03 among different test cultivars. The minimum larval population was observed on Nirala (0.29) whereas the maximum was found on Naeelam (1.03) in the year of 2007. The average fruit infestation varied from 42.39 to 54.44 on the test cultivars. In the present study, Round Brinjal 86602 showed minimum fruit infestation (42.39%) while Round White Brinjal cultivar showed maximum fruit infestation (54.44%). The results are similar with the findings of Jat *et al*. (2003) and Krishna *et al*. (2001) who found 43% fruit infestation on 12 different aubergine cultivars. In another study, Kumar and Shukla (2002) found 33 to 53% damage of fruits. Similarly, Ashoke and Abhishek (2002) evaluated 12 aubergine cultivars and reported 33.65 to 53.02% fruit infestation. The data regarding fruit infestation is also comparable with the findings of Javed *et al*. (2017a) and Kassi *et al*. (2018) who reported 35.30% and 42.47% fruit damage respectively and the average losses of 25.33% due to this pest.

The maximum hair density on leaf lamina was found on Round Brinjal 86602 cultivar (279.0/cm^2) and minimum number of hairs was observed on Short Purple (186.7/cm^2). The current findings are comparable to those of Javed *et al*. (2011) which varied from 308.5 to 214. The maximum hair density on leaf midrib/cm was found on Round Brinjal 86602 (72.25/cm) and minimum number of hairs on leaf midrib/cm was observed on Short Purple (23.00/cm). Similarly, the cultivar Round Brinjal 86602 had maximum number of hairs on crown (14.25/cm^2) followed by Singhnath 666 (12.58/cm^2) and Short Purple (12.50/cm^2), while minimum number of hairs on crown were recorded on Brinjal Long 6275 (4.16/cm^2). In the present studies the hairs had significant role towards non-preference for fruit infestation on different parts of the plant, which is in conformity with the findings of Javed *et al*. (2017a) and Kassi *et al*. (2018). According to these researchers, the susceptibility of BFSB may be due to less number of hairs on leaves of the aubergine plants.

Maximum stem girth (59.21 mm) was found on Singhnath 666 cultivar while the minimum stem girth was recorded in case of Round White Brinjal (42.27 mm). The current finding is not in conformity with those reported by Javed *et al*. (2011) which might be due to varietal differences. Brinjal Long 6275 had shown the maximum plant height (59.39 cm) while minimum plant height was recorded in case of Short Purple (38.75 cm). The Round Brinjal 86602 cultivar had minimum number of holes (1.95) on the infested fruit while Brinjal Long 6275 showed the maximum number of holes (2.35). Similarly, Round Brinjal 86602 cultivar had minimum length of holes (1.37 cm) while the maximum length of holes on infested fruit was recorded on Round White Brinjal (1.67 cm). Round Brinjal 86602 showed the maximum yield (0.944 kg) per plant while minimum fruit yield was observed on Brinjal Long 6275 (0.497 kg) per plant. These findings are in line with those of Javed *et al*. (2011).

CONCLUSIONS

It is concluded from the present findings that Round Brinjal 86602 suffered less damage by the borer and therefore, is recommended for cultivation in arid and semi-arid regions. The cultivar can also be employed as a component of integrated nematode management along with other control strategies. The cultivar will have comparatively better crop yield as compared to other cultivars.

Statement of conflict of interest

Authors have declared no conflict of interest.

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